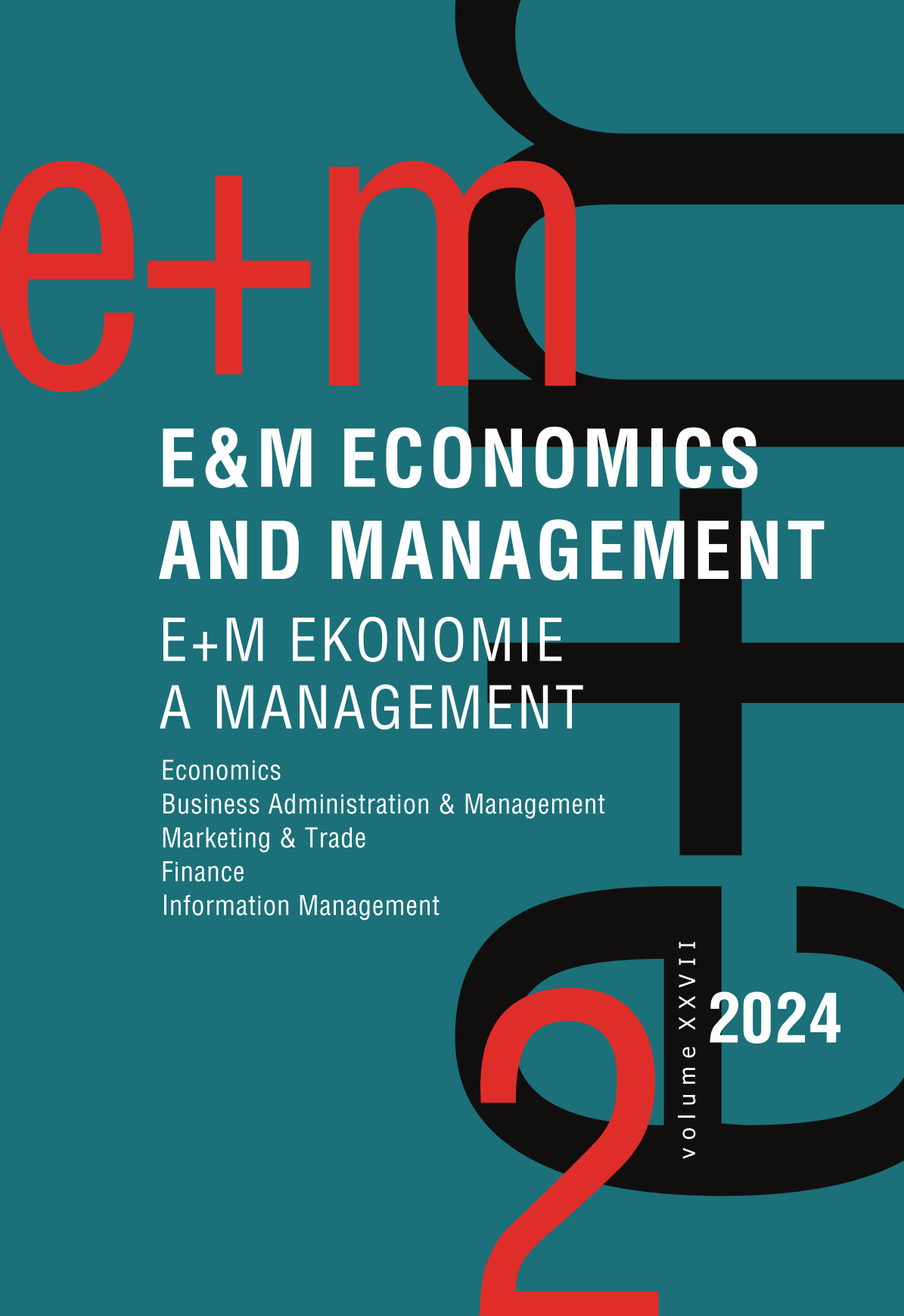

e+m
E&M ECONOMICS
AND MANAGEMENT
E+M EKONOMIE
A MANAGEMENT
Economics
Business Administration & Management
Marketing & Trade
Finance
Information Management
volume XXVII
2024

Cooperating faculties

Faculty of Economics
Technical University
of Liberec

FACULTY OF ECONOMICS TUL

Liberec
Czech Republic
https://www.ef.tul.cz/

**Faculty of Economics
and Administration**
University of Pardubice

UNIVERSITY
OF PARDUBICE
FACULTY
OF ECONOMICS
AND ADMINISTRATION

Pardubice
Czech Republic
https://fes.upce.cz

Faculty of Economics
University of West
Bohemia in Pilsen

FACULTY OF ECONOMICS
UNIVERSITY
OF WEST BOHEMIA

Plzeň
Czech Republic
https://www.fek.zcu.cz

**Faculty of Management
and Economics**
Tomas Bata University in Zlín

Tomas Bata University
Faculty of Management and Economics

Zlín
Czech Republic
https://fame.utb.cz

**Faculty of Informatics
and Management**
University of Hradec Králové

University of
Hradec Králové
Faculty of Informatics
and Management

Hradec Králové
Czech Republic
https://www.uhk.cz/fim

**Faculty of Social
and Economic Studies**
Jan Evangelista Purkyně
University in Ústí nad Labem

JAN EVANGELISTA PURKYNĚ UNIVERSITY IN ÚSTÍ NAD LABEM
Faculty of Social and Economic Studies

Ústí nad Labem
Czech Republic
https://www.fse.ujep.cz

**School of Business
Administration in Karviná**
Silesian University in Opava

SILESIAN
UNIVERSITY
SCHOOL OF BUSINESS
ADMINISTRATION IN KARVINA

Karviná
Czech Republic
https://www.slu.cz/opf/cz

Faculty of Economics
Technical University
of Košice

TECHNICAL UNIVERSITY OF KOŠICE
Faculty of Economics

Košice
Slovak Republic
https://ekf.tuke.sk

Faculty of Economics
Matej Bel University
in Banská Bystrica

FACULTY
OF ECONOMICS
MATEJ BEL UNIVERSITY
IN BANSKÁ BYSTRICA

Banská Bystrica
Slovak Republic
https://www.ef.umb.sk

scientific journal
www.ekonomie-management.cz

The journal E&M Economics and Management (E&M) publishes high quality original research articles and scientific studies based on theoretical and empirical analyses. E&M encourages new intriguing ideas and new perspectives on existing state of knowledge. Among the key topics covered are Economics, Business Administration, Finance, Management, Information Management, and Marketing & Trade. The journal features theoretical articles as well as application-oriented papers. Occasionally published review articles summarising existing knowledge are accepted only if they are based on a systematic literature review. The journal is published quarterly and all articles are double-blind peer reviewed. Editorial board consistently pays attention to compliance with the rules of publishing ethics. Therefore, among other things, articles received are checked by the Crossref's service Similarity Check.

The journal is covered in the Social Sciences Citation Index, Social Scisearch and Journal Citation Reports/ /Social Sciences Edition (https://clarivate.com). It is also monitored by Google Scholar (https://scholar.google.com/), Research Papers in Economics (RePEc; https://econpapers.repec.org/article/), the electronic EconLit index (https://www.aeaweb.org/econlit/), International Bibliography of the Social Sciences (http://www.proquest.com/products-services/ibss-set-c.html) and by Inspec (https://www.theiet.org/resources/inspec/), SCOPUS (https://www.elsevier.com/solutions/scopus), ABI/INFORM (http://www.proquest.com/products-services/abi_inform_complete.html), EBSCO Information Services (https://www.ebsco.com) and GALE (https://support.gale.com/tlist/products) databases. It is listed in the 11th Edition of Cabell's Directory of Publishing Opportunities in Economics and Finance/Management (www.cabells.com).

Contents

Finance

Marketing and trade

Information management

Call for papers
Monothematic issue 2025
E & M Economics and Management

Transitioning to the green circular economy: The age of VUCA

The global economy is at a critical juncture, facing unprecedented environmental and social challenges that necessitate a fundamental transformation in how we produce, consume, and interact with natural resources. The conventional linear approach of "take-make-waste," which has been prevalent in economic practices for generations, is no longer sustainable, resulting in significant environmental impacts and the depletion of resources. In response, the concept of the green circular economy has emerged as a beacon of hope, offering a sustainable and regenerative approach to economic development that is essential for addressing the complexities of the volatile, uncertain, complex, and ambiguous (VUCA) environment. The transition to a green circular economy presents inherent challenges for businesses, including the need to reconfigure production processes, forge novel supply chain partnerships, and navigate regulatory complexities. This monothematic issue solicits original submissions from various academic disciplines to evaluate multiperspective solutions to overcome these barriers.

Guest editors

Sandeep Kumar Dey, Assistant Professor at Tomas Bata University in Zlin
Tomas Bata University in Zlín, Czech Republic (email: dey@utb.cz)
(Advances in research methodologies in green and circular economic systems, business process innovation, circular human resource management, sustainable tourism and hospitality management)

Félix Puime-Guillén, Associate Professor at University of A Coruña (Spain)
University of A Coruña Spain, Spain (email: felix.puime@udc.es)
(Renewable energies and circular economy, green finance)

Important dates

Submission open date: June 1, 2024
Manuscript submission deadline: October 31, 2024
The submisison of the articles is accepted through the journal's editorial system: https://rizeni.ekonomie-management.cz/en/cms/review-process
After uploading the article, **please inform the editorial office that the submitted manuscript is intended for the monothematic issue** (journal@tul.cz).
Publishing of articles: September 2025

Background and objectives

The linear "take-make-waste" model dominating the global economy is no longer viable, leading to significant environmental externalities and resource depletion (Arauzo-Carod et al., 2022). In contrast, the green circular economy model aims to minimise waste, reuse materials, and regenerate natural systems (Morseletto, 2020). The concept of the green circular economy is a critical component of sustainable development, particularly in the context of the volatile, uncertain, complex, and ambiguous (VUCA) environment that businesses face today (D'Amato et al., 2017). According

to Li et al. (2022), the green circular economy is a production and consumption model involving sharing, leasing, reusing, repairing, refurbishing, and recycling existing materials and products as long as possible, thereby reducing waste and the depletion of natural resources. It emphasises the importance of designing products and services that are restorative and regenerative by design, aiming to keep materials in use for as long as possible and to recover and regenerate materials at the end of their service life (Despeisse, 2023). This approach is essential for addressing the environmental and social challenges the traditional economic input-output-based model poses. Moreover, in the VUCA environment, businesses must adapt to rapid changes in consumer behaviour, technological advancements, and shifting regulatory landscapes. The green circular economy offers a strategic framework for companies to navigate these challenges by focusing on innovation, collaboration, and sustainability (Troise et al., 2022). By adopting circular business models, companies can reduce their environmental footprint, improve resource efficiency, and create new revenue streams through product-as-a-service offerings and closed-loop recycling.

However, the shift towards a circular green economy is challenging. Businesses often face barriers, such as redesigning their production processes, establishing new supply chain relationships, and overcoming regulatory hurdles. Addressing these barriers and developing effective strategies for implementing circular economy practices is crucial for businesses to remain competitive and contribute to sustainable development.

Aim of the monothematic issue and topics

This monothematic issue explores the various aspects of transitioning to a green circular economy, including the economic benefits, barriers, and policies that can support this transformation. We invite contributions from researchers and practitioners in economics, management, and sustainability who can provide insights and case studies on how businesses can overcome the challenges and unlock the full potential of the green circular economy. We welcome papers that address the following topics, among others:

- The economic benefits of adopting circular business models, including cost savings, new revenue streams, and improved competitiveness;
- The barriers to implementing circular economy practices, including regulatory hurdles, supply chain challenges, and the need for new skills and competencies;
- The role of policy and regulation in supporting the transition to a circular economy, including the development of circular economy policies and rules at the national and international levels;
- The social and environmental impacts of the circular economy, including the creation of new jobs and the reduction of ecological externalities;
- Green circular finance and its effect on the transition pathway to corporate sustainability;
- Current and future themes on green circularity among tourism, hospitality and airline businesses;
- Divergent and convergent views on circular practices in the supply chain industry. How can a green circular supply chain become a reality?
- The issues concerning circularity in human resource management in services and manufacturing firms. Precisely, debates on human capabilities, knowledge systems, and co-creation;
- Eastern thoughts on the circular economy: theological, epistemological, and etiological;
- Pathbreaking discourses on research methods in the circular and green economies against the VUCA environment. Precisely, the use of futuristic linear/non-linear methods in dissecting, determining and predicting circular economy propagation, machine learning-based econometric modelling of green circular behaviours and interventions, advanced natural language processing towards understanding circular economy phenomenon.

This monothematic issue will provide a valuable platform for researchers and practitioners to share their knowledge and experiences and contribute to developing a more sustainable and regenerative economic system.

References

Arauzo-Carod, J.-M., Kostakis, I., & Tsagarakis, K. P. (2022). Policies for supporting the regional circular economy and sustainability. *The Annals of Regional Science*, *68*(2), 255–262. https://doi.org/10.1007/s00168-022-01124-y

D'Amato, D., Droste, N., Allen, B., Kettunen, M., Lähtinen, K., Korhonen, J., Leskinen, P., Matthies, B. D., & Toppinen, A. (2017). Green, circular, bio economy: A comparative analysis of sustainability avenues. *Journal of Cleaner Production*, *168*, 716–734. https://doi.org/10.1016/j.jclepro.2017.09.053

Despeisse, M. (2023). Applying regenerative sustainability principles in manufacturing. In S. Fukushige, H. Kobayashi, E. Yamasue, & K. Hara (Eds.), *EcoDesign for sustainable products, services and social systems I* (pp. 133–145). Springer Nature. https://doi.org/10.1007/978-981-99-3818-6_10

Li, J., Song, G., Cai, M., Bian, J., & Sani Mohammed, B. (2022). Green environment and circular economy: A state-of-the-art analysis. *Sustainable Energy Technologies and Assessments*, *52*, 102106. https://doi.org/10.1016/j.seta.2022.102106

Morseletto, P. (2020). Restorative and regenerative: Exploring the concepts in the circular economy. *Journal of Industrial Ecology*, *24*(4), 763–773. https://doi.org/10.1111/jiec.12987

Troise, C., Corvello, V., Ghobadian, A., & O'Regan, N. (2022). How can SMEs successfully navigate VUCA environment: The role of agility in the digital transformation era. *Technological Forecasting and Social Change*, *174*, 121227. https://doi.org/10.1016/j.techfore.2021.121227

Editors' biography

Sandeep Kumar Dey, PhD, Assistant Professor at Tomas Bata University in Zlín
Tomas Bata University in Zlín, Czech Republic
(email: dey@utb.cz)

Dr. Sandeep Kumar Dey is a seasoned academician whose career in tourism academia and industry spans over 10 years. He is an assistant professor at the Faculty of Management and Economics, Tomas Bata University in Zlín in the Czech Republic. He has authored several scientific articles in Web of Science and Scopus in sustainable tourism, the sharing economy, and machine learning techniques in econometrics.

He is a member of the British Academy of Management and serves as reviewer for International Journal of Contemporary Hospitality Management, Journal of Quality Assurance in Hospitality & Tourism, and Journal of Small Business and Enterprise Development.

Félix Puime-Guillén, PhD, Associate Professor at University of A Coruña (Spain)
University of A Coruña (Spain)
(email: felix.puime@udc.es)

Dr. Puime-Guillén is an acclaimed academician in energy transitions and managerial finance. Associate Prof. Puime-Guillén brings to the board a bricolage of experiences spanning over 34 years in consultancy, research and practice. Not only has he served as a financial leader for large corporations, but he also has advanced research in his field of renewable energy. He has significantly contributed to understanding energy pathway systems through high-impact publications.

His current research interests lie in energy economics, environmental strategy, and SMEs.

Natural resources and the underground economy: A cross-country study in ASEAN using Bayesian approach

Thach Ngoc Nguyen[1], My Ha Tien Duong[2], Diep Van Nguyen[3]

[1] *Ho Chi Minh University of Banking, Asian Journal of Economics and Banking, Vietnam, ORCID: 0000-0001-8822-2633, thachnn@hub.edu.vn;*
[2] *Ho Chi Minh City Open University, Faculty of Economics and Public Management, Vietnam, ORCID: 0000-0001-8796-4934, my.dth@ou.edu.vn;*
[3] *Ho Chi Minh City Open University, Faculty of Finance and Banking, Vietnam, ORCID: 0000-0002-5222-2516, diep.nv@ou.edu.vn (corresponding author).*

Abstract: *The development of the underground economy can significantly affect a country's economic indicators. Although there have been different studies on this phenomenon, many aspects of underground activities remain incompletely defined. Therefore, the current research aims to supplement the existing literature by analyzing the link between abundant natural resources and the scope of the underground economy. To accomplish this objective, we collected panel data from ten Association of Southeast Asian Nations (ASEAN) countries during the period 1991–2018. We then employed the Bayesian regression estimator to look into the influence of natural resources wealth on the scope of the underground sector. We found that the former can negatively and strongly affect the latter in ASEAN countries. That is, natural resources might be a blessing rather than a curse for economic growth and development in these countries. Other variables were found to have a strong positive relationship with the underground economy, like trade openness, tax burden, size of government, corruption, and the global financial crisis. Meanwhile, GDP growth, urbanization, and political stability had a strong negative effect on the size of the underground economy. These findings provide some implications for the governments of ASEAN countries to perform appropriate measures to control the underground economy.*

Keywords: *Natural resources, underground economy, Bayesian approach, ASEAN.*

JEL Classification: *C11, E26, O13.*

APA Style Citation: Nguyen, T. N., Duong, M. H. T., & Nguyen, D. V. (2024). Natural resources and the underground economy: A cross-country study in ASEAN using Bayesian approach. *E&M Economics and Management*, *27*(2), 1–15. https://doi.org/10.15240/tul/001/2024-2-001

Introduction

The underground economy is a section of the economy that is not subject to tax declaration, and usually involves the trade of goods and services paid in cash. The rise of the underground economy can distort investments, increase income inequality, create unfair competition for formal enterprises, reduce the quality of life, and ultimately hinder economic growth (Arezzo, 2014; Baklouti & Boujelbene, 2020; Kireenko & Nevzorova, 2015; Nguyen & Duong, 2021). Due to the prevalence and impact of the underground economy, various economists have tried to measure the size

and identify the determinants of this economy sector. Unfortunately, many aspects of the underground economy remain incompletely defined. Capasso and Jappelli (2013) argue that it is difficult to provide complete and rational explanations for why enterprises and individuals evade taxes or engage in illegal economic activities. One potential reason is mentioned in Alm et al. (2006). Notably, the authors state that taxpayers choose not to comply with if they believe they could benefit from tax evasion. The obtained benefits depend on the fine amount they are subject to pay if discovered and the probability of being discovered. The lower the expected penalty (measured in fines) and the probability of being discovered are, the higher the tax shunning is.

Nevertheless, tax rates may not be the only source of underground activities in ASEAN countries. There are ample reasons to expect that the underground economy sector and natural resources dependence are related. For instance, Le Billon (2011, p. 1) suggests that "Countries highly dependent on natural resources are among the most severely affected by the problem of illicit financial flows." Indeed, Blanton and Peksen (2023) discover that resource windfalls can enhance underground economy activities. Blanton and Peksen's (2023) result could rekindle the long-standing debate about whether abundant natural resources are a curse or a blessing for a nation's economic growth and development. Interestingly, Sovacool (2010) claims that Southeast Asia can avoid the resource curse thanks to certain characteristics, while other economists believe that natural resources are one of the most important economic assets and their presence will help countries achieve a sustainable growth trajectory (Barbier, 2019). If natural resources positively influence sustainable economic growth, or if the efficient exploitation of these resources helps promote employment in the formal sector, they might motivate individuals to participate in the official economy, thereby reducing the scope of the underground economy.

Despite the important role of this economic sector and natural resources, there is very little literature on the effect of the wealth of natural resources on the informal economy. Blanton and Peksen (2023) explore the impact of natural resources on the underground economy in numerous countries, but they do not specifically address the case of ASEAN, which represents an important economic region in the world. In that context, we aim to supplement the existing research by investigating the link between the wealth of natural resources and the scope of the underground economy in ASEAN countries over the 1991–2018 period.

Our paper attempts to improve the underground economy literature in three ways. First, to the best of our knowledge, our paper is among the first studies to empirically investigate the impact of natural resources on the underground economy in ASEAN countries. According to Elgin et al. (2021), the underground economy scope of 10 selected Southeast Asian countries between 1991–2018 varies widely, ranging from less than 13% of gross domestic product (GDP) in Singapore up to more than 50% in Thailand and Myanmar. Here comes a question that needs to be resolved: What makes countries in the same geographical region have such marked differences in the underground economy scope? Second, this paper applies new estimates of the informal economy produced by Elgin et al. (2021), given until 2018, in contrast to previous studies. Many anterior studies use data on the underground sector developed by Medina and Schneider (2019). In the analysis, we employ both estimates types of Elgin et al. (2021), namely the dynamic general equilibrium (DGE) and the multiple indicators multiple causes (MIMIC) models, to test whether the results are robust. Third, this is the first paper using the Bayesian approach, which has many advantages over the frequency approach, to explore the link between abundant natural resources and the informal economy. The findings of the study can contribute to the design of more effective policies to control underground economic activities.

The results reveal that natural resources are one of the important factors of the underground economy in ASEAN. Interestingly, we find that abundant natural resources reduce the scope of the informal economy. Such a finding suggests that natural resources might be a blessing rather than a curse for ASEAN countries.

The rest of this paper is given as follows. Section 1 presents a quick literature review. Consequently, in section 2, the dataset, models, and estimation strategies are presented. Section 3 depicts and analyzes the results. Finally, section 4 concludes and suggests some policy recommendations.

1. Theoretical background

1.1 Natural resources and the underground economy

Besides the underground economy, multiple of its synonyms terms are frequently used in the related documents, consisting of "dark", "hidden", "unofficial", "black", "informal", or "shadow" economy/area. The subsistence of many terms hints that it is indeed a vague concept. In our study, the terms are substitutable and defined as an economic activity concealed from public authorities for monetary, legal, or institutional motives (Schneider et al., 2010). Monetary motives consist of avoiding taxes and social security contributions, legal motives consist of dodging government bureaucracy or regulatory burdens, and institutional motives consist of high corruption, which is often related to poor quality of institutions (Schneider et al., 2010).

Studies on the underground economy forked into three fundamental groups. The first group focuses on calculating the scope of the underground economy (Elgin et al., 2021; Medina & Schneider, 2019). The second group analyzes the impact of the underground economy on economic indicators such as economic development and sustainable development (Gharleghi & Jahanshahi, 2020; Nguyen & Duong, 2021). The third group explores the factors that affect the scope of the underground economy (Lyulyov et al., 2021; My et al., 2022).

Natural resources involve natural products that people acquire from nature to satisfy their needs and the outcomes of human activities impacting them (Wang et al., 2021). Although there is much research on the affinity between abundant natural resources and economic growth or development, the linkage between the abundant natural resources and the scope of the underground economy is rarely mentioned.

Blanton and Peksen (2023) use natural resources rents as a substitute for natural resources revenue and find that the more abundant the natural resources of a country are, the larger the scope of the underground economy is. This is because revenues from natural resources allocate skewed production capital across sectors of the economy (Ebeke et al., 2015). Simultaneously, increased investment in natural resources will cause damage to the poor, and countries that invest less in human resources or labor-intensive industries are more inclined to employ common labor (Gylfason, 2001). Moreover, the absence of transparency regarding resource rents and the poor accountability in the way these resources are managed (Vadlamannati & De Soysa, 2016) can facilitate the creation of illegal rent-seeking. Increased revenues from resources tend to raise the scope of the informal economy because they have the effect of "pushing" labor out of the office area and creating more rent-seeking apart from the official sector. With these arguments, we suggest a positive effect of natural resources on the scope of the underground economy in ASEAN countries. Therefore, we construct the hypothesis below:

H1: The abundant natural resources positively affect the scope of the underground economy in ASEAN.

1.2 Other variables and the underground economy

Focusing on the influence of the rule of law and economic growth on the shadow economy, Luong et al. (2020) explore the impact of economic growth on the size of the shadow economy in 18 transition countries using the generalized method of moments (GMM) technique. The authors establish that economic growth decreases the activities of shadow economies. In Southeast Asia, My et al. (2024) assess the nexus between the inclusion of LGBT people and the shadow economy through the lens of Bayesian estimation techniques. The conclusion from the study suggests that economic growth reduces the size of the shadow economy. Furthermore, Blanton and Peksen (2023) establish a negative relationship between GDP per capita and the shadow economy, thus suggesting that economic growth lessens the activities of the shadow economy. Similarly, Blanton and Peksen (2021) conclude that an increase in GDP will stop the expansion of the shadow economy in 120 countries for the period 1985–2012. Many studies also confirm the negative relationship between economic growth and the size of the dark economy (Lyulyov et al., 2021; My et al., 2022; Sahnoun & Abdennadher, 2019; Siddik et al., 2022; Thach et al., 2022).

Lyulyov et al. (2021) examine the drivers of shadow economies within transition economies. Findings from the study show that an increase in tax level by 10% increases the shadow economy by 1%. Duong et al. (2021) also submit that the tax burden contributed to increasing the scale of underground economic activities in BRICS countries during

1995 and 2014. Using Bayesian regression, My et al. (2022) investigate the influence of tourism and other variables on the shadow economy in ASEAN countries. The study's outcome suggests that tourism and tax burden variables increase the shadow economy. Similarly, Arsić et al. (2015) and Sahnoun and Abdennadher (2019) conclude that the size of the tax burden is one of the fundamental factors determining tax evasion as well as participation in the underground economy.

Focusing on 18 Central Eastern European and former Soviet Union countries, Ghosh and Paul (2008) document that urbanization increases the scale of the underground economy. Meanwhile, Acosta-González et al. (2014) establish a negative relationship between the urban population and the underground economy, thus suggesting that urbanization lessens activities in the underground economy.

Sahnoun and Abdennadher (2019) examine the link between political stability and the underground economy in 38 developing and 40 developed countries over the 2000–2015 period. Findings from the study show that a negative relationship exists between political stability and the underground economy. Siddik et al. (2022) submit that political stability contributed to reducing the size of the shadow economy in the Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation Countries (BIMSTEC) during 1998 and 2015. Similarly, Razmi and Jamalmanesh (2014) conclude that the more politically stable countries will have a smaller shadow economy.

For government size, Ghosh and Paul (2008) document that government size, measured by general government final consumption expenditure, increases the shadow economy in 18 Central and Eastern European and former Soviet Union countries. My et al. (2022) conclude that government size and shadow economy were complementary in ASEAN countries from 1999 to 2017. Sahnoun and Abdennadher (2019) found a positive effect of the size of government spending on the underground economy in developed countries. However, Siddik et al. (2022), using fixed-effect or random-effect investigations for a sample period of 1998–2015, suggest that government spending has significant negative effects on the shadow economy. Similarly, My et al. (2024) found that government spending weakens activities in the underground economy.

In ASEAN nations, My et al. (2022) assess the nexus between international trade and the shadow economy using Bayesian estimation techniques. The conclusion from the study suggests that trade openness decreases the scale of the underground economy. Similarly, Blanton and Peksen (2021), Duong et al. (2021), and Siddik et al. (2022) establish a negative relationship between international trade and the underground economy, thus suggesting that international trade lessens the size of the shadow economy. Contrary to the conclusion above, Ghosh and Paul (2008) conclude that international trade by measure of percent of trade over GDP strengthens the shadow economy in 18 Central Eastern European and former Soviet Union countries. Similarly, Blanton and Peksen (2023) conclude that trade openness has a positive relationship with shadow economic activities.

Razmi and Jamalmanesh (2014) consider the influence of political indicators on the underground economies of 34 countries using data for 8 years from 2000–2007. The two authors' submission reveals that better government control of corruption decreases the size of the underground economy. Similarly, My et al. (2022) conclude that high corruption will encourage individuals and businesses to engage in illegal activities in ASEAN countries. Focusing on BRICS countries, Duong et al. (2021) document that control of corruption abates the underground economy. Numerous studies (Acosta-González et al., 2014; Blanton & Peksen, 2021, 2023; Luong et al., 2020; Sahnoun & Abdennadher, 2019; Thach et al., 2022) have confirmed the negative relationship between corruption control and the underground economy.

Finally, we examine the impact of the global financial crisis (GFC) on the size of the shadow economy. Using random effects, fixed effects, and GMM for a sample period of 1970–2011, Blanton and Peksen (2021) suggest that crises strengthen the size of the shadow economy in 143 countries. Similarly, Siddik et al. (2022) found that GFC strengthens the shadow economy in BIMSTEC countries.

2. Research methodology

2.1 Dataset

In this study, we explore the effect of natural resources on the underground economy. Using a secondary dataset available from 1991 to 2018,

we cover ten Southeast Asian countries, including Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Vietnam, to attain the study objectives.

The dependent variable is the scope of the underground economy. The variable is expressed as a percentage of gross domestic product (GDP), showing the expansion of the underground economy compared to the formal economy. It is derived from the work of Elgin et al. (2021), in which they used an estimation method based on a DGE model as well as an estimate based on a MIMIC model to evaluate the scope of the underground activities. Therefore, the scope of the underground economy will be measured by two methods, including the scope of the underground economy estimated based on the dynamic general equilibrium (DGE) model (*undecon_DGE)* and the scope of the underground economy estimated based on the multiple indicators multiple causes (MIMIC) model (*undecon_MIMIC*).

Natural resources (*ln_natures*), our main variable, are considered an independent variable since we aim to explore the relationship between natural resources and the scope of the underground economy. We employ data on natural resources rents from the World Governance Indicators (WDI) dataset of the World Bank. The data comprises oil, coal (hard and soft), natural gas, forest, and mineral rents. Following Blanton and Peksen (2023), we use the natural log of the natural resources rents to adjust the skewness of the data.

Three types of control variables are used to separate the effect of the main variable

Tab. 1: Definitions and sources of variables

Variables	Legend	Measurement	Source
Dependent variable			
Underground economy 1	*undecon_DGE*	DGE estimates of underground output (% of official GDP)	Elgin et al. (2021)
Underground economy 2	*undecon_MIMIC*	MIMIC estimates of underground output (% of official GDP)	Elgin et al. (2021)
Interest variable			
Natural resources	*ln_natures*	Whole natural resources rents (% of official GDP)	WDI database
Control variable			
GDP growth	*GDPgr*	GDP growth rate (annual %)	WDI database
Tax burden	*tax*	Total tax burden (% of official GDP)	Heritage Foundation
Urbanization	*urban*	Urbanization level (urban population/ total population)	WDI database
Political stability	*polistab*	Ranges from −2.5 (least stability) to 2.5 (most stability)	WGI database
Size of government	*gov*	General government final consumption expenditure (% of official GDP)	WDI database
Trade openness	*ln_open*	Volume of imports plus exports (% of official GDP)	WDI database
Corruption	*corrup*	Rescaled CPI from 0 (least corrupt) to 100 (most corrupt)	Transparency International
Global financial crisis	*GFC*	GFC is 1 for the global financial crisis, and 0 otherwise	Blanton and Peksen (2021), Siddik et al. (2022)

Source: own

(*ln_natures*). The first type includes macroeconomic variables, such as the GDP annual growth rate (*GDPgr*), tax burden (*tax*), and the global financial crisis (*GFC*). The second involves institutional factors, such as political stability (*polistab*), corruption (*corrup*), and the size of the government (*gov*). The third type focuses on variables such as commercial openness (*ln_open*), and urbanization (*urban*). *GDPgr*, *ln_open*, *gov*, and *urban* are collected from the WDI database. The *polistab* data is collected from the World Governance Indicators (WGI) dataset of the World Bank. The corruption perceptions index (CPI) provided by Transparency International will be used to measure corruption (*corrup*). For consistency between the data, the data from 1995 to 2011 is multiplied by ten so that they can equate to the range currently used by Transparency International from 0 to 100. Thereby, for simplicity and ease of presentation, the CPI is converted to a scale from 0 (least corrupt) to 100 (most corrupt). Tax burden (*tax*) data is obtained from the Heritage Foundation. Finally, the *GFC* is a dummy variable whose value is 1 if it denotes the financial crisis of 2007–2008, and 0 otherwise.

Detailed information about the variables is presented in Tab. 1. Whole variables are treated in percentages. The exceptions are *ln_natures* and *ln_open*, which appear in their natural logarithm form, and *polistab* and *corrup*, expressed as an index.

2.2 The models

Because the aim of this study is to delve into whether abundant natural resources impact the scope of the unofficial economy in ASEAN, by using the study conducted by Blanton and Peksen (2023), we assign a base model as follows:

$$undecon_{it} = \beta_0 + \beta_{it}\, ln\_natures + \\ + \beta_{it} X_{it} + \varepsilon_{it} \quad (1)$$

where: the dependent variable is the scope of the underground economy (*undecon*); interest variable is natural resources (*ln_natures*); β is the corresponding coefficient to measure its influence on the scope of the underground economy; *X* is the matrix of eight control variables, that is, the GDP annual percentage growth rate (*GDPgr*), tax burden (*tax*), global financial crisis (*GFC*), size of government (*gov*), political stability (*polistab*), corruption (*corrup*), trade openness (*ln_open*), urbanization (*urban*); and ε is the error term.

Control variables were chosen based on previous studies by Acosta-González et al. (2014), Arsić et al. (2015), Blanton and Peksen (2021, 2023), Duong et al. (2021), Ghosh and Paul (2008), Luong et al. (2020), Lyulyov et al. (2021), My et al. (2022), My et al. (2024), Razmi and Jamalmanesh (2014), Sahnoun and Abdennadher (2019), Siddik et al. (2022), and Thach et al. (2022). In this research, we use Stata version 17.0 to perform Bayesian regression estimates and related analyses.

2.3 Estimation strategies

Unlike previous studies that used frequentist approach, this study applies the Bayesian approach. Bayesian statistics has many advantages over the frequency approach. The first benefit of Bayesian statistics is that evidence can be continuously computed and updated as data becomes available (Oanh et al., 2023; Van De Schoot & Depaoli, 2014; Wagenmakers et al., 2017). This process is possible because all inferences in Bayesian statistics are based on actual observed data. This is a major advantage of Bayesian over frequentist methods because inference does not depend on data that has never been observed. Second, Wagenmakers et al. (2017) note that in contrast to frequentist statistics, Bayesian inference is logically coherent and internally consistent. Specifically, the Bayesian approach enables testers to explicitly report the probability of a system obtaining the desired outcome by using posterior probability. This interpretability is in direct contrast to the frequentist view which results in indirect measures of system performance with more esoteric definitions, such as *p*-values or confidence intervals. Third, Bayesian regression demonstrates superior performance compared to frequency school regression models in scenarios with limited sample sizes (Kruschke et al., 2012, Oanh et al., 2023). This approach offers accurate and evidence-based conditional conclusions that are not influenced by asymptotic approximations. The process of small sample inference follows a similar procedure as that of large sample inference. Therefore, the availability of trustworthy priors enables the attainment of meaningful Bayesian estimates (Miočević et al., 2017). Moreover, Van De Schoot and Depaoli (2014) state that another important advantage of Bayesian statistics is that they

give a probability distribution of the hypotheses. Bayesian inference lets you figure out whole probability distributions over a range of parameter values. This is done by using Bayes' theorem to set prior distributions over the parameters and then changing them based on new data. This results in posterior distributions that mirror the updated beliefs about the parameters given the data. These posterior distributions can then be used for inference, prediction, and uncertain quantification. Lastly, standard statistics models cannot be used to predict some complex models (Kruschke et al., 2012). When models are pretty complicated, numerical integration is often needed to get numbers based on maximum likelihood estimation. This method is impossible to use because it requires estimating the maximum likelihood over a lot of dimensions. Therefore, alternative estimation tools are needed. Bayesian estimation can also handle some commonly encountered problems in orthodox statistics.

Bayesian analysis is based on the Bayes rule (Bayes, 1991), which underpins Bayesian statistical inferences:

$$p(\theta \mid X) = p(X \mid \theta)p(\theta)/p(X) \quad (2)$$

where: $p(\theta \mid X)$ is desired posterior distribution; $p(X \mid \theta)$ is likelihood; $p(\theta)$ is prior information; and $p(X)$ is normalization constant.

The Bayesian linear regression model for the underground economy (y) is given in the following form:

$$y_i \sim N(\mu_i, \tau) \quad (3)$$

where: $\mu_i = X_i^{'} \beta$ ($i = 1, \ldots, n$) and $\tau = 1/\sigma^2$.

The prior distribution is determined as follows:

$$p(\beta, \tau) = \prod_{j=0}^{k} p(\beta_j) p(\tau) \quad (4)$$

where: $\beta_j \sim N(\mu_{\beta_j}, C_j^2)$ and $\tau \sim gamma(a, b)$; y_i is the underground economy; $X_i^{'}$ represents the vector of explanatory variables; β denotes the coefficient of the parameter estimates; μ_i is the mean of the estimated regression coefficients, and $1/\sigma^2$ is the precision (τ).

Using a normal distribution with substantial variance, we apply a non-informative prior for each unknown parameter in the model (Kosheleva et al., 2021). The prior mean for τ is 1, and the variance is 100, so a = b = 0.01.

For the likelihood functions of the coefficients, we assume that the parameters have parameters of normal distributions derived from Equation (1). Finally, we apply the Markov Chain Monte Carlo (MCMC) technique and Gibbs sampling algorithm to approach the corresponding posterior distributions of the parameters.

For the simulated scenarios, we used two chains with an adapt phase of 12,500 iterations, followed by a burn-in period of 2,500 iterations, and finally, the posterior distribution was drawn from the next 10,000 iterations.

In Bayesian analysis, the convergence of MCMC is one of the most important steps. Under certain conditions, MCMC algorithms will take a sample from the desired posterior distribution after it has converged to the balanced state. That is, at an equilibrium state, the distribution of samples from the chains must be the same regardless of the initial value of the chain. To test the convergence of MCMC, we calculate the R_c value of Gelman and Rubin (1992); if the diagnostic R_c value is greater than 1.2 for any model parameter, no convergence is recorded. Besides, effective sample size (ESS) is also considered when determining whether MCMC converges or not. ESS measures the degree of autocorrelation in samples that increase uncertainty compared to an independent sample. Kruschke (2015) argues that the closer the sampling efficiency is to 1, the better it is.

3. Results and discussion

3.1 Descriptive statistics

The statistical summary is presented in Tab. 2, while Tab. 3 summarizes descriptive statistics of whole variables for ten nations in the sample. For the dependent variable (*undecon*), the mean of the underground economy scope is 31.91 (*undecon_DGE*) or 33.06 (*undecon_MIMIC*), indicating that ASEAN countries have a significant scope of the underground economy. Besides, the standard deviation is 13.77 (*undecon_DGE*) or 13.73 (*undecon_MIMIC*), which explains a huge difference in the scope of the underground economy between these Southeast Asian countries. Singapore has the lowest scope of the underground economy of 12.46 (*undecon_DGE*) or 12.62 (*undecon_MIMIC*); the country with the highest scope of the underground economy

is Thailand (*undecon_DGE* is 48.70) or Myanmar (*undecon_MIMIC* is 50.74). For the main independent variable of interest, we find that natural resources (*ln_natures*) have an average of 7.25 by standard deviations of 7.08, which alludes to a large difference in natural resources in ten countries in the study sample. Brunei has the most abundant natural resources (23.14) in ASEAN countries, while Singapore has almost no natural resources, most of which have to be imported. We observe an average annual GDP growth of 5.49 by standard deviations of 4.29. Myanmar ranks first in terms of the average annual GDP growth rate (8.73), while Brunei achieves the lowest average value of 1.25. For the tax burden (*tax*), Cambodia has the highest level of the tax burden (91.12), and Vietnam has the lowest tax burden (67.14). Singapore is a country with a rapid urbanization rate, while Cambodia has the lowest urbanization rate in the region (19.41). For government size (*gov*), we find a mean of 11.53, by standard

Tab. 2: Descriptive statistics brief

Variable	Obs.	Mean	Std. dev.	Min	Max
Undecon_DGE	278	31.91	13.77	11.29	65.75
Undecon_MIMIC	260	33.06	13.73	11.89	53.78
Ln_natures	269	7.25	7.08	0.00	35.27
GDPgr	277	5.49	4.29	−34.81	14.53
Tax	217	79.20	10.58	32.20	91.70
Urban	280	46.70	24.72	15.78	100.00
Gov	248	11.53	5.57	3.46	29.87
Polistab	200	−0.17	0.94	−2.09	1.62
Ln_open	267	125.31	90.89	0.17	437.33
Corrup	194	61.17	22.04	6.00	87.00

Source: own

Tab. 3: Nation average value for variables in the model

Countries	*Undecon_ DGE*	*Undecon_ MIMIC*	*Ln_natures*	*GDPgr*	*Tax*	*Urban*	*Gov*	*Polistab*	*Ln_open*	*Corrup*
Brunei	30.70	31.04	23.14	1.25	87.08	72.65	23.76	1.18	102.71	42.49
Cambodia	47.17	48.58	3.49	6.01	91.12	19.41	5.34	−0.37	110.80	79.28
Indonesia	18.37	19.31	6.72	4.86	80.17	44.80	8.36	−1.08	54.79	73.69
Laos	30.20	30.16	8.22	6.87	68.88	25.56	10.60	−0.05	73.33	74.56
Malaysia	30.52	31.45	11.09	5.73	81.67	65.14	12.24	0.22	173.71	50.49
Myanmar	46.49	50.74	9.06	8.73	82.29	27.89	17.14	−1.15	19.68	80.88
Philippines	38.35	41.09	1.07	4.58	76.77	46.12	10.66	−1.24	80.89	70.48
Singapore	12.46	12.62	0.00	5.87	87.49	100.00	9.74	1.24	354.19	10.13
Thailand	48.70	50.41	1.84	4.22	76.29	37.98	13.87	−0.71	114.52	65.85
Vietnam	16.06	15.18	8.14	6.84	67.14	27.43	6.58	0.25	129.80	71.98
Total	31.91	33.06	7.25	5.49	79.20	46.70	11.53	−0.17	125.31	61.17

Source: own

deviations of 5.57. Brunei has the highest average value for government size, while Cambodia has the lowest median value of 5.34. Singapore has the highest average political stability, while the Philippines has the lowest.

Furthermore, we observe that the mean of trade openness (*ln_open*) is 125.31 with a standard deviation of 90.89, which shows a huge difference in the trade openness of ASEAN countries. Singapore achieves the highest value, while Myanmar achieves the lowest. In general, ASEAN countries have a relatively high level of corruption (61.17), Singapore has the lowest level of corruption (10.13), and Myanmar has the highest level of corruption among these Southeast Asia nations (80.88).

3.2 Baseline estimations

To report preliminary estimates, we exhibit the posterior mean of the parameters and a 95%-credible interval, which contains the parameter of interest with a certain probability, in Tab. 4. If a particular parameter has a positive (negative) posterior mean and the probability of its positive (negative) effect in the 95%-credible interval is greater than 50%, it is rated to cause a strongly positive (strongly negative) impact.

First of all, we evaluate the degree of convergence of MCMCs when performing Bayesian regression. The degree of convergence is considered through R_c and ESS values. In Tab. 4, our results reveal that the maximum R_c value of Gelman-Rubin diagnostics is 1.00034, less

Tab. 4: Bayesian estimation of natural resources on the underground economy (dependent variable: *undecon_DGE*)

Independent variables	Posterior mean	Probability of mean (%)	ESS min	R_c max
Ln_natures	−0.75050	95.9	1.00000	1.00002
	[−1.59378; 0.09589]			
GDPgr	−0.31934	91.9	1.00000	0.99998
	[−0.78962; 0.15264]			
Ln_open	1.36011	96.6	0.96000	1.00006
	[−0.08979; 2.80957]			
Tax	0.22749	98.4	0.99360	1.00000
	[0.02453; 0.43009]			
Urban	−0.27644	100.0	0.97690	1.00009
	[−0.41846; −0.13434]			
Gov	1.17990	100.0	1.00000	1.00007
	[0.77755; 1.58590]			
Polistab	−1.77860	98.5	0.96570	1.00005
	[−3.37112; −0.19537]			
Corrup	0.09457	86.8	0.98260	0.99999
	[−0.07544; 0.26606]			
GFC	0.40241	66.6	0.98770	0.99998
	[−1.41455; 2.24339]			
Constant	0.01638	50.8	0.99670	1.00002
	[−1.95807; 1.96093]			
Variance	94.27232	–	0.85710	1.00034
	[74.7164; 118.8254]			

Note: 95% credible interval in brackets; ESS for effective sample size and R_c is Gelman-Rubin statistic.

Source: own

than 1.1, and the smallest ESS is 0.8571, so MCMC has converged.

Next, we investigate whether the wealth of natural resources (*ln_natures*) is a blessing (i.e., reducing illegal economic activities) or a curse (i.e., increasing illicit economic activities) for ASEAN countries. Tab. 4 details the result, with the dependent variable being the underground economy's scope estimated based on the DGE model (*undecon_DGE*). The result indicates that abundant natural resources reduce the scope of the informal economy. The posterior mean of *ln_natures* is $\beta = -0.7505$, and the probability that the *ln_natures* variable has a negative effect of 95.9%. Therefore, we find strong negative evidence of the linkage between abundant natural resources and the scope of the unofficial economy. This finding implies that ASEAN countries with more abundant natural resources have a smaller scope of the underground economy. Our result contradicts hypothesis *H1* and the study of Blanton and Peksen (2023) but supports the view that natural resources wealth is a blessing. Thus, the poor economic performance of many ASEAN countries is not due to the wealth of resources but implies that certain social and political factors may shape such results.

One potential mechanism for the adverse impact of natural resource wealth on the underground economy can be through an increase in formal sector employment. That is, the efficient resources exploitation can help reduce the unemployment rate in the formal economy, which creates opportunities and motivation for individuals to leave the informal economy. For instance, Ali and Zulfiqar (2018) indicate that the agglomeration of natural resources can be a vital driver for decreasing unemployment. The authors, therefore, posit that the authorities should consider measures to promote the exploration, appropriate use and functioning of such resources. Here arises another question: what helps a country use natural resources efficiently and thereby escape the resource curse?

In this regard, Sovacool (2010) suggests three factors that could explain why Southeast Asia had avoided the resource curse. Firstly, it is due to the spread of natural resources in Southeast Asia. Normally, financiers and elites tend to easily dominate natural resources, such as oil fields. Still, oil and gas reserves in Southeast Asia are more dispersed over a wider geographical region than others. For example, the oil and gas fields in Indonesia are broad. Secondly, it is political institutions. In particular, countries with a political regime that enforces property rights, parliamentary democracies, and a strong tax system are inclined to escape the resource curse (Andersen & Aslaksen, 2008; Bulte et al., 2005; Sandbu, 2006). In addition, the lack of transparency and accountability regarding rent-seeking opportunities from natural resources is the root of the growth of the informal sector (Robinson et al., 2006). Except for Myanmar, the major oil and gas-producing ASEAN countries have relatively transparent and democratic political systems, respect for strong property rights and the rule of law, and are at average and above civil society groups. Most of these countries tend to economic diversification, such as encouraging exports and industrialization for import substitution in the 1980s and 1990s (Sovacool, 2010). Thus, political institutions in Southeast Asian countries equitably distribute benefits from natural resources. Finally, the role of collaboration in production, where resource exploitation is a partnership, ensures that revenue is distributed to more participants. Foreign-owned multinationals can react as buffers against export volatility. ASEAN nations adhere to the oil and gas cooperation model. These Southeast Asian countries have established active cooperation with biggish oil and gas firms to support probing, production, and distribution processes. For example, over 40 foreign oil companies are investing in Vietnam. Among them, many major oil companies are cooperating with Vietnam, such as Chevron (USA), Gazprom (Russia), KNOC (Korea), Petronas (Malaysia), Talisman and Repsol (Spain), ExxonMobil (USA), Total and Neon Energy (France), and PTTEP (Thailand).

In the case of the control variables, similar to Blanton and Peksen (2001, 2023), Luong et al.(2020), Lyulyov et al. (2021), My et al. (2022, 2024), Sahnoun and Abdennadher (2019), Siddik et al. (2022) and Thach et al. (2022), we find that economic growth (*GDPgr*) has an adverse and strong effect on the scope of the underground economy. The above results suggest that the association between economic growth and the underground economy is always negative. Higher-income countries have lower shadow economies. By contrast, countries with lower GDP per capita have high

poverty and unemployment rates, along with endemic income inequality, which imposes financial difficulties on low-income individuals who turn to the shadow economy for their livelihood. Another finding suggests that trade openness (*ln_open*) amplifies the scope of the underground economy, which is concordant with the result of Blanton and Peksen (2023), and Ghosh and Paul (2008). Our results can be explained as follows: international trade is sometimes seen as a catalyst for increased competitiveness among domestic manufacturers, which in turn contributes to the proliferation of informal employment. This occurs when workers in the formal market are laid off in order to reduce costs and are subsequently replaced by informal workers. Furthermore, we uncover that there are positive and strong effects of the burden of tax (*tax*) on the scope of the underground economy, which is similar to the result of Arsić et al. (2015), Duong et al. (2021), Lyulyov et al. (2021), My et al. (2022) and Sahnoun and Abdennadher (2019). The study also shows that higher urbanization (*urban*) is connected with a lower scope of the underground economy. Our observations are similar to those of Acosta-González et al. (2014). Another finding indicates that government size (*gov*) positively and strongly affects the underground economy. The above results suggest that the larger governments are proxying for an increase in government overreach that could incentivize individuals and firms to migrate to the underground economy. This result is consistent with Ghosh and Paul (2008), My et al. (2022), and Sahnoun and Abdennadher (2019) when considering developed countries. Consistent with the conclusions of Razmi and Jamalmanesh (2014), Sahnoun and Abdennadher (2019), and Siddik et al. (2022), we find the adverse impact of the extent of political stability (*polistab*) on the scope of the underground economy. That is, the higher the political stability of a country is, the smaller the scope of the underground economy is. A country with a stable political situation will have little internal conflict and violence. The smaller risk of internal conflict and violence ensures a healthy political environment, and thus political stability reduces the size of the shadow economy. Specifically, a politically stable business environment will create motivation for the growth and survival of businesses. Concerning corruption (*corrup*), our research results support the view that corruption and illicit activities are complementary, which is compatible with the conclusions of Acosta-González et al. (2014), Blanton and Peksen, (2021), Blanton and Peksen (2023), Duong et al. (2021), Luong et al. (2020), My et al. (2022), Razmi and Jamalmanesh (2014), Sahnoun and Abdennadher (2019) and Thach et al. (2022). Finally, we discover positive and strong effects of the 2007–2008 financial crisis (*GFC*) on the scope of the underground economy of ASEAN countries (Blanton & Peksen, 2023; Siddik et al., 2022). This result implies that the GFC will cause businesses to downsize or go bankrupt, while workers' income will decrease and the unemployment rate will increase. It is almost certainly true that some businesses and workers move underground when profits or incomes take a hit.

Tab. 5: **Bayesian estimation, using *undecon_MIMIC* (dependent variable: *undecon_MIMIC*) – Part 1**

Independent variables	Posterior mean	Probability of mean (%)	ESS min	R_c max
Ln_natures	−1.04162	99.6	1.00000	1.00005
	[−1.80647; −0.26545]			
GDPgr	−0.22700	85.3	1.00000	1.00003
	[−0.65072; 0.20097]			
Ln_open	0.43923	73.8	1.00000	0.99998
	[−0.91474; 1.79619]			
Tax	0.41931	100.0	0.98880	0.99995
	[0.23428; 0.60519]			

Tab. 5: **Bayesian estimation, using *undecon_MIMIC* (dependent variable: *undecon_MIMIC*) – Part 2**

Independent variables	Posterior mean	Probability of mean (%)	ESS min	R_c max
Urban	−0.46393	100.0	1.00000	1.00004
	[−0.59615; −0.33102]			
Gov	1.79628	100.0	1.00000	1.00010
	[1.42946; 2.15506]			
Polistab	−2.30423	99.8	0.95400	1.00005
	[−3.82051; −0.78275]			
Corrup	0.00266	51.5	0.98100	1.00003
	[−0.15145; 0.15702]			
GFC	0.37917	66.1	1.00000	1.00020
	[−1.41000; 2.17974]			
Constant	−0.06727	52.7	0.99760	1.00003
	[−2.04049; 1.92936]			
Variance	76.11839	—	0.81790	1.00004
	[60.2358; 96.2142]			

Note: 95% credible interval in brackets; ESS for effective sample size; R_c is Gelman-Rubin statistic.

Source: own

3.3 Robustness checks

We perform a robustness check to inquire about the stability of the results disclosed in Tab. 4. Specifically, we use an alternative to the underground economy proposed by Elgin et al. (2021). Tab. 5 shows the results of Bayesian regression with *undecon_MIMIC* (the estimate of the underground economy's scope is derived from the MIMIC model). The results related to the effects of natural resources are consistent with previous results. Specifically, the posterior mean of *ln_natures* is β = −1.04162, and the probability that the *ln_natures* variable has a negative effect of 99.6%, which means that a country with abundant natural resources has a smaller underground economy scope. For the control variables, similar to the results in Tab. 4, we detect a positive effect of trade openness, government size, corruption, and the 2007–2008 financial crisis on the scope of the underground economy. Meanwhile, annual growth in GDP, urbanization, and degree of political stability reduce illegal economic activities in ASEAN countries. At the same time, the R_c and ESS values in Tab. 5 also provide evidence that MCMC is convergent, so the Bayesian estimation is robust.

Conclusions

Is the wealth of natural resources a curse or a blessing? To contribute to the answer of this question, we examine the linkage between abundant natural resources and the informal economy's scope using a dataset of ten Southeast Asian countries during the period 1991–2018. Applying the Bayesian linear regression, our results uncover that the wealth of resources significantly negatively affects the underground economic sector. The negative effect of abundant natural resources on the informal sector remains steady and strong when we employ a different metric for the underground economy. Our findings show that resource-rich nations incline to have a smaller scope of the underground economy.

These findings suggest some interesting information that the governments should consider when designing policy. First, the authorities can influence the underground economy through the management of natural resources. Second, abundant natural resources are an advantage of a country. However, if the government does not control resource exploitation well, it can lead to undesirable effects, such as an increase in the informal economy. A potential mechanism

for this consequence is through unsustainable spending and investment patterns related to resource windfalls (Blanton & Peksen, 2023). By contrast, if a country uses natural resources efficiently, it may escape the resource curse. Notably, the efficient exploitation of natural resources can help create jobs in the formal economy and thus motivate individuals to join this sector. Hence, in countries that aim to curtail underground activities, our findings suggest that they should more closely monitor and regulate the exploration, usage, and operation of the nation's resources.

Finally, the research is not free from limitations. The link between the underground economy and natural resources still has uncertain aspects that need to be explored. The paper examines this relationship in ASEAN countries between 1991 and 2018. Nevertheless, because natural resources' characteristics and management vary across regions, further studies can compare among regions based on the natural resource management index. Moreover, further studies may also investigate different mechanisms by which natural resources can influence the underground economy. Such studies will help better clarify the picture of these two very common issues occurring in many countries worldwide.

Acknowledgments: *Supported by Ho Chi Minh University of Banking and Ho Chi Minh City Open University. We also thank anonymous reviewers for constructive comments, which are helpful for us in improving the manuscript.*

References

Acosta-González, E., Fernández-Rodríguez, F., & Sosvilla-Rivero, S. (2014). An empirical examination of the determinants of the shadow economy. *Applied Economics Letters*, *21*(5), 304–307. https://doi.org/10.1080/13504851.2013.856993

Ali, A., & Zulfiqar, K. (2018). An assessment of association between natural resources agglomeration and unemployment in Pakistan. *Journal of Pakistan Vision*, *19*(1), 110–126.

Alm, J., Martinez-Vazque, J., & Torgler, B. (2006). Russian attitudes toward paying taxes – Before, during, and after the transition. *International Journal of Social Economics*, *33*(12), 832–857. https://doi.org/10.1108/03068290610714670

Andersen, J. J., & Aslaksen, S. (2008). Constitutions and the resource curse. *Journal of Development Economics*, *87*(2), 227–246. https://doi.org/10.1016/j.jdeveco.2007.12.005

Arezzo, M. F. (2014). Social capital and undeclared work: An empirical analysis in Italy from 1998 to 2008. *Social Indicators Research*, *118*(2), 695–709. https://doi.org/10.1007/s11205-013-0434-4

Arsić, M., Arandarenko, M., Radulović, B., Ranđelović, S., & Janković, I. (2015). Causes of the shadow economy. In G. Krstić & F. Schneider (Eds.), *Formalizing the shadow economy in Serbia. Contributions to economics* (pp. 21–46). Springer International Publishing. https://doi.org/10.1007/978-3-319-13437-6_4

Baklouti, N., & Boujelbene, Y. (2020). Shadow economy, corruption, and economic growth: An empirical analysis. *The Review of Black Political Economy*, *47*(3), 276–294. https://doi.org/10.1177/0034644619885349

Barbier, E. B. (2019). *Natural resources and economic development*. Cambridge Books.

Bayes, T. (1991). An essay towards solving a problem in the doctrine of chances. 1763. *MD Computing: Computers in Medical Practice*, *8*(3), 157–171.

Blanton, R. G., & Peksen, D. (2021). A global analysis of financial crises and the growth of informal economic activity. *Social Science Quarterly*, *102*(4), 1947–1965. https://doi.org/10.1111/ssqu.12952

Blanton, R. G., & Peksen, D. (2023). Natural resource wealth and the informal economy. *International Political Science Review*, *44*(3), 418–433. https://doi.org/10.1177/01925121211991973

Bulte, E. H., Damania, R., & Deacon, R. T. (2005). Resource intensity, institutions, and development. *World Development*, *33*(7), 1029–1044. https://doi.org/10.1016/j.worlddev.2005.04.004

Capasso, S., & Jappelli, T. (2013). Financial development and the underground economy. *Journal of Development Economics*, *101*, 167–178. https://doi.org/10.1016/j.jdeveco.2012.10.005

Duong, T. H. M., Nguyen, T. A. N., & Nguyen, V. D. (2021). Social capital and the shadow economy: A Bayesian analysis of the BRICS. *Asian Journal of Economics and Banking*, *5*(3), 272–283. https://doi.org/10.1108/ajeb-05-2021-0061

Ebeke, C., Omgba, L. D., & Laajaj, R. (2015). Oil, governance and the (mis)allocation of talent in developing countries. *Journal*

of Development Economics, *114*, 126–141. https://doi.org/10.1016/j.jdeveco.2014.12.004

Elgin, C., Kose, M. A., Ohnsorge, F., & Yu, S. (2021). *Understanding informality*. Centre for Economic Policy Research.

Gelman, A., & Rubin, D. B. (1992). Inference from iterative simulation using multiple sequences. *Statistical Science*, *7*(4), 457–472, 416. https://doi.org/10.1214/ss/1177011136

Gharleghi, B., & Jahanshahi, A. A. (2020). The shadow economy and sustainable development: The role of financial development. *Journal of Public Affairs*, *20*(3), 2099. https://doi.org/10.1002/pa.2099

Ghosh, A., & Paul, S. (2008). Opening the Pandora's box? Trade openness and informal sector growth. *Applied Economics*, *40*(15), 1995–2007. https://doi.org/10.1080/00036840600915273

Gylfason, T. (2001). Natural resources, education, and economic development. *European Economic Review*, *45*(4–6), 847–859. https://doi.org/10.1016/s0014-2921(01)00127-1

Kireenko, A., & Nevzorova, E. (2015). Impact of shadow economy on quality of life: Indicators and model selection. *Procedia Economics and Finance*, *25*, 559–568. https://doi.org/10.1016/s2212-5671(15)00770-4

Kosheleva, O., Kreinovich, V., & Autchariyapanitkul, K. (2021). Why Beta priors: Invariance-based explanation. In S. Sriboonchitta, V. Kreinovich, & W. Yamaka (Eds.), *Behavioral predictive modeling in economics* (pp. 141–144). Springer International Publishing. https://doi.org/10.1007/978-3-030-49728-6_8

Kruschke, J. K. (2015). *Doing bayesian data analysis* (2nd ed.). Academic Press.

Kruschke, J. K., Aguinis, H., & Joo, H. (2012). The time has come: Bayesian methods for data analysis in the organizational sciences. *Organizational Research Methods*, *15*(4), 722–752. https://doi.org/10.1177/1094428112457829

Le Billon, P. (2011). *Extractive sectors and illicit financial flows: What role for revenue governance initiatives?* (U4 Issue 2011:13). U4 Anti-Corruption Resource Centre. Chr. Michelsen Institute.

Luong, T. T. H., Nguyen, T. M., & Nguyen, T. A. N. (2020). Rule of law, economic growth and shadow economy in transition countries. *The Journal of Asian Finance, Economics and Business*, *7*(4), 145–154. https://doi.org/10.13106/jafeb.2020.vol7.no4.145

Lyulyov, O., Paliienko, M., Prasol, L., Vasylieva, T., Kubatko, O., & Kubatko, V. (2021). Determinants of shadow economy in transition countries: Economic and environmental aspects. *International Journal of Global Energy Issues*, *43*(2/3), 166–182. https://doi.org/10.1504/ijgei.2021.115142

Medina, L., & Schneider, F. (2019). *Shedding light on the shadow economy: A global database and the interaction with the official one*. Center for Economic Studies and Ifo Institute (CESifo).

Miočević, M., MacKinnon, D. P., & Levy, R. (2017). Power in Bayesian mediation analysis for small sample research. *Structural Equation Modeling: A Multidisciplinary Journal*, *24*(5), 666–683. https://doi.org/10.1080/10705511.2017.1312407

My, D. T. H., Thach, N. N., Hue, P. T. M., & Van Diep, N. (2024). The war on the shadow economy in Southeast Asia: A new contribution from inclusion of LGBT people. In *Studies in Systems, Decision and Control* (Vol. 483, pp. 403–416). Springer Nature Switzerland.

My, D. T. H., Vi, L. C., Thach, N. N., & Van Diep, N. (2022). A Bayesian analysis of tourism on shadow economy in ASEAN countries. *Financial Econometrics: Bayesian Analysis, Quantum Uncertainty, and Related Topics*, *427*, 405–424. https://doi.org/10.1007/978-3-030-98689-6_27

Nguyen, D. V., & Duong, M. T. H. (2021). Shadow economy, corruption and economic growth: An analysis of BRICS countries. *The Journal of Asian Finance, Economics and Business*, *8*(4), 665–672. https://doi.org/10.13106/jafeb.2021.vol8.no4.0665

Oanh, T. T. K., Van Nguyen, D., Le, H. V., & Duong, K. D. (2023). How capital structure and bank liquidity affect bank performance: Evidence from the Bayesian approach. *Cogent Economics & Finance*, *11*(2), 2260243. https://doi.org/10.1080/23322039.2023.2260243

Razmi, M. J., & Jamalmanesh, A. (2014). How political indices affect the shadow economy. *Romanian Economic and Business Review*, *9*(1), 45–55.

Robinson, J. A., Torvik, R., & Verdier, T. (2006). Political foundations of the resource curse. *Journal of Development Economics*, *79*(2), 447–468. https://doi.org/10.1016/j.jdeveco.2006.01.008

Sahnoun, M., & Abdennadher, C. (2019). *The nexus between unemployment rate and shadow economy: A comparative analysis of developed and developing countries using a simultaneous-equation model* (Economics

Discussion Paper 2019-30). Kiel Institute for the World Economy.

Sandbu, M. E. (2006). Natural wealth accounts: A proposal for alleviating the natural resource curse. *World Development*, *34*(7), 1153–1170. https://doi.org/10.1016/j.worlddev.2005.11.014

Schneider, F., Buehn, A., & Montenegro, C. E. (2010). New estimates for the shadow economies all over the world. *International Economic Journal*, *24*(4), 443–461. https://doi.org/10.1080/10168737.2010.525974

Siddik, M. N. A., Kabiraj, S., Hosen, M. E., & Miah, M. F. (2022). Impacts of political stability on shadow economy: Evidence from Bay of Bengal Initiative for Multi-sectoral Technical and Economic Cooperation Countries. *Vision: The Journal of Business Perspective*, *26*(2), 221–231. https://doi.org/10.1177/0972262920988387

Sovacool, B. K. (2010). The political economy of oil and gas in Southeast Asia: Heading towards the natural resource curse? *The Pacific Review*, *23*(2), 225–259. https://doi.org/10.1080/09512741003624484

Thach, N. N., My, D. T. H., Thu, P. X., & Van Diep, N. (2022). Crime and the shadow economy: Evidence from BRICS countries. In *Financial Econometrics: Bayesian Analysis, Quantum Uncertainty, and Related Topics* (Vol. 427, pp. 269–283). Springer International Publishing. https://doi.org/10.1007/978-3-030-98689-6_17

Vadlamannati, K. C., & De Soysa, I. (2016). Do resource-wealthy rulers adopt transparency-promoting laws? *International Studies Quarterly*, *60*(3), 457–474. https://doi.org/10.1093/isq/sqw026

Van de Schoot, R., & Depaoli, S. (2014). Bayesian analyses: Where to start and what to report. *European Health Psychologist*, *16*(2), 75–84.

Wang, R., Tan, J., & Yao, S. (2021). Are natural resources a blessing or a curse for economic development? The importance of energy innovations. *Resources Policy*, *72*, 102042. https://doi.org/10.1016/j.resourpol.2021.102042

Decision-making on the job choice in the condition of Slovak households

Jan Kollar[1], Marian Kika[2], Barbora Mazurova[3]

[1] *Matej Bel University in Banska Bystrica, Faculty of Economics, Department of Economics, Slovakia, ORCID: 0000-0001-7317-6654, jan.kollar@umb.sk;*
[2] *Matej Bel University in Banska Bystrica, Faculty of Economics, Department of Economics, Slovakia, ORCID: 0000-0003-4060-1209, marian.kika@umb.sk;*
[3] *Matej Bel University in Banska Bystrica, Faculty of Economics, Department of Economics, Slovakia, ORCID: 0000-0001-6583-9585, barbora.mazurova@umb.sk.*

Abstract: *Getting, keeping as well as changing jobs are the moments in a person's life associated with not only the search and evaluation of the options but also with selection and decision-making. The article is one of the few in the Slovak Republic that deals with the issue of decision-making on the job choice in households, thus bringing new point of view into the knowledge about the Slovak labor market. The aim of the article is to analyse the decision-making process on the job choice of members of Slovak households and to identify the decision-making circumstances. It deals with the three selected parts of the decision-making process: the decision-making steps, the decision-making subject (decision-maker) and the decision-making circumstances. The contribution is based on the theoretical background concerned to decision-making, paid work and specific conditions of households and it draws the knowledge from the results of the original national research in more than 500 Slovak households. The primary data was collected through an anonymous survey, using a standardised anonymous questionnaire and guided interviews. Statistical sorting and descriptive statistics were used in data processing using the statistics software SPSS. The chi-square test was used to verify the representativeness of the research sample. The results show that the closer the final decision, the higher the proportion of individuals who implement decision-making actions. The most important decision-making circumstances include financial valuation, the character (difficulty) of the work and the childcare.*

Keywords: *Household, decision-making process, job choice, decision-makers, decision-making circumstances.*

JEL Classification: *J22, J29, D19.*

APA Style Citation: Kollar, J., Kika, M., & Mazurova, B. (2024). Decision-making on the job choice in the condition of Slovak households. *E&M Economics and Management, 27*(2), 16–31. https://doi.org/10.15240/tul/001/2024-2-002

Introduction

Work is an integral part of human life. In the past, people worked primarily to secure resources for existence. This is still true today, with additional benefits related to the satisfaction of needs, especially higher-level needs (the need for self-realisation, personal growth, social belonging, and the desire for knowledge).

Paid work performed in the workplace, recognised with wages and services, means security in modern societies. Primarily, the income from work provides basic living conditions. This is the reason why work is an essential element of people's self-esteem (Fedor, 2018; Móré, 2018). Because of technological progress and digitisation, the nature, content, complexity, and duration of work and its forms are changing significantly. The changes are reflected not only in the requirements placed on the worker, his training, and the need to acquire new skills

but also affect the extensive set of conditions in which this work is performed (Pilný, 2016).

Consistency of perception of this phenomenon requires attention to other elements forming its broader context. On the one hand, they are the labour market as an official environment in which labour demand and supply meet and which is a source of important information on both groups of participants and on the overall socio-economic situation. On the other hand, it is a relatively poorly analysed aspect of paid work – the household as the environment in which a person lives as a labour market participant. There is a mutual and very intense relationship between these environments (the labour market and the household), which reveals another current aspect on both sides (the issue of decision-making). The situation in the labour market visibly affects what is happening in households, and conversely, the household as a social unit influences its members intensively through needs and mutual relations, which can be of various natures (Riegel, 2007). In a changing labour market, declining and emerging jobs, together with career opportunities, present the greatest challenges to which household members, as labour market participants, will have to respond more quickly.

Job choice is a dynamic decision process in which job seekers move through various stages (Barber, 1988). Arguably, factors important to an individual likely vary at different stages of the job search and choice process as applicants become more aware of available opportunities and their own preferences (Boswell et al., 2003). Twenty-eight factors important to job choice were identified from a search of the academic and practitioner literature on attributes affecting job choice or attractiveness (Boswell et al., 2001; Mauger et al., 2019; Posner, 1981; Turban, 2001). The decision on paid work is not easy and it is natural that achieving the optimal state from the individual's point of view is accompanied by difficulties (Hirschi, 2018; Kulcsár et al., 2020).

The nature and content of work have different forms, complexity, and organisation, which implies the need for flexible adaptation of the workforce to these demands. The household has an important role to play in finding, hiring, and executing, but also in losing the employment of its members. Its significance lies in the fact that the household is an important microenvironment with a strong supportive but formative influence on members. The household (together with schools and educational institutions) has been influencing the behaviour of its members for a relatively long time, and further influences the acquisition of knowledge, skills, and experiences of its members. This is not only through the performance of domestic (unpaid work), but also through the formation of the values, opinions, and attitudes of its members, from which it is very difficult to liberate (Roostin, 2018; Weick, 1965). At the same time, an environment gives its members a certain status and influences them in setting goals.

In this context, it is also useful to know in more detail an important part of household management, which is to decide on the job choice of a household member. When deciding on a job choice, we consider important to answer a questions: How do individuals in the household proceed when choosing a job and which circumstances are important when deciding? The aim of the paper, in the context of the above-mentioned reasons, is to pay more detailed, but not comprehensive, attention to the decision-making process on the job choice of individuals in Slovak households. The article intends to bring new knowledge of activities that are implemented in households before the job acceptance of their members, considering the different types of households. We expect that this will help to understand the decision-making process in choosing a job in the context of household management. The ambition of the authors is to highlight the importance of the environment of the household from which the employee comes from, and thus to overcome the traditional view of employment decision-making only from the individual's perspective.

From the processed results, we have reached several initial conclusions in decision-making on the job-choice in Slovakia, which also considers the household environment. We have divided and further examined the decision-making process in terms of four steps, which are implemented differently by household members. The results show that the closer the final decision comes, the higher is the share of individuals implementing decision-making steps. In the absolute majority (84.6%), a person decides on the job choice by herself or himself. The participation of other household members in the decision-making

process on the job choice increases with household size. We consider the most important decision-making circumstance to be the financial valuation of the job (salary). More than half of the respondents identified it as decisive. More than 17% of respondents ranked the nature and difficulty of the job, and more than 10% ranked childcare as decisive.

The article is structured as follows. The introduction section presents the background of the research. The literature review section presents the current knowledge in the literature. Section Research methodology presents the description of applied research methods. The Results and discussion section presents own original conclusions from primary research conducted in Slovakia.

1. Theoretical background

The decision-making process is carried out in specific conditions and time, available options, but most often in the household. According to Baron (2008, p. 8), "Decision-making is a choice of action – what to do or not to do." Decisions are made to achieve a goal and are based on beliefs about what action will achieve the goal. According to Connoly et al. (2000), decision-making is the act of resolving or terminating a process through judgment. Any decision is a response to a stimulus and leads to a changed initial state.

The theoretical underpinnings of decision-making in the household setting have received considerable attention, which has been developed more comprehensively, particularly by the theoretical paradigm of home management (Mohanti, 2016; Varghese et al., 2005). In this paper, we discuss the decision-making on the job choice of an individual as a household member in the context of practical considerations with respect to household type. This type of decision-making represents only one of many types of decision-making in a household environment.

We consider the terms employment, job, and paid work to be synonymous, as together, they represent work that can be defined differently depending on its type. According to the International Labour Organization, an employed person is a person aged 15 years or older who has worked (for pay or profit for at least one hour during a given week) or has a job from which being absent under conditions on the reason of absence (holidays, sick leave, and maternity leave) or duration (INSEE, 2021). It is clear from the approach that this type of work differs from others so that the individual does it consciously for a reward, which is one of the most common but not the only reasons why this type of work is part of the life of household members. Although an individual or a household makes several decisions during the day (estimated at more than 35,000), which may be of different nature, regularity or importance, decisions about job choices are different precisely because they are infrequent, and the individual may not have enough relevant experience to decide on the job choice (Wansink & Sobal, 2007).

Choosing a job that is part of a career has long-term consequences for the lifestyle of individuals, emotional well-being, as well as economic and social status and the meaning of life. It is, therefore, natural for individuals to be involved in job choices at various stages of their lives, even repeatedly, with many people facing difficulties in this area (Amir et al., 2008; Gati et al., 2001; Osipow, 1999; Tinsley, 1992). Many studies have examined the organisational and job attributes important for job choice (Boswell et al., 2003; Brewer & Marsh, 2016; Carless, 2005; Harold et al., 2016), culminating in multiple meta-analyses (Chapman et al., 2005; Uggerslev et al., 2012). Individuals are likely to vary in the extent to which they make work decisions that are based on family factors (Greenhaus & Powell, 2003). Not every individual makes work decisions that take family factors into account, and not every work decision made by a given individual takes family factors into account to an equal extent. In this article, we are concerned with the cognitive processes by which individuals take family factors into account in work decisions and the factors that influence their progression through successive stages in their decision-making (Powell & Greenhaus, 2012).

Little-known background, so far, of decision-making processes can become a starting point for a better understanding of the job choice of household members and a guide on how to promote the work-life balance of individuals. Knowledge of how job candidates combine their evaluations of each individual attribute in a job offer into an overall evaluation is still limited. However, this is an important question because knowledge of the mechanisms through which job seekers combine

multiple attributes into one overall evaluation can inform employers in structuring job offers in the most suitable fashion based on each situation (Acikgoz, 2019).

In the conditions of the Slovak Republic, the issues and implications of decision-making on job choice in the context of the environment and the specific type of households are only minimally elaborated. The results of various surveys focus mainly on the expectations of potential job seekers from a particular job. However, there is a lack of deeper knowledge and understanding of how the decision-making process of an individual as a member of a household takes place before choosing a job. Considering that the labour market in Slovakia has specificities that are determined by location, historical-political context, and cultural practices, we consider that decision-making on job choice may also be influenced by these factors. The process of transition from a centrally planned economy into a market one started in Europe in the late 1980s. Since then, over a dozen countries began the transformation of their economies. Since 2004, until 2013, eleven of them joined the European Union. After thirty years of the transformation process, we can observe the convergence process for the post-communist countries. The European labour market is affected by many external factors, such as the global economic situation and crises. These factors may affect national economies in different ways (Dmytrów & Bieszk-Stolorz, 2021). Nevertheless, very few scholarly contributions in research studies examine and justify employment decisions in terms of country specificities and thus find cross-cultural differences. As we have indicated above, attention is more often paid to other aspects of the decision-making process (young people, older individuals, preferences for public and private sector employment). From the knowledge about post-communist countries from the perspective of the labour market and its development in a broader context, we argue that a more precise understanding of decision-making on the job choice with respect to the household environment in Slovakia represents a knowledge gap and thus brings a new perspective on the decision-making process.

An accumulating body of research suggests that factors in individuals' family domains influence the decisions they make in their work domain (Powell & Greenhaus, 2012). To provide additional examples, family factors have been associated with role entry decisions about whether to relocate (Baldridge et al., 2006; Challiol & Mignonac, 2005), expatriate (Tharenou, 2008), and repatriate (Tharenou & Caulfield, 2010); role participation decisions about involvement in work activities (Greenhaus & Powell, 2003), organisational citizenship behaviours (Bragger et al., 2005), and requests for managerial support (Powell & Greenhaus, 2012); and role exit decisions about whether to interrupt paid employment (Reitman & Schneer, 2005) and leave a profession (Greenhaus et al., 2001). Career decisions are amongst the most important we make. Unsurprisingly, much published research exists on this particular aspect of career behaviour. However, the overwhelming majority of studies have been carried out on young people making initial career decisions (Bimrose & Mulvey, 2015).

In addition to considering the current knowledge of decision-making regarding job choice in Slovakia, we believe it is also important to be aware of the challenges that households face in making decisions and to be able to point out the possible shortcomings that occur in this process. At the same time, it can be one of the starting points for employers when creating job offers. We consider our approach to the study of this issue to be unique in the conditions of the Slovak Republic. Part of the results and findings and the interrelationships between employment and household decisions are still in the nature of initial basic findings, which will need to be analysed and reflected more in the light of changing societal conditions in post-pandemic economics.

2. Research methodology

The aim of the article is to analyse the decision-making process on the job choice of members of Slovak households and to identify the decision-making circumstances. It deals with the three selected parts of the decision-making process: the decision-making steps, the decision-making subject (decision-maker) and the decision-making circumstances.

In relation to the aim of the article, we formulated the research questions (*RQs*):

- *Which steps of the decision-making process did respondents implement before the job choice?*
- *Who made the decision about the respondent's current job?*

- *Which decision-making circumstances did respondents consider to be decisive in their job choice?*

The research itself was carried out in two steps, based on theoretical assumptions emphasising the influence of the household as a broader and specific social environment. In the first step, we used a qualitative approach. Subsequently, we conducted primary data collection through a quantitative questionnaire survey. The qualitative phase was based on informal, structured interviews in various types of households, carried out by research team members. These interviews resulted in small and "working" case studies, which highlighted that the decision-making process on job choice has several specifics and helped us refine the questions in the questionnaire. Based on the results of informal interviews, we divided the decision-making process into four logically consecutive steps. This approach allowed us to perceive the decision-making process more realistically and, in the interest of effective communication with the respondents, to offer a choice of four steps of the decision-making process, which come into consideration before the job choice.

First step. The perception of the level of household financial resources and the resulting awareness of the need to have a job as a necessary financial resource, where the need to have a job relates to getting, keeping, or changing jobs for better/more significant financial gain.

Second step. The orientation on the labour market, search for and collection of information on the possibilities of paid work in terms of the requirements placed on applicants and at the same time in terms of the requirements placed on the household.

Third step. The evaluation and a more thorough assessment of the suitability/acceptability/fulfilment of the requirements associated with the job, while considering the requirements/needs/limits of households and, eventually, their members.

Fourth step. The job choice – the final decision for the specific job the respondent has opted for. This step can be considered as the last stage of the decision-making process, followed by the actual job performance. It is the result of individual preferences as well as the broader circumstances associated with the household of which a person is a member.

Scientific studies have pointed out that the sequence of these steps is not always linear; some may be omitted and eventually repeated (Athanasou, 2003; Singh & Greenhaus, 2004). There is also the presumption that the decision-making process does not concern only a given member of the household, but to a varying, but not negligible extent, it concerns several members or the whole household, while the dynamic process of deciding on a job considers many factors as well as individual preferences (Boswell et al., 2003). A valuable contribution of this phase was the general mapping and concretisation of a wider range of circumstances and restrictions that households consider when deciding to get a job.

The decision-making process on the job choice was only one part of an extensive questionnaire survey, which was focused on the decision-making process of Slovak households on the time allocation on paid work and unpaid work, as well as household strategies. Incorporating knowledge from the qualitative phase, we prepared questions in one section (module) of the questionnaire in such a way that the data collected could be used to obtain initial results about the employment decision-making process.

To ensure the largest possible sample of households in the survey, we included several dozen interviewers from the ranks of university students of the second degree of studies at the Faculty of Economics, Matej Bel University in Banska Bystrica (MBU). Their task was to establish contact with respondents in three households of different types in the designated region (according to pre-announced criteria), to obtain their consent to participate in the research and then to ensure the completion of the questionnaire in these households in the role of interviewers. Students were thoroughly prepared for the role of interviewers in the form of professional and practical training, the content of which was an explanation of the meaning, purpose and goal of research and their activities in achieving it, starting from household selection through preparation and visit organisation to qualified collection and sending empirical data. To minimise incorrect or misunderstanding of the questions, the preparation of the interviewers also concerned a detailed explanation of the essence of each question and the offered answers or possibility

of a free response. Two months (April and May 2019) were set aside for data collection. The interviewers recorded the data obtained from each household in a pre-prepared electronic form. This step was intentionally included in the data collection procedure to check not only the completeness of the completion but also the logical correctness of the answers before the final submission of the data. During the data collection, members of the research team were available to online interviewers and the creation of an online discussion forum was verified with a positive result, which served as a platform for informal and operational exchange of experiences the interviewer encountered and needed advice or help. We used the computer assisted personal interview method (CAPI) to record answers from respondents. The joint coordinated efforts of a twelve-member research team and interviewers obtained empirical data from 517 Slovak households and 1,202 individuals (individuals living in the surveyed households). From them, 776 respondents were employed persons. Considering that the basic set of all households employed in Slovakia is several thousands to millions and includes several specifics (or determinants), we did not claim to achieve a representative sample for the employed. We consider our approach to be correctly chosen at this stage of knowledge about employment decisions, and our results do not allow us to generalise our conclusions.

For the purposes of our research, we consider all economically active respondents to be employed. It should be noted that 13% of respondents are self-employed. We accept certain specifics in the decision-making process on this group's job choice, but regarding the effort to generalise the results of this category, we do not pay separate attention to self-employed or employed persons.

The mentioned sample of households consisted of 25% single-person households, 22% double-person households, 20% three-member households, 19% four-member and 14% five-member and more members households. From the point of view of the number of households, the sample can be considered representative regarding the structure of Slovak households (we used the chi-square test to confirm that the research sample is representative in terms of the number of household members). This criterion was the starting point for us to be able to focus on the decision-making process on job choice regarding the number of household members. We used SPSS 17 statistical software to process the obtained information.

The information and data that we present in the article are based on a part of the questionnaire (module), which focused only on individuals in the household who had at least one paid

Tab. 1: Characteristics of the research sample – Part 1

Characteristics	Percentage of respondents (%)	Cumulative percentage (%)
Education level		
Primary school	1.5	1.5
Secondary education	57.4	58.9
Higher education	41.1	100.0
Type of working contract		
Fixed-term employment (full-time)	17.4	17.4
Fixed-term employment (part-time)	3.9	21.2
Employment for an indefinite period (full-time)	63.2	84.4
Employment for an indefinite period (part-time)	2.0	86.3
Employment relationship by agreement	0.5	86.8
Self-employed	13.0	98.9
Other type	0.2	100.0

Tab. 1: Characteristics of the research sample – Part 2

Characteristics	Percentage of respondents (%)	Cumulative percentage (%)
Organisation of work		
Fixed working hours without overtime	34.6	34.6
Fixed working hours with overtime	29.1	63.7
Flexible working hours	22.4	86.1
Shift work	11.9	98.0
Other type	2.0	100.0
Income category (EUR)		
Up to 200	0.8	0.8
201–500	4.5	5.3
501–800	39.9	45.2
801–1200	38.0	83.2
1,201 and more	13.8	97.0
No response	3.0	100.0

Source: own

job at the time of the questionnaire survey. Specifically, we evaluated module II, while some other parts of the questionnaire, such as the introductory part, module I, we used to process the characteristics of the research sample, which was the focus of attention when writing the article. Of the total number of employed respondents who answered questions about the decision-making process, 54.3% were employed men, and 45.7% were employed women.

The average age of respondents was 40 years (SD = 11.393). More than half of the respondents (57.4%) had a minimum secondary education, and more than 40% of respondents had at least the first level of university degree.

More than 60% of respondents had a job agreed for an indefinite period. Only a small proportion of respondents, approximately 17%, had fixed-term jobs. As stated above, 13% of respondents employed themselves, so we consider them self-employed. More than 30% of the respondents in the research sample had fixed working hours without overtime. This number is comparable to the number of respondents who have fixed working hours but also work overtime. More than 20% of respondents used flexible working hours, and more than 10% worked shifts (or in continuous operation). Respondents also answered a question that focused on the job income. Almost 40% of respondents had a job income from EUR 501 to EUR 800. We consider the fact that only 3% of respondents were not willing to answer the question about their income as positive. We present information about the research sample of respondents in more detail in Tab. 1.

3. Results and discussion

The effort to analyse the decision-making process on the job choice of members of Slovak households is based on more detailed knowledge and mediation of findings on three selected aspects of this issue. The first aspect is the decision-making process of a household member, represented by the implementation of individual decision-making steps, which we described in more detail in the methodology. The second aspect is an in-depth knowledge of the entity that decides on the job choice in the household, and the third aspect is the circumstances that household members consider when making decisions eventually, which have an impact on the decision-making process. For a deeper understanding, the primary findings on these three aspects are specified in more detail according to household type.

Tab. 2: Implementation of decision-making steps on job choice (%)

	First step	Second step	Third step	Fourth step
Together	37.2	40.5	52.1	53.9

Source: own

3.1 Decision-making steps

The preparatory (qualitative) phase of the research demonstrated the difficulty of knowing the decision-making process. In Tab. 2, we present the processed results in the form of shares of respondents implementing individual decision-making steps.

In the questionnaire, we asked respondents to indicate the steps of the decision-making process that they implemented before the job choice. In Tab. 2, we present data on the percentage of respondents who consider each of the steps in the decision-making process when making a job choice.

The data in Tab. 2 show that respondents did not implement the individual steps of the decision-making process to the same extent.

The difference in the implementation of the first and second steps compared to the implementation of the third and fourth steps is about 12%. In practice, this means that fewer respondents considered initial decision-making activities important. The first step (the need to secure financial resources for the household) – just over a third of respondents were aware. The second step (more systematic activities aimed at orienting oneself on the labour market and obtaining current information about the possibilities and requirements of paid work) – was implemented by approximately 40% of respondents. The respondents attached greater importance to the third and fourth steps, and more than half of respondents implemented them in their decision-making process on the job choice. This indicates that the closer the final decision comes, the higher is the share of individuals implementing decision-making steps. The data in Tab. 3 indicate whether the implementation of individual steps of the decision-making process on the job choice in Slovak households differs according to the household type and, eventually, what the differences are.

The data presented in Tab. 3 shows that the tendency initially observed (the closer the decision-making process is to the final decision, the higher the proportion of respondents using the second, third and fourth steps of the decision-making process) is confirmed for two-, three- and four-member households. We can also state that with the increasing number of household members, the share of respondents implementing the second, third and fourth decision-making steps also increases. We cannot confirm this fact for single-person and five-member households. In view of their different behaviour, we consider it necessary to examine the decision-making process on the job choice in more detail in the future. The average share of respondents implementing each individual step confirms this finding. This tendency has not been confirmed for five- and more-member households. In these types of households, the first step is given greater

Tab. 3: The implementation of decision-making steps according to the household type (%)

Household type	First step	Second step	Third step	Fourth step
Single person	44	42	54	59
Two-member	27	30	39	45
Three-member	37	40	55	59
Four-member	40	53	61	54
Five-member and more	56	46	46	44

Source: own

importance and is implemented by a larger proportion of respondents (56%). This indicates the knowledge that in these types of households (compared to less-member households), the awareness of the need to secure household finances by getting, keeping, or changing jobs as the first step in the decision-making process on the job choice is significantly more current and can be seen as a strong key moment in individual decision-making process. We believe that a higher number of persons naturally increases the material and financial demands of the household's operation, and thus, the importance of the first step of the decision-making process on job choice increases. We believe that the larger proportion of respondents, single-person households (44%), who are making the first step of the decision-making process is influenced by the fact that these households are typically made up of a young woman or a young man who is at the beginning of independent living.

The findings concerning four-member households are also noteworthy. It turned out that the implementation of individual steps is clearly the highest in this type of household. It can be assumed that such a large household has an internal environment that requires adequate attention to be given to all the steps and activities that precede the final choice and the decision itself when deciding on an employment choice. We believe that from a methodological point of view, this type of household could become a model starting point when examining the decision-making process. It should be considered that with fewer or more household members, the emphasis on implementing one of the steps before the actual decision is likely to change. It is also clear that the model will require the incorporation of additional specifics that will further help to understand the essence of the decision-making process, which is characterised by several variants.

3.2 Decision-makers

We further deepen previous findings on decision-making steps with knowledge of who the final subject (decision-maker) is in the household and who decides on the selection of a suitable job option. We included this question in the questionnaire because we did not want to stay at the general level of knowledge, that follows from the overall concept in which the household is the central subject. Through free statements, the respondents indicated that even if a job (securing financial resources for the household) is a very intensive issue for the whole household, someone still must decide on it. In the questionnaire, we asked respondents to indicate who decided on their current job. The results are presented in Tab. 4.

Tab. 4: Decision-makers on the job choice (%)

	Decision-maker			
	Myself	**Partner**	**Together**	**Other**
Proportion	84.6	2.6	9.6	3.2

Source: own

The findings show that in the absolute majority (84.6%), a person decides on the job choice by herself or himself. We assume this was not an authoritative decision, but there was some degree of cooperation and influence from other household members in previous decision-making steps. The second group represents respondents who declare that they have decided on the job choice together, as a whole household. Although there are not many of them (they represent about a tenth of all households), they signal an interesting procedure that will need attention. An even smaller group (2.6%) comprises respondents from households where the partner made the final decision. This suggests that the prevailing decision-making model is based on the fact that households leave the final decision and responsibility to the member who will perform the job, and households conform to his or her decision. The model of joint decision-making, which indicates the application of certain elements of democratisation, is also not negligible. The findings also raise the question of what type, according to structure, are the households

Tab. 5: Decision-makers on the job choice according to the household type (%)

Household type	Decision-maker			
	Myself	Partner	Together	Other
Single person	99	0	0	1
Two-member	86	3	7	4
Three-member	83	3	13	1
Four-member	75	3	15	7
Five-member and more	67	2	24	7

Source: own

in which the decision was made in a different way. We are not yet able to specify this based on our findings. We believe these are fewer standard decisions made by non-family or single-parent households. We sorted the answers concerning the decision-makers according to the type of household (regarding the number of members), and we present the results in Tab. 5.

Based on the findings presented in Tab. 5, it is possible to identify three tendencies. The first is the tendency that the more members a household has, the smaller the proportion of those households in which the person decides on the job choice by her or himself. This is perfectly understandable in the case of single-person households, which are practically the decision-makers. But the proportions (approximately 75% to 85%) are also relatively large in two- to four-member households. The second tendency is the relatively constant and very low share of households (approximately 3%), in which, regardless of their size, job choice is decided by a partner. The third tendency that confirms the first one is the tendency according to which, with the growing size of the household, the share of such households in which the job choice is decided together also increases. The share of two-member households with joint decision-making is not large and does not exceed one-tenth; in the case of three- and four-member households, this share is slightly increasing and is at the level of 15%. The relatively highest share of jointly deciding households is in the case of five-member households, of which there are about a quarter in Slovakia.

The classification of findings according to household type confirms the original assumption that in households with a lower number of members, much higher emphasis is placed on saturating the individual needs of the member (two members) of the household. This is related, on the one hand, to the need to perform work according to one's individual preferences and, on the other hand, to the need to ensure that its performance and its associated contexts (e.g., commuting, and overtime) do not have a very negative impact on the household's activities.

Our findings are close to the conclusions of research studies, e.g., Powell and Greenhaus (2012) and Fouad et al. (2015), in which the authors demonstrated the influence of factors related to family background on career decisions. However, our results cannot provide deeper findings that shed more light on the influence of factors that the household and its members consider important from the perspective of the member(s)'s career path.

3.3 Decision-making circumstances

The third aspect that we considered to be topical in our more detailed knowledge of the decision-making process on the job choice is the circumstances that the respondent considered when deciding on the job choice and which he considered decisive. The inclusion of this question follows the theoretical background, which points out that various circumstances influence the course and outcome of the decision-making process in any area (Boswell et al., 2003; Ronda et al., 2020), and therefore it is appropriate to know this aspect in the environment of Slovak households. Based on the findings from the preparatory phase, we concluded that significant circumstances affecting the decision-making process might include those relating primarily to the job, but on the other hand, also circumstances arising from the household (e.g., running the household, caring for children

Tab. 6: Decisive circumstance when choosing a job according to the household type (%)

Decisive circumstance	Household type					
	Single-person	Two-member	Three-member	Four-member	Five-member and more	Average value
Quality of job information	2.4	0.1	1.0	1.1	3.4	1.6
Job income (salary)	48.6	54.8	55.1	49.8	54.8	52.3
The character (difficulty) of work	28.5	21.6	16.4	10.9	7.7	17.0
Time spent on housework	10.1	7.0	1.9	5.2	1.6	5.2
Childcare	1.5	6.6	15.1	13.9	15.5	10.5
Adult care	0.0	0.3	0.3	0.0	2.9	0.7
Working time of the partner	0.0	1.5	0.5	2.8	3.4	1.6
Health condition	0.0	3.9	1.6	11.3	10.8	5.5
Traditions	0.0	0.0	0.3	1.5	0.0	0.4
Other	8.9	4.1	7.7	3.6	0.0	4.9

Source: own

or adults). However, others also come into consideration (e.g., health status, professional and physical readiness, attendance). In the questionnaire, the respondents were offered a list of ten circumstances from which they had the opportunity to choose the one they considered crucial in their decision-making process. To delve deeper into the issue, we sorted the respondents' opinions according to the type of household. We present clearly arranged findings in Tab. 6 according to the answers to the request to specify only one circumstance that respondents considered to be decisive in their job choice.

As expected, the frequency of indications of each circumstance, and thus their importance, varies. Based on the scores, we created a ranking of several groups of circumstances. The most important circumstances were those identified by more than 50% of respondents. We consider the circumstances that were marked by more than 10% and less than 50% of respondents as moderately important. We believe circumstances marked by less than 10% of respondents are marginal.

We consider the most important decision-making circumstance to be the financial valuation of the job (salary). More than half of the respondents identified it as decisive. More than 17% of respondents ranked the nature and difficulty of the job, and more than 10% ranked childcare as decisive. Although the proportion of respondents indicating these two circumstances is noticeably lower, the finding suggests that these circumstances are moderately important in the decision-making process of these households. The marginal circumstances are those identified as crucial by less than 5% of respondents. In practice, this means that they are not among the influential circumstances in Slovak households. These are the quality of information about jobs, the length of working hours of the partner, care for adult members of the household and traditions.

The findings confirmed our initial assumptions that the issue of the money earned through paid work would be very important and would become the most salient circumstance influencing the decision to take up the job. We believe that this is because getting, keeping, or changing the job is primarily associated with its primary purpose – to provide financial resources as a basic and

universal source of household functioning. This creates all the conditions to ensure that the needs of individual household members and, not least, the needs of the household can be met. We also find it interesting to note that the character of work (its difficulty) is one of the important decision-making circumstances, which indicates that for a significant proportion of respondents (approximately 17%), financial resources are not the only important circumstance, but other job-related circumstances, especially its difficulty, also enter the decision-making process.

Findings on salary levels as well as other monetary benefits in relation to hiring and employer attractiveness, have been the subject of many scholarly studies with ambiguous conclusions that cannot be generalised. Tanwar and Prasad (2017) discovered that compensation and benefits were the least influential dimensions of the employer brand, whereas Roongrerngsuke and Liefooghe (2013) discovered, during their research in China, India, and Thailand, that the importance of compensation and benefits were high, for all three generations studied (Baby Boomers, Generation X, Generation Y). Lievens et al. (2007) identified pay and benefits as factors with the highest importance for perceived employer attractiveness among employees of the Belgian army. Schlager et al. (2011) confirmed that economic attributes (e.g., compensation) positively influence job satisfaction, although its positive correlation with organisational identification could not be confirmed. Summarising the findings, it can be said that the relevance of compensation for the perception of employer attractiveness in the eyes of employees depends on the context, and no clear views can be generalised (Dassler A. Khapova et al., 2022).

Our initial prediction that more respondents would consider household circumstances much more when deciding on a job choice has only been partially fulfilled. For example, childcare is “only” third in the order of importance of circumstances in the decision-making process. Only around 10% of respondents consider it to be a decisive circumstance. Other household-related circumstances (time spent on housework, working time of the partner and care of adult members) are also situated in the bottom half of the ranking.

A further look, considering the different household types, made it possible to identify on the one hand similarities but, on the other hand, differences in which circumstances are considered by the different household types to be decisive. The consensus is that the financial valuation of the job is the circumstance considered decisive by respondents in any type of household.

Consensus also emerged on the circumstance (the character/difficulty of paid work), which is given as the second most important in single-person and two- and three-member households. Its importance becomes progressively weaker as the number of household members increases and its indication by respondents decreases from 28.5% in single-person households to 16.4% in three-member households. The declining importance of this circumstance is even more evident in households with four, five or more members. In these households, only 10.9% and 7.7% of respondents respectively consider it to be a crucial circumstance.

A similarity can also be seen in the circumstance of childcare, which increases in importance as the number of household members increases, which was expected and logical. This circumstance is the second and third most important circumstance in households with three, four, five or more members, respectively. Although the share of this circumstance is not very high (around 15%), it confirms the finding that it plays the second most important role after the financial valuation of work in larger households.

Other findings are also interesting. The first one relates to the time devoted to housework, a circumstance that is the third most important in single-person and two-member households. It was marked by approximately 10% of respondents. Interestingly, multi-person households do not consider it as a crucial circumstance, despite the assumption that a larger number of household members is likely to require more activities to be provided and thus more time to be spent on housework.

On the other hand, housework is divided among a larger number of members. It is very likely that respondents in these households are already comfortable with having to spend more time on housework and consider it natural. Another finding relates to the consideration of health status as a circumstance influencing the decision-making process on job choice. Although this circumstance is ranked third in the overall ranking, its importance varies

across households. On the contrary, more than 10% of respondents in households with four, five or more members attach more importance to it. We assume that running a multi-person household is more demanding and has an impact on health status, which is of increasing importance when deciding on a job choice in this context.

The assessment of the importance of the length of working time of the partner was interesting. While this is understandably of no significance in single-person households, it does change noticeably with household size. It is true that the larger are the households, the more importance they attach to it. As expected, this is closely related to the optimisation of the organisation and division of labour in households.

The final findings relate to circumstances that have only a minimal impact on the decision-making process of respondents regarding job choice. These include the quality of job information, care for adults, and traditions.

Our findings show that, on average, 4.86% of respondents consider other circumstances than those we have offered to be decisive. We, therefore, believe that we have been able to appropriately complete the range of circumstances that households might consider in their decision-making process on job choice, even based on the theoretical background mentioned above.

Conclusions

Several of our considerations based on theoretical premises were confirmed in the empirical investigation and subsequent analysis of the results. We have divided and further examined the decision-making process in terms of four steps, which are implemented differently by household members. The results show that the closer the final decision comes, the higher is the share of individuals implementing decision-making steps. This finding has been shown to be valid across all household types surveyed. The decision-making process on the job choice has a similar pattern for men and women, except that men implement the decision-making steps more intensively than women do.

The assumption that the household is involved in the job decision-making process was only partially confirmed. The participation of other household members in the decision-making process on the job choice increases with household size. The highest proportion of households with five or more members makes joint decisions on job choice (almost a quarter).

In all households, irrespective of household type, job income, i.e., financial valuation for paid work (salary), is considered decisive in job decisions. Along with the job income, the character and difficulty of the work are considered as second important. Somewhat surprising was the finding that a relatively small proportion of household members consider circumstances related to the care of household members to be important in their decision-making process on the job choice. This means that although financial security is the most important consideration in the decision-making process, the importance of this circumstance diminishes as the number of household members increases and the importance of household aspects increases.

The above findings, although they relate to a selected area of household management, represent the primary information of this type in Slovakia. They seek to uncover the internal processes within households, which may be similar but also different in some respects, given the character of individual households. When expanding the knowledge on the management of other household activities, which we consider activities in the field of unpaid work and leisure time, they create the initial prerequisites for a comprehensive understanding of the issue, which is poorly known in Slovakia and the V4 countries.

We anticipate that regarding the changing environment and conditions in which households are functioning (e.g., post-pandemic environment, threatened security situation, economic impacts of the war in Ukraine, inflation), the importance of the issue of household management will grow. Learning about the decision-making process regarding job choice can have wide-ranging societal applications. The knowledge is applicable in various fields such as, e.g., labour market development (relevance for employers and their strategies), and psychology (career counselling, work-life balance). Given that employment and careers are integral parts of almost all people's lives, paying attention to knowledge about how individuals make job decisions and which factors they consider is one of the foundations for shaping labour market development strategies. Our results also show that job incomes continue to be an important consideration in employment decisions. The character of work, childcare,

and running a household are also aspects that play an important role in the decision-making process. It is essential to understand these linkages in more detail, considering the current state of the labour market in Slovakia, specifically using the example of the labour force entering the labour market. Thus, when recruiting new people, organisations need to be aware of family-related factors that might affect the prospective employee's decision to accept the job offer (Eby & Allen, 1998). We see opportunities for expanding knowledge in the context of the changing labour market, and our future research will focus on the decision-making process of specific groups of economically active individuals, such as the dependent self-employed (this type of employment is now increasingly used).

The article is one of the first in Slovakia to address the relationship between decisions and household size and environment. It thus provides original and basic findings that are treated by sorting and descriptive statistics. It is, therefore, challenging to compare the results within the Central European area, where, from our point of view, the issue has been studied only to a limited extent. We are aware that the paper has a few limitations that may arise from incomplete information about the survey sample. Another limitation of the paper is the difficulty in trying to achieve representativeness of the data due to the large and considerably heterogeneous underlying population. The information of different nature that we have obtained is only representative according to some aspects from the household perspective, such as the size structure of the surveyed households. Thus, the results are not generalisable to the conditions of the whole country in several aspects/dimensions. Another limitation of our findings is the retrospective view of respondents who made employment decisions at different times. Thus, responses may be biased and influenced by, e.g., memory optimism or, conversely, a view of the past with a tendency to evaluate events and memories negatively.

Acknowledgments: *This article was supported by the National Research Agency of Slovakia, project VEGA No. 1/0536/24 "Slovak Household Management and Decision-Making about Unpaid Work in the Post-Covid Economy" at the Faculty of Economics, Matej Bel University in Banska Bystrica, Slovakia.*

References

Acikgoz, Y. (2019). Employee recruitment and job search: Towards a multi-level integration. *Human Resource Management Review*, *29*(1), 1–13. https://doi.org/10.1016/j.hrmr.2018.02.009

Amir, T., Gati, I., & Kleiman, T. (2008). Understanding and interpreting career decision-making difficulties. *Journal of Career Assessment*, *16*(3), 281–309. https://doi.org/10.1177/1069072708317367

Athanasou, J. A. (2003). Factors influencing job choice. *International Journal for Educational and Vocational Guidance*, *3*(3), 205–221. https://doi.org/10.1023/b:ijvo.0000006600.29754.ff

Baldridge, D. C., Eddleston, K. A., & Veiga, J. F. (2006). Saying no to being uprooted: The impact of family and gender on willingness to relocate. *Journal of Occupational and Organizational Psychology*, *79*(1), 131–149. https://doi.org/10.1348/096317905x53174

Barber, A. E. (1998). *Recruiting employees: Individual and organizational perspectives. Foundations for organizational science*. SAGE Publications, Inc. https://doi.org/10.4135/9781452243351

Baron, J. (2008). *Thinking and deciding*. Cambridge University Press.

Bimrose, J., & Mulvey, R. (2015). Exploring career decision-making styles across three European countries. *British Journal of Guidance & Counselling*, *43*(3), 337–350. https://doi.org/10.1080/03069885.2015.1017803

Bonke, J., Deding, M., Lausten, M., & Stratton, L. S. (2007). *Intrahousehold specialization in housework in the United States and Denmark* (IZA Disciussion Paper, No. 227). Institute for the Study of Labor. https://doi.org/10.2139/ssrn.986351

Boswell, W. R., Moynihan, L. M., Roehling, M. V., & Cavanaugh, M. A. (2001). Responsibilities in the "new employment relationship": An empirical test of an assumed phenomenon. *Journal of Managerial Issues*, *13*(1), 307–327.

Boswell, W. R., Roehling, M. V., LePine, M. A., & Moynihan, L. M. (2003). Individual job-choice decisions and the impact of job attributes and recruitment practices: A longitudinal field study. *Human Resource Management*, *42*(1), 23–37. https://doi.org/10.1002/hrm.10062

Bragger, J. D., Rodriguez-Srednicki, O., Kutcher, E. J., Indovino, L., & Rosner, E. (2005). Work-family conflict, work-family culture, and organizational citizenship behavior among

teachers. *Journal of Business and Psychology*, *20*(2), 303–324. https://doi.org/10.1007/s10869-005-8266-0

Carless, S. A. (2005). Person-job fit versus person-organization fit as predictors of organizational attraction and job acceptance intentions: A longitudinal study. *Journal of Occupational and Organizational Psychology*, *78*(3), 411–429. https://doi.org/10.1348/096317905x25995

Carmichael, F., Hulme, C., Sheppard, S., & Connell, G. (2008). Work – Life imbalance: Informal care and paid employment in the UK. *Feminist Economics*, *14*(2), 3–35. https://doi.org/10.1080/13545700701881005

Challiol, H., & Mignonac, K. (2005). Relocation decision-making and couple relationships: A quantitative and qualitative study of dual-earner couples. *Journal of Organizational Behavior*, *26*(3), 247–274. https://doi.org/10.1002/job.311

Chapman, D. S., Uggerslev, K. L., Carroll, S. A., Piasentin, K. A., & Jones, D. A. (2005). Applicant attraction to organizations and job choice: A meta-analytic review of the correlates of recruiting outcomes. *Journal of Applied Psychology*, *90*(5), 928–944. https://doi.org/10.1037/0021-9010.90.5.928

Connolly, T., Arkes, H., & Hammond, K. R. (2000). *Judgment and decision making. An interdisciplinary reader*. Cambridge University Press.

Dassler A. Khapova, S., Lysova, E. I., & Korotov, K. (2022). Employer attractiveness from an employee perspective: A systematic literature review. *Frontiers in Psychology*, *13*. https://doi.org/10.3389/fpsyg.2022.858217

Dmytrów, K., & Bieszk-Stolorz, B. (2021). Comparison of changes in the labour markets of post-communist countries with other EU member states. *Equilibrium. Quarterly Journal of Economics and Economic Policy*, *16*(4), 741–764.

Eby, L. T., & Allen, T. D. (1998). Perceptions of relocation services in relocation decision making: An exploratory field study. *Group & Organization Management*, *23*(4), 447–469. https://doi.org/10.1177/105960119823400

Fedor, R. A. (2018). Foglalkoztatási helyzetkép és a munkával való elégedettség jellemzői [Employment situation and job satisfaction characteristics]. *Acta Medicinae et Sociologica*, *9*(27), 33–57. https://doi.org/10.19055/ams.2018.9/27/4

Fouad, N. A., Kim, S., Ghosh, A., Chang, W., & Figueiredo, C. (2015). Family influence on career decision making: Validation in India and the United States. *Journal of Career Assessment*, *24*(1), 197–212. https://doi.org/10.1177/1069072714565782

Gati, I., Saka, N., & Krausz, M. (2001). 'Should I use a computer-assisted career guidance system?' It depends on where your career decision-making difficulties lie. *British Journal of Guidance and Counselling*, *29*(3), 301–321. https://doi.org/10.1080/03069880120073021

Greenhaus, J. H., Parasuraman, S., & Collins, K. M. (2001). Career involvement and family involvement as moderators of relationships between work-family conflict and withdrawal from a profession. *Journal of Occupational Health Psychology*, *6*(2), 91–100. https://doi.org/10.1037/1076-8998.6.2.91

Greenhaus, J. H., & Powell, G. N. (2003). When work and family collide: Deciding between competing role demands. *Organizational Behavior and Human Decision Processes*, *90*(2), 291–303. https://doi.org/10.1016/s0749-5978(02)00519-8

Harold, C. M., Holtz, B. C., Griepentrog, B. K., Brewer, L. M., & Marsh, S. M. (2016). Investigating the effects of applicant justice perceptions on job offer acceptance. *Personnel Psychology*, *69*(1), 199–227. https://doi.org/10.1111/peps.12101

Hirschi, A. (2018). The Fourth Industrial Revolution: Issues and implications for career research and practice. *The Career Development Quarterly*, *66*(3), 192–194. https://doi.org/10.1002/cdq.12142

INSEE. (2021). *Employment (according to the International Labour Organization (ILO) definition)*. INSEE. https://www.insee.fr/en/metadonnees/definition/c1159

Kulcsár, V., Dobrean, A., & Gati, I. (2020). Challenges and difficulties in career decision making: Their causes, and their effects on the process and the decision. *Journal of Vocational Behavior*, *116*, 103346. https://doi.org/10.1016/j.jvb.2019.103346

Lievens, F., Van Hoye, G., & Anseel, F. (2007). Organisational identity and employer image: Towards a unifying framework. *British Journal of Management*, *18*(s1), 45–59. https://doi.org/10.1111/j.1467-8551.2007.00525.x

Mauger, Y., Wasieleski, D. M., & Hayibor, S. (2019). Exploring personal values and job attribute salience among job seekers. *Proceedings of the International Association for Business and Society*, *30*, 50–58. https://doi.org/10.5840/iabsproc2019307

Mohanti, S. R. (2016). *Introduction to home management*. Anchor Academic Publishing.

Móré, M. (2018). A foglalkoztatáspolitika helye, szerepe a társadalomban [The place and role of employment policy in society]. In A. Sebők (Ed.), *A munka világa a 21. Század elején: Foglalkoztatáspolitikai és munkaerőpiaci kézikönyv* [The world of work at the beginning of the 21st century: An employment policy and labour market handbook] (pp. 31–50). SAXUM.

Osipow, S. H. (1999). Assessing career indecision. *Journal of Vocational Behavior*, *55*(1), 147–154. https://doi.org/10.1006/jvbe.1999.1704

Pilný, I. (2016). *Digitální ekonomika* [Digital economy]. BizBooks.

Posner, B. Z. (1981). Comparing recruiter, student, and faculty perceptions of important applicant and job characteristics. *Personnel Psychology*, *34*(2), 329–339. https://doi.org/10.1111/j.1744-6570.1981.tb00946.x

Powell, G. N., & Greenhaus, J. H. (2012). When family considerations influence work decisions: Decision-making processes. *Journal of Vocational Behavior*, *81*(3), 322–329. https://doi.org/10.1016/j.jvb.2012.07.006

Reitman, F., & Schneer, J. A. (2005). The long-term negative impacts of managerial career interruptions: A longitudinal study of men and women MBAs. *Group & Organization Management*, *30*(3), 243–262. https://doi.org/10.1177/1059601104269110

Riegel, K. (2007). *Ekonomická psychologie* [Economic psychology]. Grada.

Ronda, L., Abril, C., & Valor, C. (2020). Job choice decisions: Understanding the role of non-negotiable attributes and trade-offs in effective segmentation. *Management Decision*, *59*(6), 1546–1561.https://doi.org/10.1108/md-10-2019-1472

Roongrerngsuke, S., & Liefooghe, A. (2013). Attracting gold-collar workers: Comparing organisational attractiveness and work-related values across generations in China, India and Thailand. *Asia Pacific Business Review*, *19*(3), 337–355. https://doi.org/10.1080/13602381.2012.747784

Roostin, E. (2018). Family influence on the development of children. *PrimaryEdu – Journal of Primary Education*, *2*(1), 1. https://doi.org/10.22460/pej.v1i1.654

Schlager, T., Bodderas, M., Maas, P., & Luc Cachelin, J. (2011). The influence of the employer brand on employee attitudes relevant for service branding: An empirical investigation. *Journal of Services Marketing*, *25*(7), 497–508. https://doi.org/10.1108/08876041111173624

Singh, R., & Greenhaus, J. H. (2004). The relation between career decision-making strategies and person-job fit: A study of job changers. *Journal of Vocational Behavior*, *64*(1), 198–221. https://doi.org/10.1016/s0001-8791(03)00034-4

Tanwar, K., & Prasad, A. (2017). Employer brand scale development and validation: A second-order factor approach. *Personnel Review*, *46*(2), 389–409. https://doi.org/10.1108/pr-03-2015-0065

Tharenou, P. (2008). Disruptive decisions to leave home: Gender and family differences in expatriation choices. *Organizational Behavior and Human Decision Processes*, *105*(2), 183–200. https://doi.org/10.1016/j.obhdp.2007.08.004

Tharenou, P., & Caulfield, N. (2010). Will I stay or will I go? Explaining repatriation by self-initiated expatriates. *Academy of Management Journal*, *53*(5), 1009–1028. https://doi.org/10.5465/amj.2010.54533183

Tinsley, H. E. A. (1992). Career decision making and career indecision. *Journal of Vocational Behavior*, *41*(3), 209–211. https://doi.org/10.1016/0001-8791(92)90022-r

Turban, D. B. (2001). Organizational attractiveness as an employer on college campuses: An examination of the applicant population. *Journal of Vocational Behavior*, *58*(2), 293–312. https://doi.org/10.1006/jvbe.2000.1765

Uggerslev, K. L., Fassina, N. E., & Kraichy, D. (2012). Recruiting through the stages: A meta-analytic test of predictors of applicant attraction at different stages of the recruiting process. *Personnel Psychology*, *65*(3), 597–660. https://doi.org/10.1111/j.1744-6570.2012.01254.x

Varghese, M. A., Ogale, N. N., & Srinivasan, K. (2005). *Home management*. New Age International.

Wansink, B., & Sobal, J. (2007). Mindless eating: The 200 daily food decision we overlook. *Environment and Behavior*, *39*(1), 106–123. https://doi.org/10.1177/0013916506295573

Weick, K. E. (1965). Laboratory experimentation with organizations. In *Handbook of Organizations*. Rand McNally and Comp.

Medical device regulation and its impact on the industry: A case study of Czech companies

Jan Maci[1], Martin Matejicek[2], Lukas Peter[3], Frank Lefley[4], Petra Maresova[5]

1 *University of Hradec Kralove, Faculty of Informatics and Management, Department of Economics, Czech Republic, ORCID: 0000-0002-6315-7991, jan.maci@uhk.cz;*
2 *University of Hradec Kralove, Faculty of Informatics and Management, Department of Economics, Czech Republic, ORCID: 0000-0002-8548-3114, martin.matejicek@uhk.cz;*
3 *University of Hradec Kralove, Faculty of Informatics and Management, Department of Economics, Czech Republic, ORCID: 0000-0003-4351-8291, lukas.peter@uhk.cz;*
4 *University of Hradec Kralove, Faculty of Informatics and Management, Department of Economics, Czech Republic, ORCID: 0000-0001-8367-7102, frank.lefley@uhk.cz;*
5 *University of Hradec Kralove, Faculty of Informatics and Management, Department of Economics, Czech Republic, ORCID: 0000-0002-1218-501X, petra.maresova@uhk.cz.*

Abstract: *The implementation of regulations is often seen as a necessary tool to mitigate market failures and safeguard consumer interests. The Medical Device Regulation (MDR) is a recent regulation specifically designed for the production of medical devices, aiming to ensure their safety and effectiveness. This article focuses on Czech companies and seeks to examine and quantify the effects of the MDR on their operations, considering both economic and procedural impacts. Through the analysis of primary and secondary data, this study endeavors to shed light on the repercussions of the MDR on the companies in question. The findings suggest that the MDR will have a negative impact on the profitability of these companies, consequently influencing their operational strategies. One key factor contributing to this negative outcome is the inability of the companies to transfer the increased costs resulting from regulatory requirements to their customers. As a result, affected companies are forced to make adjustments to their product portfolios, reducing their range of offerings. The research reveals that the perception of the MDR among the companies is predominantly negative. This negative sentiment arises primarily due to the financial burdens imposed by the regulation and the other associated impacts discussed in the article. Furthermore, the MDR is not perceived as a catalyst for innovation within the industry. By quantifying the effects of the MDR on Czech companies, this article provides valuable insights into the real-world implications of this regulatory framework. The findings highlight the challenges faced by companies in adapting to and complying with the MDR, particularly in terms of its impact on profitability and product offerings. This research serves as a reminder of the complex interplay between regulations, economic outcomes, and industry dynamics. Ultimately, it emphasizes the importance of considering the potential ramifications of regulations and their effects on businesses and markets.*

Keywords: *Medical device regulation, regulation, economic impact, innovation, product portfolio.*

JEL Classification: *K23.*

APA Style Citation: Maci, J., Matejicek, M., Peter, L., Lefley, F., & Maresova, P. (2024). Medical device regulation and its impact on the industry: A case study of Czech companies. *E&M Economics and Management*, *27*(2), 32–49. https://doi.org/10.15240/tul/001/2024-2-003

Introduction

Regulation is used to correct market failure, protect consumers, and improve the business environment. It has both positive (e.g., greater consumer safety) and negative (e.g., increased costs for companies) impacts and can also drive innovation (Blind, 2016).

From a broader perspective, the effects of regulations can be monitored by various indicators (Bayar & Diaconu Maxim, 2020; Broughel & Hahn, 2022; Razavi et al., 2017). According to Maci and Maresova (2022), costs are the most commonly considered variable when evaluating the impact of regulations from an individual microeconomic point of view. Tu (2020) notes that legislative changes can increase costs for businesses in the medical device sector, leading to a negative relationship between regulatory burden and productivity. Specifically, a 1% increase in cost intensity reduces labor productivity by 0.1%. Tu (2020) also found that compliance costs are lower for larger companies with higher revenue. Markiewicz et al. (2017) offer a detailed insight into the thought process of manufacturers when developing a medical device, specifically in the early assessment stage, through results derived from semi-structured interviews. Aware of this problem, governments around the world are coming up with new regulations that should ideally reduce the social as well as medical cost incurred for medical innovation (Konishi et al., 2018) and thereby enhance the chance for the emergence of such innovations that will increase the desirable feeling of satisfied health care needs of the population (Antošová et al., 2022).

The complexity of regulatory changes is evident in the European medical device market, including the Czech Republic. Regulation 2017/745 EU (MDR), effective since May 26, 2021, aims to enhance consumer safety and health protection. However, it poses challenges, particularly for small and medium-sized companies. The new MDR imposes stricter requirements than the previous Medical Device Directive (MDD), such as more precise requirements for clinical safety evaluation. Assessing clinical safety based on similarity to existing products is now more challenging; the manufacturer will now need access to the competing product's technical documentation. Post-market monitoring and clinical data collection are also more defined. Higher requirements usually entail higher costs for innovation, product launch, distribution, sale, and service of medical devices. Such an assumption in the form of increased costs for MDR in the case of software was also expressed by Becker et al. (2019).

In response to the implementation of the European Union's Medical Device Regulation (MDR), several academic authors have already addressed various aspects and broad impacts of this legislation. Wilkinson and Van Boxtel (2020) discuss the new approach to the clinical evaluation of medical devices in the EU, emphasizing the addition of intended clinical benefits to traditional safety and performance considerations. Niemiec (2022) expresses concerns regarding the performance of medical artificial intelligence devices and examines how the MDR, with its stringent safety and quality standards, aims to improve their safety and performance. Bianchini and Mayer (2022) highlight the necessity of understanding the key aspects of MDR, underlining its implications for the entire lifecycle of medical devices and its potential to enhance the efficiency of the innovation process. Carl and Hochmann (2023) present a two-year comparative study assessing the impact of the MDR on the orthopedic aids industry, focusing on challenges faced by companies, such as increased workload, resource expenditure, and downsizing of product portfolios. Collectively, these studies underscore the multifaceted impacts of the MDR on the medical device industry, ranging from clinical evaluation to market innovation, and the overarching necessity for companies to strategically adapt to these regulatory changes.

Just like the above, this article also seeks to provide a perspective on the impacts of MDR. It specifically focuses on the impact on businesses from the point of view of their economy and management. In retrospect, we can observe and evaluate whether this regulation, among other impacts, can be classified as one that has become a catalyst for further growth and development of companies and their innovation or whether the opposite is the case. This is where we see the current gap in practical, but also theoretical, observation-supported knowledge about the effects of regulation on process and financial management, as well as the innovative activity of companies in the sector.

Therefore, this paper aims to evaluate the impact of newly effective regulations on the medical device industry in the Czech Republic. Data from a questionnaire survey

and economic indicators of surveyed companies, along with other common indicators, such as device classification, are analyzed. However, it should be noted that the full impact of the regulation is not yet known due to ongoing adaptation and potential effects of the COVID-19 pandemic.

In keeping with the aim of the paper, the following research questions have been set.

RQ1: Does the company size affect the potential or perceived impacts of MDR?

RQ2: Do economic conditions of the company, such as business performance or financial health, influence the adaptation of activities to comply with MDR, as well as the perception of MDR as such?

RQ3: Are the effects of MDR reflected in the product portfolio of the company?

RQ4: Can satisfaction with the form of MDR be an innovation driver for medical device development?

The study is divided into four thematic areas, each focusing on various aspects of MDR. The first area, explored through *RQ1*, examines how MDR affects companies of diverse sizes. The aim is to determine if MDR harms some companies due to limited resources while others have an easier time with the regulation due to more resources. The second area, covered by *RQ2*, focuses on the economic impact of MDR on businesses. The research area aims to determine how companies adapt to the economic impact of MDR, including shifting increased costs onto customers or adjusting product portfolios, while also examining the impact of these changes on innovation activity. The third area (*RQ3*) overlaps with the second but focuses more on the processes involved in changes to product portfolios and innovation activity. The aim is to identify how businesses adapt to MDR and reveal any adverse effects on product groups. Finally, *RQ4* examines overall satisfaction with MDR in relation to the innovative activity of the company. The aim is to determine if businesses perceive MDR as a new challenge providing new business opportunities.

The purpose of the research presented in this paper is to identify those impacts of MDR that are already apparent in order to draw attention to any possible overregulation and start a discussion on any possible MDR adjustments that might be needed for easy, efficient, but safe practice in the medical device industry.

1. Specifics of the medical device market – European Union and the Czech Republic

The MDR is a European regulation affecting the entire EU market, of which the Czech Republic is a part. For this reason, we present selected characteristics of the medical device market in the EU as a whole and in the Czech Republic, which is the country where the questionnaire survey was conducted. Both these economic areas are characterised below in terms of innovations (patents), employment, companies, expenditures, MedTech market volume, and trade.

1.1 Medical device market in the EU

In 2020, approximately 33,000 medical technology companies were operating in Europe, with Germany having the most significant number, followed by Italy, Great Britain, France, and Switzerland. Small and medium-sized enterprises (SMEs) comprise around 95% of the industry, with the majority employing fewer than 50 people (Medtech Europe, 2021). Healthcare spending in Europe is estimated to be 11% of GDP, with less than 1% of this spent on medical technologies. The European market for medical devices and in vitro diagnostics is estimated to be around EUR 140 billion, with Germany, France, the United Kingdom, Spain, and Italy having the largest markets (Medtech Europe, 2020). Europe has a positive medical device trade balance of EUR 8.7 billion (2020), with the US, China, Mexico, and Japan being Europe's main trading partners for medical devices. The medical technology industry invests heavily in research and development, with an average global R&D investment rate estimated at around 8% (Evaluate, 2018). The industry filed over 14,200 patent applications with the European Patent Office in 2020, with medical technology representing 8% of the total number of applications (European Patent Office, 2021; Medtech Europe, 2021). The medical technology industry in Europe employs around 760,000 people, with Germany having the largest share (Medtech Europe, 2021).

1.2 Medical device market in the Czech Republic

Unfortunately, aggregate data for this industry is not publicly available. Thus, several sources of information were used to summarise the Czech environment. Specifically, we used data from The Association of Manufacturers

and Suppliers of Medical Devices (AVDZP), the Register of Medical Devices (RZPRO), financial indicators from the Albertina database, and the PatentInspiration web application.

According to data from Patentinspiration.com (2021), members of the AVDZP had 448 active patents in the medical device sector as of November 30, 2020. As for employment, the medical device industry in the country employed over 10,266 people as of the same date, with large enterprises employing 7,370 people, almost 72% of the total. There were 105 member companies in the AVDZP, with small enterprises being the most numerous (41.8%). The Czech market segment of medical devices and in vitro diagnostics was estimated at USD 1.48 billion in 2016 by Emergo (2022), which was relatively small compared to other European markets. In terms of market value per capita, the value in the Czech Republic was USD 140, while it is USD 315.7 in Germany, USD 205 in France, and USD 160 in Great Britain. The Czech Republic had a slightly negative medical device trade balance of EUR 1 million in 2020, with exports reaching a value of EUR 1.194 million and imports amounting to EUR 1.195 million (Medtech Europe, 2021).

2. Research methodology

This part of the article describes the methodology used for the research. The study's design, data collection through a questionnaire survey and data processing are described. Furthermore, research limitations that we are aware of are mentioned.

2.1 Design of the study

As stated in the Introduction, this paper aims to evaluate the impact of newly effective regulation on the medical device industry in the Czech Republic using selected, primarily economic, and operational indicators.

Data from the Albertina database were used for this study, plus a questionnaire survey was conducted among companies (natural persons and legal entities) registered as importers, distributors, or manufacturers of general medical devices in the Czech Republic. Companies registered with contact details in the databases of the AVDZP and the State Institute for Drug Control served as the initial sample (N = 3,053). Due to budget constraints, we aimed to collect 100 completed questionnaires, resulting in a sample set of 100 (n = 100). A new subject was randomly selected if any questionnaires were identified as incorrectly filled in. A total of 139 completed questionnaires were randomly selected from the initial sample from August to October 2021. After excluding forty questionnaires for various reasons, such as incomplete or incorrect responses, too young entities (founded within the last two years), entities producing only one medical device, or entities not obligated to notify products of risk class I in the RZPRO database, the final research sample consisted of ninety-nine business entities.

The questionnaire was designed based on established research questions stated in the introduction of this paper. Like other projects using a questionnaire for data collection, we carefully considered the number and sensitivity of questions regarding company information. The research questions are now elaborated into the hypotheses below. Q in parentheses denotes questionnaire question number. Variable in relationship depends on secondary data. The questionnaire is included as an Appendix.

H1: The effects of regulation in terms of the product portfolio, innovation activities, and management do not depend on the size of the company (Q11 vs. size; Q13 vs. size; Q17 and Q18 vs. size).

H2: The capability to transfer the effects of MDR in the form of increased costs on customers does not depend on the size of the company (Q20 vs. size).

H3: The satisfaction of companies with the form of MDR does not depend on the size of the company (Q27 vs. size).

H4: The expected impact on profit does not depend on the expected impact on costs (Q17 vs. Q18 – verifies match with Q20 vs. size).

H5: The expected impact on profit does not depend on the capability of shifting regulatory costs on customers (Q18 vs. Q20).

H6: Product portfolio change does not depend on the perception of the impact on the economic performance (costs, profit) (Q11 vs. Q17 or Q11 vs. Q18).

H7: The decision to stop manufacturing a product does not depend on the 3-year trend of operating results (Q11 vs. profit trend).

H8: The decision to stop manufacturing a product does not depend on the 3-year trend of debt (Q11 vs. debt trend).

H9: The extent of the perceived impact of MDR on the company's costs does not

depend on the extent of the company's linear trend line of debt.

H10: The number of medical devices that are subject to conformity assessment or that already have to meet the requirements of MDR or for which the company participates in clinical evaluation does not depend on the expected impact on the company's costs or profit (Q5 or Q7 or Q9 vs. Q17 or Q18).

H11: The perception of MDR as an impetus for innovative activity does not depend on the expected economic impacts (costs, profit) (Q17 or Q18 vs. Q13)

H12: The company's satisfaction with the form of MDR does not depend on the perceived impacts on cost or profit (Q27 vs. Q17 or Q18).

H13: Product portfolio change does not depend on the perception of MDR as an impetus for innovation (Q11 vs. Q13).

H14: Product portfolio change does not depend on the perceived satisfaction with MDR (Q11 vs. Q27).

H15: The impact of the regulation in terms of the product portfolio does not depend on the number of medical devices that are subject to conformity assessment or already have to meet the requirements of the MDR or for which the company participates in clinical evaluation (Q11 vs. Q5, Q7, Q9).

H16: The company's satisfaction with the form of MDR does not depend on its perception of MDR as an impetus for innovation (Q13 vs. Q27).

As can be seen from the hypotheses, the questionnaire focused on questions concerning the production itself (number and structure of products) and economic and financial matters and impacts. In terms of the economic process, we were also interested in the impact of MDR on innovation activity.

Some hypotheses we have established tested the independence of primary data from questionnaire surveys and secondary economic data from the Albertina database for 2018–2020, before the introduction of MDR. We considered a three-year period to eliminate the subjective perception of the situation due to the impending effective date of MDR. Due to the availability of economic data only for entities obligated to publish financial statements under Czech legislation, the research sample was narrowed down from ninety-nine subjects to forty-two subjects with "financial statements in full" available, per Czech accounting legislation requirements. These financial statements in full include balance sheet and income statements (i.e., structured data on assets, owner's equity, liabilities, revenues, expenses/costs, and profit/loss).

2.2 Data collection – questionnaire survey

A pilot verification of the functionality of the questionnaire preceded the survey itself. In cooperation with AVDZP, eighteen completed questionnaires were obtained as part of the preliminary research. The collected surveys contributed feedback on the basis of which the questionnaire underwent minor modifications with the aim of increasing its return through comprehensibility and convenience of filling and, above all, its usability for the subsequent data analysis. Changes to the questionnaire did not hinder the applicability of the completed questionnaires for the overall evaluation, and these questionnaires were also used in the overall assessment.

Considering the research objective, the questionnaire was divided into the following thematic areas:

- The company's basic characteristics and product portfolio;
- The company's perception of the effects of regulation on the internal operation of the company (portfolio, personnel, financial resources, and management);
- The company's performance based on economic indicators;
- The company's perception of the impact of regulation on the general development of the market for medical devices;
- During data collection, we aimed primarily at CEOs and CFOs to prevent potential research limiting factors such as respondents with limited knowledge of the company's processes.

2.3 Statistical processing

In the Results section of this paper, descriptive characteristics are presented, including absolute and relative frequencies, measures of location (e.g., arithmetic mean, median), and variability (standard deviation).

The tested hypotheses were previously presented in the study design section. Given the categorical or ordinal nature of the data, the non-parametric Spearman's rho correlation

coefficient was calculated to verify the (in)dependence of relationships between variables, considering the importance of their order over their values. IBM SPSS Statistics 28 program was used for calculations.

3. Results

This chapter first presents the basic business characteristics of the research sample. These characteristics affected data availability and collection (business legal form). Product portfolios are then discussed. A quantitative evaluation of the questionnaire is presented, followed by economic indicators of surveyed companies. The chapter concludes with an analysis of the relationships between questionnaire data and financial/economic data.

3.1 Characteristics of the research sample

As stated in the previous chapter, 139 responses were initially obtained through the questionnaire survey. After excluding forty questionnaires (for exclusion criteria, see chapter 2.1), the sample was reduced to ninety-nine responses from business entities operating in the medical device sector. The following paragraphs present characteristics that tend to significantly influence the results of questionnaire surveys in enterprises, such as the business's legal form, the business, the business's size, and the product portfolio's structure.

The legal form of business

Regarding the legal form of businesses, two respondents are self-employed, eighty-nine are limited liability companies, eight are joint-stock companies and zero others (i.e., limited partnership or general partnership).

Size of businesses

Regarding business size, the sample consisted of four (4.04%) large enterprises, thirteen (13.13%) medium enterprises, forty-three (43.43%) small enterprises, and thirty-nine (39.39%) microenterprises, based on the EU classification for enterprise size. The majority of the sector is comprised of small and medium-sized enterprises (SMEs).

As per Czech accounting legislation, the legal form of business and size of the company affected the availability of financial and economic data in subsequent analysis steps. Therefore, the research sample had to be reduced in some analysis steps to maintain objective economic perspectives (indicated below when applicable).

Product portfolio

The composition of the company's product portfolio is one of the most important characteristics with regard to the focus of the research. Tab. 1 shows that 46% of respondents are manufacturers, with class I medical devices most represented (33%), followed by IIa and IIb (15% and 14%, respectively). Only 21% of companies do not operate as distributors, with IIa and IIb devices most abundant in distribution. Sixty percent do not act as importers, and IIa and IIb devices are most represented in imports.

Tab. 1: Classes of medical devices in the surveyed companies

	I am not M/D/IMP	I	Im	Is	IIa	IIb	III	IVD
Manufacturers (%)	54	**33**	3	2	15	14	6	1
Distributors (%)	21	36	0	1	**59**	46	21	2
Importers (%)	60	15	0	0	**33**	28	8	1

Note: I am not M/D/IMP – such a company does not have a product in its portfolio that would place the company in the category manufacturer (M)/distributor (D)/importer (IMP); companies can have two or more roles, so the column total may not add up to 100%.

Source: own

The medical device companies in our research sample are primarily small or micro-sized limited liability companies acting as distributors for class IIa medical devices. Manufacturers, among them, mainly produce class I medical devices.

Financial characteristics

Because only forty-two out of ninety-nine business subjects had complete data available in

the Albertina database comprising financial statements from 2018 to 2020 (see more in the section on the design of the study above), the description of the financial characteristics of the research sample is limited.

Since the article focuses on the economic impacts of MDR, costs (the dominant consideration in relation to regulation), profit, profitability, and selected financial health indicators are commented on in the medium term before the MDR comes into effect.

The costs of analyzed enterprises constantly grew, reaching CZK 9.42 billion (EUR 366.8 million) in 2018 and CZK 11.27 billion (EUR 425.3 million) in 2020. Costs per average company were CZK 224.3 million (EUR 8.73 million) in 2018 and CZK 268.2 million (EUR 10.12 million) in 2020, with the median enterprise having costs of CZK 77.7 million (EUR 3.03 million) in 2018 and CZK 94.5 million (EUR 3.57 million) in 2020. The annual growth rate of costs for all forty-two companies accelerated from 3.82% in 2018/2019 to 15.20% in 2019/2020.

Operating profit, which is not affected by financing methods, decreased by 21.26% between 2018 and 2019 but revived in 2020 with a profit growth rate of 198.82%. The average company achieved an operating profit of CZK 21.25 million (EUR 0.83 million) in 2018 and CZK 50 million (EUR 1.89 million) in 2020. In 2020, seven enterprises were loss-making, and the monitored forty-two companies achieved an operating profit of CZK 2.1 billion (EUR 79.25 million) together.

Both the return on equity (ROE) and return on sales (ROS) indicators inherently track profit development (despite the fact that only operating profit development is presented above, while ROE is calculated from EAT). The average and median values for 2018–2020 are shown in Tab. 2.

Tab. 2 shows that ROE reaches about 20% for average values, except in 2019. The median ROE grew significantly in 2020. In 2020, ROS brought in slightly over CZK 0.06 of profit per CZK 1 of sales. Standard deviation increased

Tab. 2: ROE and ROS profitability indicators in 2018–2020 (*n* = 42, or 40*)

Year		2018	2019	2020
ROE (%)	Average company	19.31	14.38	22.28
	Median company	8.94	8.02	20.20
ROS* (%)	Average company	5.31	3.83	6.37
	Median company	3.06	3.11	6.47

Note: *Two companies were discarded as outliers due to extreme values.

Source: own

Tab. 3: Indebtedness and financial health indicators in 2018–2020 (*n* = 42)

Year		2018	2019	2020
Indebtedness (%)	Average company	41.34	43.06	43.88
	Median company	41.12	42.78	41.52
Taffler	Average company	1.08	0.85	1.37
	Median company	0.65	0.69	0.84
Index IN99	Average company	1.44	1.21	1.40
	Median company	0.99	0.90	1.17

Note: Taffler > 0.3 low probability of bankruptcy of the company; IN99 from the interval [1.42, 2.07] – the business creates value for the owner; IN99 from [1.089, 1.42] – it is not possible to determine whether or not the business creates value for the owner; only intervals important for the interpretation of the table are given in the note.

Source: own

for ROE and ROS in 2020, indicating growing business performance disparity. See Tab. 3 for the development of the indebtedness indicator, representing financial stability and health via the bankruptcy/creditworthiness model.

The average and median indebtedness values are similar. Businesses are not generally over-indebted (the 2020 standard deviation is 42.54, dropping to 28.37 after removing an extreme value of 248.82). Taffler's model shows low bankruptcy probability for most companies, with only three having increased risk (Taffler < 0.2). The Index IN99 suggests that it is uncertain whether businesses are creating value, with 16 (38% of the sample) creating little to no value (IN99 < 1.089).

The sample displays positive financial characteristics, with profitable, stable, and minimally indebted enterprises. Unless significantly affected by MDR, their existence should not be threatened.

3.2 Innovation activity and perception of the impact of regulation on the development of medical devices

Virtually every industry regulation impacts businesses in that industry or closely connected ones. History shows regulations can have positive/negative effects on innovation (Maresova et al., 2020). In the questionnaire, we asked about the impact of MDR on innovation. Tab. 4 shows most respondents (57.58%) view MDR as an innovation obstacle. However, 36.36% say MDR has no effect, and only 6.06% see it as an innovation impulse.

From Tab. 4, it is evident that the majority of surveyed businesses are dissatisfied with the MDR (29.29% somewhat dissatisfied and 26.26% very dissatisfied, totalling 55.55%). About 35.35% of respondents did not have an opinion on the form of MDR at the time of the survey, and only 9.09% were somehow satisfied with the regulation.

There seems to be an overlap between innovation activity and satisfaction with MDR, indicating a potential dependence (further explored in chapter 3.4 through statistical testing). Before delving into the testing, the article examines selected procedural and economic questions considering that the company's financial situation may affect the perception of MDR (independence testing to be discussed in chapter 3.4).

3.3 Procedural and economic impacts

We begin this chapter by looking at procedural matters significantly related to the effectiveness of MDR. Specifically, we focus on the involvement of a specialist in dealing with the regulatory requirements of MDR during the development of a new product (see questions Q22 and Q23 in the questionnaire; presented in Tab. 5).

From Tab. 5, it can be seen that most often, the surveyed companies did not create a new position due to MDR, or they already had such a person for the needs of MDD – Medical Device Directive (40.40%). On the other hand, roughly half of the companies (50.50%) created such a new position in some variant.

Concerning the inclusion of a regulatory specialist in the project development team, the results show a division of companies into two roughly equal-sized groups. While the first one involves the regulator specialist immediately when creating a team, the second group chooses a riskier path, where the regulator

Tab. 4: Partial questionnaire survey results for questions focused on innovative activity and satisfaction with the form of the new regulation

Q13	**MDR & innovation activity (%)**				
	Activity postponement	**Without influence**	**Impulse**		
	57.58	36.36	6.06		
Q27	**Level of satisfaction with regulation (%)**				
	Definitely not satisfied	**Rather not satisfied**	**Neutral**	**Rather satisfied**	**Definitely satisfied**
	26.26	29.29	35.35	7.07	2.02

Source: own

Tab. 5: Survey results – questions focused on procedural and economic impacts

	Creation of a new external or internal position (%)							
Q22	Yes. One internal	Yes. One external	Yes. One, internal-external combination	Yes. Two or more internal	Yes. Two or more external	Yes. Two or more, internal-external combination	No. We already have for MDD	I do not know. I cannot judge
	23.23	11.11	5.05	5.05	0	6.06	**40.4**	9.09
	Involvement of the regulatory specialist in the team (%)							
Q23	Immediately at the beginning (automatically)	Only when necessary	We do not engage					
	52.53	26.26	21.21					
	Removal of product from portfolio due to MDR (%)							
Q11	Definitely not	Rather not	I do not know now	Rather yes	Definitely yes			
	18.18	18.18	22.22	13.13	**28.28**			
	Impact of MDR on funding sources and opportunities (abs. values, selected as a true statement for the business)							
Q15	Negative influence	Increased costs limit the possibility of innovation	Financial resources are readily available	Without influence	Neither is true for us			
	45	**47**	5	31	5			
	Estimated impact of MDR on costs growth (%)							
Q17	Very weak	Weak	Moderate	Strong	Very strong	No effect		
	10.20	20.41	**28.57**	10.20	15.31	15.31		
	Estimated impact of MDR on profit (%)							
Q18	Definitely negative	Rather negative	Neutral	Rather positive	Definitely positive	No effect		
	28.57	31.63	**36.73**	3.06	0.00	0.00		
	Ability to pass on increased costs to customers (%)							
Q20	Definitely no ability	Rather no ability	I do not know	Rather able	Definitely able			
	24.49	**33.67**	31.63	7.14	4.08			

Source: own

specialist is only involved when there is a problem or not at all.

The last of the procedural questions addressed in our questionnaire was the question of possible changes to the product portfolio concerning MDR (see Q11 in Tab. 5). It can be stated that MDR will impact the product portfolio, which will be narrowed, in 41.28% of companies. This means that MDR will force a certain part of medical devices out of the market, which can mean both a reduction in supply and a price increase. From this point of view, MDR can be viewed negatively.

We will now focus on economic issues (Q15, Q17, Q18, and Q20 in Tab. 5 and Q25). New regulations often bring about negative and positive changes, including the company's economy. For MDR, expected increased costs (confirmed by Q17 when the majority of companies (85%) perceive increased costs) may lead to reduced profitability (actually quite confirmed by Q18 – approximately 60% estimate negative impact) and longer return on investment periods. This may impact funding willingness. The assumption is quite confirmed by Q15, with nearly 50% of respondents indicating a negative impact on financing, while about 31% report no impact. Increased costs also limit innovation activity in the case of almost 50% of enterprises. In addition to that,

26% face limitations in innovative activity and at the same time, these feel financing constraints. Finally, over half cannot transfer costs to customers (Q20), which roughly corresponds to the expected negative impact on companies' profits (Q15).

Lastly, Q25 evaluates investment activities, but as respondents could select multiple answers, the total number of respondents does not match the sum of answers. The involvement of any of the methods is essential for business planning and attracting venture capital (Markiewicz et al., 2017). And this research tells us how detailed the examined companies can assess the economic impacts of the MDR.

Over 25% of enterprises do not use any investment evaluation method (likely relying on ad hoc evaluation). Moreover, 30% of respondents may have been influenced by the role or knowledge of the terminology of the person filling out the questionnaire rather than reflecting on the company's practices. Other companies use both static and dynamic methods for evaluating investment effectiveness. Most businesses rely on a single method. The static ROI method dominates. Applying static methods is typical for SMEs, which were the most numerous in our research sample. However, research by Craven et al. (2012) shows that a systematic approach to these methods can benefit manufacturers concerning customers, especially in the medical device sector.

3.4 Evaluation of the impact of regulation on the sector

This chapter is based on data from our own questionnaire survey and economic data from the Albertina database.

The first four parts of the results below provide an overview of the interrelationships between the questionnaire responses. The final, fifth part reveals the relationships between the questionnaire survey data and economic data from companies' financial statements.

For statistical processing, 99 questionnaires (n = 99) were initially used to test relationships between variables from the questionnaire survey. After including economic data for the second part of the results (the final fifth part), forty-two subjects and their questionnaires were used. The sample size reduction was necessary mainly due to the public availability of economic data, which some entities were not obligated to disclose (e.g., self-employed individuals), or had limited obligation (e.g., micro and small accounting entities), or had not yet held general meetings, or did not comply with the obligation due to considering their company information private (e.g., some companies in the Czech Republic prefer paying fines over providing the information).

Selected impacts of regulation with respect to company size

This section focuses on hypotheses *H1–H3*, examining the relationship between company

Tab. 6: Relationship between company size and selected criteria (n = 99; hypotheses *H1–H4*)

	Q11 The effects on product portfolio	**Q13** Viewing MDR as a driver of innovation	**Q17** Perception of effects on costs	**Q18** Perception of effects on profit	**Q20** Capability to transfer increased costs to customers	**Q27** Satisfaction with the form of MDR
Correlation coefficient	0.164	−0.054	−0.006	0.009	−0.167	0.010
Sign.	0.105	0.595	0.953	0.933	0.099	0.921

Note: Significant at *p > 0.05, **p > 0.01, ***p > 0.001, otherwise insignificant; Q – question.

Source: own

size and the impacts of regulation. Specifically, the effects on product portfolio (Q11), capability to transfer increased costs to customers (Q20), perception of impact on costs and profit (Q17 and Q18), and satisfaction with the form of MDR (Q27). The assumption is that larger companies may perceive impacts more leniently due to greater resources. Results are presented in Tab. 6.

It is clear from Tab. 6 that the company size does not influence the perceived impacts. I.e., the given test cannot reject the hypothesis of independence between the given variables. The result can therefore be interpreted so that the size of the company does not bring any advantages or disadvantages in terms of MDR concerning profit (Q18), costs (Q17), or the ability to pass on increased costs to customers (Q20). The size of the company does not lead to different attitudes, for example, to removing a product from the portfolio (Q11), to viewing MDR as a driver of innovation (Q13), or to being satisfied with the form of MDR (Q27).

Selected impacts of regulation concerning perceived economic (financial) impacts

Economic or financial impacts were the subject of questions Q17 (MDR impact on costs), Q18 (MDR impact on profit), and Q20 (ability to transfer costs to customers).

We tested the relationship between perceived impacts on costs and profit to verify answers to question Q20 (hypothesis *H4*). We also tested the relationship between perceived impacts on profit and the ability to transfer costs to customers (*H5*). The relationship between costs or profit and the decision to modify the product portfolio was also tested (*H6*). Hypothesis *H10* examined the relationship between the number of medical devices subject to conformity assessment (Q5), those already under MDR (Q7), or for which the company is involved in the clinical evaluation or PMCF (Q9), and perceived cost impacts (Q17). Finally, a two-way dependence was tested between perceived impacts on company management (Q17 and Q18) in relation to the perception of MDR as an impetus for innovative activity (*H11*) or perceived satisfaction with the form of MDR (*H12*). Hypotheses *H7–H9* are not included here and will be presented separately due to the limited availability of accounting data, as explained in the research methodology.

Cost, profit, and the ability to pass costs on to customers. *H4*: Hypothesis of independence between perceived cost change and profit change is rejected at $\alpha = 5\%$ (p-value < 0.001, correlation coefficient = −0.662; $N = 99$). Costs and revenues strongly correlated with negative dependence but not close to −1, indicating not all increased costs are reflected in profit. *H5*: Hypothesis of independence between the ability to pass on costs to customers and perceived impact on profit is not rejected at $\alpha = 5\%$ (p-value = 0.120, correlation coefficient = 0.157). The test shows a statistically insignificant relationship. The ability to pass on costs to customers does not significantly affect the impact on profit. Thus, the reduction in the strength of the association in the case of *H4* cannot be convincingly explained by *H5*. The results for both *H4* and *H5* imply that increased costs due to MDR will be at least partially covered by manufacturers or distributors. The alternative of shifting costs to suppliers was not examined.

Cost, profit, and size or change of product portfolio. Testing hypothesis *H6* provides these results. At $\alpha = 5\%$, we can accept the alternative hypothesis indicating a statistically significant relationship between impact on costs/profit and decision to change product portfolio (costs: correlation coefficient = 0.327, $p < 0.001$; profit: correlation coefficient = −0.374, $p < 0.001$). Greater negative impact on costs/profit motivates product removal from a portfolio.

Product portfolio size impacted by MDR (questions Q5, Q7, Q9) and perceived impact on costs/profit (hypothesis *H10*) results are shown in Tab. 7.

It is apparent from Tab. 7 that, as far as costs are concerned, a statistically significant relationship is identified at the 5% level of significance between costs and the size of the product portfolio for medical devices subject to conformity assessment by a notified body or certification (Q5) and costs and the number of products for which the company actively participates in clinical evaluation or post-marketing clinical follow-up (PMCF; Q9). This relationship is indirect (correlation coefficient = −0.211 and −0.226, respectively). The indirectness of the relationship signals that some component of the costs will probably have a fixed character, which is diluted with the number of manufactured, distributed, or imported products among the total number.

Tab. 7: Relationship between product portfolio size affected by MDR and perceived cost or profit impacts (*n* = 99; hypothesis *H10*)

	Impact on costs (Q17) vs.			Impact on profit (Q18) vs.		
	Q5 How many MD are currently subject to conformity assessment	**Q7** How many MD are already subject to the requirements MDR	**Q9** For how many MD do you actively participate in clinical trials	**Q5** How many MD are currently subject to conformity assessment	**Q7** How many MD are already subject to the requirements MDR	**Q9** For how many MD do you participate in clinical trials
Correlation coefficient	−0.211	−0.191	−0.226	0.118	0.026	−0.236
Sign.	0.036*	0.059	0.024*	0.244	0.798	0.018*

Note: Significant at *p > 0.05, ** p > 0.01, *** p > 0.001, otherwise insignificant; Q – question.

Source: own

In contrast, for the number of medical devices that already must meet the requirements of MDR, the hypothesis of independence from a perceived impact on costs cannot be rejected (p-value > 0.05). For the relationship between profit and the number of medical devices, the hypothesis of independence can be rejected only for medical devices for which the subject participates in clinical evaluation or PMCF (see Q18 vs. Q9 in Tab. 7). That is, the more medical devices with this characteristic, the worse the impact on the company's profit. It is interesting, however, that for Q9, the direction of dependence expressed by Spearman's rho is negative for both costs and profit.

Cost, profit, and perception of MDR as an impetus for innovation. Hypothesis *H11* tested the independence between the perception of MDR for innovation activities and the perceived impact on the company's management in terms of costs and profit. Based on the results, it can be stated that the higher the costs related to the introduction of MDR, the lower the innovation activity (correlation coefficient = −0.559, p < 0.001). At the same time, the above-confirmed relationship also holds true that the worse the impact on profit, the worse the perception of MDR as an impetus to innovative activity (correlation coefficient = 0.533, p < 0.001).

Overall, it can be concluded that companies had to or still have to cope with the economic impacts of MDR and adapt their innovation activity accordingly.

Cost, profit, and satisfaction with MDR. In establishing hypothesis *H12*, it was assumed that the economic view associated with higher costs or lower profit levels connected with MDR would influence satisfaction with this regulation. Test results show a significant link between increased costs (or negative impact on profit) and satisfaction with MDR, with a correlation coefficient of −0.437 (p-value < 0.001). In other words, the stronger MDR influences perceived cost growth, the lower the satisfaction with MDR. Similarly, the negative link between profit and satisfaction was confirmed, with a correlation coefficient of 0.533 (p-value < 0.001). This means that a higher negative impact on profit resulted in lower satisfaction with MDR. These findings shed light on the prevailing dissatisfaction with MDR found in the questionnaire survey, where 56.25% of respondents were rather dissatisfied or very dissatisfied with MDR (Q27), and 33.93% were neither satisfied nor dissatisfied. Additional observations from open question Q28 revealed that respondents often perceive administrative or bureaucratic requirements as burdensome, which may

equate administration with costs and further influence satisfaction with MDR.

Selected impacts of regulation regarding product portfolio reduction as a response to MDR

This section evaluates hypotheses *H13*, *H14*, and *H15*. First, *H13* tests the relationship between change in product portfolio and the perception of MDR as an innovation impetus (Q11 vs. Q13). The correlation coefficient is −0.339 (p-value < 0.001), suggesting that a lower perception of MDR as an innovation impetus is associated with higher readiness to withdraw a product from the existing portfolio. However, it should be noted that over half of the respondents perceive MDR as a barrier to innovation (57.58%), while a significant number state that MDR does not affect their innovation activities (39.29%).

Hypothesis *H14* focuses on satisfaction with MDR (Q27) and portfolio change (Q11). The null hypothesis of independence between satisfaction with MDR and portfolio change is rejected at the 5% significance level (p-level = 0.014, correlation coefficient = −0.246), indicating a link between the two phenomena. This suggests that as satisfaction with MDR decreases the number of companies that will change their product portfolio increases. In other words, dissatisfaction with MDR may arise from the need to intervene in the product portfolio due to new regulatory requirements.

Hypothesis *H15*, which examines possible changes in the product portfolio in relation to MDR, is not rejected. The null hypothesis suggests no significant link between the narrowing of the product portfolio and the number of medical devices subject to conformity assessment (Q5), or already meeting MDR requirements (Q7), or for which the company participates in clinical evaluation or PMCF (Q9), as presented in Tab. 8.

The results show that the number of manufactured, distributed, or imported medical devices does not seem to influence the decision to narrow the product portfolio. It cannot be said, for example, that with the increasing number of manufactured, distributed, or imported medical devices, the probability of withdrawing a medical device from the portfolio due to MDR would increase.

Impacts of regulation in the form of perceived satisfaction with MDR

The last tested hypothesis (*H16*) showed a statistically significant relationship between perceived satisfaction with MDR and MDR as an initiator of innovative activities. Spearman's rho value of 0.481 at the 1% significance level indicates a direct relationship. Specifically, as satisfaction with MDR decreases, the perception of MDR as an initiator of innovation activities also decreases.

Perceived satisfaction was also examined (see above) concerning company size (no relation), the decision to narrow the medical device portfolio (decreasing satisfaction leads to higher willingness to reduce portfolio), and perceived impacts on costs or profit (satisfaction decreases with increasing impact on costs and adverse impact on profit).

Tab. 8: Relationship between product discontinuation and selected criteria (n = 99; hypothesis *H15*)

	Exclusion of the product from the portfolio (Q11) vs.		
	Q5 How many MD are currently subject to conformity assessment	**Q7** How many MD are already subject to the requirements MDR	**Q9** For how many MD do you actively participate in clinical trials
Correlation coefficient	0.013	−0.007	0.106
Sign.	0.896	0.949	0.295

Note: Significant at *p > 0.05, **p > 0.01, ***p > 0.001, otherwise insignificant; Q – question.

Source: own

Data from financial statements versus answers from questionnaires

The last part of the research results section examines the relationship between financial data from surveyed companies' statements and questionnaire survey data. Specifically, it tests the link between the decision to drop a medical device from the product portfolio due to MDR and the 3-year trend of operating profit or indebtedness (*H7* and *H8*). In terms of operating profit and product removal, no proven connection is found, and the hypothesis of independence cannot be rejected (p-value > 0.05). However, when the trend of indebtedness is considered, a statistically significant relationship emerges (Spearman's rho = −0.347, p-value = 0.024). Companies in debt are more inclined to exclude products from the portfolio. Finally, the declared effect of MDR-related business costs (Q17) in relation to the debt trend (*H9*) shows no proven dependence, and it is unclear if companies spread their MDR costs over the previous three years or if the declared cost increase could influence the trend.

4. Results summary and discussion

The perceived cost increase caused by MDR is statistically reflected in the worsened business performance as measured by profit. Businesses, including manufacturers, distributors, and importers of medical devices, state their inability to shift the increased costs resulting from MDR to their customers, leading to a negative impact on profit. However, this view of the companies, specifically the link between the (in)ability to transfer costs to customers and the negative impact on profit, is statistically insignificant. The impacts of regulation are perceived similarly by all businesses, irrespective of their size.

Satisfaction with the form of MDR is low, with 56.25% of respondents expressing dissatisfaction and 33.93% indicating neutrality. Our survey results indicate dissatisfaction is primarily connected with the need to change product portfolios and increased costs, which respondents often identify as an administrative burden. Therefore, the challenge for future work with MDR is to focus on measures that address administrative steps and minimise administrative burden as much as possible. Historical evidence shows that rising costs and risks adversely impact the development and launch of new products (Grabowski et al., 1978).

Tab. 9: Summary of responses to research questions

RQ1	**Does the company size affect the potential or perceived impacts of MDR on a company?**
	No, but the research sample is quite homogeneous. A high percentage of SMEs is represented.
RQ2	**Do economic conditions such as business performance or financial health influence the adaptation of processes with regard to MDR or the perception of MDR as such?**
	First of all, it can be stated that businesses mostly do not believe that they will be able to transfer MDR-related costs to customers, and increased costs will therefore translate into lower profits. The perceived negative impact on profit is accompanied by a reduction in the portfolio size.
RQ3	**Are the effects of MDR manifested in the product portfolio of companies?**
	Yes, but it does not depend on the size of the companies, but rather on the current perception of the impact of MDR on costs and profit (costs are increasing, profits are decreasing). The decision to remove products from the portfolio is not influenced by the previous medium-term trend of profit, but it is influenced by the change in indebtedness in the last 3 years before the MDR came into effect.
RQ4	**Can satisfaction with the form of MDR be an innovation impulse for medical device development?**
	Yes, it can. But this survey identified mostly dissatisfaction with MDR, which, as seen in the answer to *RQ2*, may stem from costly new requirements. The innovation impulse of MDR is, therefore, rather negative.

Source: own

Tab. 9 provides answers to the research questions formulated in the introduction of this paper with respect to the aim of the research.

The research findings indicate that businesses see increased costs and reduced profits as the effects of MDR. About one-third of companies also reduce their product portfolio in response to MDR. Carl and Hochmann (2023) also come to similar conclusions about the reduction of the product portfolio as an effect of MDR. With regard to the higher demands of the MDR (and the associated higher costs), Bayrak and Yilmaz (2022) caution that MDR may further strengthen the import position of countries already importing medical devices due to its strictness and increased costs for market actors.

Other notable findings unrelated to the research questions or tested hypotheses include the importance of regulatory specialists in the team and evaluating the economic effectiveness of investments. From this, one can infer the impact of MDR on company processes, the company's ability to respond to new MDR challenges, and the ability to economically assess MDR more in detail.

First, regarding the involvement of regulatory specialists, survey responses indicate that this role has gained greater importance in companies, with nearly 50% reporting the creation or strengthening of this position. About three-fifths of these roles are internal. Similar findings are seen in health technology assessment (HTA), as Markiewicz et al. (2017) noted. However, companies also state that they involve regulatory experts in project development teams only when necessary (26.26%) or not at all (21.21%). Scannell and Cormican (2019) recommend involving a regulatory expert early in developing new medical devices, even in spinoff scenarios. In any case, our results thus confirm the expectation (Becker et al., 2019) that MDR brings higher costs, e.g., through a higher workload.

Second, regarding the involvement of investment effectiveness evaluation methods, companies in our Czech research sample tend to use dynamic methods like net present value (NPV) less frequently compared to the Dutch research sample presented by Markiewicz et al. (2017). However, both samples show that the return on investment (ROI) method is commonly used. In our case, it is also appropriate to add that approximately 56% of businesses do not use any such method or are unaware of it.

Findings of the study develop previous studies such as Gozman and Currie (2014) describing how organizations are reviewing and altering the practices and systems employed to deliver compliance and how to ensure that new regulatory requirements are met within designated timeframes and managed on an ongoing basis. Other studies have broadly touched on compliance by addressing how specific legislation can be leveraged to add value, as well as making the case for a strategic approach to risk and compliance (Chatterjee & Milam, 2008). Our findings expand theories about knowledge from the medical device industry and open future questions in management and leadership. Effective leadership is a vital component of health care systems and has an extensive range of functions in improving organizational effectiveness and efficiency. It seems that the leaders of the institutions will have a significant role in the society's adaptation to the new setting.

One limitation of our research is the quantitative approach typical of questionnaire surveys. The identified links suggest the need for qualitative data, which could be obtained through structured interviews with a narrower panel of respondents in similar roles (e.g., CEO or CFO of the companies). Such an approach would help define MDR-related problems more precisely and enable further work within the regulatory framework. In addition, despite efforts to formulate questions clearly, illogical answers appeared, and reluctance to answer some questions was observed. In such cases, questionnaires had to be discarded. Another limitation is that distributors and importers may not perceive the impact of regulation on their role, leading to a lack of awareness of their obligations. Additionally, there is a disproportion between risk classes and company roles, as respondents are mostly distributors and importers of lower-risk class devices, limiting their ability to fully evaluate the regulation's impact on innovation and production.

In order to comprehensively describe the goal "to evaluate the impact of newly effective regulation on the medical devices industry," it is appropriate to extend the research to other European countries, ensure a longer time series of economic data, and the already mentioned additional qualitative research. Such research will then be able to assess the impact of regulation on the entire industry.

Conclusions

Implementing regulations is often seen as necessary to mitigate market failures and safeguard consumer interests. The Medical Device Regulation (MDR) is a recent European regulation specifically designed for the production of medical devices, aiming to ensure their safety and effectiveness. This article focuses on Czech companies and examines the MDR's effects on their operations regarding both economic and procedural impacts.

The findings of this research intimate that the MDR will negatively impact a company's profitability, consequently influencing its operational strategies, and are in line with the general expectations expressed, e.g., by Becker et al. (2019). In the case of the orthopedic aids sector, based on a two-year observation, Carl and Hochmann (2023) also highlight the negative impacts of MDR in the form of increased costs and a reduction in the product portfolio.

One key factor contributing to this negative outcome is the inability of the companies to transfer the increased costs resulting from regulatory requirements to their customers. As a result, affected companies are forced to adjust their product portfolios, reducing their range of offerings. The findings of this research show that approximately one-third of the research respondents (n = 99) declare that they will almost certainly discontinue one of the products from their current portfolio.

The research reveals that the perception of the MDR among medical device manufacturing companies is predominantly negative. A significant finding is almost 50% dissatisfaction with the form of MDR (approximately 35% perceive MDR neutrally). This negativity arises primarily due to the financial burdens imposed by the regulation and the other associated impacts.

Furthermore, the MDR is not perceived as a catalyst for innovation within the industry, as nearly two-thirds of companies report postponing innovation activity due to the MDR. Therefore, this may be detrimental to the end user in the long term.

By quantifying the effects of the MDR on Czech companies, this article provides valuable insights into the real-world implications of this regulatory framework. The findings highlight the challenges companies face in adapting to and complying with the MDR, particularly regarding its impact on profitability and product offerings.

This research serves as a reminder of the complex interplay between regulations, economic outcomes, and industry dynamics. Ultimately, it emphasizes the importance of considering the potential ramifications of regulations and their effects on businesses and markets. Undoubtedly, the MDR will improve safety, but at what cost? Some of the ramifications are highlighted in this article. There is, however, a need for debate on whether the current setting of risk elimination on the one hand and costs and restrictions on the other is really beneficial to either the consumer or the manufacturer. This article is timely as it addresses an important current topic of debate and seeks to fill a gap in the literature.

Acknowledgments: *The research was supported by the internal project "SPEV – Economic Impacts under the Industry 4.0, Societies 5.0 & 6.0 Concept," 2024, University of Hradec Králové, Faculty of Informatics and Management, Czech Republic.*

References

Antošová, I., Hazuchová, N., & Stávková, J. (2022). Consumers' perceptions of health and factors influencing fulfilment of the need for healthcare in EU countries. *E&M Economics and Management*, *25*(3), 19–34. https://doi.org/10.15240/tul/001/2022-3-002

Bayar, Y., & Diaconu Maxim, L. (2020). Effects of labor market and business regulations on unemployment: Evidence from EU transition economies. *Labor History*, *61*(5–6), 608–620. https://doi.org/10.1080/0023656x.2020.1841125

Bayrak, T., & Safak Yilmaz, E. (2022). What will be the economic impact of the new medical device regulation? An interrupted time-series analysis of foreign trade data. *Value in Health Regional Issues*, *29*, 1–7. https://doi.org/10.1016/j.vhri.2021.07.010

Becker, K., Lipprandt, M., Röhrig, R., & Neumuth, T. (2019). Digital health – Software as a medical device in focus of the medical device regulation (MDR). *It – Information Technology*, *61*(5–6), 211–218. https://doi.org/10.1515/itit-2019-0026

Bianchini, E., & Mayer, C. C. (2022). Medical device regulation: Should we care about it? *Artery Research*, *28*(2), 55–60. https://doi.org/10.1007/s44200-022-00014-0

Blind, K. (2016). The impact of regulation on innovation. In J. Edler, P. Cunningham, A. Gök,

& P. Shapira (Eds.), *Handbook of innovation policy impact* (pp. 450–482). Edward Elgar Publishing. https://doi.org/10.4337/9781784711856.00022

Broughel, J., & Hahn, R. W. (2022). The impact of economic regulation on growth: Survey and synthesis. *Regulation & Governance*, *16*(2), 448–469. https://doi.org/10.1111/rego.12376

Carl, A.-K., & Hochmann, D. (2023). Impact of the new European medical device regulation: A two-year comparison. *Biomedical Engineering /Biomedizinische Technik*, *2023*. https://doi.org/10.1515/bmt-2023-0325

Chatterjee, A., & Milam, D. (2008). Gaining competitive advantage from compliance and risk management. In D. Pantaleo & N. Pal (Eds.), *From strategy to execution* (pp. 167–183). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-540-71880-2_9

Craven, M. P., Allsop, M. J., Morgan, S. P., & Martin, J. L. (2012). Engaging with economic evaluation methods: Insights from small and medium enterprises in the UK medical devices industry after training workshops. *Health Research Policy and Systems*, *10*(1), 29. https://doi.org/10.1186/1478-4505-10-29

Emergo. (2022). *Czech Republic – Overview of device industry and healthcare statistics.* Emergo. https://www.emergobyul.com/resources/market-czech-republic

European Patent Office. (2021). *Patent index 2020*.http://www.sziprs.org.cn/attachment/0/37/37531/711294.pdf

Evaluate. (2018). *EvaluateMedTech world preview 2018, outlook to 2024*. https://www.evaluate.com/thought-leadership/medtech/evaluatemedtech-world-preview-2018-outlook-2024

Gozman, D., & Currie, W. (2014). The role of rules-based compliance systems in the new EU regulatory landscape: Perspectives of institutional change. *Journal of Enterprise Information Management*, *27*(6), 817–830. https://doi.org/10.1108/jeim-05-2013-0023

Grabowski, H. G., Vernon, J. M., & Thomas, L. G. (1978). Estimating the effects of regulation on innovation: An international comparative analysis of the pharmaceutical industry. *The Journal of Law and Economics*, *21*(1), 133–163. https://doi.org/10.1086/466914

Konishi, A., Isobe, S., & Sato, D. (2018). New regulatory framework for medical devices in Japan: Current regulatory considerations regarding clinical studies. *Journal of Vascular and Interventional Radiology*, *29*(5), 657–660. https://doi.org/10.1016/j.jvir.2017.12.022

Maci, J., & Maresova, P. (2022). Critical factors and economic methods for regulatory impact assessment in the medical device industry. *Risk Management and Healthcare Policy*, *15*, 71–91. https://doi.org/10.2147/rmhp.s346928

Maresova, P., Hajek, L., Krejcar, O., Storek, M., & Kuca, K. (2020). New regulations on medical devices in Europe: Are they an opportunity for growth? *Administrative Sciences*, *10*(1), 16. https://doi.org/10.3390/admsci10010016

Markiewicz, K., Til, J., & IJzerman, M. (2017). Early assessment of medical devices in development for company decision making: An exploration of best practices. *Journal of Commercial Biotechnology*, *23*(2). https://doi.org/10.5912/jcb780

Medtech Europe. (2020). *European IVD market statistics report 2020*. https://www.medtecheurope.org/wp-content/uploads/2020/12/2020_mte_european-ivd-market-statistics-2020.pdf

Medtech Europe. (2021). *The European medical technology industry in figures 2021*. https://www.medtecheurope.org/wp-content/uploads/2021/06/medtech-europe-facts-and-figures-2021.pdf

Niemiec, E. (2022). Will the EU medical device regulation help to improve the safety and performance of medical AI devices? *DIGITAL HEALTH*, *8*, 205520762210890. https://doi.org/10.1177/20552076221089079

Patentinspiration.com. (2021). *Search and analyze patents – PatentInspiration*. https://www.patentinspiration.com/

Razavi, S. M., Padash, H., & Nesbati, A. N. (2017). The role of business regulations in economic growth. In S. Rezaei, L.-P. Dana, & V. Ramadani (Eds.), *Iranian entrepreneurship* (pp. 41–53). Springer International Publishing. https://doi.org/10.1007/978-3-319-50639-5_3

Scannell, P., & Cormican, K. (2019). Spinning out of control? How academic spinoff formation overlooks medical device regulations. *Journal of Technology Management & Innovation*, *14*(3), 82–92. https://doi.org/10.4067/s0718-27242019000300082

Tu, J. (2020). *The impact of regulatory compliance costs on business performance*. Innovation, Science and Economic Development Canada.

Wilkinson, B., & Van Boxtel, R. (2020). The medical device regulation of the European Union intensifies focus on clinical benefits of devices. *Therapeutic Innovation & Regulatory Science*, *54*(3), 613–617. https://doi.org/10.1007/s43441-019-00094-2

Appendix

Questionnaire (list of questions)

- Q1. Company name
- Q2. Medical device class(es) – production
- Q3. Medical device class(es) – distribution
- Q4. Medical device class(es) – import
- Q5. How many medical devices manufactured/distributed/imported by you are currently subject to conformity assessment by a notified body or certification?
- Q6. Which class?
- Q7. How many medical devices manufactured/distributed/imported by you are already subject to the requirements of the new medical device regulation?
- Q8. Which class?
- Q9. For how many medical devices manufactured/distributed/imported by you do you actively participate in clinical trials or post-market clinical follow-ups?
- Q10. Which class?
- Q11. Are you planning to phase out any product from your portfolio due to the new regulation, even though you would not have done so under the old regulation?
- Q12. Why?
- Q13. Innovation with respect to the new medical device regulation: Do you see the new regulation as an impulse, obstacle, or irrelevant factor?
- Q14. Why?
- Q15. Financial resources and opportunities: Check all statements that are true for your business entity.
- Q16. Why?
- Q17. The new regulation has affected our financial indicators in terms of overall COSTS.
- Q18. The new regulation will affect our financial indicators in terms of overall PROFITS.
- Q19. Why?
- Q20. We are able to shift the increased costs associated with regulatory requirements on our customers.
- Q21. How/in what way? Or why not?
- Q22. Regarding the new regulation, did you have to create a new internal or external position for a person responsible for regulatory compliance (regulatory officer)?
- Q23. We usually involve an expert on regulatory issues in the project/development team.
- Q24. How/in what way? Or why not?
- Q25. Which indicators do you use to evaluate the contribution of the product to the overall performance of the company?
- Q26. If you use other indicators, which ones?
- Q27. To what extent is your company satisfied with the new medical device regulation?
- Q28. Which requirements of the new regulation do you perceive as the most burdensome/problematic? State up to three answers but at least one.
- Q29. Why?
- Q30. What do you consider the greatest LIMITATIONS of the new regulation? State up to three answers but at least one.
- Q31. What do you consider the greatest OPPORTUNITIES of the new regulation? State up to three answers but at least one.

Utilization of time-driven activity-based costing and process simulation in cost management of organization

Michal Halaska[1], Roman Sperka[2]

[1] *Silesian University in Opava, School of Business Administration in Karvina, Department of Business Economics and Management, Czech Republic, ORCID: 0000-0002-7086-9137, halaska@opf.slu.cz;*
[2] *Silesian University in Opava, School of Business Administration in Karvina, Department of Business Economics and Management, Czech Republic, ORCID: 0000-0003-2371-6450, sperka@opf.slu.cz.*

Abstract: *The deployment of information and communication technologies in organizations is on the rise. Many organizations consider the application of technologies to be a crucial key to improve their processes. However, traditional costing systems are not suitable for cost estimation of business processes due to the use of volume-based cost drivers, which are often not adequate for the structure of today's organizations. In this research, we present an overview of how the TDABC (time-driven activity-based costing) model can be combined with process mining and business process simulation for cost estimation of such processes. The objective of this paper is to use the cost dimension as a major attribute for the potential implementation of robotic process automation (RPA) in companies. However, information and communication technologies could be considered in general. We demonstrate our approach in a case study that takes advantage of a real-life event log containing transactional data representing the loan application process in an insurance company. The event log is analyzed and processed using process mining techniques. Based on the preprocessing, a simulation model representing the original loan application process is designed. The designed simulation model is then used for simulation of partial and full implementation of RPA through separate scenarios. Then, we add the cost dimension to the simulation by enriching the event log with cost data based on a formalized cost model. We show that even though partial implementation of RPA might not deliver significant increase in efficiency in the process, it might still represent significant cost savings.*

Keywords: *Business processes, process mining, simulation, TDABC, RPA, automation.*

JEL Classification: *M4, M1, C63.*

APA Style Citation: Halaska, M., & Sperka, R. (2024). Utilization of time-driven activity-based costing and process simulation in cost management of organization. *E&M Economics and Management*, *27*(2), 50–68. https://doi.org/10.15240/tul/001/2024-5-007

Early Access Publication Date: *April 10, 2024.*

Introduction

For the organization to succeed in today's highly competitive markets, it is necessary to improve its methods and processes, lower costs, and continually increase quality. The main purpose of accounting is to facilitate economic resources. This is achieved by providing accurate information to operating management, owners, and

creditors, for price setting, budgeting, planning, forecasting, and other kinds of decision-making (Sánchez & Batista, 2020; Zamrud & Abu, 2020). It can be used to determine which products are profitable, and identify waste and low value-adding activities at the operational level. This is especially important regarding the philosophy of present managers, which places more emphasis on customer satisfaction. In numerous businesses, expenses exhibit significant variations because of the diverse range of products or operations they engage in, necessitating the implementation of more advanced and adaptable costing systems.

Contemporary cost accounting systems should exhibit dynamism and flexibility, enabling the computation of various categories of cost objects, such as products, activities, distribution channels, and clients, among others. This should be done while considering the full spectrum of diversity and complexity inherent in modern production and business operations, such as high proportion of indirect costs shared between multiple cost objects, heterogeneity of cost drivers and related demand, cost-competitiveness, and availability of information systems gathering information about costs and cost drivers. Traditional-based costing was introduced when the overhead costs were significantly lower and direct labor accounted for a major portion of production cost (Pashkevich et al., 2023; Vedernikova et al., 2020). Traditional costing, based on averages, worked for simple, uniform products with mostly variable costs. But in today's dynamic manufacturing and services, overhead costs are substantial (Popesko, 2010). Traditional accounting assumed stable markets, long product cycles, and large production runs, which no longer apply due to automation, shorter product life, and greater variety. This shift has altered cost structures (Pashkevich et al., 2023; Popesko & Tučková, 2012). Traditional costing distorts product costs and cannot break them down by activities (Lu et al., 2017; Vedernikova et al., 2020), hindering decision-making. It offers little incentive to control overheads, overestimating high-volume and underestimating low-volume costs (Hadid & Hamdam, 2022).

Recent IT advancements significantly enhance cost data collection and communication in organizations, facilitating evidence-based cost analysis of business processes. Traditional costing systems, however, underutilize available data in modern organizations (Vedernikova et al., 2020; Zamrud & Abu, 2020). This study focuses on integrating TDABC (time-driven activity-based costing) with process mining techniques. It aims to incorporate cost considerations into implementing RPA (robotic process automation) and information technology. To achieve this objective, we postulated the following research questions (*RQ*).

RQ1: How can the TDABC model integrated into the event log used for the utilization of process mining techniques?

RQ2: How can process-related cost information enrich the implementation of RPA?

The paper is structured as follows: in the first section, we present TDABC systems. The second section introduces process mining. The third section presents the background and methodology of the research. The fourth section presents the case study and its results. The fifth section discusses the advantages and limitations of our approach. To conclude, we summarize our results and the perspectives for its further development.

1. Time-driven activity-based costing systems

The organizations that gain the greatest advantage from adopting activity-based costing (ABC) systems are those with high frequency of different cost objects, those with a large portion of indirect and supporting costs, and those with a great number of processes and activities (Popesko, 2010). The major difference between ABC and TDABC is that TDABC uses a time driver for each activity. TDABC involves estimating solely the unit cost of supplying capacity and the time required to perform a transaction or an activity (Cidav et al., 2020). TDABC allows usage of multiple time drivers to estimate the time spent on each activity which makes implementation, maintenance and updating of TDABC easier (Ghani et al., 2020). ABC systems often lead to oversimplification of activities as it might have to treat varying transaction times by treating each variant of the process as a distinct activity in the case of multi-driver activities, which creates difficulties in estimating the practical capacity for each sub-activity (Gervais et al., 2010). With TDABC, all we need to know is the quantity of resources required to produce one unit or one batch of the cost object and how much of the cost pool should be allocated

to the cost object (Sánchez & Batista, 2020). TDABC similarly to ABC supports operational improvements as it provides more cost transparency than traditional costing systems; thus, providing relevant information for managerial decision-making (Pashkevich et al., 2023; Sachini et al., 2022). The model eliminates activity pools, thereby simplifying the allocation of resource costs without the need for activity pools (Zamrud & Abu, 2020). TDABC was reported to be more efficient and simpler than ABC (Keel et al., 2017). The use of multiple time drivers eliminates the need for subjective, costly, and time-consuming workshops, observations, interviews, and surveys, which might provide biased process views (Cidav et al., 2020; Rahman et al., 2019). Furthermore, there are usually fewer resource groups than activities, which reduces the measurement error (Gervais et al., 2010). At the operational level, there are proven advantages through waste reduction, reduction of redundant human resources, non-value adding steps and waiting times, resulting in a detailed understanding of the cost of processes (Keel et al., 2017; Zamrud & Abu, 2020).

Together with the possibility to use data from ERP and other systems, it makes it easier to model sub-activities and maintain the modelled system in the long run (Pashkevich et al., 2023; Sachini et al., 2022). The use of different information and automatic data capture systems is no longer a privilege of large companies. Information systems help collect data about companies' processes with minimum manual effort. In this way, real-process information can be linked to cost information, resulting in automatic cost accounting. Businesses have the option to utilize alternative data collection approaches, such as radio frequency identification or automated measurements, as well as direct observations. Although TDABC is much easier to implement than ABC, data collection and analysis are laborious tasks, which may disregard the use of TDABC. The steps regarding the implementation of TDABC are very similar throughout the literature (e.g., Cidav et al., 2020; Vedernikova et al., 2020). There may be differences based on specific domains; however, in this research, we are looking for a generic approach towards the implementation of TDABC. Thus, in this research, we use the following implementation approach of TDABC:

1. **Identify activities.** In this step, we pinpoint the activities for which we seek cost information. A crucial prerequisite for implementing TDABC is having a comprehensive understanding of all processes and activities involved (Ribadeneira et al., 2019). This step implicitly includes the identification of various resource groups used by each activity.
2. **Determine the capacity cost rate.** The calculation of the capacity cost rate for these activities is essential. The capacity cost rate (CCR) can be defined as follows:

$$CCR = \frac{Cost\ of\ capacity\ supplied}{Practical\ capacity\ of\ resources\ supplied} \quad (1)$$

The cost of supplied capacity pertains to the expenses associated with the resources utilized for carrying out activities, while practical capacity indicates the amount of time allocated to perform the activity.

3. **Estimate activity time.** It is necessary to estimate the amount of time required for the completion of a single unit of the activity.
4. **Determine the cost driver rate.** The cost driver rate for an activity in TDABC is straightforwardly determined by multiplying the CCR by the time estimate required for a single occurrence of that activity.
5. **Assign activity costs to cost objects.** In this step, the expenses are allocated to the target by calculating the cost by multiplying the actual volume of cost driver units by driver rate.

For a comprehensive understanding of data, both process and organizational data must be seamlessly integrated and analyzed. To create these integrated datasets, it is essential to link the organizational data connected to each activity, whether it is performed by humans or automated systems, back to the corresponding activity within a business process case.

2. Process mining

Process mining encompasses a range of techniques aimed at helping organizations comprehend, assess, and enhance their processes (Garcia et al., 2019). Consequently, process mining holds promise as a valuable tool for implementing TDABC systems and supporting cost management decision-making. The cornerstone of process mining lies in the analysis of event logs, which are extracted from diverse information systems utilized within organizations, offering invaluable

insights into the execution of work processes. These logs must be sourced from operational systems such as customer relationship management, enterprise resource planning systems, or even embedded systems. Regardless of the type of process mining analysis, the log should contain the following essential information: i) each event contained in the log must be unique and must be sorted; ii) it is crucial to be able to differentiate between process instances; and iii) there must exist a function capable of assigning an activity name to each event.

Various types of PM analysis necessitate distinct supporting attributes. For example, constructing a social network from event logs requires the inclusion of resource information within the log. Process mining techniques usually do not consider the cost dimension of the analyzed processes. Therefore, typical event logs do not contain cost-related data. The conventional format for event logs used to be MXML. However, due to various limitations, a new standard event log format called XES was introduced. Nonetheless, there are alternative formats available, such as CSV files or software-specific FXL files, among others. Within this research, we utilize two fundamental areas of process mining: process discovery and conformance checking. The primary objective of process discovery is to identify pattern within the logs, from which a process model of the observed process is constructed. Presently, one of the most successful techniques for this purpose is called split miner (Augusto et al., 2018). It is important to note that none of these techniques guarantees that the resulting model precisely corresponds to the original process or fully represents the behavior observed in the data. Therefore, it is crucial to verify the quality of the discovered process model through conformance checking (Garcia et al., 2019).

3. Background and methodology

This section provides the formal preliminaries for our research. Through the formalization of event logs, we establish precise requirements based on those outlined in Section 2, without delving into specific syntax considerations. This formal representation serves as a foundation for querying the event log and as a starting point for subsequent analysis and reasoning. Moreover, it presents data and methodology of the case study used. Firstly, we formalize the event log and then we extend the log by parameters of the cost model.

Definition 1 (event, attribute). Let E be the set of all possible event identifiers and $AN = \{a_1, a_2, \ldots, a_n\}$ be the set of all possible attribute names. For each attribute $a_i \in AN (1 \leq i \leq n)$, D_{a_i} is the set of all possible values for the attribute a_i. *For* any event $e \in E$ and an attribute name $a \in AN$, we denote $\#_a (e) \in D_a$ as the attribute's value name a for event e. For any event $e \in E$, we define the following standard attributes: $\#_{case} (e) \in D_{case}$ is the case identifier of e; $\#_{id} (e) \in D_{id}$ is the event identifier of e; $\#_{act} (e) \in D_{act}$ is the activity name of e; $\#_{res} (e) \in D_{res}$ is the resource that triggered the occurrence of e; $\#_{stime} (e) \in D_{stime}$ is the start timestamp of e; and $\#_{ctime} (e) \in D_{ctime}$ is the complete timestamp of e.

Definition 2 (case, trace, event log). Let C be the set of all possible case identifiers. For any $c \in C$ and an attribute name $a \in AN$, we denote $\#_a (c) \in D_a$ as an attribute's value named a for case c. We denote E^* as the set of all finite sequences of events over E where a finite sequence of length n over E is a mapping $\sigma \in \{1, \ldots, n\} \rightarrow E$ and is represented as $\sigma = \langle e_1, e_2, \ldots, e_n \rangle$ where $e_i = \sigma(i)$ for $1 \leq i \leq n$. We define the special attribute $\#_{trace} (c) \in E^*$ as representing the trace of case c, which consists of all events associated with c. An event log $L \subseteq E$ is a set of events. We denote $\hat{c} = \#_{trace} (c)$ as shorthand for referring to the trace of a case and further note that the ordering in a trace should respect timestamps, i.e., for any $c \in L$, i, j such that $1 \leq i \leq j \leq |\hat{c}|$: $\#_{time} (\hat{c}(i)) \leq \#_{time} (\hat{c}(j))$.

TDABC focuses on organization's resources. For each resource cost pool, resource costs are allocated to cost objects using two sets of estimates: i) the capacity cost rate (Equation (1)); and ii) an estimate of time units required to perform a process, an activity, or a service. Based on the TDABC cost model, we have to extend the event log with additional attributes. Thus, we define the following attributes:

- $\#_{type}(e(j)) \in D_{type}$ is the activity type of event j where D_{type} is a finite set;
- $\#_{RP_i} (e(j)) \in D_{RP}$ is the i^{th} resource pool of event j where D_{RP} is a finite set;
- $\#_{PC_{RP_i}} (e(j)) \in D_{PC} \subseteq R_{\geq 0}$ is the practical capacity of i^{th} resource pool of event j;
- $\#_{CCS_{RP_i}} (e(j)) \in D_{CCS} \subseteq R_{\geq 0}$ is the cost of capacity supplied of i^{th} resource pool of event j;

- $\#_{CCR_{RP_i}}(e(j)) \in D_{CCR} \subseteq R_{\geq 0}$ is the i^{th} capacity cost rate of event *j*;
- $\#_{dur}(e(j)) \in D_{dur} \subseteq R_{\geq 0}$ is the duration of event *j;*
- $\#_{odur}(e(i), e(j)) \in D_{odur} \subseteq R_{\geq 0}$ is the overlapping duration of events *i* and *j*.

3.1 TDABC costing model

Practical capacity, time and cost represent crucial components within the TDABC system, wielding substantial influence on its outcomes. The inaccurate estimation of these elements can result in significant deviation from the actual values when calculating the costs associated with products or services. The TDABC costing model can be described as follows: Let *L* be an event log and parameters of the cost model be represented as attributes of the event log as defined above.

In step 1, all activities related to the modelled process and related cost objects, and resources used by these activities and their costs have to be identified. These resources are then grouped into resource pools based on resource cost drivers. Based on defined resource pools, the cost of capacity supplied for each resource pool is estimated.

In step 2, the capacity cost rate of each resource pool is estimated based on the cost of capacity supplied and practical capacity. Practical capacity is estimated as the quantity of resources (typically, personnel or equipment) that perform activities. It refers to the actual capacity of resources, as opposed to the amount of time theoretically available for performing the activity. Thus, the practical capacity for each activity type is estimated as follows:

$$\#_{PC_{RP_i}}(e(j)) = \sum_{j=1}^{k} \#_{dur}(e(j)), \quad \text{where } \#_{type}(e(j)) = b_i \tag{2}$$

Each activity type has assigned exactly one resource pool. Activities are classified based on activity type to differentiate between potentially different outputs of activities recorded in the log, which might consume different resources. Another option is to split such activity into several activities; however, this would add to the complexity of the process model, which is not desirable. Furthermore, *k* represents the number of events in the log *L*. Practical capacity is measured in units of time. Using Equation (2), the capacity cost rate is defined as follows:

$$\#_{CCR_{RP_i}}(e(j)) = \frac{\#_{CCS_{RP_i}}(e(j))}{\#_{PC_{RP_i}}(e(j))}, \quad \text{where } \#_{type}(e(j)) = b_i \tag{3}$$

In step 3, management estimates the amount of time it takes to a complete single unit of the activity. Usually, activity times are estimated involving different techniques like, e.g., direct observations, employee surveys. Based on activity drivers and time estimates, time equations are formulated which then determine durations of instances of activities. In our approach, we use timestamps recorded by the information systems in the event logs. Activity duration is estimated using the start timestamp and end timestamp of the event. Thus, we define the duration of the event as follows:

$$\#_{dur}(e(j)) = \#_{ctime}(e(j)) - \#_{stime}(e(j)) \tag{4}$$

In step 4, the cost driver rate for an activity in TDABC is defined as the product of the capacity cost rate and the time estimate for a single unit of the activity. However, since we are using exact times at the event level, the cost driver rate is not useful. Thus, we define the activity cost (*AC*) as follows:

$$AC = \sum_{j=1}^{k} \#_{dur}(e(j)) * \#_{CCR_{RP_i}}, \quad \text{where } \#_{type}(e(j)) = b_i \tag{5}$$

In step 5, we assign activity costs to the cost object. The costs are assigned to the cost object by summing over entire event log. Thus, we define the total cost of the process as follows:

$$TC = \sum_{j=1}^{k} \sum_{i=1}^{m} \#_{dur}(e(j)) * \#_{CCR_{RP_i}} \tag{6}$$

3.2 Data

The research utilizes a publicly available event log (van Dongen, 2012) to study the execution of the loan application process in the year 2011. This event log comprises 13,087 process instances, or cases, involving a total of 262,000 events. Each event within the log is associated with one of the 36 activity names. The log covers a reference period from October 1, 2011, to March 14, 2012, with an average case duration of 8.6 days. Events in the log are categorized into three types, each denoted by an event name beginning with either A, O, or W. Specifically, A events relate

to applications, O events pertain to offers sent to customers, and W events concern the processing of work items associated with applications. Each event recorded in the log comprises nine attributes, including "Case ID" for case identification, "Activity" for identifying activities within cases, "Resources" for identifying the resources responsible for event execution, and "Start timestamp" and "Complete timestamp" for pinpointing even occurrences. The overall workflow of the process unfolds as follows. Following the application submission, a subset undergoes scrutiny for fraudulent behavior, while the rest are examined for completeness. Subsequently, applications are pre-accepted and processes. Some applications are canceled, while offers are dispatched to the remaining customers, followed by customer contact. If the customer accepts the offer, the application undergoes assessment, leading to loan approval. In certain cases, further customer interaction might be necessary post-assessment to finalize the application. It is important to note that while the event log contains real-life transactional data, it lacks the attributes used by the presented costing model. Therefore, for the purpose of this case study, we augmented the event logs by incorporating artificial cost attributes.

3.3 Methodology

Data preparation

At this stage, it becomes imperative to prepare the log for application of individual process mining techniques. This involves extracting logs from various database sources. Process mining techniques are typically executed within software tools that operate with specific data file formats such as CSV, XES, XML, and MXML. Fortunately, the log pertaining to the loan application process was already available in CSV format. An essential step in this process involved verifying whether all events in the log contained the fundamental attributes required in the appropriate format. Events and associated cases that either lacked the necessary attributes or did not adhere to the required formats were either modified to comply with these criteria or excluded from the dataset. Any missing values were addressed through a similar approach. The outcome of this preparation stage is the refined event log, which is subsequently employed in the process discovery phase to uncover the process model of the loan application process.

Process discovery and analysis

When implementing a TDABC costing system, the identification of activities within the process and gaining insights from various process perspectives is crucial. In this context, process mining, as a data-centric approach, offers a significant advantage over other commonly used business process management practices like workshops or interviews. These traditional methods may not provide a comprehensive understanding of the entire process, especially when process owners are not intimately familiar with every aspect. To achieve this, we employed process discovery techniques within the Apromore process mining tool, allowing us to generate an executable process model. Apromore's process discovery relies on the split miner technique (Augusto et al., 2018), which excels in terms of fitness, precision and *F*-score when compared to other process discovery methods. Noise within the log is effectively filtered out using integrated nodes, arcs, and parallelism filters. The node filter screens activities based on their frequency of occurrence, the arcs filter operates based on the frequency of arc occurrences, and the parallelism filter enables adjustment for parallelism, such as AND and OR gates, discovered in the process. The quality of the process model derived through Apromore is assessed using fitness, precision, and *F*-score metrics (Buijs et al., 2012). The output of this process discovery stage yields the process model for the loan application process, forming the foundation upon which the subsequent simulation is constructed.

Process simulation model

During this stage, we design the simulation model, which serves as a tool for assessing the impact of operation changes on the cost perspective of the process. For our simulation, we adopted the approach presented by Măruşter and van Beest (2009) as well as Rozinat et al. (2009). Initially, we adjusted the discovered process model for simulation purposes using filter nodes, arcs, and parallelism. The aim was to simplify the model while retaining a maximum number of activities from the log and ensuring an acceptable level of model quality. Decision points within the model, such as XOR gates, were simulated as percentages based on the frequency of outgoing arcs. In essence, these probabilities were determined as a mathematical ratio of cases

affected by the selected path. The business instance for the simulation was directly derived from the original log, which contained 13,087 cases. However, the simulation tool we used, BIMP, had a maximum limit of 10,000 process instances. Therefore, we worked with 10,000 cases as it provided a sufficient representation of the process.

The time-related parameters in the simulation model were also based on the original logs and consisted of three components: the arrival of new cases, processing times, and waiting times. The arrival of new cases was modeled as a Poisson process, with arrival times following a Poisson distribution estimated from the original log. For processing times, we employed various probability distributions. The selection of the appropriate distribution was based on its fit to the data using Kolmogorov-Smirnov statistics, Cramer-von Mises statistics, and standard error. When distribution has similar Kolmogorov-Smirnov statistics, the one with lower Cramer-von Mises statistics was chosen. In cases where the best-fitting distribution had a high standard error leading to a significant deviation in the mean value, the standard error was considered during the selection process. The same probability distributions and selection procedures were applied to estimate waiting times. In the original log, activities were categorized into two states: "Start" and "Complete" with processing times defined as difference between the complete timestamp and start timestamp for each activity. Similarly, waiting times represented the time interval between the start timestamp of an activity and the complete timestamp of the preceding activity. We treated activities with instant processing times in the original log, where start and complete timestamps were the same as having instant processing times in the simulation model. Activities with instant waiting times in the original log, signifying very short waiting times on the order of milliseconds, were approximated as having a waiting time value of 0.001 milliseconds.

The simulation model's organizational perspective stems from the original log data. This perspective primarily focuses on resource allocation for various activities. According to the data, most resources are involved in a wide range of activities. The variation lies in the extent to which each resource engages in each specific activity, indicating how frequently the resource carries out that activity throughout the log. Activities that are instantaneously processed are attributed to the resource labeled as "System." To allocate distinct resource types to each non-instantaneous activity, we employ the *k*-means clustering technique. This clustering approach hinges on the distinctive profile of each resource. The resource profile is represented as a one-dimensional vector, with each element indicating how many times the resource executed each non-instantaneous activity. Determining the optimal number of clusters for *k*-means clustering is accomplished through the utilization of several methods, including the elbow method, the silhoutte method, and gap statistics. Each activity is then assigned to a specific cluster based on the cluster with the highest cumulative number of executions of that activity by its constituent resources (Equation (7)).

$$\max_{n} \sum_i e_i^n \tag{7}$$

where: n – the number of clusters; i – the number of resources within the cluster; e_i^n – the number of times activity a was executed by resources i belonging to cluster n.

The reliability of results obtained through simulation increases as the approximation becomes closer to reality. To achieve a simulation that closely mirrors real-world data, the following similarity indicators are employed:

- Process flow and semantics – both models should exhibit identical process flow, representing the sequence of activities and BPMN constructs. Furthermore, in terms of semantics, it is crucial that the labels assigned to the activity are the same;
- Throughput times – the throughput times for each activity in the discovered process model should closely align with those in the simulated process model for comparison;
- Bottlenecks – the location and severity of bottlenecks in the process model should closely match those in the simulation model for comparison.

What-if analysis

At this stage, we present the evaluation of the cost estimation of the business process. It is based on a combination of TDABC, process mining, and business process simulation. The evaluated scenario focuses on the deployment of RPA in the loan application process. RPA technology is employed to automate business processes

that were previously carried out by employees. As a result, this technology allows employees to engage in more complex tasks, thereby delivering greater value to the organization. RPA is best utilized for automation of rule-based, highly frequent, and repetitive tasks that are prone to error (Syed et al., 2020; Šperka & Halaška, 2023). Based on the features of RPA, we identified several activities within the loan application process suitable for the deployment of RPA. We implement these changes into simulation model and demonstrate our approach towards cost estimation using TDABC model.

4. Case study

4.1 Data preparation

In the initial stage, it is imperative to prepare the logs to facilitate the application of specific process mining techniques. For our study involving the loan application process, we had access to logs available in both XES and CSV formats. We opted for the CSV format due to its user-friendliness and accessibility, especially for individuals without prior expertise. Unlike XES, which relies on XML with a predefined syntax, CSV offers a more intuitive and straightforward structure. We conducted a thorough review to ensure that all events in the log adhered to the essential prerequisites. This included confirming the presence of unique case IDs, ensuring that each event was associated with an activity name, verifying that timestamps followed the "dd.mm.yyyy hh:mm:ss" format, and confirming that events were appropriately linked to designated resources. Any events or related cases lacking these required attributes or not conforming to the specified formats were either modified to meet these criteria or excluded from the dataset. We adopted a similar approach in handling missing values. It is worth noting that our primary focus was exclusively on the specified attributes, namely case IDs, activities, timestamps, and resources. Other attributes were disregarded. Consequently, no cases or events were omitted from the log based on these auxiliary attributes. The outcome of data preparation culminated in the creation of an event log, which served as the foundation for subsequent stages involving process discovery and analysis within the context of the loan application process.

Process discovery and analysis

The 2011 log comprises a total of 13,087 instances, encompassing a substantial 262,000

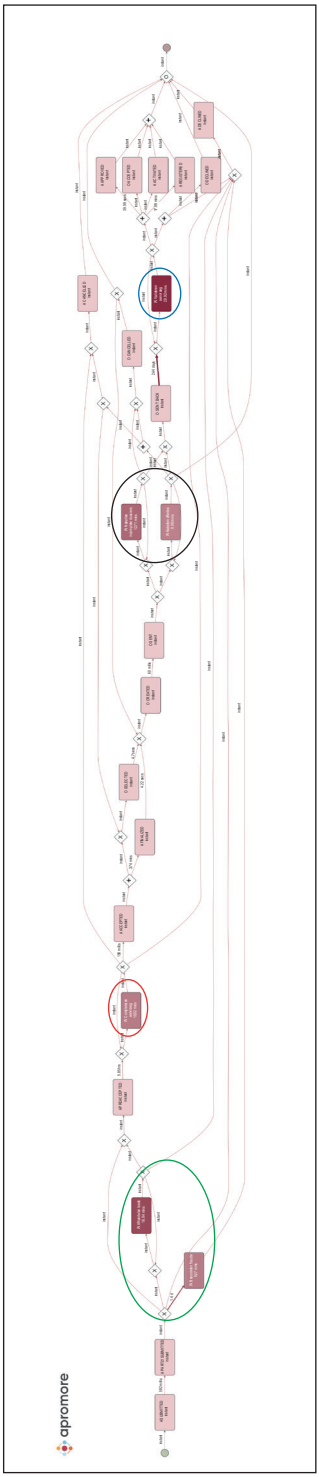


Fig. 1: BPMN process model representing the loan application process from 2011 using Apromore (values of filters nodes, arcs and parallelism set up to 100, 60, 100)

Source: own

Note: Fig. 1 is for illustrative purposes only to showcase the process flow of the discovered process.

individual events. Within this log, 23 distinct activity names have been attributed to all recorded events. It is essential to highlight that the loan application process exhibits notably complex and unstructured overall behavior. Thus, the discovered process has to be simplified to obtain a process model suitable for simulation purposes (Fig. 1). Of the 23 activities, seven activities are being done manually, and the rest of them are automated. This means that the manual activities have processing time, while the rest of the activities are being done almost instantly. Thus, in the cost analysis of the process, we will focus on the manual activities because the automated activities do not provide much information at the case level. Furthermore, we excluded activity "W_Change contract details" from the cost analysis to make the simulation model simpler as it appears in the entire log only 12 times. Similarly, we excluded loops of length one from the cost analysis because they greatly increase the number of process variants.

In Fig. 1, we can observe specific activities highlighted within colored ovals:

- Green oval – within this green oval, we find the activities "W_Assess potential fraud" and "W_Handle leads." The "W_Assess potential fraud" activity involves the valuation of loan applications for potential fraud indicators. Meanwhile, "W_Handle leads" is associated with the processing of incomplete initial application submissions;
- Red oval – in the red oval, we highlight the activity labeled "W_Call incomplete files." This activity pertains to the process of finalizing pre-accepted applications, particularly those that were initially incomplete;
- Black oval – inside the black oval, we find activities "W_Call after offers" and "W_Complete application." "W_Call after offers" corresponds to the stage where an offer is extended to a qualified applicant. Concurrently, "W_Complete application" involves gathering additional information during the assessment phase of the application.

Furthermore, it is worth noting that the "W_Validate application" activity serves as an essential component within the application review process.

Process simulation

The first step involves verifying the adherence to the indicators used to assess the suitability of the simulation model, as discussed in Section 3.3 – Process simulation. It is important to note that the process flow and semantics of both the discovered and simulation models closely align, except for the inclusion of initial and final activities in the simulation model, which are artificially introduced but do not impact the core process logic, performance, or bottlenecks. They are represented as instant activities with immediate processing and waiting times, as depicted in Fig. 2 (highlighted by orange ovals). The design of the simulation model was based on the discovered BPMN process model. The discovered process model consists of 23 activities, while the simulation model encompasses 26 activities. Fig. 2 visually illustrates the process flows and bottlenecks in both the discovered and simulation models. Key activities are highlighted within colored ovals: "W_Handle leads" and "W_Assess potential fraud" in red, "W_Call incomplete files" in green, "W_Call after offers" in blue, and "W_Applications assessment" and "W_Validate application" in black. The BPMN model, serving as the foundation for the simulation model, exhibits the following quality values: a fitness score of 0.75, precision of 0.76, and *F*-score of 0.76. It is worth noting that the model's lower quality rating is primarily due to the absence of length 1 loops, which are not considered in this model. Length 1 loops can also adversely affect other discovery techniques. Nevertheless, the quality of the model remains satisfactory for its intended purpose.

Tab. 1 provides a comparative analysis of the bottlenecks between the discovered model and the simulation model. These values represent the averages of process and waiting times obtained from fifteen simulation runs. It is noteworthy that the severity of bottlenecks in the simulation model closely mirrors the situation observed in the discovered model. Based on the information presented in Fig. 2 and Tab. 1, it can be confidently asserted that the assessment indicators for the simulation model are satisfactory. Specifically, the alignment in terms of process flow, semantics, process throughput, and bottlenecks between both models is deemed adequate.

What-if analysis

The simulation model is built on real-life transactional data contained in the event log. Data required for the cost perspective are

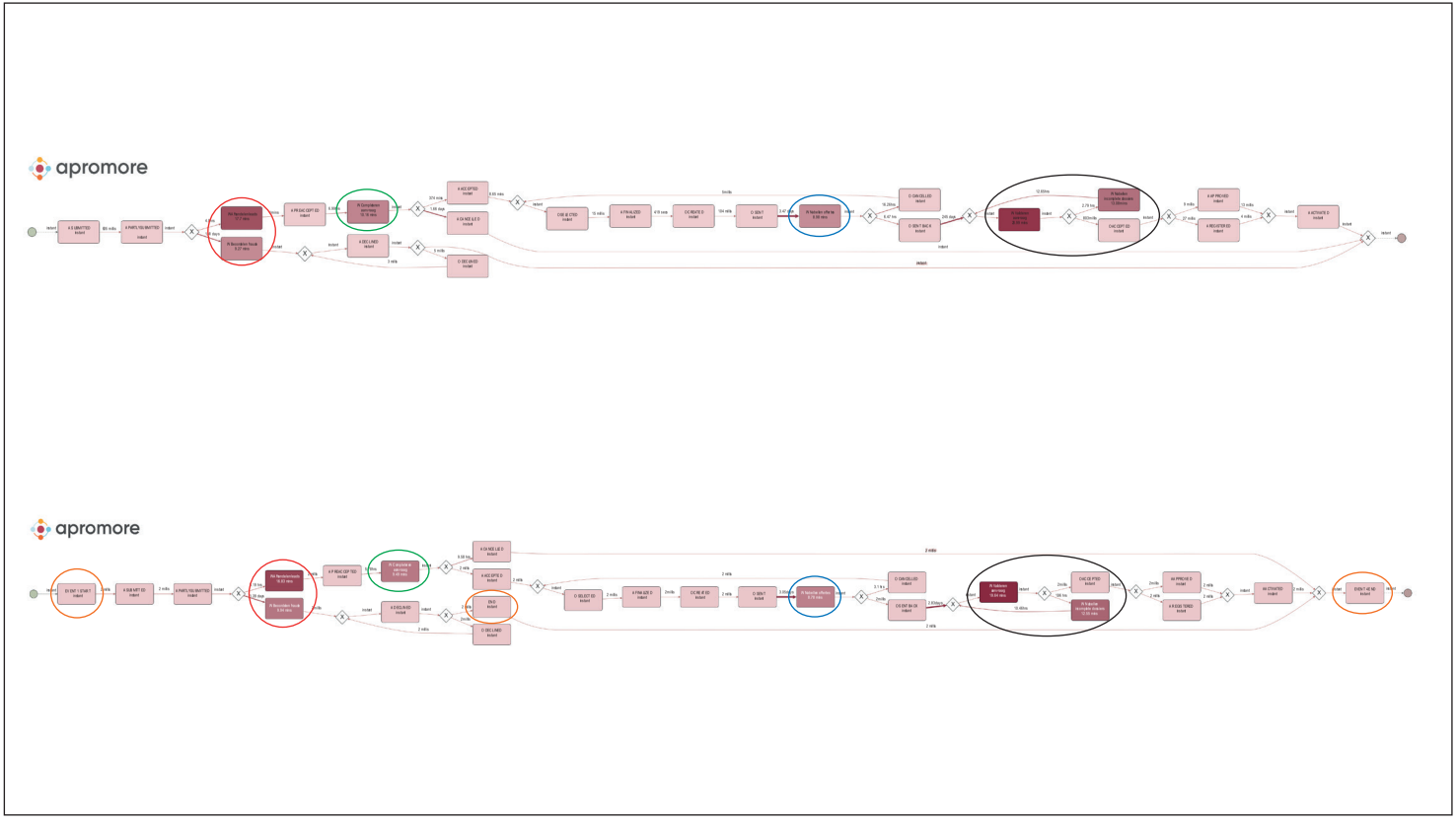


Fig. 2: **Process flow of discovered (upper part) and simulation (bottom part) models**

Note: Fig. 2 is for illustrative purposes only to showcase the process flow of the discovered process and simulation model.

Source: own

Tab. 1: Processing and waiting times of activities in the original and simulation log

		W_Handle leads	W_Assess potential fraud	W_Call incomplete files
Frequency of occurrence in the original log		4,755	108	7,367
Original log	Processing times	16.94 min	9.27 min	10.02 min
	Waiting times	5.15 h	1.40 d	5.85 h
Average of simulation logs	Processing times	16.94 min	9.87 min	9.47 min
	Waiting times	5.20 h	1.38 d	5.74 h
Std. dev. of simulation logs	Processing times	0.36 min	0.79 min	0.12 min
	Waiting times	0.06 h	0.13 d	0.08 h
		W_Call after offers	**W_Complete application**	**W_Validate application**
Frequency of occurrence in the original log		5,011	1,647	3,210
Original log	Processing times	9.08 min	12.71 min	20.92 min
	Waiting times	2.83 d	1.78 h	2.44 d
Average of simulation logs	Processing times	8.76 min	12.83 min	19.63 min
	Waiting times	3.06 d	1.70 h	2.82 d
Std. dev. of simulation logs	Processing times	0.10 min	0.16 min	0.20 min
	Waiting times	0.03 d	0.03 h	0.01 d

Source: own

added arbitrarily to demonstrate the possible implementation of our approach. For simplicity, Tab. 2 presents the i^{th} capacity cost rate (CCR) of activity type *a*. The cost model is based on Section 3 and is the same for both the discovered and simulation models due to the focus on implementation of RPA technology within the loan application process. In our cost model, we assume that each activity has exactly one resource pool. However, based on attributes defined in Section 3, it is possible to assign more than one resource pool to each activity type, which would determine different capacity cost rates for each activity type. Furthermore, the cost model does not take into consideration direct costs, as they can be directly allocated to cost objects. It was not clear how to handle automated activities occurring in the log. Automated activities are being processed almost instantaneously in the 2011 log. Thus, it is not useful to use time drivers for such activities but rather a volume-based driver. However, it is again straightforward to extend the cost model presented to include volume-based drivers. The capacity cost rate is expressed in monetary units per minute, the average activity duration is in minutes, and the average activity cost per event is in monetary units per event. The CCR is arbitrary to demonstrate the case study and implications of the integration of TDABC and process mining techniques.

Tab. 3 provides an overview of the impact of RPA deployment on the performance of the discovered process. Achieving full automation entails the elimination of processing and waiting times associated with automated activities. Tab. 3 outlines six distinct scenarios, each focused on selected activities. The results for each scenario are calculated as the averages of data obtained from fifteen simulation runs. In the “Activity” column of Tab. 3, one finds the specific activity targeted for automation in each scenario. The “Average case duration” indicates the time required to complete all activities within a case, measured in days. The “Reduction of average case duration” represents

Tab. 2: Capacity cost rates and cost characteristics at activity level

Activity	*RP*	CCR	Average activity duration	Average activity cost per event
W_Handle leads	RP_{HL}	0.09	16.943	1.525
W_Assess potential fraud	RP_{APF}	0.15	9.883	1.482
W_Call incomplete files	RP_{CIF}	0.10	9.493	0.949
W_Call after offers	RP_{CAO}	0.10	8.759	0.876
W_Complete application	RP_{CA}	0.03	12.833	0.385
W_Validate application	RP_{VA}	0.12	19.627	2.355

Source: own

the percentage reduction in the average case duration after RPA deployment in comparison to the simulation model. "Workload reduction" quantifies the time savings realized through automation via RPA, measured in hours, and is directly related to the processing times of the activities involved. Similarly, "Potential cost savings" signifies the potential cost savings achievable through RPA deployment, also measured in hours, and relates to the processing times of activities within the log. These metrics offer valuable insights into the efficiency gains and cost reductions associated with the integration of RPA into the process.

Tab. 3 illustrates the impact of introducing RPA into the simulation model across various. Statistically significant alterations, denoted by "*", in average case duration at a significance level of α = 5% are highlighted. It is worth noting that full automation exerts a statistically significant impact on the average case duration in all scenarios except for the activity "W_Assess potential fraud." The most substantial changes in average case duration were observed in activities such as "W_Call after offers," "W_Validate application," and "W_Handle leads," where reductions of 51.4737%, 38.2296%, and 3.8625% were achieved, respectively. In terms of workload

Tab. 3: Efficiency and cost dimensions of simulations of to-be process model after RPA deployment – full automation (FA) and partial automation (PA)

Activity	Average case duration (FA)	Average case duration (PA)	Reduction of average case duration (FA)	Reduction of average case duration (PA)	Reduction of workload (FA and PA)	Potential cost savings (FA and PA)
W_Call incomplete files	6.6733*	6.9067	3.5831	0.2119	1,562.23	15,092.98
W_Validate application	4.2753*	6.9053	38.2296	0.2312	2,664.08	151.21
W_Call after offers	3.3587*	6.9133	51.4737	0.1156	1,188.39	9,396.59
W_Assess potential fraud	6.9033	6.9000	0.2601	0.3082	16.78	10,157.72
W_Complete application	6.7949*	6.8714*	1.8267	0.7214	997.22	4,207.31
W_Handle leads	6.6540*	6.8688*	3.8625	0.7590	2,794.32	44,918.99

Note: *denotes statistically significant results at a significance level of α = 5%.

Source: own

reduction, the implementation of RPA yielded the most favorable outcomes for activities including "W_Handle leads," "W_Validate application," and "W_Call incomplete files." These findings underline the notable efficiency improvements associated with the deployment of RPA in these specific areas. Partial automation is specified by eliminating the processing times of automated activity. Partial automation significantly impacts average case duration in only two scenarios: "W_Complete application" and "W_Handle leads." Moreover, the reduction of the average duration of the case is less than 0.7590% in all scenarios in the case of partial automation. However, due to the reduction of workload in the case of full automation and partial automation, one can see significant potential cost savings in both cases, even though partial automation offers much less savings with regard to the time efficiency dimension.

Moreover, there are several data quality challenges that directly affect design of cost model while using event logs and exact times that need to be kept in mind:

- Overlapping activities – overlapping activities are activities that are performed by the same resource during overlapping time intervals;
- Missing activities, events, and resources – sometimes missing, incorrect, or insufficient information might be recorded in the event log;
- Missing timestamps – sometimes, timestamps might not be recorded at all for one or more events or activities. Some systems also utilize different event lifecycles, which significantly impact the possible use of the cost model within the event log (Halaška, 2021).

In our case study, missing attributes (e.g., activities, events, resources, and timestamps) were dealt with in the data preparation phase by omitting such events from the log. This is acceptable for our case study; however, it is not for a real-life setting, as it disturbs cost allocation. In the 2011 event log, there were no missing attributes among activities, start, and complete timestamps. There were 8,141 missing resources of 164,509 observations, which occurred as follows: "W_Handle leads" with 817 occurrences, "W_Call incomplete files" with 3,098 occurrences, "W_Complete application" with 972 occurrences, "W_Call after offers" with 3,210 occurrences and "W_Validate application" with 44 occurrences. Another problem with TDABC and the use of exact times through process mining is that people are usually involved

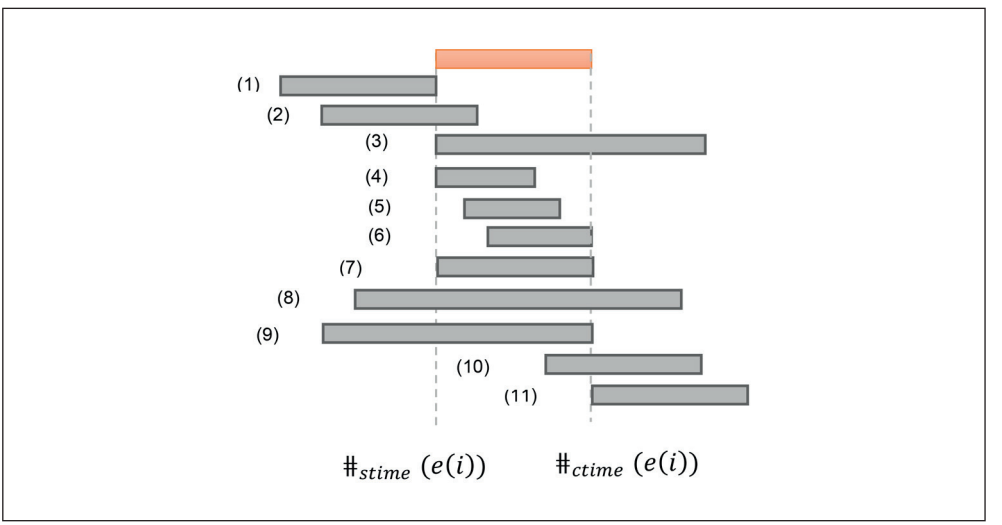


Fig. 3: **Overlapping time duration patterns of activities**

Source: own

in multiple processes. Thus, resources do not dedicate all their time to one task and may divide time simultaneously between different tasks. This is usually done based on priorities and workload. We show this problem and the impact of inaccurate cost allocation.

Tab. 4 presents inaccurate cost allocation due to the participation of multitasking based on specific resources. Since a total of 68 resources are used in the process, the 10 most utilized were selected to demonstrate the problem of cost allocation based on multitasking of resources. Multitasking was determined based on the overlapping time durations of activities performed by a specific resource (Fig. 3). For estimation of inaccurate cost allocation, we consider the following resources {10138,11169,10861,11181,10972,10609,1189,10913,11119,11180} $\in D_{resM} \subset D_{res}$, and activities $\{W\_Handle\ leads, W\_Call\ incomplete\ files, W\_Call\ after\ offers, W\_Complete\ application, W\_Assess\ potential\ fraud, W\_Validate\ application\} \in D_{actM} \subset D_{act}$. For each resource from D_{resM}, we firstly identified events with overlapping time durations based on the following condition: $\#_{ctime}(e(i)) \geq \#_{stime}(e(j)) \wedge \#_{stime}(e(i)) \leq \#_{ctime}(e(j))$. For each resource, only activities from the D_{actM} were considered. Based on Fig. 3, we define the overlapping time duration for events *i* and *j* as follows:

For Patterns (2) and (9), we define: $\#_{odur}(e(i), e(j)) = \#_{ctime}(e(j)) - \#_{stime}(e(i))$;
For Patterns (3) and (10), we define: $\#_{odur}(e(i), e(j)) = \#_{ctime}(e(i)) - \#_{stime}(e(j))$;
For Patterns (4–7), we define $\#_{odur}(e(i), e(j)) = \#_{ctime}(e(j)) - \#_{stime}(e(j))$;
For Pattern (8), we define $\#_{odur}(e(i), e(j)) = \#_{ctime}(e(i)) - \#_{stime}(e(i))$.

Thus, overlapping time duration ($OTD_{resource \in D_{resM}}$) in minutes for a specific resource from Tab. 4 is derived based on Equation (8) and the overlapping time duration pattern in Fig. 3:

$$OTD_{resource \in D_{resM}} = \\ = \sum_{\forall e(i), e(j) \in L:\ \#_{res}(e(i)) = resource \wedge \#_{res}(e(j)) = resource \wedge \#_{act}(e(i)) \in D_{actM} \wedge \#_{act}(e(j)) \in D_{actM}} \#_{odur}(e(i), e(j)) \quad (8)$$

Overall duration in Tab. 5 is the duration that the resource spends working on activities from set D_{actM} in minutes. Inaccurate allocation of costs ($IAC_{resource \in D_{resM}}$) in Tab. 5 is derived based on Equation (9):

$$OTD_{resource \in D_{resM}} = \\ = \sum_{\forall e(i), e(j) \in L:\ \#_{res}(e(i)) = resource \wedge \#_{res}(e(j)) = resource \wedge \#_{act}(e(i)) \in D_{actM} \wedge \#_{act}(e(j)) \in D_{actM}} (\#_{odur}(e(i), e(j)) * \\ * \#_{CCR_{resource}}(e(i)) + \#_{odur}(e(i), e(j)) * \#_{CCR_{resource}}(e(j))) \quad (9)$$

Tab. 4: Inaccurate cost allocation due to participation in multitasking – Part 1

Resource	Overlapping time duration	Overall duration	Overlapping time duration to overall duration ratio	Inaccurate allocation of costs
10138	64.24	26,490.21	0.2425	13.0807
11169	35986.82	75,856.05	47.4409	6,713.3370
10861	2119.24	16,175.06	13.5965	397.6516
11181	28.09	12,290.41	0.2285	4.6120
10972	24.05	41,232.85	0.0583	4.9451
10609	210.70	37,664.55	0.5594	47.0223
11189	496.21	14,255.58	3.2914	83.5944
10913	271.92	17,499.26	1.5538	40.2051

Tab. 4: Inaccurate cost allocation due to participation in multitasking – Part 2

Resource	Overlapping time duration	Overall duration	Overlapping time duration to overall duration ratio	Inaccurate allocation of costs
11119	303.99	11,742.24	2.5889	49.2679
11180	137.29	8,175.01	1.6789	23.4699

Source: own

Tab. 5: The cost share of each activity on inaccurate cost allocation of resources

Activity	Resource				
	10138	**11169**	**10861**	**11181**	**10972**
W_Handle leads	0.00	1,084.51	328.15	0.00	0.00
W_Call incomplete files	0.00	5,022.45	16.35	2.17	0.00
W_Call after offers	0.02	424.08	44.36	2.01	0.00
W_Complete application	0.78	157.56	2.88	0.43	0.28
W_Assess potential fraud	0.00	0.00	0.00	0.00	0.00
W_Validate application	12.28	24.73	5.92	0.00	4.67
	10609	**11189**	**10913**	**11119**	**11180**
W_Handle leads	0.89	14.36	2.85	0.61	1.95
W_Call incomplete files	0.04	40.16	15.09	29.73	13.07
W_Call after offers	0.02	25.37	16.33	13.79	6.82
W_Complete application	1.08	3.71	5.94	4.93	1.61
W_Assess potential fraud	0.00	0.00	0.00	0.00	0.00
W_Validate application	44.10	0.00	0.00	0.21	0.01

Source: own

Since it was not clear to which of the overlapping durations the cost should be assigned, it is counted twice for each event with an appropriate capacity cost rate.

Tab. 5 shows the cost share of each activity in inaccurate cost allocation for each resource. If we compare it to Tab. 3, we can see that, for example, the potential time savings for the implementation of RPA in the activity "W_Call incomplete files" is 15,092.98 while inaccurate cost allocation within this activity is 5,022.45 by resource 11169. Similarly, potential time savings for activity "W_Handle leads" are 44,918.99, while inaccurate cost allocation within this activity is 1,084.51.

5. Discussion

There are three reasons for the extension of the event log (data model) instead of the process model. First, it is possible to use exact times instead of time equations. Setting up time equations requires deep knowledge of process variants and their corresponding drivers. However, the 2011 log contains more than 4,200 different process variants. This is not unusual when it comes to more complex processes with a higher number of activities. Furthermore, time equations are linear; however, activity durations might not always be well approximated using linear time equations. The duration of resource execution is

not constant and should follow a probabilistic distribution. People also do not work at a constant speed. There are several studies suggesting a relationship between workload and performance (Nakatumba et al., 2012; Wickens et al., 2015). It is also not unusual to let work items related to the same task accumulate and then process all of them in one batch. The use of time equations also assumes, to a certain degree, stability of the process and organization and that neither of them changes over a certain period. However, if the flow of times becomes too long and work is accumulating. Resources may decide to skip certain activities or additional resources may be mobilized. To maintain simplicity, at a certain level, resources are treated as undifferentiated entities grouped into a resource pool with undifferentiated performance, where the processing times of an activity do not depend on the resources that perform it. The use of exact times found in the event log allows to treat resources individually, and the performance of each resource is independent of that of the other resource.

Second, extension of event log allows to stay at different levels of the analyzed process. TDABC considers non-financial measures for operational control and improvement. Thus, the TDABC covers both product and process levels for decision-making. That is, log, trace, activity, and event level. As was shown in the case study, it is possible to integrate TDABC with process mining techniques. Process mining techniques are applicable in the construction of the TDABC model, such as identifying activities and resources involved in the process. It can also assist in the automation of implementation. Maintenance and update together with the cost analysis process from both perspectives, product, and process perspective, as process mining would be involved in process mapping, measurement and cost allocation. Not all resources are identifiable using process mining; however, it is possible to extend event logs with data required for building a TDABC cost model. Such a system can also be used to assess the cost dimension of the implementation of different technologies, such as RPA, which was shown in the case study. The cost dimension in such cases has to be assessed from the process perspective. Process mining is dependent on the quality of data, and as such a costing system based on process mining would be as well. However, today companies collect large volumes of data related to their processes.

Third, process mining is well-suited for building simulation models. This is another advantage of the integration of TDBAC and process mining, since TDABC allows for the simulation of costs. This was also shown in the case study. The cost dimension is usually omitted from the analysis of business processes. The integration of process mining and TDABC has a huge potential for managing costs in a structured manner based on explicit link with business processes. There are many process mining techniques that can be used in a cost-aware manner; however, it is not clear what impact their limitations will have on the costing system and the research on this topic is relatively scarce. Thus, in our future research, we will analyze the impact of the properties of different process mining techniques on the cost model built on the integration of TDABC and process mining. However, we believe that real-time based cost information can bring significant benefits to organizations through the entire lifecycle of a business process. It empowers them to make informed decisions during the design (e.g., assess feasibility of different process designs and identify potential cost-saving opportunities), implementation (e.g., tracking costs as they occur and compare them against planned budget), monitoring (e.g., track ongoing costs associated with the process), and evaluation phases (e.g., valuable insights for assessing the performance of a business process).

There are various studies in the literature regarding the application of TDABC in different areas, e.g., manufacturing, services, healthcare, logistics, and trading (Gervais et al., 2010; Keel et al., 2017; Rahman et al., 2019; Ribadeneira et al., 2019; Sachini et al., 2022; Santana & Afonso, 2015; Vedernikova et al., 2020; Zamrud & Abu, 2020). Most of the studies on TDABC use time equations with limited focus on the implementation and integration of such costing system or derivation of time equations forming a given costing model. The costing model, time equations and underlying process map are usually derived as a black box based on analysis of underlying activities of the investigated process. The research on the integration of TDABC with process mining, business process simulations, or RPA is scarce. Vom Brocke et al. (2011) examined the intersection of accounting

and process-aware information systems and provided a generalized information model based on the ARIS information model and REA accounting model. Later, Sonnenberg and vom Brocke (2014) PAM which can be used to structure event records in process-aware information systems. In this research, we formalized an event log for the purpose of integration of TDABC and process mining for simulation and analysis of costing system. The focus was on the use of cost dimension as a major attribute for the potential implementation of RPA. Sachini et al. (2022) propose use process mining approach for human resource cost calculations. Authors calculate percentages of time spent by human resource on activities within a specific time period, which they define as effort. However, this is very simplistic notion of processing times in the event log, as authors do not consider fluctuations in processing times of such activities, multitasking, batching, and other phenomena related to records of processing times in the event log, which might cause such fluctuations. When it comes to the simulation of TDABC, Sánchez and Batista (2020) proposed a probabilistic TDABC costing model. They use probability distributions to represent time consumption in combination with Monte Carlo simulations. However, in their approach, authors do not consider the process perspective of the simulated process. Moreover, activities are modeled through triangular probability distributions, which is rarely a case in real-life setting. Rahman et al. (2019) also proposed an integration of TDABC and simulation; however, methodology is not explicit when it comes to design and creation of simulation model since time equations were used. To the best of our knowledge, there is no research on the assessment of RPA implementation using the cost dimension of the business process. Our approach could be potentially used in combination with other technologies.

Conclusions

The focus of this research is on the integration of TDABC and process mining techniques. The objective of the paper was to use the cost dimension as a main attribute for the potential implementation of robotic process automation (RPA). We demonstrated our generic approach toward the implementation of TDABC. The case study uses a real-life event log containing transactional data representing the loan application process. The following procedure was applied to demonstrate our generic approach and provide an answer to *RQ2*. First, the 2011 log was prepared for analysis and simulation purposes. At this stage, it was checked whether all events in the logs contained the basic required attributes in the appropriate formats. Events and related cases that did not possess required attributes or did not respect necessary formats were modified to respect them. Otherwise, they were excluded. Missing values were handled in a similar way. Second, we identified activities involved in the process and discovered the process model of the loan application process contained within the 2011 log. For process discovery, we used split miner, which performs very well among other process discovery techniques and produces process model in BPMN notation. Then, we analyzed the retrieved model to obtain the required process perspectives, e.g., process flow organizational perspective, and resource perspective. Third, based on the analysis, a simulation model representing the original loan application process was designed. The simulation model was checked based on similarity indicators, e.g., process flow and semantics, throughput times, and bottlenecks. Finally, a designed simulation model was then used for the simulation of the partial and full implementation of RPA through separate scenarios (Tab. 3). To answer *RQ1*, we added a cost dimension into the analysis and enriched the event log with cost data based on formalized cost model presented in Section 3. Furthermore, we focused on the data quality when using exact times in the cost model, which is crucial for integrating TDABC and process mining.

Based on analysis of different scenarios of partial and full RPA deployment, we show that even though partial implementation of RPA might not deliver a significant increase in efficiency in the process, it still might deliver significant potential time savings. Tab. 3 shows the impact of the deployment of RPA within the simulation model with respect to individual scenarios. Full automation impacts the average case duration significantly in all scenarios except for activity “W_Assess potential fraud.” The largest changes were achieved in the activities “W_Call after offers,” “W_Validate application” and “W_Handle leads,” namely by 51.4737%, 38.2296%, and 3.8625%, respectively. In terms of reduction of workload, the implementation of RPA achieves the best results for the activities “W_Handle leads,”

"W_Validate application," and "W_Call incomplete files." The impact of partial automation on the performance of the discovered process through the deployment of RPA. Partial automation is specified by eliminating the processing times of automated activity. Partial automation significantly impacts average case duration in only two scenarios: "W_Complete application" and "W_Handle leads." Moreover, the reduction of the average duration of the case is less than 0.7590% in all scenarios in the case of partial automation. However, due to the reduction of workload in the case of full automation and partial automation as well, one can see significant potential cost savings in both cases, even though partial automation offers much less savings with regard to efficiency dimension. Moreover, we demonstrated that utilizing exact times from information systems, as opposed to relying on time equations, can substantially disrupt cost allocation. This disruption often arises from employees engaging in multitasking activities (Tabs. 4–5). Consequently, this can undermine the effectiveness of implementing RPA, particularly in cases where multitasking is prevalent within specific tasks.

Acknowledgements: *This paper was supported by the Ministry of Education, Youth and Sports of the Czech Republic within the Institutional Support for Long-term Development of a Research Organisation in 2023.*

References

Augusto, A., Conforti, R., Dumas, M., Rosa, M., & Bruno, G. (2018). Automated discovery of structured process models from event logs: The discover-and-structure approach. *Data & Knowledge Engineering*, *117*, 373–392. https://doi.org/10.1016/j.datak.2018.04.007

Buijs, J. C. A. M., van Dongen, B. F., & van der Aalst, W. M. P. (2012). On the role of fitness, precision, generalization and simplicity in process discovery. In R. Meersman, H. Panetto, T. Dillon, S. Rinderle-Ma, P. Dadam, X. Zhou, S. Pearson, A. Ferscha, S. Bergamaschi, & I. F. Cruz (Eds.), *On the Move to Meaningful Internet Systems: OTM 2012, Lecture Notes in Computer Science* (Vol. 7565, pp. 305–322). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-33606-5_19

Cidav, Z., Mandell, D., Pyne, J., Beidas, R., Curran, G., & Marcus, S. (2020). A pragmatic method for costing implementation strategies using time-driven activity-based costing. *Implementation Science*, *15*(1), 28. https://doi.org/10.1186/s13012-020-00993-1

Garcia, C. dos S., Meincheim, A., Faria Junior, E. R., Dallagassa, M. R., Sato, D. M. V., Carvalho, D. R., Santos, E. A. P., & Scalabrin, E. E. (2019). Process mining techniques and applications – A systematic mapping study. *Expert Systems with Applications*, *133*, 260–295. https://doi.org/10.1016/j.eswa.2019.05.003

Gervais, M., Levant, Y., & Ducrocq, C. (2010). Time-driven activity-based costing (TDABC): An initial appraisal through a longitudinal case study. *Journal of Applied Management Accounting Research*, *8*(2), 1–20.

Ghani, N. F. A., Zaini, S. N. A. M., & Abu, M. Y. (2020). Assessment the unused capacity using time driven activity based costing in automotive manufacturing industry. *Journal of Modern Manufacturing Systems and Technology*, *4*(1), 82–94. https://doi.org/10.15282/jmmst.v4i1.3839

Hadid, W., & Hamdan, M. (2022). Firm size and cost system sophistication: The role of firm age. *The British Accounting Review*, *54*(2), 101037. https://doi.org/10.1016/j.bar.2021.101037

Halaška, M. (2021). The importance of lifecycle extension model for implementation of RPA. In J. D. Šebestová, R. Šperka, P. Suchánek, Š. Čemerková, Ž. Rylková, K. Matušínská, R. Bauerová, J. Mazurek, & R. Dolák (Eds.), *Proceedings of 3rd International Conference on Decision Making for Small and Medium-Sized Enterprises* (pp. 173–182). Silesian University in Opava, School of Business Administration in Karviná.

Keel, G., Savage, C., Rafiq, M., & Mazzocato, P. (2017). Time-driven activity-based costing in health care: A systematic review of the literature. *Health Policy*, *121*(7), 755–763. https://doi.org/10.1016/j.healthpol.2017.04.013

Lu, T.-Y., Wang, S.-L., Wu, M.-F., & Cheng, F.-T. (2017). Competitive price strategy with activity-based costing – Case study of bicycle part company. *Procedia CIRP*, *63*, 14–20. https://doi.org/10.1016/j.procir.2017.03.102

Măruşter, L., & Beest, N. R. T. P. (2009). Redesigning business processes: A methodology based on simulation and process mining techniques. *Knowledge and Information Systems*, *21*(3), 267–297. https://doi.org/10.1007/s10115-009-0224-0

Nakatumba, J., Westergaard, M., & Aalst, W. M. P. (2012). Generating event logs with

workload-dependent speeds from simulation models. In M. Bajec & J. Eder (Eds.), *Advanced Information Systems Engineering Workshops. Lecture Notes in Business Information Processing* (Vol. 112, pp. 383-397). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-31069-0_31

Pashkevich, N., von Schéele, F., & Haftor, D. M. (2023). Accounting for cognitive time in activity-based costing: A technology for the management of digital economy. *Technological Forecasting and Social Change*, *186*, 122176. https://doi.org/10.1016/j.techfore.2022.122176

Popesko, B. (2010). Activity-based costing application methodology for manufacturing industries. *Economics and Management*, *1*(1), 103–114.

Popesko, B., & Tučková, Z. (2012). Utilization of process oriented costing systems in healthcare organizations. *International Journal of Mathematical Models and Methods in Applied Sciences*, *6*(1), 200–208.

Rahman, M. S. bin A., Mohamad, E. bin, & Rahman, A. A. A. (2019). Enhancement of time-driven activity-based costing (TDABC) by using simulation in manufacturing process towards Industry 4.0. *International Journal of Innovative Technology and Exploring Engineering*, *8*(10), 1895–1900. https://doi.org/10.35940/ijitee.j9243.0881019

Ribadeneira, C., Tuapante, L., Siguenza-Guzman, L., Ayabaca, F., Tello, A., & Vanegas, P. (2019). A process collection methodology towards TDABC costing optimization of IT services: A case study in an Ecuadorian university. *Iberian Journal of Information Systems and Technologies*, *1*(E20), 541–552.

Rozinat, A., Mans, R. S., Song, M., & van der Aalst, W. M. P. (2009). Discovering simulation models. *Information Systems*, *34*(3), 305–327. https://doi.org/10.1016/j.is.2008.09.002

Sachini, E., Nikou, E., & Glykas, M. (2022). Process mining human resources cost calculations in time driven activity based costing. In E. N. Degirmenci (Ed.), *New Frontiers for Management and Strategy in the Post-Pandemic Era (Vol. 130)*, *European Proceedings of Social and Behavioural Sciences* (pp. 170–193). European Publisher. https://doi.org/10.15405/epsbs.2022.12.02.15

Sánchez, M. A., & Batista, M. D. (2020). Probabilistic time-driven activity-based costing. *Journal of Corporate Accounting & Finance*, *31*(4), 73–81. https://doi.org/10.1002/jcaf.22468

Santana, A., & Afonso, P. (2015). Analysis of studies on time-driven activity based costing (TDABC). *The International Journal of Management Science and Information Technology*, *15*(1), 133–157.

Sonnenberg, C., & Brocke, J. (2014). The missing link between BPM and accounting: Using event data for accounting in process-oriented organizations. *Business Process Management Journal*, *20*(2), 213–246. https://doi.org/10.1108/bpmj-12-2012-0136

Šperka, R., & Halaška, M. (2023). The performance assessment framework (PPAFR) for RPA implementation in a loan application process using process mining. *Information Systems and E-Business Management*, *21*(2), 277–321. https://doi.org/10.1007/s10257-022-00602-2

Syed, R., Suriadi, S., Adams, M., Bandara, W., Leemans, S. J. J., Ouyang, C., ter Hofstede, A. H. M., van de Weerd, I., Wynn, M. T., & Reijers, H. A. (2020). Robotic process automation: Contemporary themes and challenges. *Computers in Industry*, *115*, 103162. https://doi.org/10.1016/j.compind.2019.103162

Van Dongen, B. (2012). *BPI Challenge 2012* [Dataset]. 4TU.ResearchData. https://data.4tu.nl/articles/dataset/BPI_Challenge_2012/12689204

Vedernikova, O., Siguenza-Guzman, L., Pesantez, J., & Arcentales-Carrion, R. (2020). Time-driven activity-based costing in the assembly industry. *Australasian Business, Accounting & Finance Journal*, *14*(4), 3–23. https://doi.org/10.14453/aabfj.v14i4.2

Vom Brocke, J., Sonnenberg, C., & Baumoel, U. (2011). Linking accounting and process-aware information systems – Towards a generalized information model for process-oriented accounting. *Proceedings of 19th European Conference on Information Systems. ECIS 2011*. https://aisel.aisnet.org/ecis2011/23

Wickens, C. D., Hollands, J. G., Banbury, S., & Parasuraman, R. (2015). Engineering psychology and human performance. In *Engineering psychology and human performance*. Psychology Press. https://doi.org/10.4324/9781315665177

Zamrud, N. F., & Abu, M. Y. (2020). Comparative study: Activity based costing and time driven activity based costing in electronic industry. *Journal of Modern Manufacturing Systems and Technology*, *4*(1), 68–81. https://doi.org/10.15282/jmmst.v4i1.3840

Managers' attitudes as a critical success factor of kaizen

Mirjana Todorovic[1], Milan Cupic[2], Dejan Jovanovic[3]

[1] *University of Kragujevac, Faculty of Economics, Department of Accounting, Auditing and Business Finance, Serbia, ORCID: 0000-0003-0209-6694, mtodorovic@kg.ac.rs;*
[2] *University of Kragujevac, Faculty of Economics, Department of Accounting, Auditing and Business Finance, Serbia, ORCID: 0000-0002-0150-6682, mcupic@kg.ac.rs (corresponding author);*
[3] *University of Kragujevac, Faculty of Economics, Department of Accounting, Auditing and Business Finance, Serbia, ORCID: 0000-0002-0424-0656, djovanovic@kg.ac.rs.*

Abstract: *The purpose of our study is to examine the manager's attitudes towards different aspects of kaizen, their commitment to the idea of kaizen, and their attitudes towards the motivation and participation of employees. We use a questionnaire to investigate the attitudes of 124 managers – 62 economists and 62 engineers, from 62 manufacturing companies operating in Serbia. We employ exploratory factor analysis (EFA) and Mann-Whitney's U test. We find a moderate level of managers' agreement with the statements on the importance and effects of kaizen, and a relatively low level of agreement with the statements on employees' participation and motivation. Using the EFA, managers' attitudes are grouped into three areas requiring attention – perceived kaizen effects, employees' development and motivation, and employees' participation. Finally, we find that economists and engineers do not differ in their attitudes towards kaizen, which indicates their similar and common attitudes towards certain aspects of kaizen. We contribute to the literature by examining managers' attitudes towards the critical success factors of kaizen implementation and identifying the areas requiring more attention from the managers to support the social aspects of kaizen implementation and effects. Our results should change the perceptions of managers and contribute to the development of a new approach that involves more active and effective managers' participation in the kaizen implementation. Our results can also be beneficial to practitioners seeking to implement and use kaizen more efficiently in their companies. Although our study does not consider the direct impact of a specific economic environment on kaizen implementation, it can be beneficial to companies in emerging and transitioning economies similar to Serbian.*

Keywords: *Kaizen, perceived kaizen effects, manager's attitudes, manager's commitment, critical success factors.*

JEL Classification: *M11, M12, M54.*

APA Style Citation: Todorovic, M., Cupic, M., & Jovanovic, D. (2024). Managers' attitudes as a critical success factor of kaizen. *E&M Economics and Management*, *27*(2), 69–86. https://doi.org/10.15240/tul/001/2024-2-005

Introduction

Although kaizen has been researched in numerous studies and applied in business practice for several decades, its popularity is not diminishing. Researchers still study the process and effects of kaizen implementation and generally agree that successfully implemented kaizen leads to the achievement of business excellence (Lina & Ullah, 2019; Mohammad & Oduoza, 2020). Many companies around the world still largely rely on the use of this philosophy and a continuous improvement tool to reduce waste and increase business performance (Alvarado-Ramirez et al., 2018; Verbickas, 2021).

The effects of kaizen implementation are, nevertheless, often below expectations, which opens the question of the critical success factors (CSFs) that affect it. The significance and impact of these CSFs differ among companies and economies, but they all need to be identified and managed (Garcia et al., 2013; Glover et al., 2011; Hailu et al., 2017; Rivera-Mojica & Rivera-Mojica, 2014).

Some authors argue that the national context and the specific business culture significantly determine the success of kaizen and other continuous improvement programs (CIPs) implementation (Janjic et al., 2020; Todorovic & Cupic, 2017). Some argue that the most important CSFs of kaizen implementation are related to human factors (Buren, 2021; Garza-Reyes et al., 2022; Kharub et al., 2023; Lina & Ullah, 2019; Oropesa-Vento et al., 2016). The participation and contribution of employees and managers are considered essential in making small and gradual changes involved in kaizen implementation. Lina and Ullah (2019) point out that the success of kaizen comes from people and their actions, not from new pieces of equipment and machinery. Garcia et al. (2014) suggest that the main CSF of kaizen is managerial commitment and motivation, the second most important is support from senior management and resource allocation, while the third most important is leadership. Oropesa-Vento et al. (2016) show that factors such as the development of management skills and knowledge, adopting more positive attitudes, professional development of employees, communication with employees, and employee motivation are important for kaizen success.

Managers' attitudes towards kaizen reflect their perceptions of the idea of kaizen and indirectly indicate the level of their knowledge and commitment, which in turn affects the level of their motivation to implement it. We propose that the managers' attitudes towards kaizen are their main drivers and motivators. They determine their behaviour, the decisions they make, and consequently, the success of kaizen. Given the importance of managers for kaizen success, we aim to examine the manager's attitudes towards different aspects of kaizen, their commitment to the idea of kaizen, and their attitude towards motivation and participation of employees. More specifically, we aim to answer the following research questions:

RQ1: What are managers' attitudes towards the implementation and effects of kaizen?

RQ2: How do managers perceive employees' motivation and participation in the context of kaizen?

Although we conduct the research in a specific environment of the emerging and transitioning Serbian economy, our study does not consider the direct impact of the economic environment on kaizen implementation but can be beneficial to companies in similar economies. By addressing our research questions, we address several research gaps and thus make several contributions to the extant literature.

Although previous studies often identify employees' and managers' attitudes as CSFs of kaizen, they rarely investigate these attitudes. We find only a few studies examining managers' or employees' attitudes towards kaizen or CSFs of kaizen (Garza-Reyes et al., 2022; Janjic et al., 2020; Liu et al., 2015; Oropesa-Vento et al., 2016). The first contribution of our study is, therefore, a comprehensive analysis of managers' attitudes towards the CSFs of kaizen implementation. Few studies examine the social aspects of building sustainable kaizen within a company or achieving sustainable kaizen effects. For example, Ahuja et al. (2019) argue that there is no study available that covers the modelling of people related critical success factors of SM (sustainable manufacturing) practices, while Glover et al. (2011) argue that a majority of the current literature focuses on the sustainability of kaizen event technical system outcomes, with fewer studies considering social system outcomes. The second contribution of our study is, therefore, the identification of the areas requiring more attention from the managers to support social aspects of kaizen implementation and long-term effects. Although previous studies often conclude that managers can largely impact employee participation, the evidence on management approaches to and attitudes towards employee participation is scarce (Jurburg et al., 2019; Tafvelin et al., 2019). Our third contribution is, therefore, an empirical investigation of the managers' attitudes towards employee participation, employees' education and training, and identification of the problematic areas in this respect. Finally, our study also complements scarce literature on the specific individual-level factors and their interaction with organisation-level factors in driving kaizen activities (Nguyen et al., 2023), as well as the literature on the influence

of motivation and attitudes on work performance (Deressa & Zeru, 2019).

In addition to the introduction and conclusion, the paper consists of four parts. The first part of the paper provides a review of the previous research and presents our hypotheses. The second part presents the research methodology. The third part presents the results, while the fourth part presents a discussion of the results.

1. Theoretical background

Word kaizen is Japanese and means continuous improvement, principles of continuous improvement, or change for the better (Ahlstrom et al., 2021; Carnerud et al., 2018; Imai, 1986; Singh & Singh, 2015; Suarez-Barraza et al., 2011). Kaizen involves all managers and employees in a company and can be understood as a corporate capability that forms a part of improvement and innovation activities (Marin-Garcia et al., 2018). It is a management philosophy generating incremental improvements in the working method, that makes it possible to reduce waste and improve performance (Garza-Reyes et al., 2022), and increase productivity and produce high-quality products with minimum efforts (Carnerud et al., 2018; Garza-Reyes et al., 2022; Singh & Singh, 2015). It relies on the creative ideas of employees and produces results that are often barely noticeable in the short term.

Carnerud et al. (2018) find that the concept of kaizen is often used as a synonym for continuous improvement (CI), (although) essential disagreements exist in academia and practice concerning the definition and (in)compatibility of the two terms. Similarly, Suarez-Barraza et al. (2011) identify two variants of kaizen – Japanese and Western, understood as CI. They further explain that the Western variant of kaizen tends to be understood from a more practical managerial and organisational angle as a methodology and/or technique, as well as factor in other management approaches such as total quality management (TQM), lean manufacturing or the Toyota Production System (TPS).

Ahlstrom et al. (2021) argue that lean companies can improve soft skills practices, engagement of employees and social outcomes by studying the determinants of successful kaizen implementation. They also point out that kaizen can be understood as a possible definition or perspective of lean. Chiarini et al. (2018) argue that lean-TPS is often confused with kaizen, although kaizen is more related to TQM. They further explain that kaizen can be seen as a philosophy embracing TQM and lean-TPS. Singh and Singh (2015), on the other hand, point out that kaizen and TQM are interdependent but different – kaizen involves gradual, while TQM involves radical improvements.

Suarez-Barraza et al. (2011) and Carnerud et al. (2018) find that research on kaizen is scarce and that research on CI usually includes references to kaizen. They also find that kaizen studies often have a weak or no theoretical base and do not include a clear definition of kaizen and an explanation of the relationship between kaizen and CI. Carnerud et al. (2018), accordingly, argue that clarifying the theoretical foundations of both kaizen and CI is necessary to ensure successful implementation, while Suarez-Barraza et al. (2011) point out that there is a need to develop the theory of kaizen.

Kaizen needs to be understood and defined as more than just a set of tools, techniques and methods or an event – kaizen is also a philosophy, mindset, company-wide process, and vehicle to achieve strategic imperatives and execute improvement plans (Ahlstrom et al., 2021; Carnerud et al., 2018; Suarez-Barraza et al., 2011).

Kaizen implementation has potential. However, positive effects are not guaranteed. Their realisation depends on a large number of CSFs. In the present paper, we focus on the manager's attitudes towards different aspects of kaizen as a CSF of kaizen implementation.

1.1 Managers' commitment and support to kaizen

Jurburg et al. (2017) and Marin-Garcia et al. (2018) argue that kaizen implementation is not always straightforward and successful and that kaizen can be hard to sustain in the long term. Previous research shows that the knowledge and continuous training, i.e., continuous professional development of managers and employees, are CSFs of kaizen implementation (Garcia et al., 2014; Janjic et al., 2020; Lina & Ullah, 2019; Oropesa-Vento et al., 2016; Rivera-Mojica & Rivera-Mojica, 2014). Rivera-Mojica and Rivera-Mojica (2014), for example, find that the CSFs of kaizen implementation are the management commitment, focus on customers, training, communication process, integration of human resources, organisational culture, documentation, and evaluation.

The role of managers in kaizen implementation is the subject of numerous studies, mostly dealing with issues of managers' training and knowledge of kaizen. Bwemelo (2014) shows that the most important CSFs of kaizen implementation are well-trained managers and managers who motivate employees. Managers are expected to be dedicated, i.e., possess adequate knowledge and skills, be trained, and understand kaizen's ideas. In practice, however, it is not rare for managers to not understand the ideas of kaizens. They often expect instant results, while in reality, it takes time before the benefits of continuous improvements become visible (Todorovic et al., 2022). Alvarado-Ramirez et al. (2018) point out that a new managerial behaviour is the basis of continuous improvement, where the training and development of the human resource increases the commitment to achieve organisational changes.

Some researchers find that the managers' commitment and support are CSFs of kaizen (Aoki, 2008; Garcia et al., 2014; Glover et al., 2011; Janjic et al., 2020; Oropesa-Vento et al., 2016; Rivera-Mojica & Rivera-Mojica, 2014). Manager's commitment positively impacts the level of commitment of all employees (Suarez-Barraza et al., 2011), the profits and competitiveness of the company (Oropesa-Vento et al., 2016), and should lead to sustainable kaizen effects. Managers should demonstrate their dedication to kaizen, i.e., strong will, commitment, and persistence (Lina & Ullah, 2019). Suarez-Barraza et al. (2011) find that the lack of managers' support is the reason for abandoning kaizen implementation projects in 50% of cases. Management commitment and leadership capabilities are also often considered as CSFs of CI (Paipa-Galeano et al., 2020), lean (Argiyantari et al., 2022; Todorovic et al., 2022), and TQM (Aletaiby et al., 2021).

In the present study, we focus on the commitment and support of managers to kaizen. Specifically, we aim to analyse managers' attitudes towards the idea, importance, and effects of kaizen. Given the theoretical background and the results of previous studies, our first hypothesis is as follows:

H1: Managers' attitudes towards the implementation and effects of kaizen are positive.

1.2 Relationship of managers with employees

Managers are expected to motivate and positively affect employees. A key prerequisite for employee satisfaction is the attitude of managers or leaders both toward the achievement of goals and toward their subordinate employees (Stacho et al., 2023). The professional development and training of employees must be appropriately planned in the process of kaizen implementation. Managers are expected to train employees in different techniques and problem-solving skills in order to maintain and expand kaizen and similar concepts at all levels of a company (Marksberry et al., 2010). Oropesa-Vento et al. (2016) argue that training provides employees with the knowledge needed to be actively involved in CIPs, increases trust in the organisation, and supports processes of change. Aoki (2008) finds that the actions of managers are observed by employees and that these actions can give them the legitimacy to engage in kaizen activities. He adds that managers must show a lot of self-discipline if they want the workers to show the same self-discipline. Beraldin et al. (2019) similarly find that the adoption of soft lean practices increases employee engagement, while Argiyantari et al. (2022) find that employee skills development, along with leadership capability, helps reduce the resistance to lean implementation.

The fact that effective leadership is essential for encouraging employees to achieve goals is often overlooked. Hailu et al. (2017) show that one of the most important CSFs of kaizen implementation is effective leadership. Kaizen can be successfully implemented in different socio-economic contexts, but only with adequate company leadership (Lina & Ullah, 2019), dealing with the implementation of changes to face new challenges (Oropesa-Vento et al., 2016). Managers are expected to take on the role of facilitators to help employees achieve their goals (Buren, 2021). They are the major motivators during the kaizen implementation process.

One of the organisational culture conditions for the success of kaizen is adequate, efficient, and free information flow across the company. Janjic et al. (2020) stress the importance of an adequate system of internal communication and communication of strategic and operational goals. Karacsony et al. (2023) examined employees' attitudes towards organisational change and concluded that managers are expected to play an important role in the context of information and communication. Management should understand the importance of information sharing and build

an adequate communication system. Management is also responsible for creating adequate interpersonal relationships and a positive climate in the organisation. Lina and Ullah (2019) find that a good management-employee relationship where trust and empowerment are ingrained in the management practice, including management's willingness to communicate with employees and train them is one of the CSFs of kaizen implementation. Managers may encourage employees to perform better by boosting their sense of authority, support and commitment (Bakotic & Rogosic, 2017), while the hostile attitude of managers may result in emotional stress (Wu & Wu, 2019).

Greater trust between managers and employees increases the level of commitment to kaizen. The level of commitment also increases when employees are seen as part of the organisation (Suarez-Barraza et al., 2011). Buren (2021) argues that kaizen has been revolutionary in the way employees on the lowest level are treated. Kaizen fundamentally changes the position of the employees, placing them at the centre of attention. Buren (2021) further states that kaizen is built on cooperation between managers and employees and that employees should feel safe to share ideas and take responsibility. Macpherson et al. (2015) argue that kaizen results in an energy that permeates the organisation and creates a shared state of mind among employees to achieve proactive change and innovation. If changes are managed well, employees can have a positive attitude toward them (Karacsony et al., 2023).

Alvarado-Ramirez et al. (2018) argue that the participation of employees is essential for the correct application of CIP and that the presence of managers is key in order to achieve improvement in workers' skills, in addition to notable motivation, participation, and training, among other factors. Carnerud et al. (2018) similarly find that the concept of participation is a key issue for a definition of kaizen. Janjic et al. (2020) note, however, that often managers do not properly understand the importance of employees' ideas and initiatives, and argue that the education of managers and employees is probably the best solution to this problem. Given the theoretical background and the results of previous studies, our second hypothesis is as follows:

H2: Managers have a positive attitude towards employees' motivation and participation in the context of kaizen.

2. Research methodology

The main steps and activities of the research methodology used in this study are summarised in Fig. 1.

2.1 Questionnaire design

Given the theoretical background and the results of the previous studies on managers'

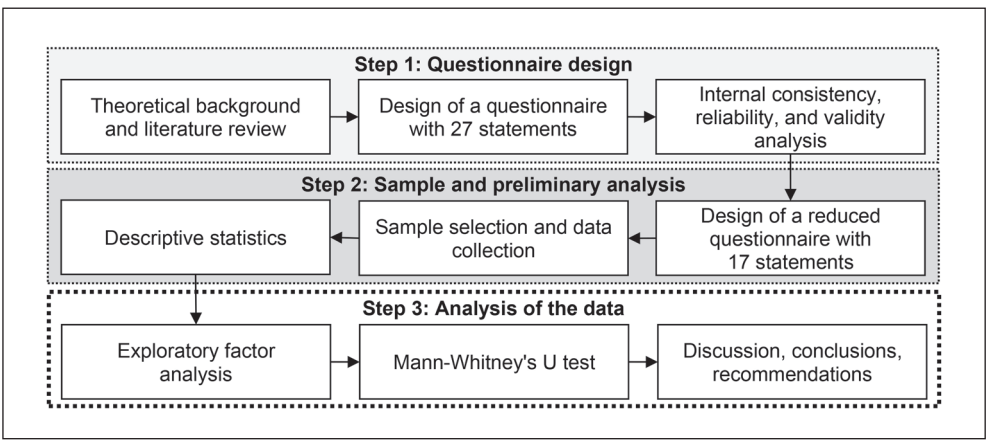


Fig. 1: Research methodology

Source: own

commitment and support to kaizen (Garcia et al., 2014; Glover et al., 2011; Janjic et al., 2020; Oropesa-Vento et al., 2016) and the relationship of managers with employees (Buren, 2021; Lina & Ullah, 2019; Marksberry et al., 2010; Suarez-Barraza et al., 2011), we first design a questionnaire with 27 statements to measure managers' attitudes towards different aspects of kaizen. Our assumptions for the questionnaire development are presented in Fig. 2. We made an effort to avoid lengthy statements, ambiguous pronoun references, and negatively worded and connotatively inconsistent statements, as well as to consider the readability of each statement (DeVellis, 2016).

To determine the content validity, we invited seven academics familiar with kaizen and its social aspects to assess the statements, judge the suitability of statements, and check the clarity of wording (DeVellis, 2016). In addition, we led a small pilot focus group of professionals familiar with kaizen to ensure proper interpretation and reduce statement ambiguity. The final version of the questionnaire consists of 17 statements. The respondents were asked to specify if their company implement kaizen and, if it does, to what degree – fully or partially. Our idea was to exclude the questionnaires referring to the companies where the kaizen is not organised. Given that there were no such questionnaires, we further analysed all the filled-out questionnaires we received.

DeVellis (2016) points out that Likert scaling is widely used in instruments measuring opinions, beliefs, and attitudes. We use a five-point Likert scale. Managers were offered responses ranging from 1 – strongly disagree to 5 – strongly agree. Jamieson (2004) points out that Likert scales fall within the ordinal level of measurement and that for ordinal data, one should employ the median or mode as the measure of central tendency. We will base our conclusions on the median and mode, but will also determine and interpret the mean. The five-point Likert scale implies that a median and mean higher than 3.00 indicates that the managers agree with the statement, while a median and mean lower than 3.00 indicates that the managers disagree with the statement. The final part of the questionnaire includes a section on general information about the manager, including gender, age, and education, as well as the legal form and size of the company in which the manager is employed.

2.2 Sample

To develop our sample, we use the following three approaches: i) searching the internet for companies and professionals related to kaizen in Serbia (we use several Serbian terms); ii) investigating the online and hard paper magazines in the areas of business and management; and iii) conversation with the participants at scientific and professional conferences in Serbia. By using these approaches, in 2019,

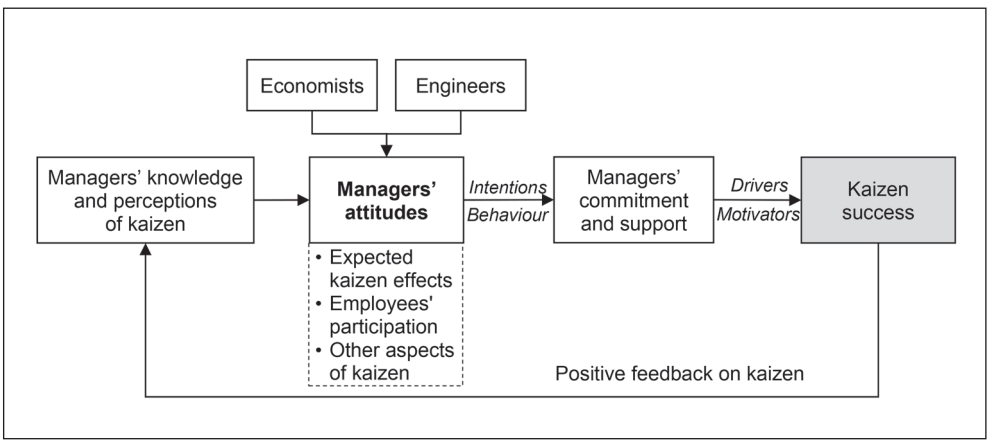


Fig. 2: Assumptions for the questionnaire development

Source: own

we identified 220 manufacturing companies that possibly implemented kaizen. An economist and an engineer from each company in managerial positions were invited to fill out a questionnaire (the potential number of respondents was 440). Our sample consists of 124 managers from 62 companies who filled out the questionnaire, giving a response rate (28.2%) which is high compared to the average for surveys in the social sciences (Vannette & Krosnick, 2018). This is important given that the best way to obtain unbiased estimates is to achieve a high response rate (Fosnacht et al., 2017). All the respondents answered that the company where they work implements kaizen fully (39%) or partially (61%).

Given that the questionnaire was anonymous, we are unable to identify the pairs of respondents

Tab. 1: Sample description

	Number	(%)
Gender		
Men	59	47.6
Women	65	52.4
Age (years)		
Up to 30	22	17.7
31–40	59	47.6
41–50	29	23.4
More than 50	14	11.3
Level of education		
High school	6	4.8
College	15	12.1
Bachelor	93	75.0
Master	10	8.1
Area of expertise		
Economics	52	41.9
Mechanical engineering	26	21.0
Electronics	8	6.5
Other	38	30.6
The legal form of the company		
JSC	11	17.7
LLC	51	82.3
Company size*		
Micro	1	1.6
Small	14	22.6
Medium-sized	24	38.7
Large	23	37.1

Note: *According to the criteria defined in the 2019 Accounting Law of the Republic of Serbia.

Source: own

(one manager and one economist) from each company, i.e., we are unable to connect specific pairs of respondents to a specific company. This is acceptable for our research, given that we examine managers and not companies implementing kaizen. Tab. 1 presents basic information on managers and companies in the sample. The majority of respondents are female (52.4%) and aged less than 40 years (65.3%). The sample mainly includes respondents who have a bachelor's degree (75.0%) and expertise in economics (41.9%) and mechanical engineering (21.0%). The majority of managers work in limited liability companies (82.3%), and in large (37.1%) and medium-sized companies (38.7%).

Our sample allows for the analysis of economists' and engineers' attitudes as CSFs of kaizen. Previous literature often points to the importance of a heterogeneous and multidisciplinary leadership team for the successful implementation of kaizen (Lina & Ullah, 2019; Marin-Garcia et al., 2018; Ramezani & Razmeh, 2014). Ramezani and Razmeh (2014), specifically, stress that the kaizen strategy requires support from a leadership team consisting of all levels of management, including economists, engineers, technicians, and production supervisors. The position of the engineers is very specific. They represent a link between senior management structures, the complex implementation team, and employees (Janjic et al., 2020), and are a critical success or fail factor for their company results (Laglera et al., 2013). They are often the leaders of the kaizen implementation teams and are directly involved in the kaizen implementation, they first notice the effects of kaizen implementation and are in direct contact with the employees, so they are very important in the process of coaching, mentoring, and motivating employees (Janjic et al., 2020). Engineers are especially important for the realisation of the maintenance activities in the implementation stage of kaizen transfer (Yokozawa et al., 2011).

Economists, mostly management accountants, have an important role in kaizen implementation and are usually responsible for performance measurement and monitoring (Fullerton et al., 2013, 2014; Nuhu et al., 2016). Fullerton et al. (2013) point out that management accountants provide information that enables effective employee empowerment and contributes to lean manufacturing implementation, while Fullerton et al. (2014) emphasise that operations management cannot operate in a vacuum and that operations and accounting personnel must partner to ensure that lean management accounting practices are strategically integrated into the lean culture. Cherrafi et al. (2019) similarly argue that performance measurement permits organisations to identify process issues, evaluate the effectiveness of an action plan, and monitor progress towards the goals, while strategic planning supports CI, reflects stakeholders' imperatives, and takes into consideration current performance and challenges faced by an organisation.

2.3 Methods

The data obtained from the questionnaire were analysed using SPSS version 20.0. The analysis was completed using the EFA and Mann-Whitney's U test.

Factor analysis is a statistical tool often used in social sciences to analyse the structure of correlations among a large number of variables (e.g., questionnaire responses) by defining sets of highly interrelated variables known as factors (components). These factors are assumed to represent dimensions within the data that can guide the researcher in creating new composite measures. Factor analysis can achieve its purpose from either an exploratory or confirmatory perspective. We use the exploratory approach as a tool in searching for structure among our variables (Hair et al., 2019).

We use principal components analysis (PCA) as a method for data reduction because we aim to derive a minimum number of factors accounting for the maximum portion of the total variance represented in the variables. In addition, we use varimax as an orthogonal factor rotation method focusing on simplifying the columns in a factor matrix (Hair et al., 2019). Although our sample is relatively small, it meets the minimum requirements for performing factor analysis – we have more than a hundred observations, as well as more than five times more observations (managers) than the analysed variables (statements) in our research (Hair et al., 2019; Tabachnick & Fidell, 2007). Specifically, we have 7.29 times more managers in our sample than statements in our questionnaire.

As factor analysis is based on correlations between measured variables, we estimate Spearman's correlation coefficients. The majority of coefficients between statements are statistically significant and greater than 0.3,

which implies that factor analysis is an appropriate statistical approach for our research (Tabachnick & Fidell, 2007). We also conduct the Kaiser-Meyer-Olkin (KMO) and Bartlett's tests to determine if the data set is suitable for factor analysis. Given that the KMO measure of sampling adequacy is greater than 0.5 (Hair, 2019), i.e., 0.905, and that the approximate chi-square of Bartlett's test of sphericity is 2,112.217, with 136 degrees of freedom, and statistically significant ($p < 0.05$), we conclude that the factor analysis is justified.

Given that our sample consists of economists and engineers, the question arises as to whether there is a statistically significant difference in the attitudes of these two groups of respondents towards kaizen. The question is also if there are differences in the attitudes of women and men. To answer these questions, we use Mann-Whitney's U test.

3. Research results

3.1 Descriptive statistics

Tab. 2 shows the average level of the managers' agreement with each of the statements provided in the questionnaire, along with the standard deviation, median, and mode level of agreement. It also shows the mean of unit-variance scaled data, which is not biased towards variables with larger ranges, as well as the results of a one-sample *t*-test for each statement to find out whether the difference between the means and the level denoting neutral attitude (3.00) is statistically significant.

The statements are sorted by the average level of managers' agreement with each. The managers have the highest average level of agreement with the following statements: i) top management believes that kaizen is important for the continuous improvement of a company (3.99); ii) employees initiate solving minor problems during routine work (3.85); and iii) product quality has improved thanks to kaizen (3.80). On average, the managers agree with 16 statements in the questionnaire, and the average level of their agreement with each statement is lower than four. The mean of unit-variance scaled data leads to slightly different conclusions, although the highest level of managers' agreement is still with the statements concerning the top managers' support of kaizen and employees' involvement in kaizen implementation. The results of the one-sample *t*-test reveal 16 statistically significant and positive differences and one statistically significant and negative difference between the mean attitude and the neutral attitude.

The median level of managers' agreement with the statements is 4 (76.5% of statements) or 3 (23.5% of statements), while the most frequent response to 64.7% of statements is 4. When it comes to the expected effects of kaizen, in support of *H1*, managers believe that kaizen increases product quality, work conditions, and the company's efficiency and reduces the rate of defective products. When it comes to the relationship of managers with employees, managers indicate that the best employees are not announced monthly and that employees' participation in kaizen and other CI activities is only weakly encouraged. Measures of central tendency imply that managers attach relatively little importance to motivating, rewarding, and encouraging employees. Since managers generally have a positive, although relatively weak attitude towards employees' motivation and participation, we land support to *H2* but continue with our analysis.

3.2 Exploratory factor analysis (EFA)

Analysis of the main components in the exploratory factor analysis indicates the presence of three factors with an eigenvalue greater than 1, which cumulatively explain 77.67% of the total variance. Tabachnick and Fidell (2007) point out that the number of factors is usually between the number of variables divided by three and the number of variables divided by five. This is not exactly the case in the present study, given the average of 5.67 variables (statements) per factor. Tabachnick and Fidell (2007) also argue that factors should have at least three variables. Concerning the cumulative percentage of total variance extracted by the factors, Hair et al. (2019) argue that about 60% is satisfactory in social sciences.

Cronbach's α and composite reliability (CR) were used to examine the reliability of scales. As suggested by Hair et al. (2019), both Cronbach's α and CR should be greater than 0.70. The analysis showed Cronbach's α values between 0.86 and 0.96, and CR values between 0.797 and 0.927 for factors identified with EFA. Cronbach's α values suggest that the list of statements has a high degree of internal consistency in measuring the managers' attitudes. The convergent validity is evaluated

Tab. 2: Descriptive statistics

Statements	Mean	SD	SM	Median	Mode	*t*
S1 Top management believes that kaizen is important for the continuous improvement of the company	3.99	1.12	3.58	4	4	9.90
S2 Employees initiate solving minor problems during routine work	3.85	1.05	3.66	4	4	8.96
S3 Product quality has improved thanks to kaizen	3.80	1.19	3.20	4	4	7.48
S4 The general achievement of the goals of kaizen has improved the company's efficiency	3.74	1.10	3.39	4	4	7.49
S5 Work conditions have improved due to kaizen	3.73	1.11	3.38	4	4	7.40
S6 Stakeholders are satisfied with the company's performance	3.73	1.13	3.29	4	4	7.21
S7 Kaizen reduced the rate of defective products	3.72	1.18	3.15	4	5	6.78
S8 There is good vertical and horizontal communication between different levels of the organisational structure	3.71	1.07	3.46	4	4	7.37
S9 Employees are ready to give suggestions for improvements	3.63	1.05	3.47	4	4	6.69
S10 Kaizen motivated the team members in the company	3.55	1.01	3.52	4	4	6.07
S11 The overall activities of kaizen achieved kaizen goals	3.50	1.09	3.22	4	3	5.13
S12 Employee training is conducted to improve interactive skills	3.46	1.08	3.21	4	4	4.75
S13 Employees' participation in kaizen activities is encouraged	3.39	1.10	3.09	3	3	3.94
S14 Employees are motivated to participate through the reward system	3.39	1.17	2.89	3	3	3.67
S15 The internal organisational process has been improved due to kaizen	3.38	1.19	2.83	4	4	3.54
S16 Employees are awarded financial compensation for excellent suggestions for improvements	3.30	1.34	2.46	3	5	2.47
S17 The best employees are announced monthly	2.65	1.32	2.00	3	3	−2.99

Note: The number of respondents for each statement is 124; SD – standard deviation; SM – mean of unit-variance scaled data; *t* – result of the one-sample *t*-test of the significance of the difference between the mean and a neutral attitude (3.00); the results of the one-sample *t*-test are statistically significant at 0.05 (2-tailed).

Source: own

with average variance extracted (AVE), which should not be less than 0.50 (Hair et al., 2019). The analysis showed AVE values between 0.561 and 0.567. Thus, our study also met this criterion.

Tab. 3 presents identified factors, as well as the loadings to identify a particular factor and the percentage of total variance explained by each factor. The loadings above 0.50 (Hair et al., 2019) are usually considered acceptable. Given that the smallest loading is 0.635, all items were included in the final model. As suggested by Hair et al. (2019), we name each of the factors by interpreting the pattern of the factor loadings. Hair et al. (2019) stress that the process of naming the factors is based on the subjective opinion of the researcher and, therefore, subject to criticism.

Tab. 3 shows that the first factor relates to the perceived effects of kaizen, i.e., better product quality, greater stakeholder satisfaction, and increased efficiency. This factor involves

Tab. 3: Results of exploratory factor analysis

Variables (statements)	Factor 1	Factor 2	Factor 3
Factor 1: Perceived effects of kaizen (Cronbach's α: 0.96, CR: 0.927, AVE: 0.561)			
S7 Kaizen reduced the rate of defective products	0.839		
S3 Product quality has improved thanks to kaizen	0.832		
S1 Top management believes that kaizen is important for the continuous improvement of the company	0.814		
S6 Stakeholders are satisfied with the company's performance	0.797		
S4 The general achievement of the goals of kaizen has improved the company's efficiency	0.778		
S5 Work conditions have improved due to kaizen	0.734		
S10 Kaizen motivated the team members in the company	0.698		
S15 The internal organisational process has been improved due to kaizen	0.667		
S11 The overall activities of kaizen achieved kaizen goals	0.652		
S13 Employees' participation in kaizen activities is encouraged	0.643		
Factor 2: Employees' development and motivation (Cronbach's α: 0.86, CR: 0.837, AVE: 0.567)			
S17 The best employees are announced monthly		0.880	
S16 Employees are awarded financial compensation for excellent suggestions for improvements		0.815	
S14 Employees are motivated to participate through the reward system		0.654	
S12 Employee training is conducted to improve interactive skills		0.635	
Factor 3: Employees' participation (Cronbach's α: 0.89, CR: 0.797, AVE: 0.570)			
S9 Employees are ready to give suggestions for improvements			0.836
S2 Employees initiate solving minor problems during routine work			0.770
S8 There is good vertical and horizontal communication between different levels of the organisational structure			0.647
% of total variance explained	62.545	8.960	6.167

Note: The extraction method is the principal component analysis and a rotation method is varimax; a total of 124 respondents expressed their attitude towards each statement; CR – composite reliability; AVE – average variance extracted.

Source: own

ten variables and explains 62.545% of the variance. The second factor is named employees' development and motivation. This factor includes four variables and explains 8.960% of the variance. The third factor includes three variables, explains 6.167% of the variance, and refers to employees' participation.

Identification of the factors using EFA reveals critical areas to which attention should be paid to ensure more efficient and effective management and long-term kaizen effects. The first factor shows that managers believe that kaizen has a positive impact on business, which implies that they have a positive attitude towards kaizen as an idea and its implementation. This is in support of *H1*. The second and third factors refer to the managers' attitudes towards participation and position of the employees, and the importance of the employees for kaizen success. We support our *H2* but confirm the results of descriptive statistics that managers possibly do not pay enough attention to employees' motivation and participation.

3.3 Results of Mann-Whitney's U test

Results of Mann-Whitney's U test show that there is no statistically significant difference in attitudes of economists and engineers towards the different aspects of kaizen: perceived effects of kaizen (U = 1603.5, $z = -0.611$, $p = 0.541$); employees' development and motivation (U = 1663, $z = -0.288$, $p = 0.773$), and employees' participation (U = 1514, $z = -1.105$, $p = 0.269$). Also, there is no statistically significant difference in the attitudes of women and men: perceived effects of kaizen (U = 1759, $z = -0.795$, $p = 0.427$), employees' development and motivation (U = 1782.5, $z = -0.678$, $p = 0.498$), and employees' participation (U = 1817.5, $z = -0.505$, $p = 0.613$). Such results can be explained by the fact that our research involves mostly highly educated persons under the age of 40, employed in medium-sized and large companies, and familiar with modern tendencies in business.

4. Discussions

Our research contributes to the literature on employees' and managers' attitudes towards kaizen (Garza-Reyes et al., 2022; Janjic et al., 2020; Liu et al., 2015; Oropesa-Vento et al., 2016). It relies on the assumption that the managers' attitudes towards kaizen are their main drivers and motivators, which determine their behaviour, the decisions they make, and consequently the success of kaizen. It is in line with Oropesa-Vento et al. (2016), who find that the managers' attitudes are important for kaizen success, and Ahlstrom et al. (2021), who argue that lean companies can improve soft skills practices, engagement of employees, and social outcomes.

It is encouraging that managers in our sample express the highest average level of agreement with the statement on the importance of kaizen. This means that they generally have a positive attitude towards the idea and effects of kaizen, which implies that they are committed to kaizen. This is important since managers' commitment and support are often considered to be CSFs of kaizen (Garcia et al., 2014; Glover et al., 2011; Janjic et al., 2020; Oropesa-Vento et al., 2016). Nevertheless, managers' agreement with the statement is only moderate and indicates a need to improve their knowledge and motivation. Oropesa-Vento et al. (2016) find a similar level of commitment, while Liu et al. (2015) find that managers' commitment is generally not perceived as an important inhibitor or enabler of kaizen event effectiveness. Given the different results and conclusions of previous studies on the importance and influence of managers' attitudes on their behaviour and kaizen effects, our study contributes to the literature by showing managers' commitment to kaizen.

EFA confirms that managers have a positive attitude towards the idea of kaizen. Such an attitude of the managers has a positive impact on the level of their motivation and behaviour in the process of kaizen implementation. Improving company business and performance is the primary responsibility of the managers, meaning that the managers should consider their own strengths and weaknesses, and accordingly take the activities necessary for self-improvement. This finding confirms that managers' attitudes and motivation are CSFs of kaizen requiring special attention in the process of kaizen implementation. This is in line with the conclusion of some previous studies (Garcia et al., 2014; Glover et al., 2011; Oropesa-Vento et al., 2016).

We find a lower level of managers' agreement with the statements concerning employees' motivation and participation. Previous studies suggest a direct link between managers' commitment, employees' participation, and

kaizen performance (Garcia et al., 2013; Hailu et al., 2017; Yokozawa & Steenhuis, 2013). This means that managers should pay more attention to employees' participation, which is considered fundamental in the context of kaizen (Alvarado-Ramirez et al., 2018; Carnerud et al., 2018). Indirectly, the managers' attitudes towards employees' participation are a reflection of their level of knowledge and indicate the necessity for professional development. It should also be noted that more effective kaizen implementation will have positive effects on managers and employees. Cheser (1998) suggests that kaizen increases job enrichment and employee motivation, and may move employees to higher levels of growth need strength. Managers should address the employees with the message: you are important, you are the key link, and develop a sense of belonging to the kaizen team.

Another important contribution of our study is the analysis of the differences in the attitudes of economists and engineers towards kaizen. The economists and engineers in our sample generally have a similar attitude towards certain aspects of kaizen. If their attitudes were found to be significantly different, this could be understood as an indication of differences in their knowledge of and commitment to kaizen, which could consequently impede the process of kaizen implementation. That could also be an indication of a need for better preparation of the kaizen team and coaching and training of managers with a certain background. Everyone in the kaizen team has a certain place and role. We emphasise the role of economists and engineers. The role of economists and, above all, management accountants, is crucial from the perspective of measuring kaizen effects. It is, nevertheless, important to emphasise the role of the engineers in kaizen implementation.

Special attention should be paid to the selection of engineers for project teams, as well as to their knowledge, experience, and competencies. Ktoridou et al. (2019) argue that engineering managers are distinguished from other managers as they have the ability to apply engineering principles and skills in organising and managing people and projects. Engineers are required to transition into managerial and leadership roles more quickly than ever before (Nittala & Jesiek, 2018) and to have an understanding of both the technical and business aspects of organisations (Riley et al., 2013). However, Riley and Cudney (2015) find that engineers often experience challenges in communication, conflict resolution, and leadership, and, therefore, use defensive routines more commonly than non-engineering managers. Ortiz (2006) stresses that kaizen is not a fly-by-night idea that goes away when management and engineers are not comfortable adapting to change. Changes need to be accepted by everyone and at all hierarchical levels starting with top managers.

Conclusions

Our study aims to examine the manager's attitudes towards different aspects of kaizen, their commitment to the idea of kaizen, and their attitude towards the motivation and participation of employees. Our results show a moderate level of managers' agreement with the statements on the importance and effects of kaizen, and a relatively low level of agreement with the statements on employees' participation and motivation. They indicate a low to moderate level of managers' knowledge and perception of kaizen, and consequently of managers' commitment and support to kaizen. Our results also show that managers' attitudes towards kaizen can be grouped into three areas requiring special attention: perceived kaizen effects, employees' development and motivation, and employees' participation. Finally, we find that economists and engineers do not differ in their attitudes towards kaizen, which indicates their similar and common knowledge of and commitment to certain aspects of kaizen. We emphasise the role of the engineers in kaizen implementation, and the importance of their selection, knowledge, experience, and competencies.

By answering the research questions posed in the introduction, our study provides significant theoretical and practical contributions. The first theoretical contribution of our study is a comprehensive analysis of managers' attitudes towards the CSFs of kaizen. This is important since we find only a few studies examining managers' or employees' attitudes towards kaizen or CSFs of kaizen. Given that we focus on managers and employees as major participants in kaizen implementation, our study's second theoretical contribution is identifying the areas requiring more attention from the managers to support social aspects of kaizen implementation and its long-term effects. This is important as only a few studies examine the social aspects of building sustainable

kaizen within a company or achieving sustainable kaizen effects. The third theoretical contribution of our study is an empirical investigation of the managers' attitudes towards employees' participation, as well as towards employees' education and training, and the identification of the problematic areas in this respect. This is important since studies on managers' approaches to employee participation are relatively scarce. Our study also complements scarce literature on the specific individual-level factors and their interaction with organisation-level factors in driving kaizen activities, as well as the literature on the influence of motivation and attitudes on work performance. Finally, it should be noted that the failure of numerous kaizen implementations points to the need for additional research on the CSFs of kaizen. By focusing on managers' attitudes as CSF of kaizen, our study makes an additional contribution to the existing literature.

Although our study does not consider the direct impact of a specific socio-economic environment on kaizen implementation, it can be beneficial to companies in economies similar to Serbian. Our results indicate the problems of insufficient motivation or resistance to change, as well as a low level of managers' interest in the empowerment of employees. The problem is arguably the mentality of people in Serbia and the Serbian cultural and political heritage that needs to be managed. Management teams for kaizen implementation should deal with the specifics of the environment in which the company operates and accordingly manage the implementation process. Previous studies point to the specificities of business changes in transitioning economies (Todorovic & Cupic, 2017) and the importance of socio-economic and national context to the success of kaizen implementation (Lina & Ullah, 2019). Companies in transitioning economies, like Serbian, also face the problem of inadequate managers' and employees' participation in the processes of continuous improvement (Janjic et al., 2020). Hence, our results may be of particular relevance to companies in countries with similar national contexts. Investigating the managers' and employees' attitudes in these countries can be considered even more significant than in developed countries. We, therefore, believe that the influence of the socio-economic environment should be examined in more detail in future studies.

Our paper has significant practical implications. The study results point to the need to analyse and shape managers' attitudes and explore the connection between managers' attitudes, their behaviour, and kaizen success. They also point to the importance and specificities of the relationship between managers' attitudes and employees' participation and commitment. The results, therefore, imply that companies considering and initialising kaizen implementation should identify and understand managers' attitudes towards various aspects of kaizen in order to develop guidance for problem-solving and successful kaizen implementation. The study results could also be of importance to companies that have already implemented kaizen, but have a problem with its sustainability. They could guide the process of improving kaizen activities and help identify CSFs of kaizen implementation related to managers' attitudes in order to answer the question of why the implementation of kaizen sometimes fails or does not produce the expected results.

Although our study confirms the findings of some previous studies that managers' attitudes are one of the CSFs of kaizen implementation, by analysing the attitudes of engineers and economists, we make a significant step forward. The study results point to the necessity of forming a cross-functional kaizen implementation team and a careful approach to choosing its members. It is necessary to involve the engineers who represent a link between senior management structures, the implementation team, and employees. Attention should also be paid to the involvement of economists, who are crucial in the processes of performance measurement and monitoring. Additionally, the study results could be used to change the perceptions of managers (engineers and economists). The recommendation is to empower managers and employees, and continuously work on education and training, especially in the areas of change management.

Although kaizen is one of the continuous improvement programmes, it should be noted that the study results can be used to support and improve the sustainability of various improvement programmes. In addition to already mentioned, companies are expected to build an adequate reward system, especially in the initial stages of programme implementation, and to efficiently and effectively communicate the results to lower levels of management

regarding initial and subsequent effects in order to build a positive attitude towards innovation and increase the level of trust. Both individual benefits and benefits for the company as a whole should be pointed out, given that the managers and employees should believe that the improvement programme is in their interest and the interest of the company. Finally, a detailed methodological framework used in the study, in existing or partially modified form, can serve practitioners when analysing specific companies before starting the kaizen or some other programme implementation.

The research conducted in the study has several limitations. According to some authors, the recommended sample size for factor analysis is at least 300 participants (Hair et al., 2019). This makes sample size potentially the most important limitation of our research. In addition, the sample includes companies from only one country. A larger sample with a larger number of variables would possibly give different results. The data collected using the questionnaire refers to only one point in time and does not reflect the possible influence of some recent events, such as the COVID-19 pandemic. Given that the managers' attitudes are possibly influenced by the trending component, future research could rely on the multiyear survey allowing the comparisons and drawing more generally valid conclusions. Another limitation is related to our objective inability to fully identify and neutralise the answers that, intentionally or unintentionally, do not reflect respondents' attitudes and facts concerning them. Hence, more detailed results could have been obtained if the interview was used in addition to the questionnaire. Future research should pay particular attention to identifying CSFs of kaizen implementation relevant to developing and transitioning economies. A more advanced statistical methodology can also be used, like regression analysis of the influence that managers' attitudes have on kaizen implementation and effects.

References

Ahlstrom, P., Danese, P., Hines, P., Netland, T. H., Powell, D., Shah, R., Thürer, M., & van Dun, D. H. (2021). Is lean a theory? Viewpoints and outlook. *International Journal of Operations & Production Management*, *41*(12), 1852–1878. https://doi.org/10.1108/ijopm-06-2021-0408

Ahuja, J., Panda, T. K., Luthra, S., Kumar, A., Choudhary, S., & Garza-Reyes, J. A. (2019). Do human critical success factors matter in adoption of sustainable manufacturing practices? An influential mapping analysis of multi-company perspective. *Journal of Cleaner Production*, *239*, 117981. https://doi.org/10.1016/j.jclepro.2019.117981

Aletaiby, A. A., Rathnasinghe, A. P., & Kulatunga, P. (2021). Influence of top management commitment towards the effective implementation of TQM in Iraqi oil companies. *Journal of Petroleum Exploration and Production Technology*, *11*(4), 2039–2053. https://doi.org/10.1007/s13202-021-01131-3

Alvarado-Ramírez, K. M., Pumisacho-Álvaro, V. H., Miguel-Davila, J. Á., & Suárez Barraza, M. F. (2018). Kaizen, a continuous improvement practice in organizations: A comparative study in companies from Mexico and Ecuador. *The TQM Journal*, *30*(4), 255–268. https://doi.org/10.1108/tqm-07-2017-0085

Aoki, K. (2008). Transferring Japanese Kaizen activities to overseas plants in China. *International Journal of Operations and Production Management*, *28*(6), 518–539. https://doi.org/10.1108/01443570810875340

Argiyantari, B., Simatupang, T. M., & Basri, M. H. (2022). Transportation performance improvement through lean thinking implementation. *International Journal of Lean Six Sigma*, *13*(3), 622–647. https://doi.org/10.1108/ijlss-06-2020-0075

Bakotic, D., & Rogosic, A. (2017). Employee involvement as a key determinant of core quality management practices. *Total Quality Management and Business Excellence*, *28*(11–12), 1209–1226. https://doi.org/10.1080/14783363.2015.1094369

Beraldin, A. R., Danese, P., & Romano, P. (2019). An investigation of the relationship between lean and well-being based on the job demands-resources model. *International Journal of Operations and Production Management*, *39*(12), 1295–1322. https://doi.org/10.1108/ijopm-05-2019-0377

Buren, P. (2021). *The role of a manager when implementing improvement programs: Reflecting on kaizen, lean/agile production and supply chain management*. Academia. https://www.academia.edu/31987151/the_role_of_a_manager_when_implementing_improvement_programs_reflecting_on_kaizen_lean_agile_production_and_supply_chain?auto=download

Bwemelo, G. (2014). Kaizen as a strategy for improving SSMEs' performance: Assessing its acceptability and feasibility in Tanzania. *European Journal of Business and Management*, *6*(35), 79–91.

Carnerud, D., Jaca, C., & Bäckström, I. (2018). Kaizen and continuous improvement – Trends and patterns over 30 years. *The TQM Journal*, *30*(4), 371–390. https://doi.org/10.1108/tqm-03-2018-0037

Cherrafi, A., Elfezazi, S., Hurley, B., Garza-Reyes, J. A., Kumar, V., Anosike, A., & Batista, L. (2019). Green and lean: A Gemba-Kaizen model for sustainability enhancement. *Production Planning & Control*, *30*(5–6), 385–399. https://doi.org/10.1080/09537287.2018.1501808

Cheser, R. N. (1998). The effect of Japanese kaizen on employee motivation in U.S. manufacturing. *The International Journal of Organizational Analysis*, *6*(3), 197–217. https://doi.org/10.1108/eb028884

Deressa, A. T., & Zeru, G. (2019). Work motivation and its effects on organizational performance: The case of nurses in Hawassa public and private hospitals: Mixed method study approach. *BMC Research Notes*, *12*(1). https://doi.org/10.1186/s13104-019-4255-7

DeVellis, R. F. (2016). *Scale development: Theory and applications*. Sage publications.

Fosnacht, K., Sarraf, S., Howe, E., & Peck, L. K. (2017). How important are high response rates for college surveys? *The Review of Higher Education*, *40*(2), 245–265. https://doi.org/10.1353/rhe.2017.0003

Fullerton, R. R., Kennedy, F. A., & Widener, S. K. (2013). Management accounting and control practices in a lean manufacturing environment. *Accounting, Organizations and Society*, *38*(1), 50–71. https://doi.org/10.1016/j.aos.2012.10.001

Fullerton, R. R., Kennedy, F. A., & Widener, S. K. (2014). Lean manufacturing and firm performance: The incremental contribution of lean management accounting practices. *Journal of Operations Management*, *32*(7–8), 414–428. https://doi.org/10.1016/j.jom.2014.09.002

Garcia, J. L., Maldonado, A. A., Alvarado, A., & Rivera, D. G. (2014). Human critical success factors for kaizen and its impacts in industrial performance. *The International Journal of Advanced Manufacturing Technology*, *70*(9–12), 2187–2198. https://doi.org/10.1007/s00170-013-5445-4

Garcia, J. L., Rivera, D. G., & Iniesta, A. A. (2013). Critical success factors for Kaizen implementation in manufacturing industries in Mexico. *The International Journal of Advanced Manufacturing Technology*, *68*(1–4), 537–545. https://doi.org/10.1007/s00170-013-4750-2

Garza-Reyes, J. A., Christopoulos, C., Kumar, A., Luthra, S., González-Aleu, F., Kumar, V., & Villarreal, B. (2022). Deploying Kaizen events in the manufacturing industry: An investigation into managerial factors. *Production Planning & Control*, *33*(5), 427–449. https://doi.org/10.1080/09537287.2020.1824282

Glover, W. J., Farris, J. A., Van Aken, E. M., & Doolen, T. L. (2011). Critical success factors for the sustainability of kaizen event human resource outcomes: An empirical study. *International Journal of Production Economics*, *132*(2), 197–213. https://doi.org/10.1016/j.ijpe.2011.04.005

Hailu, H., Kedir, A., Bassa, G., & Jilcha, K. (2017). Critical success factors model developing for sustainable Kaizen implementation in manufacturing industry in Ethiopia. *Management Science Letters*, *7*(12), 585–600. https://doi.org/10.5267/j.msl.2017.8.006

Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2019). *Multivariate data analysis*. Cengage Learning EMEA.

Imai, M. (1986). *Kaizen: The key to Japan's competitive success*. McGraw–Hill.

Jamieson, S. (2004). Likert scales: How to (ab) use them. *Medical Education*, *38*(12), 1217–1218. https://doi.org/10.1111/j.1365-2929.2004.02012.x

Janjic, V., Todorovic, M., & Jovanovic, D. (2020). Key success factors and benefits of kaizen implementation. *Engineering Management Journal*, *32*(2), 98–106. https://doi.org/10.1080/10429247.2019.1664274

Jurburg, D., Viles, E., Tanco, M., & Mateo, R. (2017). What motivates employees to participate in continuous improvement activities? *Total Quality Management & Business Excellence*, *28*(13–14), 1469–1488. https://doi.org/10.1080/14783363.2016.1150170

Jurburg, D., Viles, E., Tanco, M., Mateo, R., & Lleó, Á. (2019). Understanding the main organisational antecedents of employee participation in continuous improvement. *The TQM Journal*, *31*(3), 359–376. https://doi.org/10.1108/tqm-10-2018-0135

Karacsony, P., Metzker, Z., Vasic, T., & Koltai, J. P. (2023). Employee attitude to organisational change in small and medium-sized enterprises. *E&M Economics and Management*, *26*(1), 94–110. https://doi.org/10.15240/tul/001/2023-1-006

Kharub, M., Gupta, H., Rana, S., & McDermott, O. (2023). Employee's performance and Kaizen events' success: Does supervisor behaviour play a moderating role? *The TQM Journal*, *35*(8), 2336–2366. https://doi.org/10.1108/tqm-06-2022-0203

Ktoridou, D., Doukanari, E., & Karayiannis, A. (2019). Educating the new generation of engineering managers to stay relevant in the 21st century workforce. In *Proceedings of 2019 IEEE Global Engineering Education Conference (EDUCON)* (pp. 1547–1551). https://doi.org/10.1109/educon.2019.8725177

Laglera, J.-L. M., Collado, J. C., & de Oca, J.-A. M. M. (2013). Effects of leadership on engineers: A structural equation model. *Engineering Management Journal*, *25*(4), 7–16. https://doi.org/10.1080/10429247.2013.11431991

Lina, L. R., & Ullah, H. (2019). The concept and implementation of kaizen in an organization. *Global Journal of Management and Business Research*, *19*(1), 9–17.

Liu, W.-H., Asio, S., Cross, J., Glover, W. J., & Van Aken, E. (2015). Understanding team mental models affecting Kaizen event success. *Team Performance Management*, *21*(7/8), 361–385. https://doi.org/10.1108/tpm-03-2015-0012

Macpherson, W. G., Lockhart, J. C., Kavan, H., & Iaquinto, A. L. (2015). Kaizen: A Japanese philosophy and system for business excellence. *Journal of Business Strategy*, *36*(5), 3–9. https://doi.org/10.1108/jbs-07-2014-0083

Marin-Garcia, J. A., Juarez-Tarraga, A., & Santandreu-Mascarell, C. (2018). Kaizen philosophy: The keys of the permanent suggestion systems analyzed from the workers' perspective. *The TQM Journal*, *30*(4), 296–320. https://doi.org/10.1108/tqm-12-2017-0176

Marksberry, P., Badurdeen, F., Gregory, B., & Kreafle, K. (2010). Management directed kaizen: Toyota's Jishuken process for management development. *Journal of Manufacturing Technology Management*, *21*(6), 670–686. https://doi.org/10.1108/17410381011063987

Mohammad, I. S., & Oduoza, C. F. (2020). Lean-excellence business management for manufacturing SMEs focusing on KRI. *International Journal of Productivity and Performance Management*, *69*(3), 519–539. https://doi.org/10.1108/ijppm-11-2018-0389

Nguyen, H. A., Yokozawa, K., & Suárez-Barraza, M. F. (2023). A sense of urgency as a driver of individual kaizen performance: Moderating role of organizational culture. *The TQM Journal* (in press). https://doi.org/10.1108/tqm-06-2023-0169

Nittala, S., & Jesiek, B. K. (2018). Work experiences of engineering managers: Challenges, strategies, competencies. In *Proceedings of 2018 IEEE Frontiers in Education Conference (FIE)*. https://doi.org/10.1109/fie.2018.8658499

Nuhu, N. A., Baird, K., & Appuhami, R. (2016). The association between the use of management accounting practices with organizational change and organizational performance. In *Advances in Management Accounting* (Vol. 26, pp. 67–98). Emerald Group Publishing Limited.

Oropesa-Vento, M., García Alcaraz, J. L., Maldonado Macías, A. A., & Martínez Loya, V. (2016). The impact of managerial commitment and Kaizen benefits on companies. *Journal of Manufacturing Technology Management*, *27*(5), 692–712. https://doi.org/10.1108/jmtm-02-2016-0021

Ortiz, C. A. (2006). *Kaizen assembly: Designing, constructing, and managing a lean assembly line*. CRC Press. https://doi.org/10.1201/9781420006605

Paipa-Galeano, L., Bernal-Torres, C. A., Agudelo Otálora, L. M., Jarrah Nezhad, Y., & González-Blanco, H. A. (2020). Key lessons to maintain continuous improvement: A case study of four companies. *Journal of Industrial Engineering and Management*, *13*(1), 195–211. https://doi.org/10.3926/jiem.2973

Ramezani, A., & Razmeh, A. P. (2014). Kaizen and kaizen costing. *International Journal of Accounting Research*, *2*(8), 43–52.

Riley, T., & Cudney, E. A. (2015). Defensive routines in engineering managers and non-engineering managers – A case analysis. *International Journal of Engineering Business Management*, *7*(7–8), 8. https://doi.org/10.5772/60114

Riley, T., Cudney, E., & Long, S. (2013). A comparative analysis of defensive routines in engineering managers versus non-engineering managers. *Engineering Management Journal*, *25*(4), 44–51. https://doi.org/10.1080/10429247.2013.11431994

Rivera-Mojica, D., & Rivera-Mojica, L. (2014). Critical success factors for Kaizen implementation. In J. Garcia-Alcaraz, A. Maldonado-Macías, & G. Cortes-Robles (Eds.), *Lean manufacturing in the developing world* (pp. 157–178). Springer International Publishing. https://doi.org/10.1007/978-3-319-04951-9_8

Singh, J., & Singh, H. (2015). Continuous improvement philosophy – Literature review and directions. *Benchmarking: An International Journal*, *22*(1), 75–119. https://doi.org/10.1108/bij-06-2012-0038

Stacho, Z., Stachová, K., Lukáč, M., Kupec, V., & Petrů, N. (2023). Management reflections on innovations in digitalization, with an emphasis on degree of work autonomy. *E&M Economics and Management*, *26*(1), 78–93. https://doi.org/10.15240/tul/001/2023-1-005

Suarez-Barraza, M. F., Miguel-Davila, J., & Castillo-Arias, I. (2011). The implementation of Kaizen in Mexican organizations: An empirical study. *Journal of Globalization, Competitiveness, and Governability*, *5*(1), 60–74. https://doi.org/10.3232/gcg.2011.v5.n1.04

Tabachnick, B. G., & Fidell, L. S. (2007). *Using multivariate statistics*. Pearson Education.

Tafvelin, S., von Thiele Schwarz, U., Nielsen, K., & Hasson, H. (2019). Employees' and line managers' active involvement in participatory organizational interventions: Examining direct, reversed, and reciprocal effects on well-being. *Stress and Health*, *35*(1), 69–80. https://doi.org/10.1002/smi.2841

Todorovic, M., & Cupic, M. (2017). How does 5s implementation affect company performance? A case study applied to a subsidiary of a rubber goods manufacturer from Serbia. *Engineering Economics*, *28*(3), 311–322. https://doi.org/10.5755/j01.ee.28.3.16115

Todorovic, M., Cupic, M., & Jovanovic, D. (2022). Sustainable lean implementation: A study of Serbian companies. *Economic Annals*, *67*(234), 81–107. https://doi.org/10.2298/eka2234081t

Vannette D. L., & Krosnick J. A. (2018). *The Palgrave handbook of survey research*. Palgrave Macmillan.

Verbickas, D. (2021). Research on Kaizen implementation in industrial companies. *Mokslas – Lietuvos Ateitis*, *13*, 1–16. https://doi.org/10.3846/mla.2021.14340

Wu, T.-J., & Wu, Y. J. (2019). Innovative work behaviors, employee engagement, and surface acting: A delineation of supervisor-employee emotional contagion effects. *Management Decision*, *57*(11), 3200–3216. https://doi.org/10.1108/md-02-2018-0196

Yokozawa, K., Steenhuis, H. J., & Bruijn, E. J. (2011). Process of international kaizen transfer in the Netherlands. *Journal of Japanese Operations Management and Strategy*, *2*(1), 38–57.

Yokozawa, K., & Steenhuis, H.-J. (2013). The influence of national level factors on international kaizen transfer: An exploratory study in The Netherlands. *Journal of Manufacturing Technology Management*, *24*(7), 1051–1075. https://doi.org/10.1108/jmtm-05-2011-0046

The role of leadership in managing digital transformation: A systematic literature review

Lazar Rakovic[1], Slobodan Maric[2], Lena Djordjevic Milutinovic[3], Vuk Vukovic[4], Radmila Bjekic[5]

1 *University of Novi Sad, Faculty of Economics in Subotica, Department for Business Informatics, Serbia, ORCID: 0000-0002-1465-588X, lazar.rakovic@ef.uns.ac.rs;*
2 *University of Novi Sad, Faculty of Economics in Subotica, Department for Management, Serbia, ORCID: 0000-0002-7414-4037, slobodan.maric@ef.uns.ac.rs (corresponding author);*
3 *University of Belgrade, Faculty of Organisational Sciences, Department for Production and Services Management, Serbia, ORCID: 0000-0002-3758-0147, lena.djordjevic.milutinovic@fon.bg.ac.rs;*
4 *University of Novi Sad, Faculty of Economics in Subotica, Department for Business Informatics, Serbia, ORCID: 0000-0002-0040-9936, vuk.vukovic@ef.uns.ac.rs;*
5 *University of Novi Sad, Faculty of Economics in Subotica, Department for Management, Serbia, ORCID: 0000-0002-7263-8025, radmila.bjekic@ef.uns.ac.rs.*

Abstract: *Digital transformation should not be seen as a time-bound project, but rather as a process that needs to be continuously improved and managed over time. In the absence of leadership, digital transformation will occur spontaneously in an organisation, but it is necessary to monitor and manage the process itself to achieve the goal and establish a digital organisation. A person who leads the digital transformation must possess the appropriate competencies. Leadership competencies, especially the combination of digital and human skills, are crucial to the development and success of the digital transformation process. The authors of this article identify a vaguely described process of digital transformation as the main research problem, highlighting the need for the systematisation of leadership competencies necessary for effective digital transformation management. In this regard, the research objectives are to define and describe the process of digital transformation and identify the leadership competencies necessary for successful management of the digital transformation process. In order to achieve the objectives of the paper, a systematic literature review was conducted for the period 2001–2022 and 90 papers were identified based on the criteria outlined by the Web of Science and Scopus index databases. The identified papers were then analysed from the aspect of defining digital transformation, the activities of the digital transformation process, and the characteristics of digital leadership. Following a thorough analysis of the selected literature, the paper provides a comprehensive definition of digital transformation, proposes a framework for its management, and analyses the key competencies of digital transformation leaders (digital leaders), which together make up the paper's main contribution. The paper can be used not only as a starting point for future research in this area, but also as initial guidelines for the implementation and management of the digital transformation process. The systematic literature review conducted has certain limitations. Only two, albeit the largest, citation databases were searched, and only papers in English were identified. The established framework should be verified and expanded through empirical research.*

Keywords: *Digital transformation, leadership, digital leadership, systematic literature review.*

JEL Classification: *M10, M15.*

APA Style Citation: Rakovic, L., Maric, S., Djordjevic Milutinovic, L., Vukovic, V., & Bjekic, R. (2024). The role of leadership in managing digital transformation: A systematic literature review. *E&M Economics and Management*, *27*(2), 87–107. https://doi.org/10.15240/tul/001/2024-2-006

Introduction

The existing literature within the research field is insufficiently homogeneous and inadequately integrated, resulting in insufficient knowledge about the competencies required for leaders to successfully carry out the process of digital transformation (Müller et al., 2024). Leaders must develop their individual capacities and competence to provide a better understanding of the change in dynamic environments through a strong global vision (Elidjen et al., 2019). Digital transformation is changing many aspects of how people work (Schwarzmüller et al., 2018), and these changes do not exhibit any signs of deceleration. Leaders have a fundamental role in organisations, such as leading these changes (Evans et al., 2021) and influencing people to perform activities in more efficient and creative ways (Grigore & Coman, 2018). Digital transformation requires leaders to quickly adapt existing approaches in today's highly dynamic environment. Business and IT leaders need to collaborate (since technology and leadership skills are complementary), and new approaches should be adapted to respond to changes in the competitive and technological environment (Hansen et al., 2011; Ko et al., 2022; Philip & Gavrilova Aguilar, 2022). Leadership and digital transformation cannot be considered separately, but they must support each other in the application and sustainability of any digital transformation initiative in an organisation (Jayawardena et al., 2020; Zulu & Khosrowshahi, 2021).

Digital transformation is the driver of positive but also devastating market changes (Al-Nuaimi et al., 2022; Kokolek et al., 2019) and represents more than just a technological evolution (Criado-Perez et al., 2022) that must be adequately managed. As for devastating market changes, Kokolek et al. (2019) argue that technology is increasingly entering everyday life as well as the world of business, and changing how business is conducted. Moreover, emerging IT risks, such as security breaches, privacy concerns, and safety issues (Vial, 2019), alongside implementation costs, can have profoundly adverse effects on the market.

According to Luo et al. (2023), it is necessary to attract highly qualified top managers in order to ensure a successful digital transformation, but they did not address what competencies they should possess. Porfírio et al. (2021) concluded that managers' characteristics, especially democratic leadership styles, are particularly important at the beginning of digital transformation. Furthermore, a three-fold alignment and involvement are necessary, comprising organisation, digital transformation and leadership. According to Carvalho et al. (2023), top managers differ in different industries (sectors or economic activities) and essential changes to the leadership process have been identified based on environmental factors. In this way, a set of characteristics that are essential for the effective achievement of organisational objectives is identified, predominantly from a communication perspective.

As Müller et al. (2024) point out, the literature exists in fragments, and knowledge about the leadership competencies required for digital transformation is lacking. The same authors emphasise that leaders must possess different competencies depending on the drivers and goals of the digital transformation. A key finding of their research is that the classic all-encompassing leadership approach cannot guide digital transformation. Moreover, they assert that different combinations of technical, business, and people-oriented competencies will be needed depending on whether market innovations are explored, operational efficiency is supported, stakeholder involvement is ensured, and competitive positioning is improved.

Thus, digital transformation leadership is becoming increasingly relevant in theoretical and empirical research. The previous statements are illustrated by fragmented and missing knowledge about which leadership competencies the business requires in order to facilitate digital transformation. According to a theoretical perspective, four archetypical competency portfolios are outlined, which are based on the types of leaders who embody the constituent competencies: the challenger (exploring the market innovations), the bricoleur

(supporting operational efficiency), the organiser (ensuring active stakeholder participation), and the competitor (improving competitive position; Müller et al., 2024).

Strategic implications of digital transformation must be considered both at the daily operational level and in the development process. Kringelum et al. (2024) identified five strategic actions that leaders should consider when embarking on digital transformation to succeed with strategic change: i) discussion and communication about vision and strategy; ii) aligning resources and activities with strategy; iii) developing the competencies of top managers, middle managers and employees; iv) ensuring operational improvements and efficiency; and v) creating an orientation toward customer or user needs and expectations.

Based on several sources, Braojos et al. (2024) argue that digital leadership is conceptualised as a style of competencies, behaviours, and practices that inspire and motivate employees in the context of digital transformation. Moreover, Zivkovic (2022) points out that the necessary leadership competencies are flexibility, experimentation, and understanding of digital technologies. In his opinion, digital transformation leaders should not be IT experts, but they should understand how digital technologies impact organisational culture, performance, and development. In support of this statement, Schwarzmüller et al. (2018) state that digital transformation leaders must possess the competence to lead a team of people from diverse cultures. Furthermore, this implies language competence and the ability to lead from a distance as well.

Therefore, digital leadership is crucial for leading digital transformation, i.e., strong leadership is necessary for the success of digital transformation (Zulu & Khosrowshahi, 2021). There is an evident lack of research aimed at understanding digital transformation and leadership itself (Henderikx & Stoffers, 2022), while digital transformation in the digital era requires extraordinary skills and competencies (Noonpakdee et al., 2020).

Kontic and Vidicki (2018) point out that initiative-taking leadership is one of the key factors that will help the organisation become digital. Leadership in the digital era implies a deep understanding of digital business models (Jacobi & Brenner, 2018). Given the new circumstances, Schwaferts and Baldi (2018) raise the question as to whether standard management concepts are still adequate for the period during and after the digital transformation. Digital transformation must be initiated by the management rather than by the IT department, which could only achieve part of the necessary changes (Ko et al., 2022). Digitisation, digitalisation and digital transformation are the terms often identified with each other (Kohnke, 2017). Digital transformation includes digitisation and digitalisation (Paul et al., 2024), but digital transformation is a more complex and comprehensive concept (O'Leary, 2023). According to Venkatesh et al. (2019), digital transformation has evolved through digitisation and digitalisation up to the digital transformation itself, which encompasses the entire company's business model.

To recognise the necessary characteristics of digital transformation leadership, it is necessary to understand the very concept of digital transformation as well as the implied steps (key activities; Ubiparipovic et al., 2023), as explained in the paper based on the literature. Müller et al. (2024) pointed the theoretical-practical gap in digital transformation management, taking into account the fact that digital transformation requires persistent digital leadership at the top level of the organisation, and that no coherent concept of digital leadership exists today (Müller et al., 2024). Since most organisations are only halfway through the digital transformation process, it is necessary to emphasise that most companies must undertake a challenging path in order to achieve digital maturity. However, 70% of digital transformation initiatives fail to achieve their objectives (Alshehab et al., 2022). The path to digital transformation within an organisation is a multidimensional and complex process that requires effective leadership. This entails that in the digital era, and leaders must adapt their knowledge, skills, and abilities to successfully drive the process of digital transformation within the organisation (Urs et al., 2023).

After reviewing the previous research, a research problem was identified in the form of a vaguely described and defined digital transformation process, along with the need to systematise the leadership competencies required to successfully manage digital transformation. The main objective of the research is to define and describe the process of digital transformation as well as to identify the necessary leadership

competencies for the successful management of the digital transformation process.

To address the main objective of the research, the authors analysed and used 90 selected papers published in the period from 2001 to 2022. A systematic review of the literature was conducted to identify these papers, which is described in the following section. The papers were then analysed from the aspect of three identified sub-units. Based on the analysed papers, a comprehensive definition of digital transformation was proposed, followed by a conceptual framework of digital transformation and key leadership characteristics needed for the successful implementation of the digital transformation process.

1. Research methodology

As part of the research process and the implementation of the systematic literature review methodology, as well as in order to answer the basic research question and achieve the set research goals (which will be discussed in the following sections), three basic segments can be identified (Xiao & Watson, 2019): i) planning the review; ii) conducting the review; and iii) reporting the review (Fig. 1). In accordance with the mentioned methodology and within the first phase of the systematic literature review, the authors managed to: 1) define a specific research problem (general research questions); and 2) develop a complete research algorithm (protocol) to be used for the research in this paper. Step 3 – the initial search within the selected databases by title, abstract and key words was carried out in the second part of conducting the literature review. During this phase, the fourth step entails screening for inclusion by analysing abstracts according to the inclusion criteria. As the research was done in two databases (Web of Science and Scopus, for the period 2001–2022), duplicates were eliminated in the fifth step based on the received list of potential papers. In this segment of the process, the sixth step involves evaluating the quality of the complete papers, as well as respecting the general quality of the papers regarding the methodology applied, concept, content, and results of the research, and in accordance with the inclusion criteria previously mentioned. Once the final set of papers was obtained, an additional review of the literature of the identified papers, as well as papers that cited the identified papers (forward and backward research) was performed in the seventh step. Finally, in step 8, the analysis and synthesis of the papers were carried out in accordance with the defined concept of the research. A review report was created based on the obtained results in the third segment of the literature review process, which is also the final, ninth step of the comprehensive literature review.

Based on the identified research problem stated in the Introduction section, the following research questions were formulated as the basis of this study in the first stage of the methodology – planning the review:

RQ1: What is implied by the term digital transformation and what are the challenges, factors and steps of the digital transformation process?

RQ2: What leadership competencies and characteristics are necessary to successfully lead the digital transformation process?

Xiao and Watson (2019) also recommend that during certain segments of the literature review process, the research is to be conducted in such a way that the authors are divided into two groups that carry out each step independently, and then integrate their findings and discuss the differences in each step in order to screen the selected papers for final analysis. In Fig. 1, the steps of the applied methodology and the results of the selection as part of the analysis of the papers are described in detail.

Following an initial search and analysis of the literature, the authors identified the insufficient success of the digital transformation process and the inability of businesses to achieve their desired goals through digital platforms. Furthermore, as we delved deeper into the research area, we realised that the key role in digital transformation is played by the human factor, i.e., human versus technology, which led us to include the sub-unit of management or leadership in organisations in our research. A key point that must be noted during this phase of the research is that the research questions were developed through an iterative process, after the authors had gathered more information and knowledge by conducting a literature search and analysis focusing on the most common digital transformation issues.

Fig. 1 shows how the review was conducted according to all stages and relevant criteria and what results each stage reached.

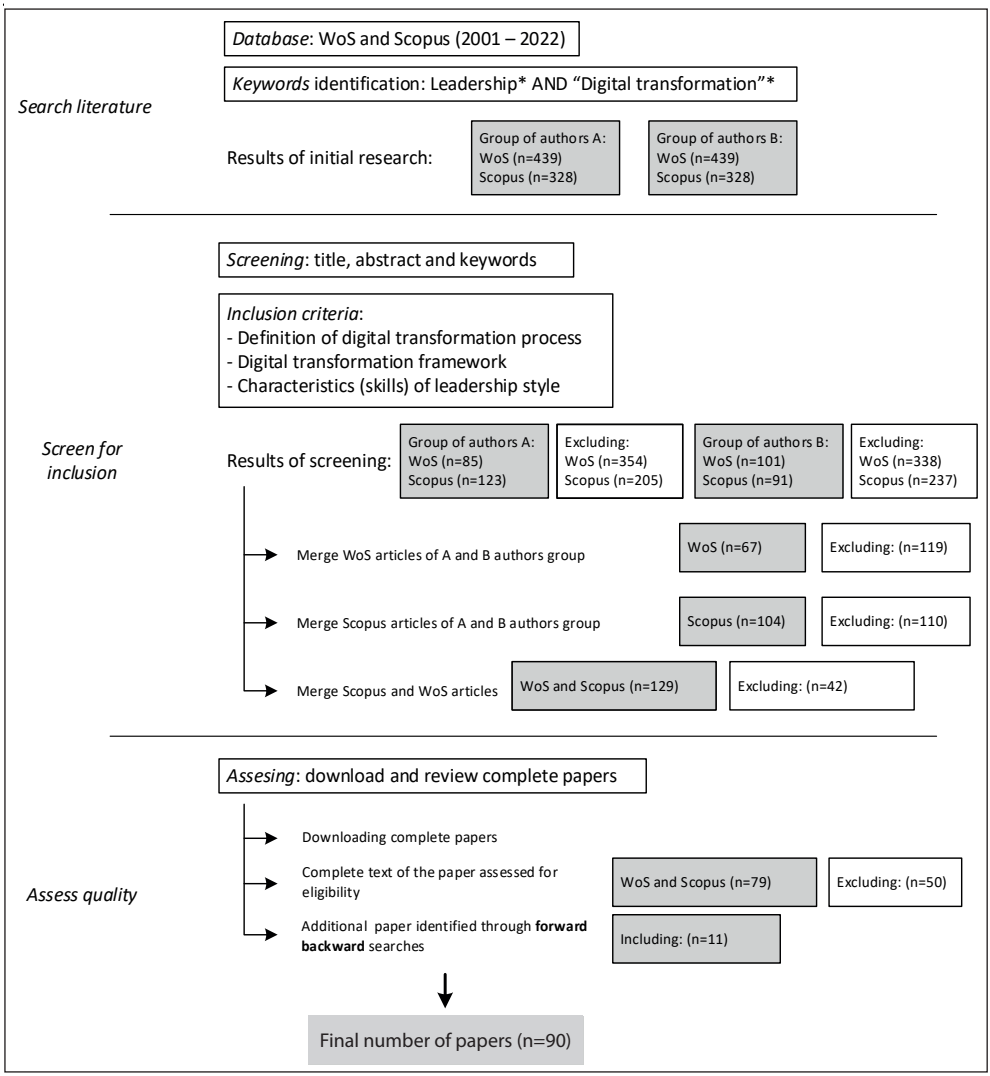


Fig. 1: Search strategy and selection criteria

Source: own

Literature search. Three main search sources were used as literature search channels: i) the mentioned electronic databases (WoS and Scopus); ii) backward searching (identifying the relevant papers cited in the included articles, using the reference list at the end of the paper is a good way to find these articles); and iii) forward searching (finding and selecting articles that cite the original paper that has been found).

The search was performed for the period from 2001 to 2022. This time period was determined based on the topicality of the research area, the volume of published papers and the electronic availability of papers. Based on the research question, the keywords related to "leadership" and "digital transformation" were selected. Among the papers included were only those published in English in journals and

at conferences, as well as chapters in monographs. The search ended after determining that no new results would be obtained by applying the search strategy. Group authors A and B conducted the search within selected databases and defined keywords during December 2022, while the search results, i.e., the number of initial hits, due to the same search criteria, was identical and amounted to WoS *n* = 439 and Scopus *n* = 328.

Screening for inclusion. For screening and selecting papers for final analysis, Xiao and Watson (2019) recommend that at least two researchers evaluate papers independently according to set criteria. Two groups of authors A and B, conducted the literature review separately in this paper, with phase alignment and consultation between both groups. A screening process for selecting papers/including papers was conducted by both groups of authors based on the title, abstract, and keywords of the papers, along with defined inclusion criteria.

Three separate criteria were used to select the papers on which this research is based. On the one hand, these criteria represent the derivative of the research questions, while on the other hand, they serve as the basis for selecting an individual study on which further steps will be taken in the research process. For a paper to be selected for further analysis, it must meet at least one of the following criteria: the first criterion, defining digital transformation – from a leadership position, understanding the digital transformation process is necessary if we are going to ensure its success, which is why we need to define the concept of digital transformation and ensure that its absolute understanding is presented at the beginning of the paper. The second criterion, the conceptual framework, or steps of digital transformation – understanding the essential elements of the concept of digital transformation – is significant for the successful management of the digital transformation process and the achievement of set goals. The third criterion is the leadership characteristics necessary for the successful management of the digital transformation process.

Following the screening procedure previously described, the following results were obtained for the initial list of papers: from the original number of hits (*n* = 439) within the WoS database, the authors of Group A selected 85 papers and excluded 354 papers (Group A, WoS, *n* = 85, excluding *n* = 354), while the authors from the same group within the Scopus database, selected 123 papers and excluded 205 papers (Group A, Scopus, *n* = 123, excluding *n* = 205) from the original number of hits (*n* = 328). From the original number of hits (*n* = 439) within WoS, the authors from Group B selected 101 papers and excluded 338 papers (Group A, WoS, *n* = 101, excluding *n* = 338), while the authors from the same group within the Scopus database, selected 91 papers and excluded 237 papers (Group B, Scopus, *n* = 91, excluding *n* = 237) from the original number of hits (*n* = 328). The next step involved combining the selected papers of the two groups of authors from both databases, removing duplicates, and discussing the reasons for choosing different papers between the two groups of authors. During the discussion, it was decided to exclude papers for which there were not enough arguments for the selection stage. As a result of combining papers from both groups of authors, eliminating duplicates and excluding papers based on discussion within the WoS database, 67 papers remained, while 119 papers were eliminated (WoS, *n* = 91, excluding *n* = 237). By combining the papers of both groups of authors, eliminating duplicates and excluding papers based on the discussion within the Scopus database, 104 papers remained and 110 papers were excluded (WoS, *n* = 104, excluding *n* = 110). The next step of the screening process was to combine papers from both databases and exclude duplicates. After combining the papers from both databases and excluding duplicates, 129 papers remained, while 42 papers were excluded since they appeared in both databases in the previous step (WoS + Scopus, *n* = 129, excluding *n* = 42).

Assess quality. Following the screening process, the next segment of the conducted literature review involved downloading previously selected papers from the screening process and assessing their quality. In preparing the final list of papers for data extraction and synthesis, the quality of the complete papers is assessed. Research questions and the application of defined selection criteria are used to evaluate the papers' completeness. A paper's quality is also assessed based on the method of collecting data, the analysis process, the methodology applied, and

the obtained results and conclusions. Based on the quality assessment, 79 papers were selected and 50 were excluded (preliminary final list, *n* = 79, excluding *n* = 50). During this stage of assessing the quality of the complete papers, the authors from Groups A and B independently assessed each paper in order to harmonise the selected papers and reach the results described previously. As a final step toward reaching the final list of papers which will serve as the basis for this paper, forward and backward searches were conducted, and an additional 19 papers were included on that basis (for and back search, *n* = 11), bringing the total number of papers selected to be 90 to provide a response to the research question (final number of papers, *n* = 90).

Extract data. Based on the literature review of the selected papers, information was extracted on two topics: i) definition of digital transformation and conceptual framework of digital transformation; and ii) characteristics, role and style of leadership. Data extraction from the selected papers is guided by the method of synthesis selected, which, in this case, is a textual narrative synthesis. Generally, coding is used to extract data, especially during a literature review, which was conducted inductively according to selected topics.

Analyse and synthesise data. After the data was extracted, the authors organised the data in accordance with the review concept. In this phase of the literature review, techniques such as tables and text descriptions were used. The method of contingent design was used as the main method of analysis and synthesis of the extracted data, which represents a cyclical research synthesis. Consequently, the selected quantitative and qualitative papers are intended to address a specific research question.

2. Research findings

2.1 Defining digital transformation

The continuous emergence of new technologies is evident in recent years (Zhu et al., 2021). Although digital transformation has penetrated many aspects of organisations, transformed business models (Danielsen, 2020), in some cases disrupting existing businesses and economies (Philip & Gavrilova Aguilar, 2022; Zimmermann et al., 2019), being inevitable in all industries (Gurkan et al., 2020), and becoming a buzzword in the last few years (Abbu et al., 2021), it is a relatively new concept that is very difficult to define clearly (Kokolek et al., 2019). The authors generally agree that digital transformation is a process (Egor, 2020; Engesmo & Panteli, 2021; Lorentzen, 2022) that manifests itself in different ways and with different intensity (Engesmo & Panteli, 2021). As digital transformation is a continuous process, its monitoring and management are necessary (Egor, 2020). It can be said that digital transformation is an inevitable and irreversible process (Zhu et al., 2021) that represents a chance for innovation within organisations (Zulu & Khosrowshahi, 2021) driven by clients' expectations and behaviour (Evans et al., 2021). Digital transformation is often associated with technology, corporate culture, society, creativity and change management (Tungpantong et al., 2021). Many organisations focus digital transformation too much on technology alone. This is precisely why many digital transformation processes fail (Jayawardena et al., 2020). Digital tools cannot just be purchased and simply attached to an organisation (Egor, 2020). Needless to say, digital technologies cannot be neglected in the digital transformation, because they play one of the main roles in the digital transformation (Vial, 2019). A company should learn about new technologies, as well as develop new capabilities that allow it to reposition itself strategically, because new technologies can cause disruptions that can threaten the business of a particular company (Pihlajamaa et al., 2021). Therefore, it is impossible to talk about digital transformation without mentioning the technologies, in which the authors often include, e.g., social media, internet of things, mobility, big data and analytics, cloud computing, artificial intelligence and blockchain (Florek-Paszkowska et al., 2021; Tekic & Koroteev, 2019). From these groups of technologies, it is necessary to choose and apply the ones (Venkatesh et al., 2019) that are most appropriate to the organisation or to the strategy of digital transformation.

Carcary et al. (2016) even state that organisations should not initially focus on a holistic set of required capabilities, but on the development of basic capabilities that will become the starting point for digital transformation and later lead to the development of all necessary digital capabilities. The same authors point out the following as basic or key areas on which organisations should initially focus: promoting and implementing an agile digital culture, developing

digital leadership skills, building digital talent and defining and implementing a transformative digital business strategy. According to Zhu et al. (2021), digital transformation implies a transition from a product-centric to a customer-centric strategy. Therefore, the management needs to adapt its business strategy to the digital reality (Reis & Melao, 2023).

Florek-Paszkowska et al. (2021) group the levers that will influence successful digital transformation into two groups: human-based and non-human based factors. The first group includes, in the first place, competent, responsible, and open-minded leaders, who are open to change, flexible and able to quickly adapt. The authors then mention talented employees who are ready to share their expertise, learn quickly, and adapt, as part of the first group. The second group, non-human based factors, implies a business culture that should empower employees, and business models that are easily transformed in order to create an innovative business model, new strategies and support (disruptive) technologies. This can be followed by team-based levers that enable digital transformation, which were identified in their research by Guinan et al. (2019): diverse team composition, iterative goal setting, continuous learning

Tab. 1: The definitions of digital transformation

Source	Definition/explanation of the concept of digital transformation
Reis and Melao (2023)	Digital transformation is the use of new digital technologies that enables major business improvements and influences all aspects of customers' lives.
Kutnjak et al. (2019)	Digital transformation is a complex and demanding process that requires the engagement of all enterprise resources – human, technological, physical, organisational and financial. DT is the transformation of an organisation driven by digital technology, and it directly affects the change of the organisation's core, that is, the change of its business model.
Brown and Brown (2019)	Digital transformation is defined as the implementation of innovative and new digital technologies to effect business improvements in an organisation.
Venkatesh et al. (2019)	Digital transformation or digital business transformation is thus about embracing digitisation and digitalisation concepts to create novel and different business designs or business model as a whole for better long-term value. It is much more than automating or digitising business processes or digitising products and services.
Vial (2019)	Digital transformation is a process that aims to improve an entity by triggering significant changes to its properties through combinations of information, computing, communication, and connectivity technologies.
Tu and Chi (2020)	Digital transformation has been defined as the use of new digital technologies, such as mobile, artificial intelligence (AI), cloud, blockchain, and IoT technologies, to enable major business improvements to augment customer experience, streamline operations, or create new business models. The key long-term technological trends are the increasing capability of the firm with customers to communicate, collect, store and analyse information.
Fachrunnisa et al. (2020)	Digital transformation is a process or business for the company in facilitating the relationship between customers with the company itself, simplifying the various processes by changing the business model through the recent technology. This change is not only limited to the use of technology but also has an impact on the structure and strategy of the company to fit the business model due to the new technology.
Abdallah et al. (2021)	Digital transformation (DT) is a customer-centric mechanism that enables continuous improvement in the productivity of the manufacturing processes using advanced digital technologies such as cloud computing, internet of things, big data analytics, digital twin in all aspects of the organisation.

Source: own

and talent management. Based on the research conducted, Engesmo and Panteli (2021) suggest that organisations should adapt their IT functions to support digital transformation. When discussing digital transformation, it is important to take into account that digital business models often require the organisation to participate in or initiate a certain digital ecosystem in which traditional relationships with suppliers and customers are challenged (Criado-Perez et al., 2022; Schwaferts & Baldi, 2018).

Reis and Melao (2023) identified three different elements of digital transformation based on a review of different definitions of digital transformation. The first element includes the technological digital transformation that encompasses technologies (e.g., social media, mobile, analytics). The second element is the structural digital transformation, which requires changes in business processes and the creation of new business models. Finally, as the third element, the authors mention the human digital transformation that affects all aspects of human life (e.g., improving customer experience). According to Weritz et al. (2020) three main parts of digital transformation are products (services), clients and processes. Tab. 1 shows the definitions of digital transformation identified through a systematic review of the literature.

2.2 The framework of digital transformation

The road map for digital transformation should be developed, which will guide the organisation to where it wants to be in the future (Evans et al., 2021). The problem is that digital initiatives are not always strategically oriented and clearly defined (Engesmo & Panteli, 2021), or management often does not see the difference between digital transformation initiatives and smaller-scale initiatives aimed at increasing efficiency (Solberg et al., 2020). In other words, a non-strategic view of digitisation is precisely what is reflected here.

Kokolek et al. (2019) state that the prerequisite for the success of digital transformation is the acquisition and development of six key factors, as follows: digital knowledge and skills, ability to apply new technologies to the business, continuous learning, strategic vision, network leadership and agility. Criado-Perez et al. (2022) point out that traditional organisations cannot adapt to the changing environment by solely relying on educational institutions as they once did. They argue that employee training is essential for organisations to adapt to the changing environment. As challenges of digital transformation, Hai et al. (2021) cite limited infrastructure, lack of skills and the fact that management has not adapted to the digital transformation process. Digital transformation is a widely adopted process, which significantly complicates its successful implementation. Therefore, companies need both employees who are engaged and support the digital transformation process, as well as leaders who are reliable and possess adequate competencies to lead and support employees through the digital transformation process (Heracleous & Gledhill, 2024). As a result, digital transformation presents a number of challenges to organisations (Tab. 2 provides the most significant challenges).

Imran et al. (2021) identify leadership, organisational structure, and culture as the main drivers of digital transformation. According to their research, developing leadership competencies facilitates digital transformation

Tab. 2: Challenges of digital transformation

Challenge	Source
Limited infrastructure	Hai et al. (2021)
Lack of skills	Hai et al. (2021)
Not adapted management, lack of knowledge to lead digital transformation	Hai et al. (2021), Salume et al. (2021)
Lack of resources to incorporate digital technologies	Van Tonder et al. (2020)
Culture in an organisation	Evans et al. (2021)
Employee resistance	Trenerry et al. (2021)

Source: own

because organisations become more agile, more customer-centric and more collaborative. They mention organisational structure and culture as the next drivers. Having a flexible organisational structure and an organisational culture that embraces change will make implementing digital transformation easier.

Digital transformation requires commitment from management, while the IT department plays a less significant role (Ko et al., 2022). According to Ko et al. (2022), a strategic framework for digital transformation is one of the key activities of digital transformation. Although digital transformation is necessary for the survival of modern organisations (Trenerry et al., 2021), the management often lacks adequate knowledge about the different elements that should be considered when transforming a business digitally (Salume et al., 2021). Organisations today face a big challenge when it comes to managing digital transformation (Boneva, 2018). As a result, identifying the key factors of digital transformation is vital (Tab. 3).

Strategy in the digital age must be swift and supported by a roadmap for implementation (Jacobi & Brenner, 2018). As a result, digital transformation is not much different from other business transformations, and a roadmap is required (Evans et al., 2021; Jacobi & Brenner, 2018; Kohnke, 2017; Zaoui & Souissi, 2020). Organisations should identify the steps they should follow in their digital transformation process. Tab. 4 shows the most frequently mentioned steps of digital transformation in the literature. It is important to consider that they are not sequential and should be implemented according to the needs of the industry and organisation on the path to digital transformation.

Tab. 3: Key factors of digital transformation

Factors	Source
Customer centricity	Mhlungu et al. (2019), Abdallah et al. (2021)
Corporate processes and structure	Imran et al. (2021), Jacobi and Brenner (2018), Alshehab et al. (2022)
Digital knowledge and skills	Kokolek et al. (2019), Imran et al. (2021)
Agility	Kokolek et al. (2019)
Leadership	Kokolek et al. (2019), Imran et al. (2021), Jacobi and Brenner (2018), Alshehab et al. (2022), Trenerry et al. (2021)
Continuous learning/upgrading/retraining	Kokolek et al. (2019), Weritz et al. (2020)
Commitment of the management	Ko et al. (2022)
Strategic vision, creation of the strategic framework of DT	Kokolek et al. (2019), Ko et al. (2022)
Ability to apply new technologies to the business	Kokolek et al. (2019),
Possessing the necessary capabilities to ensure digital transformation	Van Tonder et al. (2020)
Creating a digital transformation team	Evans et al. (2021)
Culture and people	Jacobi and Brenner (2018)

Source: own

2.3 Leadership in process of digital transformation

Based on a systematic review of the literature, we found that three aspects are present within the analysed publications that explicitly discuss the definition of digital leadership. Firstly, existing literature does not clearly define the relationship between e-leadership and digital leadership. E-leadership is defined as a process of social influence with the mediation

Tab. 4: Steps/dimensions of digital transformation

Steps/dimensions of digital transformation	Van Tonder et al. (2020)	Gaffley and Pelser (2021)	Evans et al. (2021)	Jacobi and Brenner (2018)	Peter et al. (2020)	Andriole (2020)
Install digital leadership				✓	✓	✓
Development of new products/services and/or digitalisation of existing ones	✓					
Development of employees' digital competences		✓		✓		
Digitalisation of customer platforms (channels)	✓					
Transforming the user experience (customers, partners, workforce)						
Identifying and acquiring the necessary resources for incorporating digital technologies	✓					
Digitalisation of business processes					✓	✓
Changing/modifying the organisation – structure, incentives and culture			✓			✓
Digitalisation of existing capabilities	✓					
Building a digital strategy	✓	✓		✓	✓	
Creating cross-functional teams		✓		✓		
Building stronger ties with stakeholders				✓		
Collecting digital knowledge and experience at the organisational level				✓		
Creation and measurement of key performance areas KPAs		✓				

Source: own

of advanced information technologies in order to change the attitudes, feelings, opinions, behaviour and performance of individuals, groups and organisations. Furthermore, e-leadership does not change the basis of business; rather, technology helps to realise business. Also, some authors treat e-leadership and digital leadership as synonyms. Secondly, the analysed literature provides a concise definition of digital leadership that blurs the distinction between e-leadership and digital leadership. Thirdly, the results show that e-leadership and digital leadership are not synonyms, suggesting that digital leadership is much broader than e-leadership, as e-leadership primarily uses technology to support existing business. Digital leadership is an important component of achieving the goal of digitally enabled business model, digital organisations, and management of employees (Eberl & Drews, 2021).

Digital leadership entails the ability to direct resources and utilise information communication technologies to achieve the organisation's goals, significantly contributing to organisational performance (Suryadi Muslim & Setyono, 2024). Furthermore, the leadership required to achieve digital transformation can be identified by the strategic leadership of digitalisation, which involves leaders' ability to create a clear and understandable vision for the digitalisation process as well as the ability to implement the strategy in order to achieve the digital transformation (Engesmo & Panteli, 2021). Digital leadership is a combination of a transformational leadership

style and the use of digital technology (Mihardjo & Rukmana, 2019), or even a combination of digital competencies and digital culture (Mihardjo et al., 2019). Digital leadership can also be defined as the complete transformation of business operations, as well as the enhancement of organisational performance in specific areas through the application of technology across all aspects of business (Arabiun et al., 2024).

Values, skills and behaviour of leaders are crucial in directing and leading organisational development processes (Zivkovic, 2022). Taking into account the role of leadership in the process of digital transformation, starting with authors that emphasise the exclusive responsibility for digital transformation success lies with top management (Abbu et al., 2022; Kontic & Vidicki, 2018; McCarthy et al., 2021; Sow & Aborbie, 2018), the research results indicate that digitally mature organisations support agile principles to a much greater extent such as transparent and open communication regarding digital projects and draw and generate new ideas based on communication

Tab. 5: Competencies/skills/characteristics of digital leaders

Source	Characteristics of leadership
Karakose et al. (2021)	Use of technology, managerial skills, individual skills
Zivkovic (2022)	Vision, innovation, flexibility, understanding of digital technologies, collaboration, empowerment, multiple intelligences, continuous learning, experimentation
Guzmán et al. (2020)	Cognitive skills, interpersonal skills, strategic skills
Gilli et al. (2023)	Cooperation, strategic thinking, team leadership skills, customer orientation, communication skills
Imran et al. (2021)	Adaptability, data-driven decision-making, understanding new digital technologies, risk taking ability, vision, empowerment, failing fast
Schiuma et al. (2022)	Mentor, pragmatist, catalyst, communicator, righteous, facilitator
Schiuma et al. (2021)	Righteous, dreamer, builder, charismatic, bright, generous
Abdallah et al. (2021)	Flexibility, diversified knowledge, priority and results focus, ownership and responsibility
Bygstad et al. (2017)	Deep employee participation, leadership that leverages employee knowledge
Cortellazzo et al. (2019)	Digital skills, human skills, change initiation, problem solving
Cuya and Bayona-Oré (2022)	Communication knowledge, technological knowledge
Eberl and Drews (2021)	Visionary, digital literacy, cooperation, adaptability, motivation
Imran et al. (2021)	Digital vision, digital knowledge, empowerment, management of diverse teams, risk taking
Larjovuori et al. (2018)	Strong vision and clear goals, commitment and investment, leading cultural changes, coaching, promoting participation, customer orientation, collaboration and partnership
McCarthy et al. (2021)	Digital architect, digital strategist, digital culturalist, customer centrist, business process optimiser, digital workplace landscaper, data advocate, organisational agilist
Mihardjo et al. (2019)	Communication, computing, content, telecommunications
Noonpakdee et al. (2020)	Business, digital technology, leadership, process, change (strategy)

Source: own

with clients, suppliers and business partners to a much greater extent. Digitally mature organisations also have leaders who have a high level of education, exhibit entrepreneurial behaviour, and foster digital transformation. In conclusion, leaders in digitally mature organisations contribute significantly to digital transformation. Overcoming negative perceptions of organisational digital transformation is possible by adopting new trends in developing the skills of employees, especially leaders (Sousa & Rocha, 2019). The successful leader in the digital age is one who has leadership skills (Mihardjo et al., 2019), a mindset that adapts to digital transformation, and is able to recognise and seize the opportunity to be informed, make timely decisions in order to adjust strategy when risky situations arise, contributing significantly to the organisation's optimal development (Hai et al., 2021).

Tab. 5 presents a list of the most common competencies of digital leadership that are cited in the analysed papers as research results. However, a conclusion can be found that there is no single conceptual framework of digital leadership competencies, which are not unified (Wahyuningsih & Asri, 2024).

According to previous studies, digitally mature organisations differ from digitally developing organisations when it comes to leadership competencies. As a result, leadership competencies play an important role in the development and success of the digital transformation process, particularly the combination of digital and human skills (Cortellazzo et al., 2019). One of the key competencies of a leader in the digital era is trust (Savolainen, 2018), which can be the basis of a separate leadership style. Digital transformation requires a new form of leadership (Kohnke, 2017), while innovations in digital leadership are set as a new type of support in the form of digital innovations (Nurhidayati & Ratnasari, 2021; Wasono & Furinto, 2018) of the business model (Yopan et al., 2022). In order to achieve digital leadership, there are three leadership styles – administrative leadership, adaptive leadership, and enabling leadership, on the one hand, and four platforms – an adoption platform, a learning platform, an innovation platform, and a system and business platform – on the other (Tanniru et al., 2018).

Digital leadership enabled business model by: i) transforming the role, skills, and style of the digital leader; ii) realising a digital organisation, including governance, vision, values, structure, culture, and decision processes; and iii) adjusting management, virtual teams, knowledge, and communication and collaboration on the individual level (Eberl & Drews, 2021). In the digital age, leadership is clearly becoming a recognised leadership style based on two dimensions that are balanced. Firstly, it is characterised by a behavioural perspective and a focus on the human aspects and teamwork of the organisation, but on the other hand, it is characterised by a strong focus on innovation and digital technology adoption (Oberer & Erkollar, 2018; Weber et al., 2022), which is affected by digital transformation (Panshin et al., 2021).

Leaders in today's organisations need to ask a few key questions (Ko et al., 2022): How will the development of digital technologies and business models affect organisations in the future? How well do we understand the power of digitalisation that determines our present and are we capable of making effective choices about how to change it? How to lead the transformation of the company, and develop the necessary organisational capabilities?

Successful digital transformation begins with a change in mindset among employees, leadership, and throughout all levels of the organisation. These changes lead to a cultural shift that enables the organisation to be agile and ready to take risks. Organisations that initiate this process with a focus solely on technology often find themselves disappointed with the results (Kane, 2019). It is also important to highlight that ineffective leadership is the primary cause of digital transformation failure (Aditya et al., 2021). In the information systems research, top management support is often regarded as a positive phenomenon essential to successful digital transformation, including the implementation of information systems associated with organisational, operational, and strategic changes (Alieva & Powell, 2023; Elbanna & Newman, 2022; Gudergan et al., 2021; Gurkan et al., 2020; Wrede et al., 2020).

Conclusions and discussion

Organisations today are more or less affected by digital transformation. Generally, the authors agree that digital transformation is not a one-time project, but rather a process that manifests itself in different ways and at different

intensities. Without management, digital transformation will happen spontaneously in the organisation, but to achieve the desired results, it must be monitored and managed. There is no doubt that digital transformation is technologically based, but the emphasis should not be solely on technology. Digital transformation is often associated with the following technologies: social media, the internet of things, mobility, big data and analytics, cloud computing, artificial intelligence and blockchain. The main factors enabling digital transformation include (among others) technologies. A customer-centric approach and an effective digital strategy that includes, among other things, the digital ecosystem, or, extending beyond the traditional boundaries of the organisation are essential.

The literature does not offer a generic and generally accepted definition of digital strategy. This is due to the fact that digital transformation takes a different form in different organisations, and it is viewed differently by experts. The following characteristics can be attributed to digital transformation according to the literature review: digital transformation is a continuous process of changing business processes; digital transformation includes the creation of new or the modification of existing business models; digital transformation is more than the implementation of new technologies; digital transformation includes new digital technologies that enable improvements and/or transformation of business processes; digital transformation is a customer-centric mechanism that enables continuous improvements; digital transformation includes the following technologies among others: social media, internet of things, mobility, big data and analytics, cloud computing, artificial intelligence, blockchain, and cloud computing.

Despite the fact that digital transformation can take place spontaneously within organisations, it needs to be managed professionally. The management must have well-defined paths, or road maps, for leading the digital transformation effectively. A strategic approach to digital transformation is very important. Digital transformation challenges must first be identified within the organisation. Limited infrastructure, a lack of digital skills among employees, management's inability to adapt, a lack of resources to integrate digital transformation, organisational culture, a lack of clear plan, and employee resistance all contribute to the challenges of digital transformation. It is essential to identify the challenges of digital transformation, take measures to overcome them, and analyse the key factors of digital transformation. There are numerous actions that must be carried out simultaneously, starting with

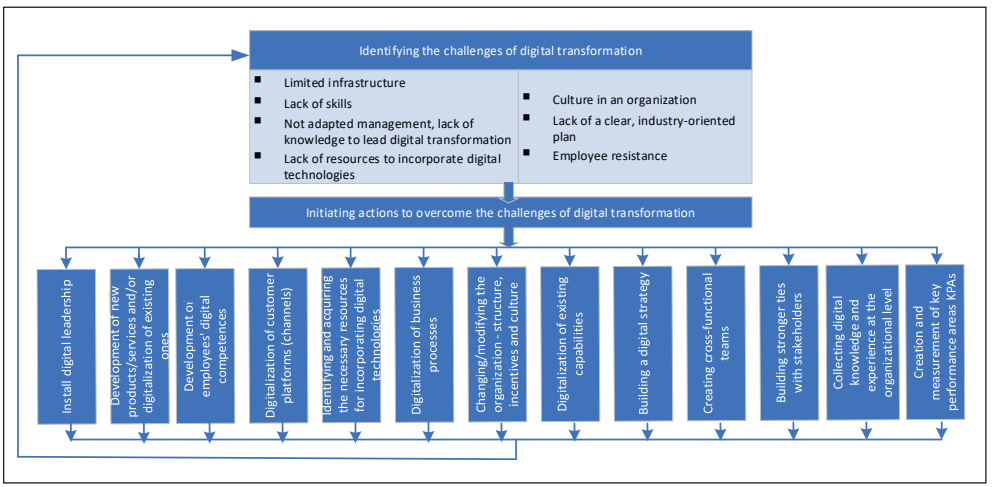


Fig. 2: Framework of digital transformation

Source: own

developing a digital strategy, installing digital leadership, and creating and measuring key performance areas (Fig. 2).

All of the above supports the position that leadership (people, strategy, leadership, business processes and technology) is the fundamental component of digital transformation (Abbu et al., 2022; Abdallah et al., 2021; Grigore & Coman, 2018). Leadership and digital transformation are closely related, which starts with a leader with possessing visionary thinking, agility, an understanding of the value of data, data-driven decision-making, knowledge of strategy, and a willingness to embrace change and changes in culture and networking (Larjovuori et al., 2018; Philip et al., 2023).

The readiness of an organisation for transformation can be determined by a number of factors. From the position of practical and academic views, it is concluded that organisations in this process require not only individual commitments, such as executive directors, but also teams of competent managers, who will take responsibility for the success of the digital transformation process. Whether they succeed or fail depends greatly on their ability to build leadership trust and apply it for transformation. Digital transformation research suggests that leaders create a roadmap for the transformation process so as to know where they want their organisations to be in three to five years. A chief executive officer (CEO) plays a very important role in the transformation process, and managers and leaders will face significant challenges in the future (Cortellazzo et al., 2019; Zeike et al., 2019). Changing the way an organisation thinks has a big impact on leadership and management (Evans et al., 2021).

Digital transformation brings significant challenges when it comes to managerial competencies. In order to improve business efficiency and introduce digital innovations, digital technologies require new competencies that must be combined with existing ones (Henderikx & Stoffers, 2022; Pihlajamaa et al., 2021), since the development of higher levels of digital transformation is far more related to the characteristics of the management than to the characteristics of the organisation (Porfírio et al., 2021).

A key requirement for the positive development of the change process is a change in leadership style, which managers realise is necessary. Study results indicate that managers need to remove themselves from their personal comfort zones in order to learn a new way of behaving and implement changes. To address possible uncertainties (and potential fears) on the part of employees, managers believe it will be helpful to define a clear vision that will enable the new culture of leadership to flourish (Sokolovic et al., 2022). On the other hand, they propose specific goals that can be achieved with AI in leadership and culture and indicate the personal use of new technologies.

Contribution, limitations and suggestions for future research. Both practitioners and researchers can benefit from a clearer definition of digital transformation. This proposed framework can serve as a starting point for digital transformation research, both for researchers and for organisations managing digital transformation. In establishing training requirements and recruiting adequate employees, HR management can utilise the proposed competencies list. There are certain limitations in the conducted systematic literature review. Only two, albeit the largest, citation databases were searched, and only papers in English were identified. The established framework should be verified and expanded through empirical research (Gudergan et al., 2021), due to a lack of empirical research that addresses the relationship between digital leadership and digital transformation process (Müller at al., 2024). Both HR management and experts who are familiar with and lead digital transformations in organisations should empirically verify the identified competencies. Future research should focus on the relationship between digital leadership and organisational performance (Abbu et al., 2022), as well as the development of the digital maturity assessment model, which comprises a variety of dimensions, although most of them cover technology, people, and strategy. Furthermore, future research should also analyse companies with a high level of digital transformation maturity and identify the characteristics of leaders that enabled this maturity and the degree of implementation of the digital workplace.

References

Abbu, H., Fleischmann, D., & Gopalakrishna, P. (2021). The case of digital transformation in grocery business: A conceptual model of digital grocery ecosystem. In *Proceedings of 2021 IEEE International Conference on*

Engineering, Technology and Innovation (ICE/ITMC) (pp. 1–9). IEEE. https://doi.org/10.1109/ice/itmc52061.2021.9570219

Abbu, H., Mugge, P., Gudergan, G., Hoeborn, G., & Kwiatkowski, A. (2022). Measuring the human dimensions of digital leadership for successful digital transformation: Digital leaders can use the authors' digital leadership scale to assess their own readiness and ability to accelerate digital transformation. *Research-Technology Management*, *65*(3), 39–49. https://doi.org/10.1080/08956308.2022.2048588

Abdallah, Y. O., Shehab, E., & Al-Ashaab, A. (2021). Towards managing digital transformation in manufacturing industry: Theoretical framework. In M. Shafik & K. Case (Eds.), *Advances in manufacturing technology XXXIV* (pp. 21–26). IOS Press. https://doi.org/10.3233/atde210006

Aditya, B. R., Ferdiana, R., & Kusumawardani, S. S. (2021). Categories for barriers to digital transformation in higher education: An analysis based on literature. *International Journal of Information and Education Technology*, *11*(12), 658–664. https://doi.org/10.18178/ijiet.2021.11.12.1578

Alieva, J., & Powell, D. J. (2023). The significance of employee behaviours and soft management practices to avoid digital waste during a digital transformation. *International Journal of Lean Six Sigma*, *14*(1), 1–32. https://doi.org/10.1108/ijlss-07-2021-0127

AlNuaimi, B. K., Kumar Singh, S., Ren, S., Budhwar, P., & Vorobyev, D. (2022). Mastering digital transformation: The nexus between leadership, agility, and digital strategy. *Journal of Business Research*, *145*, 636–648. https://doi.org/10.1016/j.jbusres.2022.03.038

Alshehab, A., Alfozan, T., Gaderrab, H. F., Alahmad, M. A., & Alkandari, A. (2022). Identifying significant elements of the digital transformation of organizatios in Kuwait. *Indonesian Journal of Electrical Engineering and Computer Science*, *26*(1), 318. https://doi.org/10.11591/ijeecs.v26.i1.pp318-325

Andriole, S. J. (2020). The hard truth about soft digital transformation. *IT Professional*, *22*(5), 13–16. https://doi.org/10.1109/mitp.2020.2972169

Arabiun, A., Tajpour, M., & Zahedi, M. R. (2024). The effect of digital leadership on the performance of businesses: The mediating role of organizational entrepreneurship. *International Journal of Human Capital in Urban Management*, *9*(1), 17–28. https://doi.org/10.22034/IJHCUM.2024.01.02

Boneva, M. (2018). Challenges related to the digital transformation of business companies. In O. Dvoulety, M. Lukes, & J. Misar (Eds.), In *Proceedings of The 6th International Conference Innovation Management, Entrepreneurship and Sustainability* (pp. 101–114). OECONOMICA PUBLISHING HOUSE.

Braojos, J., Weritz, P., & Matute, J. (2024). Empowering organisational commitment through digital transformation capabilities: The role of digital leadership and a continuous learning environment. *Information Systems Journal*, 12501. https://doi.org/10.1111/isj.12501

Brown, N., & Brown, I. (2019). From digital business strategy to digital transformation – How: A systematic literature review. In *Proceedings of the South African Institute of Computer Scientists and Information Technologists 2019* (No. 13, pp. 1–8). Association for Computing Machinery. https://doi.org/10.1145/3351108.3351122

Bygstad, B., Aanby, H.-P., & Iden, J. (2017). Leading digital transformation: The Scandinavian way. In *Nordic contributions in IS research* (pp. 1–14). Springer International Publishing. https://doi.org/10.1007/978-3-319-64695-4_1

Carcary, M., Doherty, E., & Conway, G. (2016). A dynamic capability approach to digital transformation: A focus on key foundational themes. In P. Silva, A. Guerreiro, & R. Quaresma (Eds.), *Proceedings of the 10th European Conference on Information Systems Management* (pp. 20–28). Academic Conferences Ltd.

Carvalho, J., Pires, H., Borges, A. P., Vieira, E., & Monteiro, M. (2023). Digital leadership: Characteristics, challenges. And opportunities. In A. M. Even & B. Christiansen (Eds.), *Enhancing employee engagement and productivity in the post-pandemic multigenerational workforce* (pp. 204–218). IGI Global. https://doi.org/10.4018/978-1-6684-9172-0.ch010

Cortellazzo, L., Bruni, E., & Zampieri, R. (2019). The role of leadership in a digitalized world: A review. *Frontiers in Psychology*, *10*. https://doi.org/10.3389/fpsyg.2019.01938

Criado-Perez, C., Shinkle, G. A., Höllerer, M. A., Sharma, A., Collins, C., Gardner, N., Hank Haeusler, M., & Pan, S. (2022). Digital transformation in the Australian AEC industry: Prevailing issues and prospective leadership thinking. *Journal of Construction Engineering and Management*, *148*(1). https://doi.org/10.1061/(asce)co.1943-7862.0002214

Cuya, M., & Bayona-Oré, S. (2022). From e-government to digital transformation: Leadership. In *Lecture Notes in Networks and Systems* (pp. 147–155). Springer Singapore. https://doi.org/10.1007/978-981-16-2380-6_13

Danielsen, A. V. (2020). Digital transformation and its potential effects on future management: Insights from an ETO context. In B. Lalic, V. Majstorovic, U. Marjanovic, G. Cieminski, & D. Romero (Eds.), *Advances in production management systems. Towards smart and digital manufacturing* (Vol. 592, pp. 146–153). Springer International Publishing. https://doi.org/10.1007/978-3-030-57997-5_18

Eberl, J. K., & Drews, P. (2021). Digital leadership – Mountain or molehill? A literature review. In *Innovation through information systems* (pp. 223–237). Springer International Publishing. https://doi.org/10.1007/978-3-030-86800-0_17

Egor, P. (2020). Digital transformation of industrial companies: What is Management 4.0? In *Proceedings of 2020 The 11th International Conference on E-Business, Management and Economics* (pp. 131–138). ACM. https://doi.org/10.1145/3414752.3414779

Elbanna, A., & Newman, M. (2022). The bright side and the dark side of top management support in digital transformation – A hermeneutical reading. *Technological Forecasting and Social Change*, *175*, 121411. https://doi.org/10.1016/j.techfore.2021.121411

Elidjen, D., Mihardjo, L. W. W., & Rukmana, R. A. N. (2019). Intervening role of innovation management on relationship between digital leadership and dynamic capability accelerated by collaboration. *International Journal of Innovation, Creativity and Change*, *6*(1), 249–264.

Engesmo, J., & Panteli, N. (2021). Digital leaders and the transformation of the IT function. *Scandinavian Journal of Information Systems*, *33*(1), 4.

Evans, N., Qureshi, A., & Miklosik, A. (2021). Digital enterprise transformation: Lessons learnt from expert experience. In *Proceedings of the European Conference on Knowledge Management* (pp. 268–275). EKCM.

Fachrunnisa, O., Adhiatma, A., Lukman, N., & Ab. Majid, M. N. (2020). Towards SMEs' digital transformation: The role of agile leadership and strategic flexibility. *Journal of Small Business Strategy*, *30*(3), 65–85.

Florek-Paszkowska, A., Ujwary-Gil, A., & Godlewska-Dzioboń, B. (2021). Business innovation and critical success factors in the era of digital transformation and turbulent times. *Journal of Entrepreneurship, Management and Innovation*, *17*(4), 7–28. https://doi.org/10.7341/20211741

Gaffley, G., & Pelser, T. G. (2021). Developing a digital transformation model to enhance the strategy development process for leadership in the South African manufacturing sector. *South African Journal of Business Management*, *52*(1). https://doi.org/10.4102/sajbm.v52i1.2357

Gierlich-Joas, M. (2021). Identifying and overcoming future challenges in leadership: The role of IS in facilitating empowerment. In F. Ahlemann, R. Schütte, & S. Stieglitz (Eds.), *Innovation Through Information Systems* (Vol. 48, pp. 537–553). Springer International Publishing. https://doi.org/10.1007/978-3-030-86800-0_38

Gilli, K., Nippa, M., & Knappstein, M. (2023). Leadership competencies for digital transformation: An exploratory content analysis of job advertisements. *German Journal of Human Resource Management: Zeitschrift Für Personalforschung*, *37*(1), 50–75. https://doi.org/10.1177/23970022221087252

Grigore, A. M., & Coman, A. (2018). The hourglass effect: Leadership transformations in the digital era. In *Proceedings of the 12th International Management Conference: Management Perspectives in the Digital Era* (pp. 603–610). Editura ASE.

Gudergan, G., Mugge, P., Kwiatkowski, A., Abbu, H., Hoeborn, G., & Conrad, R. (2021). Digital leadership – Which leadership dimensions contribute to digital transformation success? In *Proceedings of 2021 IEEE International Conference on Engineering, Technology and Innovation (ICE/ITMC)* (pp. 1–8). IEEE. https://doi.org/10.1109/ice/itmc52061.2021.9570231

Guinan, P. J., Parise, S., & Langowitz, N. (2019). Creating an innovative digital project team: Levers to enable digital transformation. *Business Horizons*, *62*(6), 717–727. https://doi.org/10.1016/j.bushor.2019.07.005

Gurkan, G. C., Cıftcı, G., & Ozyurt, B. (2020). Mutual relationships between digital transformation and leadership. In U. Hacioglu (Ed.), *Advances in e-business research* (pp. 311–331). IGI Global. https://doi.org/10.4018/978-1-7998-1125-1.ch013

Guzmán, V. E., Muschard, B., Gerolamo, M., Kohl, H., & Rozenfeld, H. (2020). Characteristics and skills of leadership in the context of Industry 4.0. *Procedia Manufacturing*, *43*, 543–550. https://doi.org/10.1016/j.promfg.2020.02.167

Hai, T. N., Van, Q. N., & Thi Tuyet, M. N. (2021). Digital transformation: Opportunities and challenges for leaders in the emerging countries in response to COVID-19 pandemic. *Emerging Science Journal*, *5*, 21–36. https://doi.org/10.28991/esj-2021-sper-03

Hansen, A. M., Kraemmergaard, P., & Mathiassen, L. (2011). Rapid adaptation in digital transformation: A participatory process for engaging IS and business leaders. *MIS Quarterly Executive*, *10*(4), 175–185.

Henderikx, M., & Stoffers, J. (2022). An exploratory literature study into digital transformation and leadership: Toward future-proof middle managers. *Sustainability*, *14*(2), 687. https://doi.org/10.3390/su14020687

Heracleous, L., & Gledhill, D. (2024). Why digital transformation may fail – And what can be done about it. *The Journal of Applied Behavioral Science*, *60*(1), 215–219. https://doi.org/10.1177/00218863231176567

Imran, F., Shahzad, K., Butt, A., & Kantola, J. (2021). Digital transformation of industrial organisations: Toward an integrated framework. *Journal of Change Management*, *21*(4), 451–479. https://doi.org/10.1080/14697017.2021.1929406

Jacobi, R., & Brenner, E. (2018). How large corporations survive digitalization. In C. Linnhoff-Popien, R. Schneider, & M. Zaddach (Eds.), *Digital marketplaces unleashed* (pp. 83–97). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-662-49275-8_11

Jayawardena, C. D. W., Albattat, A., & Jaharadak, A. A. (2020). Synthesis of digital transformation beyond technology perspective: Digital strategy, leadership & culture. *Journal of Critical Reviews*, *7*(09), 349–357. https://doi.org/10.31838/jcr.07.09.01

Kane, G. (2019). The technology fallacy: People are the real key to digital transformation. *Research-Technology Management*, *62*(6), 44–49. https://doi.org/10.1080/08956308.2019.1661079

Karakose, T., Polat, H., & Papadakis, S. (2021). Examining teachers' perspectives on school principals' digital leadership roles and technology capabilities during the COVID-19 pandemic. *Sustainability*, *13*(23), 13448. https://doi.org/10.3390/su132313448

Ko, A., Fehér, P., Kovacs, T., Mitev, A., & Szabó, Z. (2022). Influencing factors of digital transformation: Management or IT is the driving force? *International Journal of Innovation Science*, *14*(1), 1–20. https://doi.org/10.1108/ijis-01-2021-0007

Kohnke, O. (2017). It's not just about technology: The people side of digitization. In G. Oswald & M. Kleinemeier (Eds.), *Shaping the digital enterprise* (pp. 69–91). Springer International Publishing. https://doi.org/10.1007/978-3-319-40967-2_3

Kokolek, N., Jakovic, B., & Curlin, T. (2019). Digital knowledge and skills – Key factors for digital transformation. In *Proceedings of the 30th International DAAAM Symposium 2019* (pp. 0046–0053). DAAAM International Vienna. https://doi.org/10.2507/30th.daaam.proceedings.006

Kontić, L., & Vidicki, Đ. (2018). Strategy for digital organization: Testing a measurement tool for digital transformation. *Strategic Management*, *23*(1), 29–35. https://doi.org/10.5937/straman1801029k

Kringelum, L. B., Holm, C. G., Holmgren, J., Friis, O., & Jensen, K. F. (2024). Digital transformation: Strategy comes first to lay the groundwork. *Journal of Business Strategy*. https://doi.org/10.1108/jbs-09-2023-0199

Kutnjak, A., Pihiri, I., & Furjan, M. T. (2019). Digital transformation case studies across industries – Literature review. In *Proceedings of 2019 42nd International Convention on Information and Communication Technology, Electronics and Microelectronics (MIPRO)* (pp. 1293–1298). IEEE. https://doi.org/10.23919/mipro.2019.8756911

Larjovuori, R.-L., Bordi, L., & Heikkilä-Tammi, K. (2018). Leadership in the digital business transformation. In *Proceedings of the 22nd International Academic Mindtrek Conference* (pp. 212–221). ACM. https://doi.org/10.1145/3275116.3275122

Lorentzen, A.-C. R. (2022). Digital transformation as distributed leadership: Firing the change agent. *Procedia Computer Science*, *196*(2022), 245–254. https://doi.org/10.1016/j.procs.2021.12.011

Luo, Y., Cui, H., Zhong, H., & Wei, C. (2023). Business environment and enterprise digital transformation. *Finance Research Letters*, *57*, 104250. https://doi.org/10.1016/j.frl.2023.104250

McCarthy, P., Sammon, D., & Alhassan, I. (2021). Digital transformation leadership characteristics: A literature analysis. *Journal of Decision Systems*, *32*(1), 79–109. https://doi.org/10.1080/12460125.2021.1908934

Mhlungu, N. S. M., Chen, J. Y. J., & Alkema, P. (2019). The underlying factors of a successful organisational digital transformation. *SA Journal of Information Management*, *21*(1), 52–72. https://doi.org/10.4102/sajim.v21i1.995

Mihardjo, L. W. W., & Rukmana, R. A. (2019). Dynamic capability, market orientation and innovation capability: The role of digital leadership for Indonesia telecommunication firms in facing disruptive era. In *Proceedings of the International Conference on Industrial Engineering and Operations Management* (pp. 1218–1222). IEOM Society International.

Mihardjo, L. W. W., Sasmoko, S., Alamsjah, F., & Elidjen, E. (2019). Digital leadership role in developing business model innovation and customer experience orientation in Industry 4.0. *Management Science Letters*, *9*(11), 1749–1762. https://doi.org/10.5267/j.msl.2019.6.015

Müller, S. D., Konzag, H., Nielsen, J. A., & Sandholt, H. B. (2024). Digital transformation leadership competencies: A contingency approach. *International Journal of Information Management*, *75*, 102734. https://doi.org/10.1016/j.ijinfomgt.2023.102734

Noonpakdee, W., Phothichai, A., Khunkornsiri, T., & Nuntree, A. (2020). CIO competency in digital era: A comparative study between government organisations and private enterprises. In *Proceedings of 2020 IEEE 7th International Conference on Industrial Engineering and Applications (ICIEA)* (pp. 948–952). IEEE. https://doi.org/10.1109/iciea49774.2020.9101988

Nurhidayati, & Ratnasari, S. W. (2021). Digital transformation of organisations: Perspectives from digital citizenship and spiritual innovative leadership. In L. Barolli, A. Poniszewska-Maranda, & T. Enokido (Eds.), *Advances in intelligent systems and computing* (pp. 485–489). Springer International Publishing. https://doi.org/10.1007/978-3-030-50454-0_50

Oberer, B., & Erkollar, A. (2018). Leadership 4.0: Digital leaders in the age of Industry 4.0. *International Journal of Organizational Leadership*, *7*(4), 404–412. https://doi.org/10.33844/ijol.2018.60332

O'Leary, D. E. (2023). Digitization, digitalization, and digital transformation in accounting, electronic commerce, and supply chains. *Intelligent Systems in Accounting, Finance and Management*, *30*(2), 101–110. https://doi.org/10.1002/isaf.1524

Panshin, I., Solovieva, O., Kornilova, O., & Eronin, V. (2021). The impact of digitalization on leadership. In E. G. Popkova & B. S. Sergi (Eds.), *Modern Global Economic System: Evolutional Development vs. Revolutionary Leap* (Vol. 198, pp. 1272–1278). Springer International Publishing. https://doi.org/10.1007/978-3-030-69415-9_139

Paul, J., Ueno, A., Dennis, C., Alamanos, E., Curtis, L., Foroudi, P., Kacprzak, A., Kunz, W. H., Liu, J., Marvi, R., Nair, S. L. S., Ozdemir, O., Pantano, E., Papadopoulos, T., Petit, O., Tyagi, S., & Wirtz, J. (2024). Digital transformation: A multidisciplinary perspective and future research agenda. *International Journal of Consumer Studies*, *48*(2), 13015. https://doi.org/10.1111/ijcs.13015

Peter, M. K., Kraft, C., & Lindeque, J. (2020). Strategic action fields of digital transformation: An exploration of the strategic action fields of Swiss SMEs and large enterprises. *Journal of Strategy and Management*, *13*(1), 160–180. https://doi.org/10.1108/jsma-05-2019-0070

Philip, J., & Gavrilova Aguilar, M. (2022). Student perceptions of leadership skills necessary for digital transformation. *Journal of Education for Business*, *97*(2), 86–98. https://doi.org/10.1080/08832323.2021.1890540

Philip, J., Gilli, K., & Knappstein, M. (2023). Identifying key leadership competencies for digital transformation: Evidence from a cross-sectoral Delphi study of global managers. *Leadership & Organization Development Journal*, *44*(3), 392–406. https://doi.org/10.1108/lodj-02-2022-0063

Pihlajamaa, M., Malmelin, N., & Wallin, A. (2021). Competence combination for digital transformation: A study of manufacturing companies in Finland. *Technology Analysis & Strategic Management*, *35*(10), 1355–1368. https://doi.org/10.1080/09537325.2021.2004111

Porfírio, J. A., Carrilho, T., Felício, J. A., & Jardim, J. (2021). Leadership characteristics and digital transformation. *Journal of Business Research*, *124*, 610–619. https://doi.org/10.1016/j.jbusres.2020.10.058

Reis, J., & Melão, N. (2023). Digital transformation: A meta-review and guidelines for future research. *Heliyon*, *9*(1), e12834. https://doi.org/10.1016/j.heliyon.2023.e12834

Salume, P. K., Barbosa, M. W., Pinto, M. R., & Sousa, P. R. (2021). Key dimensions of digital maturity: A study with retail sector companies in Brazil. *RAM. Revista de Administração Mackenzie*, *22*(6). https://doi.org/10.1590/1678-6971/eramd210071

Savolainen, T. (2018). Trust as leadership resource and skill in the services and tourism business: Views on managing intangibles in the digital era. In *Proceedings of International Conference on Tourism Research* (pp. 129–133). ACAD.

Schiuma, G., Schettini, E., & Santarsiero, F. (2021). How wise companies drive digital transformation. *Journal of Open Innovation: Technology, Market, and Complexity*, *7*(2), 122. https://doi.org/10.3390/joitmc7020122

Schiuma, G., Schettini, E., Santarsiero, F., & Carlucci, D. (2022). The transformative leadership compass: Six competencies for digital transformation entrepreneurship. *International Journal of Entrepreneurial Behavior & Research*, *28*(5), 1273–1291. https://doi.org/10.1108/ijebr-01-2021-0087

Schwaferts, D., & Baldi, S. (2018). Digital transformation management and digital business development. In R. Dornberger (Ed.), *Studies in systems, decision and control* (pp. 147–159). Springer International Publishing. https://doi.org/10.1007/978-3-319-74322-6_10

Schwarzmüller, T., Brosi, P., Duman, D., & Welpe, I. M. (2018). How does the digital transformation affect organisations? Key themes of change in work design and leadership. *Management Revue*, *29*(2), 114–138. https://doi.org/10.5771/0935-9915-2018-2-114

Sokolović, B., Katić, I., Grubić-Nešić, L., Ivanišević, A., & Pavlović, A. (2022). The specific role of transformational leadership in the organizational culture of service organizations. *Anali Ekonomskog Fakulteta u Subotici*, (47), 131–145. https://doi.org/10.5937/aneksub2247131s

Solberg, E., Traavik, L. E. M., & Wong, S. I. (2020). Digital mindsets: Recognizing and leveraging individual beliefs for digital transformation. *California Management Review*, *62*(4), 105–124. https://doi.org/10.1177/0008125620931839

Sousa, M. J., & Rocha, Á. (2019). Digital learning: Developing skills for digital transformation of organizations. *Future Generation Computer Systems*, *91*, 327–334. https://doi.org/10.1016/j.future.2018.08.048

Suryadi, S., Muslim, A. Q., & Setyono, L. (2024). Exploring the nexus of digital leadership and digital literacy on higher education performance: The role of digital innovation. *European Journal of Educational Research*, *13*(1), 207–218. https://doi.org/10.12973/eu-jer.13.1.207

Tanniru, M., Khuntia, J., & Weiner, J. (2018). Hospital leadership in support of digital transformation. *Pacific Asia Journal of the Association for Information Systems*, *10*(3), 1–24. https://doi.org/10.17705/1pais.10301

Tekic, Z., & Koroteev, D. (2019). From disruptively digital to proudly analog: A holistic typology of digital transformation strategies. *Business Horizons*, *62*(6), 683–693. https://doi.org/10.1016/j.bushor.2019.07.002

Trenerry, B., Chng, S., Wang, Y., Suhaila, Z. S., Lim, S. S., Lu, H. Y., & Oh, P. H. (2021). Preparing workplaces for digital transformation: An integrative review and framework of multi-level factors. *Frontiers in Psychology*, *12*. https://doi.org/10.3389/fpsyg.2021.620766

Tu, Y., & Chi, M. (2020). Exploring the digital transformation based on big data with ubiquitous internet of everything. In *Proceedings of Nineteenth Wuhan International Conference on E-Business* (pp. 131–136). UNIV CALGARY PRESS.

Tungpantong, C., Nilsook, P., & Wannapiroon, P. (2021). A conceptual framework of factors for information systems success to digital transformation in higher education institutions. In *Proceedings of 2021 9th International Conference on Information and Education Technology (ICIET)* (pp. 57–62). IEEE. https://doi.org/10.1109/iciet51873.2021.9419596

Ubiparipovic, B., Matkovic, P., & Pavlicevic, V. (2023). Key activities of digital business transformation process. *Strategic Management*, *28*(1), 33–40. https://doi.org/10.5937/straman2200016u

Urs, N., Nisioi, I., & Roja, A. (2023). Leading the way: How leaders facilitate digital transformation in organizations. In *Proceedings of the Central and Eastern European eDem and eGov Days 2023* (pp. 145–152). ACM. https://doi.org/10.1145/3603304.3603352

Van Tonder, C., Schachtebeck, C., Nieuwenhuizen, C., & Bossink, B. (2020). A framework for digital transformation and business model innovation. *Management*, *25*(2), 111–132. https://doi.org/10.30924/mjcmi.25.2.6

Venkatesh, R., Mathew, L., & Singhal, T. K. (2019). Imperatives of business models and digital transformation for digital services providers. *International Journal of Business Data Communications and Networking*, *15*(1), 105–124. https://doi.org/10.4018/ijbdcn.2019010107

Vial, G. (2019). Understanding digital transformation: A review and a research agenda. *The Journal of Strategic Information Systems*,

28(2), 118–144. https://doi.org/10.1016/j.jsis.2019.01.003

Wahyuningsih, S. H., & Asri, R. W. P. (2024). The conceptual structure and thematic evolution of the digital leadership knowledge base. *Multidisciplinary Reviews*, *7*(4), 2024073. https://doi.org/10.31893/multirev.2024073

Wasono, L., & Furinto, A. (2018). The effect of digital leadership and innovation management for incumbent telecommunication company in the digital disruptive era. *International Journal of Engineering & Technology*, *7*(2.29), 125–130. https://doi.org/10.14419/ijet.v7i2.29.13142

Weber, E., Büttgen, M., & Bartsch, S. (2022). How to take employees on the digital transformation journey: An experimental study on complementary leadership behaviors in managing organizational change. *Journal of Business Research*, *143*, 225–238. https://doi.org/10.1016/j.jbusres.2022.01.036

Weritz, P., Braojos, J., & Matute, J. (2020). Exploring the antecedents of digital transformation: Dynamic capabilities and digital culture aspects to achieve digital maturity. In *AMCIS 2020 Proceedings* (pp. 1–10). Association for Information Systems.

Wrede, M., Velamuri, V. K., & Dauth, T. (2020). Top managers in the digital age: Exploring the role and practices of top managers in firms' digital transformation. *Managerial and Decision Economics*, *41*(8), 1549–1567. https://doi.org/10.1002/mde.3202

Xiao, Y., & Watson, M. (2019). Guidance on conducting a systematic literature review. *Journal of Planning Education and Research*, *39*(1), 93–112. https://doi.org/10.1177/0739456x17723971

Yopan, M., Kasali, R., Balqiah, T. E., & Pasaribu, M. (2022). The role of digital leadership, customer orientation and business model innovation for IoT companies. *International Journal of Business*, *27*(2), 1–22. https://doi.org/10.55802/IJB.027(2).007

Zaoui, F., & Souissi, N. (2020). Roadmap for digital transformation: A literature review. *Procedia Computer Science*, *175*, 621–628. https://doi.org/10.1016/j.procs.2020.07.090

Zeike, S., Bradbury, K., Lindert, L., & Pfaff, H. (2019). Digital leadership skills and associations with psychological well-being. *International Journal of Environmental Research and Public Health*, *16*(14), 2628. https://doi.org/10.3390/ijerph16142628

Zhu, X., Ge, S., & Wang, N. (2021). Digital transformation: A systematic literature review. *Computers & Industrial Engineering*, *162*, 107774. https://doi.org/10.1016/j.cie.2021.107774

Zimmermann, A., Schmidt, R., & Sandkuhl, K. (2019). Multiple perspectives of digital enterprise architecture. In *Proceedings of the 14th International Conference on Evaluation of Novel Approaches to Software Engineering* (pp. 547–554). SCITEPRESS – Science and Technology Publications. https://doi.org/10.5220/0007769105470554

Zivkovic, S. (2022). Inspiring digital transformation: An integrative leadership competency framework. *Ekonomska Misao i Praksa*, *31*(1), 237–254. https://doi.org/10.17818/emip/2022/1.11

Zulu, S. L., & Khosrowshahi, F. (2021). A taxonomy of digital leadership in the construction industry. *Construction Management and Economics*, *39*(7), 565–578. https://doi.org/10.1080/01446193.2021.1930080

An attempt to resolve no-wait flow shop scheduling problems using hybrid ant colony and whale optimization algorithms

Reza Rostamzadeh[1], Arezou Gholipour[2], Mohammad Reza Komari Alaei[3], Edmundas Kazimieras Zavadskas[4], Jonas Saparauskas[5]

1 *Artificial Intelligence, Automation, Big Data Research Center, Urmia Branch; Islamic Azad University, Iran, ORCID: 0000-0002-6161-7173, reza.rostamzadeh@iau.ac.ir (corresponding author);*
2 *Alghadir Institute of Higher Education, Department of Industrial Engineering Management, Iran, ORCID: 0000-0002-6366-5283, Arezougholipour072@gmail.com;*
3 *Alghadir Institute of Higher Education, Department of Industrial Engineering Management, Iran, ORCID: 0000-0002-5547-5703, komari.reza@alghadir.ac.ir;*
4 *Vilnius Gediminas Technical University, Faculty of Civil Engineering, Institute of Sustainable Construction, Lithuania, ORCID: 0000-0002-3201-949X, edmundas.zavadskas@vilniustech.lt;*
5 *Vilnius Gediminas Technical University, Faculty of Civil Engineering, Department of Construction Management and Real Estate, Lithuania, ORCID: 0000-0003-3685-7754, jonas.saparauskas@vilniustech.lt.*

Abstract: *The incentive for many developments and scientific progresses within the field of scheduling has emerged from industrial environments, and naturally, it could be utilized in expressing the scheduling concepts regarding terms used in the industry. Generally speaking, scheduling problems are known as limited optimization issues through which decisions related to the machines' assignment and works processing sequence are probed. Thus, following a review of the related literature, the major goal of this research is to design a mathematical model and to solve it through a meta-heuristic for no-wait flow shop scheduling problem using different machines for the purpose of minimizing the time required to complete the work using whale and ant colony optimization (ACO) algorithms in Sanat-Gostar-e-Hamgam Shoe Company. The ACO and whale algorithm methods are used to compare and predict scheduling activities in manufacturing line of shoe industry. The results showed an ACO algorithm with two stages in mean ideal distance (MID) end amounting to 76.65 and 77.38, respectively. Also, regarding the amounts of standard error mean squares, it could be claimed that the model designed using the improved whale algorithm has a better prediction, and the minimum time required to complete works using the whale algorithm is estimated to be equal to 86.1071. This could lead to an optimal state in achieving the predetermined goals.*

Keywords: *Open shop scheduling, different work stations, single machine problems, resource assignment, ant colony optimization (ACO), whale optimization algorithm (WOA).*

JEL Classification: *C6, C61, C63, M11.*

APA Style Citation: Rostamzadeh, R., Gholipour, A., Komari Alaei, M. R., Zavadskas, E. K., & Saparauskas, J. (2024). An attempt to resolve no-wait flow shop scheduling problems using hybrid ant colony and whale optimization algorithms. *E&M Economics and Management, 27*(2), 108–124. https://doi.org/10.15240/tul/001/2024-2-007

Introduction

Scheduling the process of resources' assignment to activities refers to considering the related timespan in order to optimize one or several goals. Scheduling theory is related to the mathematical models that explain scheduling processes. A theoretical perspective leads to a quantitative outlook to achieve a structure for issues within the framework of mathematic models. This can be achieved through explaining resources, activities and transferring decision-making goals into a target function. Thus, the activities mentioned and goal functions are known as the key elements in mathematical scheduling models. The major decisions in scheduling process include utilizing the resources, rapid responses to the demands and the precise adjustment between delivery and the predetermined delivery times (Arroyo et al., 2011). These include, e.g., operations research (OR), management science, production and operations management, and theoretical computer science. Also, it could be mentioned that many different results were gained as a result. Online scheduling, as a fundamental issue in scheduling theory, has absorbed great attention in studies during recent decades. Workshop flow scheduling has recently been widely used in industrial environments (Ran et al., 2021). Scheduling issues often deal with workshop environments where machine installation time is ignored or considered as part of the processing time. These types of workshop environments are modeled presupposing that installation times are short compared to processing times so that they can be ignored or that installation times are independent of the processing sequence on machines. Therefore, they can be added to processing times. However, in many industrial environments a sequence-dependent installation time occurs when switching jobs on machines. In this case, the installation time is considered as a separate part of the processing time, the amount of which, in addition to the type of work that will be processed on the machine, depends on the type of previous work on which the machine is processed (Baykasoğlu et al., 2020).

The structure of the current research paper is as follows. In section one, the literature review of the study, including scheduling, single and parallel machines, is presented in detail. Section two describes the methodology of the study, specifically the whale optimization algorithm (WOA). Finally, data analysis and conclusions are presented in sections three and four.

1. Review of the related literature

1.1 A review of scheduling problems

Many patterns have been introduced to define scheduling problems and their categorization. There exists a lot of patterns to process each operation regarding scheduling problems due to product manufacturing processes based on the number of operations to process a work and the machines' number presented in each process. Generally, a common problem of scheduling is explained using three symbols in the form of α/β/γ, where α represents the status and position of the machine or the source and usually entails one symbol, β showing the characteristics and details of processing and the current limitations attributed to it and may lack any symbols or may entail several symbols, γ expresses the goal use of the problem and usually entails only a single symbol. Considering the number of operations required to complete a work, scheduling problems could be categorized as follows (Ma et al., 2010).

Single machine problems

Problems related to one machine investigation are known as a crucial part in examining more complex multi-processor problems, as this could be understood as a special case related to them. Furthermore, it can lead to better enhancement and control of more complicated scheduling atmospheres (Pinedo, 2016). Da Silva et al. (2019) introduced makespan minimization in the field of a dynamic single-machine scheduling problem using set-up times being sequence-dependent. Guo et al. (2016) tried to study one machine rescheduling through which new jobs are reworked and added to an existing schedule. Angel-Bello et al. (2021) noticed that it is efficient and fast to control the dynamism in a single machine scheduling problem using set-up times featured with sequence-dependency.

Parallel machines

In this type of machines' settlement, some similar machines are accessible and the work is a single operation and it can be processed on each of these machines. This system is divided into two categories comprising same and different parallel machines regarding the machine characteristics such as processing speed,

manufactured products and production costs (Moradi & Zandieh, 2010). Parallel machines scheduling is known as the most important basic practical and theoretical problem. More recently, Fu et al. (2017) investigated unrelated parallel machines' scheduling problem in the metal packaging industry using job splitting and sequence-dependent set-up time. Also, Baykasoğlu and Ozsoydan (2018) explored a dynamic problem of scheduling with a problem based on the features of parallel heat treatment furnaces of a manufacturing company. Gonzalo and Yuraszeck (2020) carried out a research project on making heuristics for the unrelated parallel machines scheduling problem using machine eligibility and set-up times.

Flow shop introduction

In this manufacturing system, each work requires several operations to be completed. Works are processed on several machines using the same sequence. However, each work's processing time on any machine may differ from the processing time of other works on the same machine (Naderi et al., 2011).

Mixed work flow shop

This is the generalized state of shop flow and parallel machines. In this system, there are several shops using a consecutive form, and several machines work in a parallel state in each shop, through which a maximum of one work is done on a single machine. Often, real-world problems are compatible with the environment in mixed shop flow. The hybrid flow shop scheduling problem (HFSSP), proposed by Arthanari and Ramamurthy (1971) for the first time, is known as a sub-division of the flow shop scheduling problem. Practical manufacturing systems production uses HFSSP (Long et al., 2018). Dios et al. (2018) derived an HFSSP focusing on missing operations. Ying and Lin (2018) suggested a spread HFSSP using multi-processor works. Wei et al. (2019) investigated a two-machine HFSSP using the same works, and Zohali et al. (2019) combined an economic lot-sizing and sequencing problem into an HFSSP. Furthermore, workers' flexibility was introduced in a flexible multi-purpose shop planning problem (FJSSP; Gong et al., 2018a, 2018b; Gong et al., 2019). Worker assignment, known as a dual resource limitation, was investigated by Long et al. (2018) in FJSSP. Resources provided by humans were taken into consideration by Villa et al. (2018) in a machine with an unrelated parallel machine scheduling problem. Gong et al. (2020) proposed an energy-efficient flexible flow shop scheduling and probed the flexibility of the worker to enhance the energy efficiency. Han et al. (2020) recognized evolutionary algorithms with multi-objective alongside heuristic decoding for the problem of hybrid flow shop scheduling problem in the presence of a limitation on the part of the worker.

No wait flow shop

Shop planning without waiting for flow refers to the continuous flow of work through various machines. The work after start-up must have continuous processing in the machine without any delay. This situation occurs when there is no intermediate storage between job processing on two consecutive machines (Nailwal et al., 2016). The problem of unidentified planning of flow shops has important applications in many areas, such as chemical, plastics, metals, food and pharmaceutical industries. Engin and Güçlü (2018) envisioned a new hybrid ACO algorithm to address pending storage flow synchronization issues. Considering a no-wat flow shop scheduling problem, *n* jobs should be carried out on *m* machines when a given creation is optimized. On the other hand, in many practical applications, there should be certain limitations applied on jobs. An important example of such constraint entails continuous processing of a given job, leading to no-wait flow shop scheduling problems.

Flexible construction system

Regarding this type of systems, each machine may be able to carry out more than one operation. Therefore, both machines may be considered as two parallel machines in doing a series of operations and in some cases, they could not carry out joint activities (Moradi et al., 2017).

Flexible job shop scheduling (FJSP) was probed in many research articles lately (Deliktas et al., 2019; Deng, et al., 2017; Gong et al., 2019). In FJSP, all works are supposed to be done in only a single location (Al Aqel et al., 2019; Deng, et al., 2017; Wang et al., 2018). Meanwhile, usual production works are normally processed in different agencies, located and distributed in different regions since cooperative production with different agencies has obvious advantages regarding response speed and production cost. Jiang et al. (2021)

dealt with multi-objective optimization based on decomposition for FJSP under time-of-use electricity prices. Luo et al. (2020) thought about a suitable memetic algorithm regarding the problem of distributed FJSP with transfers.

Parallel machines problems
In the literature, scheduling parallel machines utilize different heuristic and non-heuristic algorithms most of which is related to the same and similar parallel machines. Wang and Liu (2015) addressed the problem using the total weight work completion time function.

Operation sequencing
Operation sequencing problems entail identifying the order of processes of a work on a working station. Also, it can contain identifying performing operations of work on different work centers. When assigning works to resources, works should be prioritized to achieve the best method to utilize the capacity in each work center. In fact, scheduling and sequencing is a type of decision-making process that has a fundamental role in production and service industries. In today's competitive world, it is a basic need for survival in institutions to have the best sequencing and scheduling appropriate for activities to reduce costs (Nagano et al., 2012).

2. Research methodology

Considering a resolution for the open shop scheduling problem using different machines aiming at minimizing the maximum completion time of works using ACO and WOA methods in the discovery of studies and research literature, the researchers first investigated agents affecting scheduling and operations sequencing. The result gained was to select a theoretical framework and to adjust a conceptual model.

2.1 Determining a prediction of scheduling activities

To measure every constituent of scheduling criteria and their function in predicting the completion time of the activities, all data and information related to scheduling manufacturing line activities of the company have been extracted. This research used the current data in the Iranian market for the period between 2019 and 2020.

2.2 The conceptual model validation

To ensure the construction of a relationship between variables in the research, the authors completed the following tasks consecutively: based on the results using the variance analysis method and through SPSS, the possibility of the existence of a relationship between variables and the effect of the variables on each other were estimated.

2.3 Analyzing ant colony algorithm

The model called ACO algorithm was first proposed by Marco Diego in a doctoral thesis in 1992 and emerged as ant colony. The ACO algorithm is introduced as a swarm intelligence (group intelligence) algorithm, and it follows the model of the behavior of real ants. These creatures form groups (colonies) and live together. The existence of a population-oriented approach makes it possible for the ACO algorithm to help solve dynamic optimization problems quite efficiently. It is believed that ants are self-organizing creatures. This characteristic is known as the focal point in their behavior compared to the problem because it precisely makes insects quickly adapt to changing environmental conditions to achieve goals through low-level interactions. Regarding the fact that ants lack eyes, their interactions are done through the chemical substance called pheromone, which is used to mark the path. The more pheromone put in the path, the more the rest of the ants use this path; therefore, such a quantity shows that this route is one of the most optimal and shortest ways.

2.4 Ant colony algorithm procedure

The different stages of the ACO algorithm are as follows.

Ants of valuation (initial valuation)
Regarding this case, two different approaches are utilized: placing all the ants at one point or at different points. The required method must depend on the specific situation. First, the initialization is carried out to locate the pheromones. The value of the pheromone should be a small integer. This should be done in order to avoid the ants from standing still and not moving at the commencement location.

Search for a solution
Since the ACO algorithm follows the traits of real ants using the simulation process, a probability function is used to explain the path. The probability of reaching point *j* from point *i* (probability of transfer) is calculated using the following formula.

$$P_{ij}\left\{\frac{\tau_{ij}^{\alpha}.\eta_{ij}^{\beta}}{\sum_{h\in tabuK}\tau_{ij}^{\alpha}.\eta_{ij}^{\beta}}, \quad \text{if } j \notin tabuK\right. \tag{1}$$

where: τ_{ij} refers to the amount of the chemical substance of pheromone in points (*i, j*) – also it is called an ant sense; η_{ij} is the visibility ratio of points (*i, j*), known as the ant's eye and is the heuristic of the problem, and is determined as $\eta_{ij} = 1/d_{ij}$, through which d_{ij} is the distance between two nodes of *i* and *j*; α and β are compatible parameters that represent outstanding roles of the path against the visibility ratio when choosing the next point for movement; *TabuK* list of visited nodes in the current path form ant's memory. If α = 0, the algorithm becomes greedy, so that the selection of the next node does not consider the quantity of pheromones, and as a result the selection of the closest path is prioritized. If β = 0, the algorithm considers only the number of pheromones without regarding the path length.

Pheromones update

When the path follows end by the ants, it is time to change the quantity and number of pheromones. It is comprised of two stages. First, we need to reduce the amount of all pheromones. After that, it is required to update the pheromones connected to the visited points by increasing their amount and quantity. The following formula is utilized to define path evaporation.

$$\tau_{ij} = (1-\rho)\,\tau_{ij} \tag{2}$$

where: ρ refers to the evaporation coefficient of the pheromone. The parameter ρ helps to avoid infinite path accumulations. Thus, this process causes the ants to avoid forgetting the bad paths that they have already discovered. When a point is left unused by ants, the pheromones surface decreases exponentially after each iteration. To consider the evaporation definition, we are required to update the number of ants' pheromones. Thus, the path volume is updated using the formula below.

$$\tau_{ij} = \tau_{ij} + \sum_{k=1}^{m}\Delta\tau_{ij}^{k} \tag{3}$$

where: $\Delta\tau_{ij}^{k}$ is the quantity of pheromones located on the points (*i, j*) transferred by the k^{th} ant and it can be calculated regarding the following equation.

$$\Delta\tau_{ij}^{k} = \begin{cases} \frac{Q}{L_k} & if\ ant\ k\ used\ edge\ (i,j)\ in\ this\ tour \\ 0 & otherwise \end{cases} \tag{4}$$

where: *Q* refers to the constant value, which artificially increases pheromones; *L* is attributed to the total length of the path, and the better the path, the more pheromones are put on this path. Generally speaking, the points that are used by many ants involve part of the short paths, receive more pheromones, and thus are more likely to be selected by ants in the future iteration of this algorithm path. The repetition process ends when at least one of the requirements is realized (Dorigo et al., 1999; Dorigo & Stützle, 2004).

2.5 Analyzing WOA

The WOA proposes a unique search method and surround hunting mechanisms of humpback whales to find the optimal solution, which mainly contains three important stages: encircling prey, bubble-net attacking strategy and search for prey (Mirjalili & Lewis, 2016). Considering WOA, the position of each humpback whale represents a search agent. The WOA finds the optimal solution to the global optimization problem through continuous updating of the search agent. On the other hand, WOA is a new swarm intelligence algorithm suggested by Mirjalili and Lewis (2016), and it has the advantages of low internal parameters and easy application. The WOA has attained good results in many optimization problems, such as the DNA segment assembly problem, resource allotment problems in wireless networks, predicting gold price fluctuations, connection weights in neural networks, optimal reactive power dispatch problems, maximum power point tracking (MPPT), hyperparameters of convolutional neural networks (CNN), photovoltaic model recognition, fuzzy programming, the proportional-integral (PI) design, and controller and feature selection (Lee & Zhuo, 2021).

Feature selection using WOA

In problems through which the datasets are big in dimensions, we can utilize WOA to select a subset of the data with the highest effects on learning. To do so, from among the two values of presumably 0 and 1 observables in solutions, it can be claimed that if the intended number is greater than 0.5, it would be selected as a specific feature, and if it is smaller, it would not be chosen. WOA is considered to be one of the optimization algorithms inspired from the environment and it can be used in different fields (Ning & Cao, 2021). WOA is carried out in three stages or phases as follows:

siege hunting, operation phase: fight against net bubble method, and discovery stage: search for prey.

Siege hunting

Whales can recognize hunting location and siege it. Since the location for optimal designing in the search area could not be known using comparison, the algorithm presupposes that the best resolution is hunting the goal or a state close to the optimal one. After recognizing the best search agent, other search agents try to update their locations regarding the best search agent. This behavior has been represented through Equations (5–6):

$$\vec{D} = \left|\vec{C}.\vec{X}^*(t) - \vec{X}(t)\right| \quad (5)$$

$$\vec{X}(t+1) = \vec{X}^*(t) - \vec{A}.\vec{D} \quad (6)$$

where: *t* represents current repetition; $\vec{A}$ and $\vec{C}$ are coefficients' vectors; $\vec{X}^*$ is the location vector for the best current resolution and $\vec{X}^*$ is the location vector. It should be noted that if a better solution exits, *X** should be updated in each repetition. $\vec{A}$ and $\vec{C}$ vectors are calculated as follows.

$$\vec{A} = 2\vec{a}.\vec{r} - \vec{a} \quad (7)$$

$$\vec{C} = 2.\vec{r} \quad (8)$$

where: *a* reduces linearly from 2 to 0 during the repetitions (in both discovery and extraction phases) and *r* is the random vector within the distance between 0 and 1.

Operation phase: Fight against net bubble method

For mathematical modeling of whales' net bubble behavior, two methods have been designed.

Contractile siege mechanism. This behavior results through increasing Equation (7). The fluctuation range $\vec{A}$ is reduced through *a*. In other words, $\vec{A}$ is a random amount between *a* and −*a* and *a* is reduced from 2 to 0 during the repetitions. Regarding the selection of the random *A* values within the interval between 1 and −1, we can define the new location for the search agent at any point between the original location of the agent and the agent's best current location.

Spiral updating location. The distance between the whale located in *X** and *Y* and the coordinates of the prey located in *X** and *Y** was first calculated using this method. A spiral equation is formed between the position of the whale and the prey to mimic the spiral movement of the humpbacked whale.

$$\vec{X}(t+1) = \overrightarrow{D'}.e^{bl}.\cos(2\pi l) + \vec{X}^*(t) \quad (9)$$

where: $\overrightarrow{D'}$ refers to the distance between the first whale and the hunt (the best resolution gained up to this point); *b* is a fixed amount to define the logarithmic spiral form and random numbers between 1 and −1. It should be noted that the humpbacked whale swims within a spiral route around the hunt along with a contractile circle. To model this concurrent behavior, it has been presupposed that the whale selects one with a 50% probability from among contractile siege mechanism and the spiral model to update the position of whales during the optimization. The mathematical model is as follows.

$$\vec{X}(t+1) = \begin{cases} \vec{X}^*(t) - \vec{A}.\vec{D} & \text{if } p < 0.5 \\ \overrightarrow{D'}.e^{bl}.\cos(2\pi l) + \vec{X}^*(t) & \text{if } p \geq 0.5 \end{cases} \quad (10)$$

where: *p* is a random number between 0 and 1. In addition to the net bubble method, the humpbacked whales search for the prey randomly.

Discovery stage: Prey search

A similar method can be used to search for the prey (discovery) based on vector $\vec{A}$ variation. In fact, humpbacked whales search randomly based on the location of each other. Therefore, vector $\vec{A}$ is used with bigger random values or less than −1 to force the search agent to get away from the reference whale. Unlike the extraction phase, the random agent selection has been utilized to update the position of the search agent in the discovery phases instead of using the best search agent data. This mechanism, along with $\left|\vec{A}\right| > 1$ emphasizes discovery and lets the WOA do a general search. The mathematical model is as follows.

$$\vec{D} = \left|\vec{C}.\overrightarrow{X_{rand}} - \vec{X}\right| \quad (11)$$

$$\vec{X}(t+1) = \overrightarrow{X_{rand}} - \vec{A}.\vec{D} \quad (12)$$

where: $\overrightarrow{X_{rand}}$ is the selected random position (random whale) throughout the current population. WOA starts working with a set of random solutions. Parameter *a* is reduced from 2 to 0

to prepare for discovery and extraction. A random search agent is selected in $|\vec{A}| > 1$ format. Meanwhile, the best solution is selected when the position of search agents for updating locate in $|\vec{A}| < 1$. Depending on the amount of *p*, the WOA has the capability to select from among circular movement or spiral one. Finally, WOA ends with satisfying ending conditions. The function of WOA is to find the optimal point within the whole different test functions (Ning & Cao, 2021).

3. Result and discussion

3.1 Result of ant colony

In the current study, four levels were chosen as the parameters related to the research problem (movement time, machine time, machine set-up time and control time). Regarding Tab. 1, the values of the parameters and also in Tab. 2, the factors and different levels of the investigated parameters for this algorithm are represented accordingly.

Tab. 1: Levels for each parameter by ACO

Size	(NAnt, MaxIt)
Small	(15, 140)
Medium	(25, 280)
Large	(35, 320)

Source: own

Tab. 2: Factors of the ACO algorithm and its corresponding levels

Parameters	Symbol	Level
p	M	[0 1] – [0.2 0.8]
τ_{ij}	M	10 – 15 – 25 – 35
ρ	S	0.07 – 0.14 – 0.4 – 0.6
q_0	C	0.2 – 0.3 – 0.4 – 0.5

Source: own

In Tab. 1, the level of each one of the parameters includes the size in three forms of small, medium, and big (NAnt, MaxIt). (NAnt) represents the initial population size of ants, and (MaxIt) shows the maximum repetition number. For example, in small size, the number of ants is 15, and the maximum repetition is 15 times, which is randomly shown in MATLAB software.

Tab. 2 represents parameters as follows: *p* for probability, ρ for precipitation rate, and q_0 for exploitation rate. The algorithm proposed in this paper is one of meta-heuristic algorithms, and these parameters (the number of repetitions and initial population size) are directly related to the quality of solutions gained regarding the calculation time. Usually, the amount of these two parameters is directly related to the dimensions of the problem in a way that the identification of small sizes for these two parameters limits the effective search for solution spaces, while big sizes reduce the algorithm's efficiency in achieving the optimal solutions within reasonable calculation times. Hence, the identification of these two parameters depends on the problem size and the amount of time appropriated to it. On the other hand, three groups of test issues using three sizes of small, medium, and big were applied. Thus, we have only presented the difference between parametric levels above in these three groups of issues only through repetition numbers and the initial population amount. Therefore, in the present study, we have considered fixed and reasonable amounts for both parameters of repetition and initial population size based on a trial an error test for each group of these problems depending on the type

Tab. 3: Factors of the ACO algorithm and its corresponding levels

Trial	p	τ_{ij}	ρ	q_0	Response
1	[0 – 1]	10	0.07	0.2	26.02
2	[0 – 1]	15	0.14	0.3	22.40
3	[0 – 1]	25	0.40	0.4	28.30
4	[0 – 1]	35	0.60	0.5	23.50

Source: own

of algorithm. For example, in Tab. 2, τ_{ij} represents the amount of chemical material called pheromone in points (*i, j*) using three parameters of *p* for probability, ρ for precipitation rate, q_0 for exploitation rate.

Regarding the existence of four factors in the ACO algorithm, the same four factors are used to comply with the brevity of each level, the requirements for checking their different combinations and the final answers related to each level, which are all denoted in Tab. 3. MINITAB 14 software represented the data and they were analyzed.

Considering variance analysis in Tab. 4, three factors, τ_{ij} and a *p*-value of less than 0.05, have a considerable effect on the responses, while the factor q_0 amounting to 0.070 has less effect on the responses. Furthermore, variance analysis of average responses leads to all four mentioned factors with a *p*-value of less than 0.05 have a significant effect on the responses. Regarding the analysis of Tabs. 2–3,

Tab. 4: Analysis of variance for ACO algorithm

Source	DF	SS	MS	*F*	Percent *X* (%)	Cumulative (%)	*p*-value
p	1	27.07	23.035	11.86	27.86	27.86	0.005
τ_{ij}	2	21.05	8.120	4.03	21.53	19.39	0.040
ρ	2	18.04	6.650	3.22	18.35	67.74	0.050
q_0	2	12.90	5.350	2.15	12.28	80.02	0.070
Error	10	17.94	1.010		19.98	100.00	
Total	17	97					

Source: own

Tab. 5: Analysis of variance for mean responses for ACO algorithm

Source	DF	SS	MS	*F*	Percent *X* (%)	Cumulative (%)	*p*-value
p	1	155.6	155.58	11.86	24.28	24.28	0.004
τ_{ij}	2	145.7	70.40	4.95	22.82	47.10	0.016
ρ	2	110.3	36.48	3.41	16.92	64.02	0.050
q_0	2	113.0	37.98	3.49	17.24	81.26	0.048
Error	10	133.9	18.23		18.72	100.00	
Total	17	658.5					

Source: own

Tab. 6: Response ratios for ACO algorithm

Level	λ	τ_0	ρ	q_0
1	−28.96	−28.09	−28.97	−26.47
2	−26.55	−26.31	−26.56	−28.51
3		−28.86	−27.74	−28.29
Delta	2.41	2.55	2.41	2.04
Rank	3	1	2	4

Source: own

Tab. 7: Average response for ACO algorithm

Level	λ	τ_0	ρ	q_0
1	28.24	25.65	28.43	21.70
2	22.27	21.53	22.34	26.84
3		28.58	25.00	27.22
Delta	5.15	7.06	6.09	5.52
Rank	3	1	2	4

Source: own

it is apparent that the primary pheromone factor ranks first considering changes in the levels of responses.

Variance analysis is used to show the relative effect of each factor on the value of the response level. Variance analysis has been done for average responses for ACO algorithm and the results are shown in Tab. 5. Accordingly, as it can be seen, three factors p, τ_{ij} and ρ with p-value less than 0.05 have a significant effect on the responses and this is while the factor q_0 with a value of 0.048 has less effect on the answers. On the other hand, with the analysis of variance for the average responses, it is determined that all four mentioned factors have had a significant effect on the responses with p-value less than 0.05.

By analyzing Tabs. 6–7, it was made clear that the primary pheromone factor τ_0 first ranks in terms of making changes in the levels of responses.

In order to check the performance of the algorithm used in small problems, a number of four test problems are performed in the order of movement time, machine time, set-up time, and control time, and the results of this algorithm are compared in terms of the quality of the answer. The values of movement time, machine time, set-up time, and control time in Tab. 8 are randomly generated through the following uniform distribution and are used as input data to experimental problems.

The current study has tried to consider performance evaluation criteria to enable the comparison of the algorithm's performance using different dimensions. Quantitative measures used in the present study entail the mean ideal distance (MID), number of the Pareto solutions (NPS) and diversity metric (DM). MID is known as a simple metric that measures the average of distances from an ideal point. This metric is commonly used in minimization problems through which the ideal point is (0, 0), for a problem with two objectives. The more Pareto solutions a method has, leads it to become the more favorable. DMs are the assigned quantitative values that help employers assess strategies to achieve a more diverse workforce. Here and to do comparisons, seven small-scale test problems containing seven production problems and the results of solving by the algorithm are put forward in the form of tables. MATLAB R2012a software was used to implement the algorithms mentioned above. Furthermore, to check the performance of the algorithm used in this project,

a number of experimental problems in small dimensions and the results obtained from this algorithm are compared regarding the quality of the answer. Based on Tab. 8, the values of movement time, machine time, set-up time and control time are randomly created using the uniform distribution mode and are used as input data to be compared through experimental problems represented in Tab. 8.

Considering small problems, the following tables and the results of the algorithm implementation are reported. Based on the results, it can be easily understood that the ACO algorithm performed better. According to the average values obtained in the last row of Tabs. 9–10, it can be concluded that the ACO algorithm is more successful in obtaining the approximate optimal Pareto edge both quantitatively and qualitatively.

3.2 Result of WOA

Problem definition

The open shop scheduling problem using different machines aimed at minimizing the maximum work completion is represented below.

A set of n different works $N = \{1, 2, \ldots, n\}$ is processed within M consecutive stages $M = \{1, 2, \ldots, m\}$. In each stage t, $t \in M$, we have one or some machines $M_t = \{1, 2, \ldots, m_t\}$ in a way that in each moment, every work is processed on only one machine, and each machine is able to process only one work at a time. Each of the works in each stage could be processed on a subset of machines in the form of $M_j \subsetneq M_i$.

These sub-sets are technically called processing sets, and n number of processing sets exists in a problem. Prior to the commencement of the processing of a work on a machine, an activity is carried out that is called machine installation operation, and the timespan through which the machine installation operation is done is known as machine installation time. The type of work done on a processing machine depends on the previously processed work and the machine type. Literally, this is known as the installation time depending on the sequencing works. If the work done is the very first work processed on the machine,

Tab. 8: Input data values for experimental problems

Input data values	Experimental problems
U ~ [35 55]	Movement time
U ~ [1 35]	Machine time
U ~ [1 7]	Set up time
U ~ [1 10]	Control time

Source: own

Tab. 9: Calculation results of solving problems with small dimensions of the first part

No.	$N \times M$	ACO		
		NPS	DM	MID
1	**6 × 2**	6.65	13.55	76.69
2	**6 × 3**	5.45	8.12	62.27
3	**8 × 2**	4.85	18.22	116.45
4	**8 × 3**	6.43	13.48	61.55
5	**10 × 2**	7.25	21.30	125.75
6	**10 × 3**	5.75	12.20	81.48
7	**10 × 4**	8.46	16.40	73.95
Average value		5.40	13.01	76.65

Source: own

Tab. 10: Calculation results of solving problems with small dimensions of the second part

No.	*N* × *M*	ACO		
		NPS	DM	MID
1	6 × 2	1.780	100.00	22.00
2	6 × 3	0.002	89.80	39.00
3	8 × 2	1.290	67.25	21.00
4	8 × 3	4.150	61.02	36.00
5	10 × 2	5.350	67.10	38.00
6	10 × 3	1.200	77.12	32.00
7	10 × 4	4.400	79.40	63.00
Average value		2.590	77.38	35.86

Source: own

the machine identifies the installation time. Each work has an independent access time. It is impossible to process any work before the access time for its start. Each work is completed considering its position within the sequence of works processing on the related machine following installation time pass, regarding the probable fixing time, the work time access, and the time required to process it. Works may have different delivery times and the deviations in work completion in the form of early processing or the tardy jobs processing, would also be calculated. Weights in the form of different coefficients are allocated for each of the works when they are done early or with tardy jobs, and they represent early and late completions. The sum of the weights is known as an optimization criterion, and thus the target function represents the minimization of the works' completion time.

Problem presuppositions. The presuppositions below were considered in proposing the model:

- Works are called up regarding access time and are not necessarily ready to be processed in starting time (moment zero);

Tab. 11: Signs and symbols used in heuristic and meta-heuristic algorithms

Components	Definition
j_i	(j = 1, …, n): number of work
s_i	(i = 1, 2): number of stage
$P_{1,j}$	m in the first stage, j is the processing time of the work
$P_{2,j}$	m in the second stage, j is the processing time of the work
d_j	m, j the date of delivery of the work
r_j	m, j the time of entering the work shop
$M_{1,d}$	The earliest machine available in the first stage
$M_{2,\varepsilon}$	The earliest car available in the second stage
$t_{1,d}$	(d = 1, ..., m_1): in the first stage d, the current time of the machine
$t_{2,\varepsilon}$	(e = 1, ..., m_2): in the second step, the current time of the machine
C_i	j, job completion time

Source: own

- Works are arranged based on their preparation time and are not necessarily ready to be processed in starting time (moment zero);
- The installation time of each work depends on their sequence on machines;
- Each machine can maximally process one work in every moment;
- Each work can only be processed on one machine;
- Machines are not permanently accessible;
- It is not legal to process one work before the end of the process time of the previous one.

The proposed model

In this section, the mathematical model of the proposed meta-heuristic algorithms using an integer programming approach has been investigated. First, the indices and input parameters, decision-making variables, constraints, and the objective functions are explained.

Shop flow in the first stage is shown as S_1, and the second stage is represented using S_2. Also, it presupposes that there exist m_1 parallel machines in the first stage, and we show them in the form of $[M_{1,1}, M_{1,2}, \ldots, M_1, m_1]$. Similarly, there are m_2 parallel machines in the second stage represented as $[M_{2,1}, M_{2,2}, \ldots, M_2, m_2]$. Also, $P_{1,1}, P_{1,2}, \ldots, P_{1,n}$ indicate processing times in the first stage and $P_{2,1}, P_{2,2}, \ldots, P_{2,n}$ are known as processing times in the second stage. Moreover, the delivery times for works are represented through $d_1, d_2, \ldots, d_n$ and finally, $r_1, r_2, \ldots, r_n$ are defined as accessible times of the works or the entry time of the works into the shop. In other words, L means total scheduled works, and k represents the works remained for scheduling. In Tab. 11, the signs and symbols used are represented, and in Tab. 12, the objective functions used are shown.

Optimized whale algorithm

The goal of optimization algorithms is to find acceptable solutions considering the limitations and problem requirements. Several different solutions may determine the responses

Tab. 12: Objective functions used in heuristic and meta-heuristic algorithms

Components	Definition
$\overline{C}$	$\Delta c = c(x) - c(y)$
C_{max}	Max (C_j)
MFT	$\frac{\sum_j^n (C_j - r_j)}{n}$
Utilization	$\frac{\sum_{i=1}^n (p_{1,j} + p_{2,j})}{\sum_{i=1}^n (p_{1,j} + p_{2,j}) + Maxhire\ Idel\ time} = \frac{\sum_{i=1}^n (p_{1,d} + p_{2,j})}{\sum_{i=1}^n (t_{1,j} + t_{2\varepsilon})}$
T_i	Max ($C_j - d_j$, 0)
T_{max}	Max (T_j)
$\overline{T}$	$\frac{\sum_j^n T_j}{n}$
L_j	$C_j - d_j$
L_{max}	Max ($C_j - d_j$)
$\overline{L}$	$\frac{\sum_j^n (C_j - d)}{n}$
U_j	If m is delayed, its value is equal to 1, and otherwise, if it is work, the dose is zero
Tardy jobs	$\sum_{j=1}^{n} U_j$

Source: own

for the quests in any problem. To compare the solutions for a certain problem and to select an optimized solution, a function called cost function should be considered. The selection of such a function depends on the problem's nature. The whale algorithm represented an acceptable level of performance in comparison with some other meta-heuristic algorithms.

The whale algorithm has a good level of capability to reach acceptable solutions from among the problem's search space using prey surrounding and swirling around the prey. During recent years, using this algorithm has proved to be very common due to its great flexibility, and it is widely utilized in different optimization problems.

Algorithm stages and results gained after administering the algorithm

The following is Mirjalili and Lewis's (2016) improved algorithm and the only changes are made in the objective function and its variables. This means that the change in the objective function and its variables in the whale algorithm was only in the minimum time required to complete the tasks, and this is one of the new aspects of our research. Also, ACO was utilized in the present research to get better results.

It is believed that exact algorithms can lead to the optimal solutions precisely, but they cannot be effectively used for hard optimization problems, and the time required to solve those increases exponentially. Approximate algorithms can reach well (near optimal) solutions in short solution times for hard optimization problems. Furthermore, approximate algorithms can be divided into three subgroups: heuristic, meta-heuristic and hyper-heuristic groups. Shortcomings of heuristic algorithms include their placement in local optima, and their inability to be used in various problems. In order to solve the problem in heuristic algorithms, meta-heuristic algorithms have been suggested. Meta-heuristic algorithms are among the types of approximate optimization algorithms that have solutions different from the local optimum and can be used to solve problems in various formats.

Regarding Fig. 1, the congruence speed is very high in initial repetitions but the speed will gradually slow down, and finally, the strength

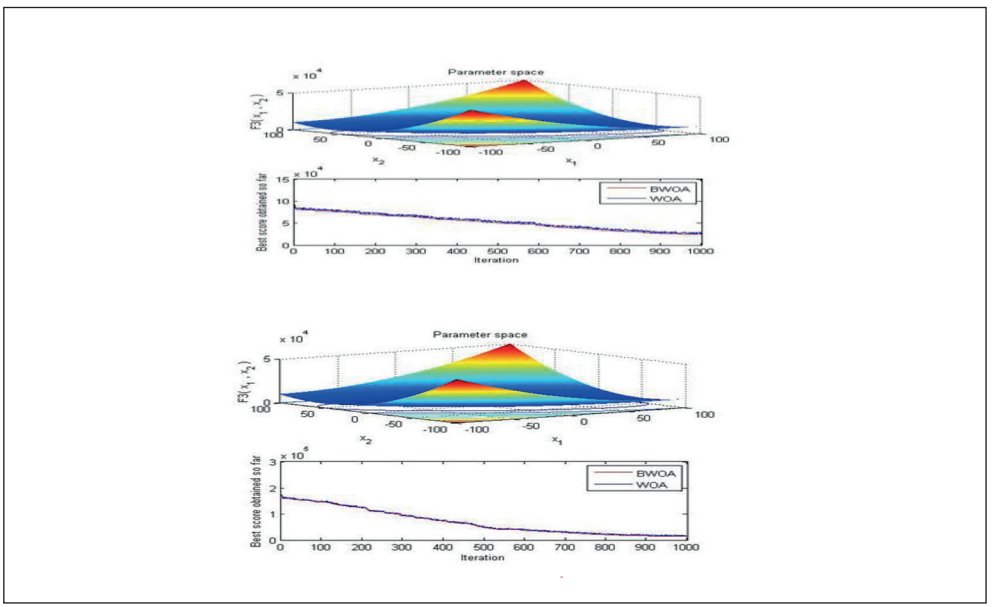


Fig. 1: **The convergence trend in WOA**

Source: own

of congruence becomes fixed. As it is apparent, a different congruence fitness function will be represented in each stage. There would be more rapid congruence almost up the implementation of the 100th repetition. The congruence slowed down from it up to almost 300. Then, less congruence would be present from 300 to 500. Finally, congruence will change into a gradual state from 500 repetitions. On the whole, the results of Fig. 1 showed that congruence will be more rapid at the initial stages of the algorithm running, and then a gradual congruence with low speeds will be encountered.

Considering the results in Fig. 1, there are two maximum points, one of which is the only local maximum. Using mathematical optimization methods, we have to find the maximum value of the function in a very small interval. For instance, it can be started from point 1 and maximize the function. Clearly, if we start from point 1, we will only gain the local maximum value, and our algorithm will end after that. But regarding intelligent methods, such as the WOA, and considering its random nature, even if we start from point 1, point *A* may be selected randomly in the middle of the way, in which case we tend to have a chance to reach the overall optimum point. Another point is that mathematical optimization methods often result in a specific formula or instruction to solve each problem. Therefore, to solve difficult problems and gain near-optimal solutions, artificial intelligence algorithms like ant colony algorithms and WOA are deemed to be proper.

Algorithm consistency parameter

As it was pointed out before, the more similar results occurring in consecutive implementations will lead to a more consistent algorithm. To check this criterion, the algorithm was implemented

Tab. 13: Mean square error of standard error in the model

Model name	Standard mean square error
Improved whale algorithm	86.1071

Source: own

Tab. 14: Compare of ACO and WOA methods

Name of model		Amount
Ant colony algorithm	**First stage**	76.6500
	Second stage	77.3800
Improved whale algorithm		86.1071

Source: own

10 times. The variance for the changes in final algorithm solutions was calculated in 10 different running times. In order to have a better understanding and compare better, the normalized data variance would be used. Due to the presence of normalized data, the variance will vary within 0 and 1, and the closer amount to 0 will lead to a more consistent algorithm. The variance of the normalized solutions in 10 implementations in the improved whale algorithm was calculated to be equal to 86.1071, which shows an almost appropriate consistency of the algorithm. Accordingly, the average ideal points within the ants' colony algorithm in the first and second stages were equal to 76.65 and 77.38 to solve the problem in a small-scale format. On the other hand, the improved whale algorithm with the value of 86.1071 could work extremely better than the values of the ant algorithm method in a small scale and in two stages. Therefore, to compare and predict the minimum time required to do the work in company, an improved whale algorithm was used. Tabs. 13–14 summarize the results.

Conclusions

Within the process of flow shop problems scheduling, the sequence of doing the activities predetermined for a manufacturing system is identified. This is due to the fact that the proper scheduling of the works can have an important role in reducing costs in a factory. The model considered in the present research has dealt with an integer planning to resolve no-wait flow shop scheduling problem using different machines aiming at minimizing the maximum completion time of works using ant colony and whale algorithms. The primary constraints were as follows: installation time limitations related to sequence and machines, relaxation period, clearing time, machine setting time, movement time, control time, limited access to the machine, and access to works' time. Based on research in the field, this issue has even been a problem regarding the flow shop state of the NP-hard type, through which, as the number of works increases, the resolution becomes almost impossible through optimization software. Therefore, in the present study, the improved Mirjalili and Lewis's (2016) whale algorithm was used in order to solve no-wait flow shop scheduling problems. To do so, the results could be summarized as follows for small problems and some suggestions were proposed using WOA.

Whale algorithm has a good capability in finding solutions using the problem's search spaces. In recent years, this algorithm has become widespread due to its high flexibility and is still used in different optimization problems. For the problems with great dimensions of a dataset, the whale algorithm can be used to select a subset of the dataset with the highest effects in the learning section. In this way, it can be said that from among the values presupposed to be equal to 0 and 1 seen in the responses, if the number is greater than 0.5, it will be selected as a feature, and if it is smaller, it will not be chosen.

Following the identification of the proposed algorithms for average and big problems, the efficiency of improved whale algorithms was found to be better than other commonly used algorithms in the field. The reformed WOA for average and big problems worked better than many algorithms proposed in the literature.

In future research, due to the presupposition that cuts in works are unauthorized, considering works cuts and transfer delays of a work on a machine onto another machine and adding it on objective function can be noticed. The enhanced carrying out similar studies using multiple criteria optimization and considering different technological constraints in order to reduce the distance between real problems and theoretical issues seems to be completely logical. All parameters of the intended problem are considered to be absolute. This can also be applied in fuzzy settings and uncertainty. Considering other environments in scheduling in the presence of works' completion time constraint and utilizing multiple objective functions can be studied. Also, it could be suggested to study the addition of other constraints using meta-heuristic whale algorithms along with the expected risk criterion. This can help to overgeneralize the model and approach the optimal algorithms to come closer to reality. Finally, using the integration of proper planning and innovative algorithms to find more efficient algorithms could be considered.

References

Al Aqel, G., Li, X., & Gao, L. (2019). A modified iterated greedy algorithm for flexible job shop scheduling problem. *Chinese Journal of Mechanical Engineering*, *32*(1), 21. https://doi.org/10.1186/s10033-019-0337-7

Angel-Bello, F., Vallikavungal, J., & Alvarez, A. (2021). Fast and efficient algorithms to handle the dynamism in a single machine scheduling problem with sequence-dependent setup times. *Computers & Industrial Engineering*, *152*, 106984. https://doi.org/10.1016/j.cie.2020.106984

Arroyo, J. E. C., dos Santos Ottoni, R., & de Paiva Oliveira, A. (2011). Multi-objective variable neighborhood search algorithms for a single machine scheduling problem with distinct due windows. *Electronic Notes in Theoretical Computer Science*, *281*, 5–19. https://doi.org/10.1016/j.entcs.2011.11.022

Arthanari, T. S., & Ramamurthy, K. G. (1971). An extension of two machines sequencing problem. *Opsearch*, *8*, 10–22.

Baykasoğlu, A., Madenoğlu, F. S., & Hamzadayı, A. (2020). Greedy randomized adaptive search for dynamic flexible job-shop scheduling. *Journal of Manufacturing Systems*, *56*, 425–451. https://doi.org/10.1016/j.jmsy.2020.06.005

Baykasoğlu, A., & Ozsoydan, F. B. (2018). Dynamic scheduling of parallel heat

treatment furnaces: A case study at a manufacturing system. *Journal of Manufacturing Systems*, *46*, 152–162. https://doi.org/10.1016/j.jmsy.2017.12.005

Da Silva, N. C. O., Scarpin, C. T., Pécora, J. E., & Ruiz, A. (2019). Online single machine scheduling with setup times depending on the jobs sequence. *Computers & Industrial Engineering*, *129*, 251–258. https://doi.org/10.1016/j.cie.2019.01.038

Deliktas, D., Torkul, O., & Ustun, O. (2019). A flexible job shop cell scheduling with sequence-dependent family setup times and intercellular transportation times using conic scalarization method. *International Transactions in Operational Research*, *26*(6), 2410–2431. https://doi.org/10.1111/itor.12407

Deng, Q., Gong, G., Gong, X., Zhang, L., Liu, W., & Ren, Q. (2017). A bee evolutionary guiding no dominated sorting genetic algorithm II for multi objective flexible job-shop scheduling. *Computational Intelligence and Neuroscience*, *2017*, 1–20. https://doi.org/10.1155/2017/5232518

Dios, M., Fernandez-Viagas, V., & Framinan, J. M. (2018). Efficient heuristics for the hybrid flow shop scheduling problem with missing operations. *Computers & Industrial Engineering*, *115*, 88–99. https://doi.org/10.1016/j.cie.2017.10.034

Dorigo, M., Caro, G. D., & Gambardella, L. M. (1999). Ant algorithms for discrete optimization. *Artificial Life*, *5*(2), 137–172. https://doi.org/10.1162/106454699568728

Dorigo, M., & Stützle, T. (2004). *Ant colony optimization*. The MIT Press. https://doi.org/10.7551/mitpress/1290.001.0001

Engin, O., & Güçlü, A. (2018). A new hybrid ant colony optimization algorithm for solving the no-wait flow shop scheduling problems. *Applied Soft Computing*, *72*, 166–176. https://doi.org/10.1016/j.asoc.2018.08.002

Fu, L.-L., Aloulou, M. A., & Triki, C. (2017). Integrated production scheduling and vehicle routing problem with job splitting and delivery time windows. *International Journal of Production Research*, *55*(20), 59425957. https://doi.org/10.1080/00207543.2017.1308572

Gong, G., Chiong, R., Deng, Q., & Gong, X. (2019). A hybrid artificial bee colony algorithm for flexible job shop scheduling with worker flexibility. *International Journal of Production Research*, *58*(14), 4406–4420. https://doi.org/10.1080/00207543.2019.1653504

Gong, G., Chiong, R., Deng, Q., Han, W., Zhang, L., Lin, W., & Li, K. (2020). Energy-efficient flexible flow shop scheduling with worker flexibility. *Expert Systems with Applications*, *141*, 112902. https://doi.org/10.1016/j.eswa.2019.112902

Gong, G., Deng, Q., Gong, X., Liu, W., & Ren, Q. (2018a). A new double flexible job-shop scheduling problem integrating processing time, green production, and human factor indicators. *Journal of Cleaner Production*, *174*, 560–576. https://doi.org/10.1016/j.jclepro.2017.10.188

Gong, X., Deng, Q., Gong, G., Liu, W., & Ren, Q. (2018b). A memetic algorithm for multi-objective flexible job-shop problem with worker flexibility. *International Journal of Production Research*, *56*(7), 2506–2522. https://doi.org/10.1080/00207543.2017.1388933

Gonzalo, M., & Yuraszeck, F. (2020). A self-tuning variable neighborhood search algorithm and an effective decoding scheme for open shop scheduling problems with travel/setup times. *European Journal of Operational Research*, *285*(2), 484–496. https://doi.org/10.1016/j.ejor.2020.02.010

Guo, Y., Huang, M., Wang, Q., & Jorge Leon, V. (2016). Single-machine rework rescheduling to minimize maximum waiting-times with fixed sequence of jobs and ready times. *Computers & Industrial Engineering*, *91*, 262–273. https://doi.org/10.1016/j.cie.2015.11.021

Han, W., Deng, Q., Gong, G., Zhang, L., & Luo, Q. (2020). Multi-objective evolutionary algorithms with heuristic decoding for hybrid flow shop scheduling problem with worker constraint. *Expert Systems with Applications*, *168*, 114282. https://doi.org/10.1016/j.eswa.2020.114282

Jiang, E., Wang, L., & Wang, J. (2021). Decomposition-based multi-objective optimization for energy-aware distributed hybrid flow shop scheduling with multiprocessor tasks. *Tsinghua Science and Technology*, *26*(5), 646–663. https://doi.org/10.26599/tst.2021.9010007

Lee, C.-Y., & Zhuo, G.-L. (2021). A hybrid whale optimization algorithm for global optimization. *Mathematics*, *9*(13), 1477. https://doi.org/10.3390/math9131477

Long, J., Zheng, Z., Gao, X., & Pardalos, P. M. (2018). Scheduling a realistic hybrid flow shop with stage skipping and adjustable processing time in steel plants. *Applied Soft Computing*, *64*, 536–549. https://doi.org/10.1016/j.asoc.2017.12.044

Luo, Q., Deng, Q., Gong, G., Zhang, L., Han, W., & Li, K. (2020). An efficient memetic algorithm for distributed flexible job shop

scheduling problem with transfers. *Expert Systems with Applications*, *160*, 113721. https://doi.org/10.1016/j.eswa.2020.113721

Ma, Y., Chu, C., & Zuo, C. (2010). A survey of scheduling with deterministic machine availability constraints. *Computers & Industrial Engineering*, *58*(2), 199–211. https://doi.org/10.1016/j.cie.2009.04.014

Mirjalili, S., & Lewis, A. (2016). The whale optimization algorithm. *Advances in Engineering Software*, *95*, 51–67. https://doi.org/10.1016/j.advengsoft.2016.01.008

Moradi, E., Fatemi Ghomi, S. M. T., & Zandieh, M. (2017). An efficient architecture for scheduling flexible job-shop with machine availability constraints. *The International Journal of Advanced Manufacturing Technology*, *51*(1–4), 325–339. https://doi.org/10.1007/s00170-010-2621-7

Moradi, E., & Zandieh, M. (2010). Minimizing the makespan and the system unavailability in parallel machine scheduling problem: A similarity-based genetic algorithm. *The International Journal of Advanced Manufacturing Technology*, *51*(5–8), 829–840. https://doi.org/10.1007/s00170-010-2666-7

Naderi, B., Fatemi Ghomi, S. M. T., Aminnayeri, M., & Zandieh, M. (2011). Scheduling open shops with parallel machines to minimize total completion time. *Journal of Computational and Applied Mathematics*, *235*(5), 1275–1287. https://doi.org/10.1016/j.cam.2010.08.013

Nagano, M. S., da Silva, A. A., & Lorena, L. A. N. (2012). A new evolutionary clustering search for a no-wait flow shop problem with set-up times. *Engineering Applications of Artificial Intelligence*, *25*(6), 1114–1120. https://doi.org/10.1016/j.engappai.2012.05.017

Nailwal, K. K., Gupta, D., & Jeet, K. (2016). Heuristics for no-wait flow shop scheduling problem. *International Journal of Industrial Engineering Computations*, *7*(4), 671–680. https://doi.org/10.5267/j.ijiec.2016.2.005

Ning, G.-Y., & Cao, D.-Q. (2021). Improved whale optimization algorithm for solving constrained optimization problems. *Discrete Dynamics in Nature and Society*, *2021*, 8832251. https://doi.org/10.1155/2021/8832251

Pinedo, M. L. (2016). *Scheduling: Theory, algorithms, and systems*. Springer International Publishing.

Ran, M., Sainan, G., & Cuixia, M. (2021). A semi-online algorithm and its competitive analysis for parallel-machine scheduling problem with rejection. *Applied Mathematics and Computation*, *392*, 125670. https://doi.org/10.1016/j.amc.2020.125670

Villa, F., Vallada, E., & Fanjul-Peyro, L. (2018). Heuristic algorithms for the unrelated parallel machine scheduling problem with one scarce additional resource. *Expert Systems with Applications*, *93*, 28–38. https://doi.org/10.1016/j.eswa.2017.09.054

Wang, H., Jiang, Z., Wang, Y., Zhang, H., & Wang, Y. (2018). A two-stage optimization method for energy-saving flexible job-shop scheduling based on energy dynamic characterization. *Journal of Cleaner Production*, *188*, 575–588. https://doi.org/10.1016/j.jclepro.2018.03.254

Wang, S., & Liu, M. (2015). Multi-objective optimization of parallel machine scheduling integrated with multi-resources preventive maintenance planning. *Journal of Manufacturing Systems*, *37*(1), 182–192. https://doi.org/10.1016/j.jmsy.2015.07.002

Wei, Q., Wu, Y., Jiang, Y., & Cheng, T. C. E. (2019). Two-machine hybrid flowshop scheduling with identical jobs: Solution algorithms and analysis of hybrid benefits. *Journal of the Operational Research Society*, *70*(5), 817–826. https://doi.org/10.1080/01605682.2018.1458018

Ying, K.-C., & Lin, S.-W. (2018). Minimizing makespan for the distributed hybrid flowshop scheduling problem with multiprocessor tasks. *Expert Systems with Applications*, *92*, 132–141. https://doi.org/10.1016/j.eswa.2017.09.032

Zohali, H., Naderi, B., Mohammadi, M., & Roshanaei, V. (2019). Reformulation, linearization, and a hybrid iterated local search algorithm for economic lot-sizing and sequencing in hybrid flow shop problems. *Computers & Operations Research*, *104*, 127–138. https://doi.org/10.1016/j.cor.2018.12.008

The importance of corporate image and social responsibility for consumer engagement in sustainable consumption

Dalia Streimikiene[1], Ilona Kiausiene[2], Greta Makunaite[3]

[1] *Vilnius university, Kaunas Faculty, Institute of Social Sciences, Lithuania, ORCID: 0000-0002-3247-9912, dalia.streimikiene@knf.vu.lt;*
[2] *Vilnius university, Kaunas Faculty, Institute of Social Sciences, Lithuania, ORCID: 0000-0001-7880-7216, ilona.kiausiene@knf.vu.lt;*
[3] *Vilnius University, Kaunas Faculty, Institute of Social Sciences, Lithuania, ORCID: 0009-0001-2442-2801, greta.makunaite@knf.vu.lt.*

Abstract: *Rampant consumption and society's growing demands are leading to ever-deteriorating quality of environment and life. Changing consumption patterns is essential to reduce the effects of climate change and create a more sustainable environment for generations to come. The rise of fast fashion is leading to overconsumption of clothing and textiles, which leads to high levels of pollution. In order to promote public awareness and the implementation of sustainability in all areas of life, companies need to contribute to the promotion of sustainable consumption. The way in which fashion sector creates its image and sees social responsibility has an impact on consumers' decisions to use sustainable products. The aim of the research is to identify the impact of corporate image on consumer engagement in sustainable consumption and to investigate the impact of social responsibility in creating corporate image. A questionnaire-based survey was conducted. 406 respondents from Lithuania were interviewed. The results were analysed using descriptive statistical methods. The study shows that a positive corporate image and engagement in social responsibility are important factors in consumers' engagement in sustainable consumption. Weak but statistically significant relationships were found between these variables. Social responsibility has been found to have a positive impact on corporate image, with corporate environmental responsibility being the most important. Also, it was found that more than 90% of respondents have a positive view of the company's corporate social responsibility and that the implementation of corporate social responsibility initiatives changes their perception of the company itself.*

Keywords: *Corporate image, social responsibility, sustainable consumption, consumer engagement.*

JEL Classification: *M14, M30.*

APA Style Citation: Streimikiene, D., Kiausiene, I., & Makunaite, G. (2024). The importance of corporate image and social responsibility for consumer engagement in sustainable consumption. *E&M Economics and Management, 27*(2), 125–141. https://doi.org/10.15240/tul/001/2024-2-008

Introduction

Corporate image can be one of the most important criteria for consumer engagement in sustainable consumption and corporate social responsibility (CSR) plays an important role in today's concept of corporate image. CSR is a strategic element in the formation of a positive corporate image (Cha & Jo, 2019). The implementation of socially responsible initiatives is an important part of each company's strategy, not only to build long-term and trusting relationships with consumers, but also to attract

potential consumers who prefer sustainable consumption. Consumers may be inclined to have a positive perception of the corporate image and to engage positively with the company's products or services. Scholars have different views on the corporate image (Belas et al., 2023; Lee, 2019; Özkan et al., 2020; Rozsa et al., 2022; Triatmano et al., 2021; Yu et al., 2021) but some identify the components of that create the corporate image. Corporate social responsibility can lead to the image of companies and make an impact on consumers engagement in sustainable consumption. The literature examines the impact of corporate social responsibility on corporate image (Chen et al., 2012; Stoyanov, 2017; Wang, 2018; Wong & Kim, 2020), presents the concept and meaning of corporate social responsibility (Brin & Nehme, 2019; Hassan et al., 2022a; Jung, 2020; Sharma, 2019), discusses the importance and benefits of corporate social responsibility for companies and their stakeholders (Ali et al., 2019; Asiaei et al., 2021; Chen et al., 2012, 2021; Prentice et al., 2019; Rodriguez-Gomez et al., 2020), and identifies the areas of CSR (economic, ethical, legal, philanthropic and environmental) (Gürlek et al., 2017; Hadi & Udin, 2021; Kumar, 2018).

Researchers are focusing in particular on the sustainable clothing industry in order to reduce the negative environmental consequences of fast fashion have led to rapid consumption through frequent and affordable clothing changes, which has led to the fashion industry being recognised as one of the most polluting industries in the modern world (Hassan et al., 2022b), and the increase in garment production over the past few decades has also led to serious concerns about the contribution of the fashion industry to the climate change crisis (Mizrachi & Tal, 2022). CSR developed by fashion companies has a significant positive impact on corporate image (Jeon, 2021). When consumers perceive a company as socially responsible, they are more likely to engage positively (Chen et al., 2012).

In the fashion market, more attention is paid to such factors as price, size, value, quality, style, ease of purchase, materials, durability, and environmental aspects, which are of little importance in the choice of fashion products. Studies have already found that CSR is an important part of the image of companies, and that it is the economic and ethical CSR initiatives that are the most important in creating a positive image of companies in the minds of consumers (Zhang & Cui, 2018). According to a study conducted in China, CSR has an impact on consumer engagement in sustainable consumption. A study in Pakistan (Huo et al., 2022) revealed the direct impact of CSR initiatives on sustainable purchase intention and also that brand trust and brand loyalty can act as mediators between CSR and consumer intention to purchase sustainable clothes.

Lee and Lee (2018) determined that companies' CSR initiatives can improve their corporate image and increase sales revenues. A positive corporate image can also increase consumers' decision to purchase the goods or services in question. The importance of CSR in creating a positive corporate image was also found by Vătămanescu et al. (2021). According to the insights from the study, consumers' choice to engage in sustainable consumption is influenced by the attitudes of fashion companies' towards social responsibility.

The aim of the research is to identify the impact of corporate image and social responsibility on consumer engagement in sustainable consumption. To achieve the aim of the study, the following objectives were formulated: i) to identify the links between corporate social responsibility and corporate image; ii) to determine the impact of corporate image components on consumers' engagement in sustainable consumption when choosing sustainable clothing and textiles. The study highlights the theoretical contribution to explaining the links between corporate image and corporate social responsibility and between consumer engagement and sustainable consumption.

An online survey was carried out and 406 responses were received from Lithuanian respondents. Correlation, linear regression, and multiple regression analyses were performed to evaluate the hypotheses and establish the significance of the relationships between the variables under investigation.

The remainder of the paper is structured in the following way. Section 1 provides a literature review, explains basic concepts, conceptualises the links between corporate image and social responsibility and explains sustainable consumption meaning, presents a model for studying the influence of corporate image and social responsibility on consumer engagement in sustainable consumption. Section 2

presents the research methodology. Section 3 presents results of empirical study for assessment of the impact of corporate image and social responsibility on consumer engagement in sustainable consumption in Lithuania and develops discussions.

1. Theoretical background

1.1 Corporate image and social responsibility

Corporate image is an important factor in attracting and retaining consumers. It is an important company's objective to attract consumers and also create a favourable public perception. The right corporate image can ensure market competitiveness. A satisfied and loyal consumer can contribute to an increase in supply, which is the hallmark of the development of competitive firms. Corporate image can help to improve the public's perception of the company itself, which is why many companies are actively working to create a positive image and convey it to the public (Obioma, 2019).

Corporate image can be defined as a concept that refers to consumers' perceptions of a company through the media or through direct and indirect experiences (e.g., from acquaintances and word-of-mouth recommendations; Dokmaipum et al., 2019). Different scholars (Horng et al., 2018; LeBlanc & Nguyen, 1996; Lee, 2019; Özkan et al., 2020; Triatmano et al., 2021) put the consumer at the centre of the concept of corporate image, as consumers determine the perception of the corporate image based on their own personal experiences, recommendations and perceptions. This means that corporate image is evaluated by the consumer, and communication to other consumers can become an important aspect in defining corporate image. However, the consumer is not the only important representative that should be focused on. In the context of corporate image development, it is important to understand the structure of corporate image – the parts that make a positive image possible. Scholars (Triatmano et al., 2021) identified emotional (managerial reputation and corporate identity) and functional (service offering, physical environment, accessibility and communication) attributes that create a corporate image, but when looking at the components of corporate image, it is possible to find quite different variations.

The components of corporate image that are often identified in the literature are: institution/corporate image, functional image and brand image. Corporate image is understood as consumers' perception of the company and includes consumers' attitudes towards corporate social responsibility practices. The functional image covers business and marketing aspects related to product innovation, pricing, marketing strategy and consumer service. Product image refers to consumers' impressions of a company's products or services (Stoyanov, 2017; Teng, 2019).

Service or product quality, differentiation, price, technology, culture and recognition (Gouji et al., 2016), consumer recommendations, sharing of experiences and consumer satisfaction (Sallam, 2016), and the importance of the brand in the image of companies (Latif et al., 2016) are also factors that contribute to the image of companies. The literature often focuses on the characteristics of a product or service that create a positive or negative corporate image. It has been noted that corporate image refers to the consumer's perception of the characteristics of the goods or services offered (Duque & Carvajal, 2018), or it has been pointed out (Ismail et al., 2021) that corporate image is composed of several components: tradition, ideology, the company's name, its reputation, the level of price of the goods or services, the perceived quality of the consumer, and the advertising. Corporate image also refers to the group of people who create the company in terms of its objectives, work ethic, methods, strategy and relationship with employees (Pérez & Torres 2017).

The Scholar (Rubtcova & Pavenkov, 2019) identifies eight components that create corporate image: 1) product/service image (includes the specifications of the product or service being sold, includes the name, design elements, packaging, quality, additional services/features); 2) consumer image (defines the consumer who chooses a particular service or product; this is influenced by personal qualities, character traits, lifestyle choices, the pursuit of needs, and status in society); 3) the internal image of the organisation (reflects the attitudes of those working in the company to the working environment, the psychological environment, communication between team members, and the relationship between managers and subordinate employees); 4) the image of the founder and/or key managers of the organisation (focusing on the verbal and non-verbal behaviour

and social traits of the key representatives of the company); 5) the image of the staff (collective, generalised; the behaviour, culture and communication manners of the company's employees in communicating the overall corporate image); 6) the visual image of the organisation (covering the aesthetic highlights of the company; 7) social image of the organisation (includes participation in social, community, projects, cooperation with other institutions); 8) corporate image (business image; includes building corporate reputation, ethical standards, fair play, competitive market presence, sales promotion, innovation, modernisation).

Corporate social responsibility is related to corporate image. Corporate social responsibility is part of corporate image, which contributes to the image of companies and is becoming one of the more important factors in determining consumer engagement in the context of sustainability these days. Corporate social responsibility is defined by different authors (Brin & Nehme, 2019; Hassan et al., 2022a,b; Sharma, 2019) in a similar way, as the pursuit of activities that are fair, legally just, ethical, socially relevant and that minimise negative environmental impacts. Corporate social responsibility is becoming an important aspect of creating a positive corporate image that leads to consumer engagement in sustainable consumption. Corporate social responsibility plays an important role in a company's profits, its reputation and consumers' perception of the company (Wang, 2018). It is identified as an essential marketing strategy for the sustainable development of a company. Chen et al. (2012) argued that CSR can have a positive impact on a company's interaction with consumers, creating a positive reputation and consumer satisfaction. CSR is often associated with the elimination of the effects of climate change in the literature. Companies whose activities have a negative impact on the quality of the environment need to focus on mitigating the negative effects.

Carroll's pyramid used in the literature to explain social responsibility (Carroll, 2016), which includes the four areas of social responsibility, but adds the area of sustainability, i.e., environmental responsibility, which is one of the most important in the context of sustainable consumption (Aldeia, 2021; Wang, 2018). The economic dimension refers to the ability of an enterprise to ensure the supply of goods or services to consumers, at socially appropriate prices, while at the same time being able to sustain economic growth. The legal domain defines the implementation of legal regulations in the business, the fairness of the tax system and the responsible conduct of business. Ethical responsibility refers to social norms and ethics, while the philanthropic sphere is defined as the "voluntary" sphere, which is manifested through the provision of assistance in the fields of education, health, art and culture (Gürlek et al., 2017; Hadi & Udin, 2021). Many authors have analysed and modified the triple bottom line theory. This theory defines three important aspects of CSR: the planet (environmental), profits (economic) and people (social) (Shim et al., 2021). Together, these domains provide an important implementation of CSR.

While the economic, legal, ethical and philanthropic domains are equally important in the context of CSR, the environmental domain is given special attention. CSR can be identified with corporate sustainability and this is the main driver of CSR (Singh & Misra, 2021). It is for this reason that CSR is an important part of corporate image in the context of sustainable consumption.

In summary, corporate image has a significant impact on consumers' engagement as corporate image can attract and retain consumers. Corporate image is determined by many factors: quality of service, feedback, internal environment (employees), name, reputation, and communication methods. As sustainability is becoming more important, corporate social responsibility can be one of the factors contributing to a positive image of a company, which can contribute to consumer engagement in sustainable consumption.

1.2 Consumer engagement in sustainable consumption

Consumer satisfaction is one of the most important "antecedents" of consumer engagement, as it is satisfied consumers who can create a positive relationship with the firm, but in the current literature, consumer satisfaction cannot be considered synonymous with consumer engagement, but rather as a determinant of consumer engagement (Gligor, 2019). Companies need to focus on slightly different management solutions because, in today's business world, achieving consumer satisfaction is not enough to maintain consumer

loyalty (Rosado-Pinto & Loureiro, 2020). Creating a positive relationship between business and consumer is crucial. This highlights an important objective for companies to ensure consumer engagement.

Consumer engagement, which refers to the investment of consumer resources in interacting with a brand (Hollebeek et al., 2019), has been proclaimed as one of the company's key objectives (Chang et al., 2019). Researchers (Kumar et al., 2019) argue that consumer engagement contributes to increased sales, increased share of wallet, improved corporate reputation and competition.

A rapidly changing world, a growing population and increasing consumption mean that people's consumption habits are closely linked to environmental changes. Declining quality of agricultural production, global warming, loss of biodiversity, depletion of non-renewable natural resources, are driving societies to rethink their consumption patterns and adopt environmentally friendly consumption. Sustainable consumption is a very important goal of sustainable development, which is linked to sustainable lifestyles and, according to the United Nations, is expressed as doing more and better with less (Simeone & Scarpato, 2020).

Sustainable consumption can be defined as the choice of environmentally friendly products also includes resource efficiency, promotion of the use of renewable resources, and the improvement of the quality of life. According to Quoquab et al. (2019), the concept refers to the ongoing action of managing desire by avoiding extravagant purchases. Sustainable consumption requires that society, companies, and individuals individually reduce their footprints in the interest of environmental protection (Anantharaman, 2018). In summary, sustainable consumption can be associated with consumer behaviour (choosing to buy from companies whose activities are more sustainable), limiting consumption, recycling products and materials, and choosing environmentally friendly consumption patterns such as the use of public transport, purchasing services and products that reduce the negative impact on the environment and society.

Sustainable consumption can be defined as the avoidance of non-essential purchases, responsible travel choices (e.g., public transport), the reuse of packaging and materials, the reduction of chemicals in the home, waste separation, the conservation of natural resources and the choice of environmentally friendly products or services (Jonkutė, 2015). One of the most important areas of sustainable consumption in the current literature and a cause of environmental change is the use of sustainable clothing. Throughout the entire life cycle of clothing, from production to use, there is a negative impact on the ecosystem and the environment (Connell & Kozar, 2014), which is why it is important to ensure sustainable consumption in the clothing and textiles sector (Jacobson & Harrison, 2022). In the context of sustainable consumption, key aspects (e.g., meeting basic human needs, caring for environmental well-being, caring for quality of life, caring for future generations, adopting a life-cycle thinking approach) are identified that convey why it is important to make sustainable consumption choices in today's society (Marques & Coelho, 2022; Quoquab & Mohammad, 2020).

Sustainable consumption patterns can be defined as consumer behaviour based on sustainable aspects. It shows how consumers behave in order to minimise their negative impact on the environment. Three important dimensions can influence sustainable consumer decisions (Shin & Bull, 2019): decision-making power, information (feedback) and motivation.

The fashion industry and sustainability are an integral part of today's sustainable development. It is important to influence sustainable consumption when choosing clothing and textile products. The environmental impact of the fashion industry is confirmed by the European Union's Sustainable and Circular Textiles Strategy, which aims to develop a greener use of textiles to combat the consequences of fast fashion and to reduce the negative environmental impact. The European Commission's (2022) report states that it is important to curb the consumption of textiles because the textile production almost doubled between 2000 and 2015, and consumption of clothing and clothing-linen is projected to increase by as much as 63% by 2023 (Lazaric et al., 2020). It can be argued that growing consumer demands and fast fashion goods are encouraging wasteful and unsustainable consumption and negative impacts on environmental quality.

According to the World Bank, the fashion industry consumes around 93 m^3 of water each year, the dyeing and processing of fabrics

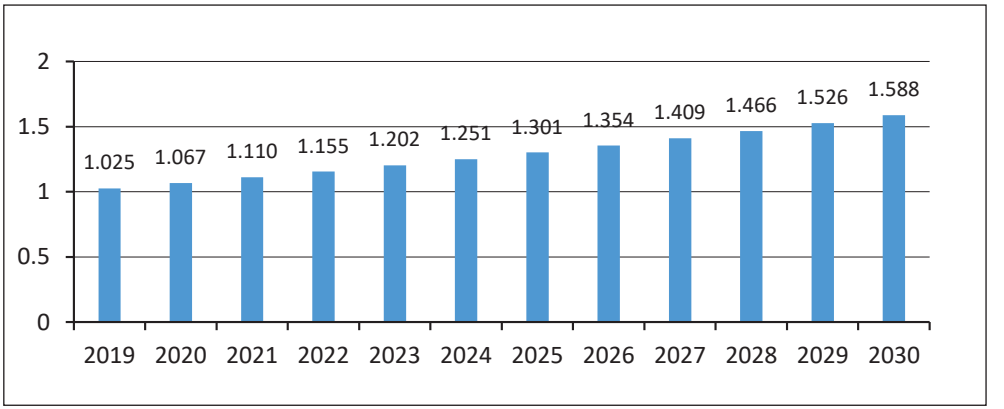


Fig. 1: **Carbon dioxide equivalent emissions from the global apparel industry 2019–2030 (Gt)**

Source: Projected carbon dioxide equivalent emissions of the apparel industry worldwide from 2019 to 2030 (Statista, 2022a,b)

account for 20% of the world's wastewater, and 10% of the an-carbon dioxide emitted annually is from the fashion industry (The World Bank, 2019). It is estimated that if rates continue, the fashion industry's greenhouse gas emissions could increase by more than 50%. Rapidly growing and changing demands mean that rates may increase due to fast fashion and unsustainable clothing. For this reason, promoting sustainable consumption is the first step towards reducing the negative environmental impact of the expansion of unsustainable production by companies in the clothing and textile sector. The high carbon emissions in the fashion industry are confirmed by the latest estimates of the Statista data portal (Fig. 1; Statista, 2022a,b).

Fig. 1 shows that in 2019, the fashion industry emitted 1.01 Gt of CO_2; without drastic action, it could reach 1.6 Gt by 2030. Although the clothing industry is one of the most polluting industries, a sustainable clothing market is

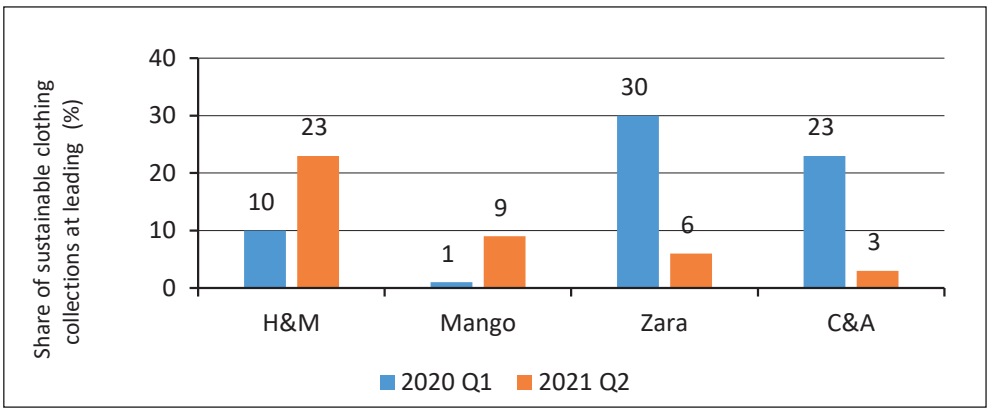


Fig. 2: **Share of the sustainable clothing collection in leading fast fashion stores in Europe (%; Q1 2020–Q1 2021)**

Source: Share of sustainable clothing collections at leading fast fashion retailers in Europe in the first quarter of 2020 and 2021 (Statista, 2022a,b)

not yet well developed. According to data from Statista (2022a,b) in 2021, sustainable clothing accounted for around 3.9% of global market sales and this is expected to increase to 6.1% in 2026.

Although sales in the fashion industry are growing, sustainable clothing represents only a small share of the total, as evidenced by the range of clothing sold by the most popular fashion chains, where sustainable clothing collections represent a small percentage of total sales (Fig. 2; Statista, 2022a,b). H&M offered the highest share of sustainable clothing in its range in Q1 2021 and the percentage of sustainable clothing increased by 13% year-on-year. Zara and C&A saw a significant decrease in the percentage of sustainable clothing between Q1 2020 and Q1 2021. The lowest proportion of sustainable clothing in the total range was offered by Mango chain stores, which accounted for only 1% in Q1 2020. The H&M group states that 95% of the cotton used is recycled and that they aim to use 100% renewable electricity by 2023 and to produce only from 100% recycled or other sustainably produced materials (H&M Group, 2018).

In summary, one of the tools to engage consumers in sustainable consumption is corporate image, which reflects consumers' attitudes towards a company. For this reason, the aim is to investigate whether corporate image can influence consumer engagement in sustainable consumption and which components of corporate image are most influential. The analysis of the empirical studies has shown that corporate image is influenced by socially responsible corporate actions, which are important for sustainable consumption. As companies can create a favourable image and gain the trust of consumers by implementing social responsibility, the impact of corporate image is examined by looking at how social responsibility relates to corporate image in terms of the perceived importance of social responsibility by consumers. Social responsibility is examined as an overall factor, but five areas of social responsibility are also identified.

The model (Fig. 3) also reflects the relationship between corporate image and consumer engagement in sustainable consumption.

In the light of the aspects examined, the following hypotheses are put forward:

H1: *Corporate social responsibility has a positive impact on corporate image.*

H2: *Corporate economic responsibility has a positive impact on corporate image.*

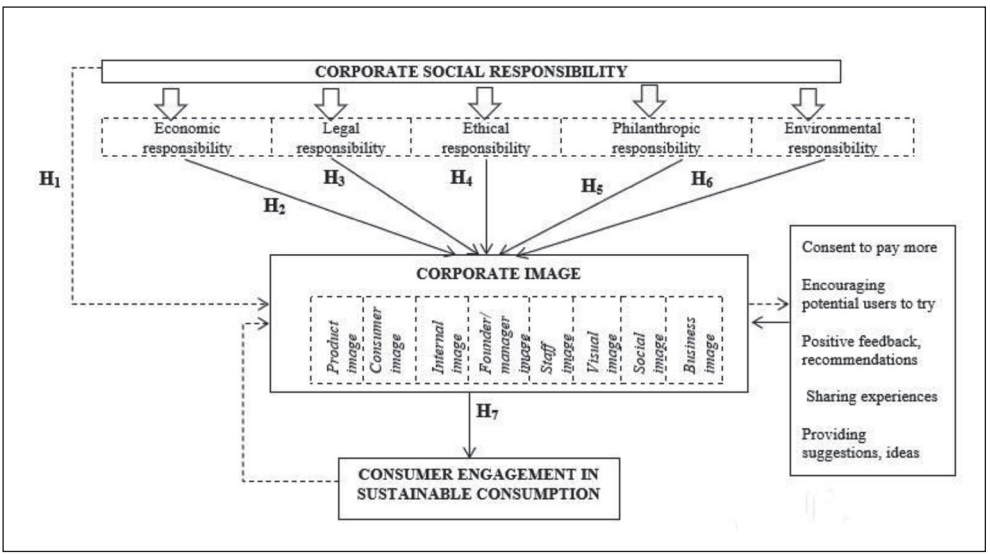


Fig. 3: A model for studying the impact of corporate image and social responsibility on consumer engagement in sustainable consumption

Source: own

H3: Corporate ethical responsibility has a positive impact on corporate image.

H4: Corporate legal responsibility has a positive impact on corporate image.

H5: Corporate philanthropic responsibility has a positive impact on corporate image.

H6: Corporate environmental responsibility has a positive impact on corporate image.

H7: Corporate image influences consumers' engagement in sustainable consumption by choosing sustainable clothing and textiles.

2. Research methodology

The statistical information confirms the relevance and importance of the topic. Pollution levels in the clothing and textile industry are increasing rapidly and sustainable clothing collections in fast fashion stores are not replacing conventional clothing. In order to reduce negative environmental impacts, it is important to raise consumer awareness of sustainable consumption and to promote the choice of sustainable clothing and textiles.

In order to investigate consumers' attitudes towards sustainable consumption, the meaning of social responsibility and the impact of corporate image on consumer engagement, the survey was carried out between March and April 2023. The questionnaire was posted online, and the survey link was shared on various social platforms. This research method is modern, scientifically valid and can be considered a reliable and appropriate method of data collection. The availability of social media is wide, which allows it to reach respondents with different socio-demographic characteristics and to speed up data collection.

The questions are grouped according to themes that address different aspects of the study, and a Likert scale (with a maximum of 5 and a minimum of 1) is used to rate the questionnaire statements.

The concept of corporate image is assessed based on an analysis of the literature (Lee, 2019; Özkan, 2020; Triatmano et al., 2021; Yu et al., 2021). The components of the corporate image (product, consumer, internal, managerial, personnel, social, and business image) are identified (Rubtcova & Pavenkov, 2019). Consumer behaviour determined by a positive corporate image is analysed by adapting the statements: "I only say positive things about the company to others"; "I encourage friends and relatives to buy and use it"; "I recommend this product to others, when I am approached for advice," etc. (Leckie et al., 2021). In order to make consumers evaluate a socially responsible company, the questions and answers are based on the statements identified by Chen et al. (2021): "I have a positive view of a company that carries out CSR"; "CSR activities developed by a company change my view of the company," etc.). The importance of corporate social responsibility is explored through the statements developed by Lee (2019) and Cha and Jo (2019), who define the domains of social responsibility.

To assess consumer engagement, the statements describing consumer engagement by Mandarić et al. (2022) are adapted from theoretical and empirical material. Criteria for assessing sustainable consumption are used to assess the understanding of the concept of sustainable consumption (Jonkutė, 2015). In order to investigate consumers' engagement in sustainable consumption when choosing sustainable clothing and textiles, the statements developed by D'Adamo and Colasante (2022): "My choice to buy sustainable clothing and textiles is influenced by the positive image of the companies"; "Before buying clothing and textiles, I seek information about the sustainability policies and socially responsible practices of these companies," etc.). The study defines sustainable clothing and textiles as clothing and textiles that are environmentally friendly, less harmful to the environment and made from recycled, natural materials, in accordance with all the principles of social responsibility (Jacobson & Harrison, 2022).

The Paniotto formula is used to determine the sample for the quantitative survey. A sampling error of 5% is chosen, with a probability of 95%. The age of the sampled population In 2023, the population of Lithuania was 2,428,680 at the beginning of the year, so the sample size of the survey is 384 respondents.

Four hundred six respondents completed the questionnaire, of which 49.8% were male and 48% female. 9 respondents, i.e., 2.2%, did not wish to disclose their gender. More than half of the respondents, i.e., 54.2%, stated that their monthly after-tax income was between EUR 1,001 and EUR 1,500, 27.8% stated that their monthly after-tax income was between EUR 1,501 and EUR 2,000. 85.5% of the respondents were employed, 11.1% were students. The largest share of respondents in the survey was in the 25–44 and 45–64 age

Tab. 1: Evaluation of the internal consistency of the questionnaire

	Number of statements	Cronbach's alpha coefficient	Spearman-Brown coefficient
The impact of corporate social responsibility on corporate image	21	0.973	0.974
The impact of corporate image on consumer engagement in sustainable consumption	5	0.792	0.797
Full questionnaire		**0.892**	**0.916**

Source: own

groups (43.1% and 44.1%, respectively). It was noted that the majority of the respondents have a university degree (35%) or a post-secondary education (30.3%).

The questionnaire questions are grouped according to themes dealing with different aspects of the study and a Likert scale (with a maximum value of 5 and a minimum value of 1) was used to evaluate the questionnaire statements. The assessment of the consistency and reliability of the statements is very high, with a Cronbach's alpha coefficient of 0.973 (Tab. 1).

It can be concluded that the questionnaire has adequate reliability for data analysis and generalization of results.

Correlation, linear regression and multiple regression analyses are carried out to test the hypotheses and to determine the significance of the relationships between the variables. Pearson's correlation coefficients for linear correlation and Spearman's correlation coefficients for rank correlation are calculated. These methods of analysis are used to examine one dependent and one independent variable and to construct a linear regression equation, which is used to predict the values of the dependent variable (Hae-Young, 2018):

$$y = b_0 + b_1 x + e \quad (1)$$

where: b_0 – constant; b_1 – direction coefficient; e – random error.

The regression equation can be used to determine how much of the variance of the variable y depends on the value of the variable x, i.e., how the values of the dependent variable will vary with the values of the independent variable.

The statistical significance of the regression model is checked against the values obtained from the ANOVA table produced by the SSPS. The regression model is statistically significant when the p-value of the F-criterion is 0.000. To check the reliability of the regression, the R-squared – coefficient of determination ($R^2 < 0.25$) is used. This indicator shows the proportion of one variable that is determined by the other variable, and therefore provides a check on the adequacy of the regression analysis.

In summary, it can be argued that social responsibility can influence corporate image, which can lead to a positive corporate image that encourages consumer involvement in sustainable consumption.

3. Results and discussion

3.1 Results

The first questions of the questionnaire were designed to explore the importance of sustainable consumption for the respondents and how they individually pursue sustainable consumption. The most important aspects of sustainability for respondents were that the products they use are environmentally friendly (90.9% of respondents agreed with this statement) and that they are concerned that the planet's resources are not wasted (86.7%). As many as 23.9% of respondents strongly disagreed with the statement that they can be described as environmentally responsible consumers.

When looking at how respondents themselves contribute to sustainable consumption, it was found that they mainly pursue sustainable consumption by sorting waste (48.5%), reducing the use of chemicals in the household (50.2%), reusing packaging materials, shopping bags, etc. (64%), and choosing environmentally friendly products (57.1%). Fewer respondents agreed with the statement that they choose to travel

responsibly, with only 7 respondents strongly agreeing with this statement. Women gave the highest average score of 4.42 to the statement "I separate my waste," while men gave the highest average score of 4.29.

Consumers were asked to indicate what they think makes a corporate image. 54.7% of respondents said that corporate image is defined as the evaluation of a company through consumers' direct and indirect experiences with the company. This answer was chosen by 59.9% of women and 39.2% of men. The most important components of corporate image, according to the respondents, are the image of the product (i.e., name, design, packaging, quality and other product characteristics; average score 4.38) and the image of the staff (behaviour of staff, culture; score 4.33). Visual image (the company's physical environment, the style of its employees; 4.29) is slightly less important, while consumer image, i.e., what characterises the company's consumers, was the least important to respondents (mean score of 2.61).

When assessing the importance of CSR for corporate image, it was found that more than 90% of respondents have a favourable view of a company that is engaged in CSR. When looking at the different areas of social responsibility that can affect corporate image, consumers gave the highest average score to the economic area (4.49) and the lowest to the philanthropic area (4.17; Tab. 2).

Respondents believe that companies should comply with laws and regulations (4.52), operate in a transparent manner (4.5), reduce environmental damage (4.49), increase employment (4.49) and improve the quality of services (4.49). It is important to note that women aged 19–24 were the most likely to strongly agree with these statements. Women scored higher on average than men in terms of the importance of CSR areas for corporate image.

Also, it was found that 37.5% of women aged 45–64, 18.4% of women aged 25–44 and only 5.4% of women aged 19–24 prefer only sustainable clothing products. 51% of men aged 25–44 and 36.4% of men aged 45–64 strongly disagreed with the statement that they prefer to buy only sustainable clothing products. Only 7.4% of respondents said that they prefer clothing and textile companies that have sustainable clothing lines and only 10.1% strongly agree with the statement that they look for information on companies' sustainability policies and social responsibility initiatives before buying clothing and textiles. 22.4% of respondents had a negative view of corporate sustainability and social responsibility and strongly agreed that such actions are just a marketing tool. More than 57.1% of respondents strongly agreed that corporate image influences their choice to buy sustainable clothing and textiles. 49.5% of men and 65.6% of women strongly agree with the statement that corporate image influences the choice to buy sustainable clothing and textiles.

In summary, respondents recognise the importance of sustainable consumption, especially in terms of not wasting the planet's resources and not having a negative impact on the environment. Respondents pursue sustainable consumption in a variety of ways, e.g., sorting waste, reducing the use of chemicals in the home, and reusing packaging materials. Respondents consider that corporate image is mainly driven by the image of the product and the image of the staff, and that a positive corporate image leads to positive feedback, recommendations, and encouragement to buy

Tab. 2: Assessment of the importance of social responsibility for corporate image (average score)

CRS	Female	Male	Total average score
Environmental responsibility	4.55	4.35	4.44
Economic responsibility	4.63	4.38	4.49
Ethical responsibility	4.63	4.36	4.48
Philanthropic responsibility	4.18	4.18	4.17
Legal responsibility	4.62	4.37	4.48

Source: own

and use. Respondents have a favourable view of a company with corporate social responsibility and highlight the importance of economic and legal responsibility.

The analysis of the correlation between the two variables corporate image and corporate social responsibility, showed a moderate correlation (r = 0.423 and p = 0.000, p < 0.05), suggesting that hypothesis *H1* is true. There is a statistically significant and positive moderate relationship between corporate image and corporate social responsibility. Corporate social responsibility (CSR) improves corporate image.

The regression model is statistically significant with an F-criterion of p = 0.000 (Tab. 3).

The coefficient of the variable corporate image in the regression model is statistically significantly different from zero at p = 0.000. The coefficient of determination (R = 0.179) shows that corporate social responsibility is a 17.9% determinant of corporate image.

The correlation of individual CSR areas with corporate image is statistically significant (Tab. 4).

The strongest correlation was found between corporate environmental responsibility and corporate image, with a correlation coefficient of r = 0.436 and p = 0.000 (p < 0.05), which means that hypothesis *H6* was confirmed and that corporate environmental responsibility has a positive impact on corporate image (Tab. 4). The weakest correlation (r = 0.268, p = 0.000) was found with philanthropic social responsibility and corporate image, but this correlation is statistically significant, so it can be concluded that hypothesis *H5* has been supported.

Tab. 3: Results of linear regression

Model	Unstandardised coefficients*		Standardised coefficients*	*t*	Sig.
	B	Std. error	Beta		
(Constant)	12.409	0.614		20.194	0.000
Corporate social responsibility components	0.164	0.017	0.423	9.392	0.000
F = 88.201 (p = 0.000), R = 0.423, R-square = 0.179, adjusted R-square = 0.177					

Note: *Dependent variable: components of corporate image.

Source: own

Tab. 4: Statistical assessment of the impact of social responsibility on corporate image

Hypotheses	Correlation coefficient (r)	p-value	Regression equation
H1 – **Corporate social responsibility has** a **positive impact on corporate image**	0.423	0.000	12.409 + 0.164*x*
H2 – **Corporate economic responsibility has** a **positive impact on corporate image**	0.366	0.000	17.930 + 0.543*x*
H3 – **Corporate ethical responsibility has** a **positive impact on corporate image**	0.420	0.000	16.730 + 1.023*x*
H4 – **Corporate legal responsibility has** a **positive impact on corporate image**	0.412	0.000	16.557 + 0.757*x*
H5 – **Corporate philanthropic responsibility has** a **positive impact on corporate image**	0.268	0.000	22.368 + 0.466*x*
H6 – **Corporate environmental responsibility has** a **positive impact on corporate image**	0.436	0.000	16.390 + 0.619*x*

Source: own

Philanthropic corporate responsibility explains only 0.72% of the changes in the other variable, i.e., corporate image. It can be seen that there is a weak but statistically significant relationship with economic responsibility, and the coefficient of determination shows that economic responsibility is likely to have a 13% effect on corporate image. This means that hypothesis *H2* is confirmed. A moderate statistically significant relationship was found with legal and ethical responsibility, which means that hypotheses *H3* and *H4* were confirmed.

Corporate image may have a small influence on consumer engagement in sustainable consumption when choosing sustainable clothing and textiles; therefore, *H7* – corporate image influences consumer engagement in sustainable consumption when choosing sustainable clothing and textiles – is not supported. A moderate relationship was found between consumer engagement in sustainable consumption when choosing sustainable clothing and textiles and social image (correlation coefficient 0.474); a moderate relationship (correlation coefficient of 0.471) was found between consumer engagement in sustainable consumption when choosing sustainable clothing and textiles and product image, and a weak relationship (correlation coefficient of 0.471) was found between consumer engagement in sustainable consumption when choosing sustainable clothing and textiles and staff image (correlation coefficient of 0.325), a weak relationship (correlation coefficient of 0.298) was found between consumer engagement in sustainable consumption when choosing sustainable clothing and textiles and visual image. Considering all the components of corporate image (product, consumer, internal, managerial, staff, visual, social, business image) and respondents' engagement in sustainable consumption when choosing sustainable clothing and textiles together, there was a very weak, although statistically significant, correlation (r = 0.183, p = 0.000). The linear regression model shows that corporate image is only a 0.33% predictor of consumer engagement in sustainable consumption when choosing sustainable clothing and textiles products.

The correlation analysis between corporate social responsibility image and consumer engagement in sustainable consumption in sustainable clothing and textiles also shows a weak but statistically significant relationship (r = 0.384, p = 0.000). It can be argued that corporate social responsibility has a stronger influence on consumer engagement in sustainable consumption when choosing sustainable clothing and textiles, but that this influence is also not strong. The coefficient of determination shows that the socially responsible corporate image explains only 15% of the consumers' engagement in sustainable consumption when choosing sustainable clothing and textiles.

To summarise the results of the study, it can be concluded that social responsibility has an impact on corporate image and clothing and textile companies should not only strive to create a socially responsible corporate image but also contribute to promoting sustainable consumption through communication and consumer awareness.

3.2 Discussion

The link between corporate image and corporate social responsibility has emerged in the study of sustainable consumption aspects. Many authors (Chen et al., 2021; Stoyanov, 2017; Wang, 2018; Wong & Kim, 2020) have highlighted the importance of corporate social responsibility in creating a positive corporate image, and the results of the studies already carried out have shown that in the context of sustainable consumption, corporate image is seen through the exercise of social responsibility. This is supported by Yu et al. (2021), who investigated the influence of the corporate image of organic products on consumer purchasing behaviour and corporate social responsibility. These authors highlighted that a positive corporate image will attract and retain consumers, while high-quality products and social responsibility practices will ensure consumer trust. As corporate social responsibility increases, i.e., as more corporate social responsibility initiatives are undertaken, corporate image, i.e., what consumers see, understand and value, improves.

Scholars (Gürlek et al., 2021; Hadi & Udin, 2021; Kumar, 2018) have looked at social responsibility in several areas: economic, ethical, legal, and philanthropic, or have identified one of the most important areas today, environmental responsibility. A statistical assessment of the impact of social responsibility on corporate image has shown that the strongest link also exists between environmental corporate responsibility and corporate image. Corporate environmental responsibility has a 19% impact

on corporate image. The weakest relationship was found between philanthropic social responsibility and corporate image (changes in philanthropic corporate responsibility explain only 0.72% of the changes in corporate image). However, different insights can be found in other authors' studies. A survey of the Chinese population (Zhang & Cui, 2018) showed that economic and ethical CSR initiatives are the most important in creating a positive image of companies in the minds of consumers.

The analysis of empirical studies (Hassan et al., 2022a,b; Mizrachi & Tal, 2022; Quoquab & Mohammad, 2020) has shown that the apparel and textile sector and consumers' engagement in sustainable consumption of apparel and textile products are particularly important in the context of sustainable consumption. The promotion of fast fashion and the use of unsustainable clothing and textiles have a negative impact on the quality of the environment and contribute to the year-on-year increase in pollution levels. In order to promote consumer engagement in sustainable consumption, companies need to focus on corporate image development (James & James, 2022; Mandarić et al., 2022). However, the results of the study showed a very weak but statistically significant relationship (r = 0.183, p = 0.000) between all components of corporate image and respondents' engagement in sustainable consumption when choosing sustainable clothing and textiles products. Moreover, engaging in sustainable initiatives involves higher costs for the consumer, and it's also important to have a product offering that gives the consumer a choice – something that fast-fashion clothing and textile production allows.

Social responsibility is important not only for corporate image but also for consumer engagement in sustainable consumption. The assessment of the relationship between the image of socially responsible companies and consumer engagement in sustainable consumption when choosing sustainable clothing and textiles shows that the image of socially responsible companies has a stronger influence on consumer engagement in sustainable consumption when choosing sustainable clothing and textiles, but that this influence is also not strong.

In developing sustainable business models, companies need to integrate environmental, social, and economic considerations to create sustainable and long-term value for their businesses, society, and the environment. Future questions include: what sustainable business models can encourage consumers to engage in sustainable consumption? A further line of research is planned to include corporate labelling and certification tools that can influence consumer engagement in sustainable consumption.

Conclusions

The concept of corporate image can be defined by looking at two key concepts in the context of corporate image: corporate individuality and corporate identity, and explained through eight components. It is important to ensure the development of social responsibility in corporate image building, as it can contribute to a positive corporate image. Consumer engagement is a consumer behaviour that is favourable to the company, which is important for the business in terms of benefits such as increased consumer traffic, profitability, competitiveness, improved image, and reputation.

A positive corporate image can lead consumers to choose sustainable consumption. Consumers whose engagement is driven by corporate image are more likely to share positive recommendations and respond more flexibly to price changes. A positive corporate image can lead to consumer satisfaction and long-term consumer retention, i.e., loyalty, which can influence positive consumer engagement with sustainable consumption.

Corporate social responsibility plays an important role in the context of corporate image. Corporate social responsibility has a positive impact on corporate image, and clothing and textile companies implement social responsibility not only by ensuring the production of sustainable clothing and textile products, but also by participating in social activities, supporting environmental organisations and improving the working environment. The study highlights the importance of economic, ethical, legal and environmental responsibility. Corporate image was found to have an impact on consumers' engagement in sustainable consumption through the choice of sustainable clothing and textiles, but correlation-regression analysis showed a weak relationship.

This study confirmed the theoretical insights that highlighted the positive impact of corporate image on consumer engagement in sustainable consumption. It also confirmed the importance

of social responsibility in creating a positive corporate image and in encouraging consumers to choose sustainable consumption.

References

Aldeia, S., Monteiro, M., Conde, R., & Lopes, J. (2021). Corporate social responsibility dimensions and sustainable entrepreneurship. In *Proceedings of the European Conference on Innovation and Entrepreneurship 2021*, 1–7. https://doi.org/10.34190/eie.21.126

Ali, H. Y., Danish, R. Q., & Asrar ul-Haq, M. (2019). How corporate social responsibility boosts firm financial performance: The mediating role of corporate image and customer satisfaction. *Corporate Social Responsibility and Environmental Management*, *27*(1), 166–177. https://doi.org/10.1002/csr.1781

Anantharaman, M. (2018). Critical sustainable consumption: A research agenda. *Journal of Environmental Studies and Sciences*, *8*(4), 553–561. https://doi.org/10.1007/s13412-018-0487-4

Asiaei, K., Barani, O., Bontis, N., & Sidhu, J. (2021). The role of sustainability control systems in translating CSR into performance in Iran. *Management Decision*, *60*(31), 1438–1468. https://doi.org/10.1108/md

Belas, J., Smrcka, L., Palcak, L., & Khan, K. A. (2023). The influence of CSR on significant factors of SMEs human resource management in V4 countries. *Transformations in Business & Economics*, *22*(2), 178–195.

Brin, P., & Nehme, M. N. (2019). Corporate social responsibility: Analysis of theories and models. *EUREKA: Social and Humanities*, *5*, 22–30. https://doi.org/10.21303/2504-5571.2019.001007

Carroll, A. B. (2016). Carroll's pyramid of CSR: Taking another look. *International Journal of Corporate Social Responsibility*, *1*(1), 2–8. https://doi.org/10.1186/s40991-016-0004-6

Cha, J.-B., & Jo, M.-N. (2019). The effect of the corporate social responsibility of franchise coffee shops on corporate image and behavioral intention. *Sustainability*, *11*(23), 6849. https://doi.org/10.3390/su11236849

Chang, C.-W., Huang, H.-C., Wang, S.-J., & Lee, H. (2019). Relational bonds, customer engagement, and service quality. *The Service Industries Journal*, *41*(5–6), 330–354. https://doi.org/10.1080/02642069.2019.1611784

Chen, C.-C., Khan, A., Hongsuchon, T., Ruangkanjanases, A., Chen, Y.-T., Sivarak, O., & Chen, S.-C. (2021). The role of corporate social responsibility and corporate image in times of crisis: The mediating role of customer trust. *International Journal of Environmental Research and Public Health*, *18*(16), 8275. https://doi.org/10.3390/ijerph18168275

Chen, C.-C., Lin, S.-Y., Cheng, C.-H., & Tsai, C.-C. (2012). Service quality and corporate social responsibility, influence on post-purchase intentions of sheltered employment institutions. *Research in Developmental Disabilities*, *33*(6), 1832–1840. https://doi.org/10.1016/j.ridd.2012.05.006

Connell, K. Y. H., & Kozar, J. M. (2014). Environmentally sustainable clothing consumption: Knowledge, attitudes, and behavior. In *Roadmap to sustainable textiles and clothing* (pp. 41–64). Springer Singapore. https://doi.org/10.1007/978-981-287-110-7_2

D'Adamo, I., & Colasante, A. (2022). Survey data to assess consumers' attitudes towards circular economy and bioeconomy practices: A focus on the fashion industry. *Data in Brief*, *43*, 108385. https://doi.org/10.1016/j.dib.2022.108385

Dokmaipum, S., Khantanapha, N., & Piriyakul, R. (2019). Corporate image management of retail business (downstream). *Open Journal of Business and Management*, *7*(02), 892–907. https://doi.org/10.4236/ojbm.2019.72061

Duque, E. J., Oliva, & Carvajal, L. A. P. (2015). La identidad organizacional y su influencia en la imagen: Una reflexión teórica [Organizational identity and its influence on image: A theoretical reflection]. *Suma de Negocios*, *6*(13), 114–123. https://doi.org/10.1016/j.sumneg.2015.08.011

European Commission. (2022). *Questions and answers on EU strategy for sustainable and circular.* https://ec.europa.eu/commission/presscorner/detail/en/QANDA_22_2015

Gligor, D., Bozkurt, S., & Russo, I. (2019). Achieving customer engagement with social media: A qualitative comparative analysis approach. *Journal of Business Research*, *101*, 56–59. https://doi.org/10.1016/j.jbusres.2019.04.006

Gouji, R. K., Taghvaei, R., & Soleimani, H. (2016). The effect of corporate image on the formation of customer attraction. *Management Science Letters*, *6*, 655–670. https://doi.org/10.5267/j.msl.2016.8.003

Gürlek, M., Düzgün, E., & Meydan Uygur, S. (2017). How does corporate social responsibility create customer loyalty? The role of corporate image. *Social Responsibility*

Journal, *13*(3), 409–427. https://doi.org/10.1108/srj-10-2016-0177

Hadi, N., & Udin, U. (2021). Testing the effectiveness of CSR dimensions for small business entrepreneurs. *Journal of Open Innovation: Technology, Market, and Complexity*, *7*, 1–15.

Hae-Young, K. (2018). Statistical notes for clinical researchers: Simple linear regression 2 – Evaluation of regression line. *Restorative Dentistry & Endodontics*, *43*(3), 4–5. https://doi.org/10.5395/rde.2018.43.e34

Hassan, S. H., Yeap, J. A. L., & Al-Kumaim, N. H. (2022). Sustainable fashion consumption: Advocating philanthropic and economic motives in clothing disposal behaviour. *Sustainability*, *14*(3), 1875. https://doi.org/10.3390/su14031875

Hassan, Y., Pandey, J., Behl, A., Pereira, V., & Vaz, D. (2022). CSR authenticity and micro-foundations of business: A systematic review. *Cross Cultural & Strategic Management*, *30*(1), 37–68. https://doi.org/10.1108/ccsm-11-2021-0213

H&M Group. (2018). *H&M sustainability report*. H&M Group. https://hmgroup.com/wp

Hollebeek, L. D., Srivastava, R. K., & Chen, T. (2019). S-D logic-informed customer engagement: Integrative framework, revised fundamental propositions, and application to CRM. *Journal of the Academy of Marketing Science*, *47*(1), 161–185. https://doi.org/10.1007/s11747-016-0494-5

Horng, J.-S., Liu, C.-H., Chou, S.-F., Tsai, C.-Y., & Hu, D. C. (2018). Does corporate image really enhance consumer's behavioural intentions? *Asia Pacific Journal of Tourism Research*, *23*(10), 1008–1020. https://doi.org/10.1080/10941665.2018.1513946

Huo, C., Hameed, J., Zhang, M., Bin Mohd Ali, A. F., & Amri Nik Hashim, N. A. (2022). Modeling the impact of corporate social responsibility on sustainable purchase intentions: Insights into brand trust and brand loyalty. *Economic Research – Ekonomska Istraživanja*, *35*(1), 4710–4739. https://doi.org/10.1080/1331677x.2021.2016465

Ismail, A., Bakri, M. H., & Nordin, M. N. (2021). Auditee satisfaction impact on compliance and corporate image concerning Malaysian SMEs. *Turkish Journal of Computer and Mathematics Education*, *12*(10), 3436–3452. https://doi.org/10.17762/turcomat.v12i10.5020

Jacobson, J., & Harrison, B. (2021). Sustainable fashion social media influencers and content creation calibration. *International Journal of Advertising*, *41*(1), 150–177. https://doi.org/10.1080/02650487.2021.2000125

James, P., & James, J. (2022). Green brand image and sustainability: Marketing implications of high-school student responses. *International Journal of Marketing Studies*, *14*(1), 81–94. https://doi.org/10.5539/ijms.v14n1p81

Jeon, J.-H. (2021). The effect of corporate social responsibility on the corporate image and purchase intention. *Journal of the Korean Society of Clothing and Textiles*, *35*(5), 547–560. https://doi.org/10.5850/jksct.2011.35.5.547

Jonkutė, G. (2015). The consumers' approach to sustainable consumption and production: A case study in Lithuania. *Environmental Research, Engineering and Management*, *71*(4), 28–46. https://doi.org/10.5755/j01.erem.71.4.13642

Jung, H. J., Choi, Y. J., & Oh, K. W. (2020). Influencing factors of Chinese consumers' purchase intention to sustainable apparel products: Exploring consumer "attitude–behavioral intention" gap. *Sustainability*, *12*(5), 1770. https://doi.org/10.3390/su12051770

Kumar, V. (2018). A theory of customer valuation: Concepts, metrics, strategy, and implementation. *Journal of Marketing*, *82*(1), 1–19. https://doi.org/10.1509/jm.17.0208

Kumar, V., Rajan, B., Gupta, S., & Pozza, I. D. (2019). Customer engagement in service. *Journal of the Academy of Marketing Science*, *47*(1), 138–160. https://doi.org/10.1007/s11747-017-0565-2

Latif, W. B., Aminul Islam, Md., Noor, I. Md., Mohamad, M., & Kongsompong, K. (2016). Imagination of brand image for tourism industry. *Problems and Perspectives in Management*, *14*(2), 138–142. https://doi.org/10.21511/ppm.14(2-1).2016.02

Lazaric, N., Le Guel, F., Belin, J., Oltra, V., Lavaud, S., & Douai, A. (2020). Determinants of sustainable consumption in France: The importance of social influence and environmental values. *Journal of Evolutionary Economics*, *30*(5), 1337–1366. https://doi.org/10.1007/s00191-019-00654-7

LeBlanc, G., & Nguyen, N. (1996). Cues used by customers evaluating corporate image in service firms: An empirical study in financial institutions. *International Journal of Service Industry Management*, *7*(2), 44–56. https://doi.org/10.1108/09564239610113460

Leckie, C., Rayne, D., & Johnson, L. W. (2021). Promoting customer engagement

behavior for green brands. *Sustainability*, *13*(15), 8404. https://doi.org/10.3390/su13158404

Lee, C.-Y. (2019). Does corporate social responsibility influence customer loyalty in the Taiwan insurance sector? The role of corporate image and customer satisfaction. *Journal of Promotion Management*, *25*(1), 43–64. https://doi.org/10.1080/10496491.2018.1427651

Lee, J., & Lee, Y. (2018). Effects of multi-brand company's CSR activities on purchase intention through a mediating role of corporate image and brand image. *Journal of Fashion Marketing and Management*, *22*(3), 387–403. https://doi.org/10.1108/jfmm

Mandarić, D., Hunjet, A., & Vuković, D. (2022). The impact of fashion brand sustainability on consumer purchasing decisions. *Journal of Risk and Financial Management*, *15*(4), 176. https://doi.org/10.3390/jrfm15040176

Marques, D. L., & Coelho, M. C. (2022). A literature review of emerging research needs for micromobility – Integration through a life cycle thinking approach. *Future Transportation*, *2*(1), 135–164. https://doi.org/10.3390/futuretransp2010008

Mizrachi, M. P., & Tal, A. (2022). Regulation for promoting sustainable, fair and circular fashion. *Sustainability*, *14*(1), 502. https://doi.org/10.3390/su14010502

Obioma, O. (2019). A three dimensional model of corporate image configuration: Lesson for managers. *Saudi Journal of Engineering and Technology*, *3*(11), 472–479. https://doi.org/10.36348/sjef.2019.v03i11.001

Özkan, P., Süer, S., Keser, I. K., & Kocakoç, I. D. (2020). The effect of service quality and customer satisfaction on customer loyalty. *International Journal of Bank Marketing*, *38*(2), 384–405. https://doi.org/10.1108/ijbm

Pérez, J. P., & Martínez Torres, E. (2017). Evaluation of the organizational image of a university in a higher education institution. *Contaduría y Administración*, *62*(1), 123–140. https://doi.org/10.1016/j.cya.2016.01.007

Prentice, C., Wang, X., & Loureiro, S. M. C. (2019). The influence of brand experience and service quality on customer engagement. *Journal of Retailing and Consumer Services*, *50*, 50–59. https://doi.org/10.1016/j.jretconser.2019.04.020

Quoquab, F., & Mohammad, J. (2020). A review of sustainable consumption (2000 to 2020): What we know and what we need to know. *Journal of Global Marketing*, *33*(5), 305–334. https://doi.org/10.1080/08911762.2020.1811441

Quoquab, F., Mohammad, J., & Sukari, N. N. (2019). A multiple-item scale for measuring "sustainable consumption behaviour" construct: Development and psychometric evaluation. *Asia Pacific Journal of Marketing and Logistics*, *31*(4), 791–816. https://doi.org/10.1108/apjml-02-2018-0047

Rodriguez-Gomez, S., Arco-Castro, M. L., Lopez-Perez, M. V., & Rodríguez-Ariza, L. (2020). Where does CSR come from and where does it go? *Administrative Sciences*, *10*(3), 60. https://doi.org/10.3390/admsci10030060

Rosado-Pinto, F., & Loureiro, S. M. C. (2020). The growing complexity of customer engagement: A systematic review. *EuroMed Journal of Business*, *15*(2), 167–203. https://doi.org/10.1108/emjb-10-2019-0126

Rozsa, Z., Tupa, M., Belas, J., Metzker, M. Jr., & Suler, P. (2022). CSR conception and its prospective implementation in the SMEs business of Visegrad countries. *Transformations in Business & Economics*, *21*(1), 274–289.

Rubtcova, M., & Pavenkov, O. (2019). Features of forming corporate image. In *Proceedings of The IIER – 517th International Conference on Law and Political Science*, Tamil Nadu, India 23rd–24th April 2019.

Sallam, M. A. (2016). An investigation of corporate image effect on WOM: The role of customer satisfaction and trust. *International Journal of Business Administration*, *7*(3), 27–35. https://doi.org/10.5430/ijba.v7n3p27

Sharma, E. (2019). A review of corporate social responsibility in developed and developing nations. *Corporate Social Responsibility and Environmental Management*, *26*(4), 712–720. https://doi.org/10.1002/csr.1739

Shim, J., Moon, J., Lee, W. S., & Chung, N. (2021). The impact of CSR on corporate value of restaurant businesses using triple bottom line theory. *Sustainability*, *13*(4), 2131. https://doi.org/10.3390/su13042131

Shin, H. D., & Bull, R. (2019). Three dimensions of design for sustainable behaviour. *Sustainability*, *11*(17), 4610. https://doi.org/10.3390/su11174610

Simeone, M., & Scarpato, D. (2020). Sustainable consumption: How does social media affect food choices? *Journal of Cleaner Production*, *277*, 124036. https://doi.org/10.1016/j.jclepro.2020.124036

Singh, K., & Misra, M. (2021). Linking corporate social responsibility (CSR) and

organizational performance: The moderating effect of corporate reputation. *European Research on Management and Business Economics*, *27*(1), 100139. https://doi.org/10.1016/j.iedeen.2020.100139

Statista. (2022a). *Projected carbon dioxide equivalent emissions of the apparel industry worldwide from 2019 to 2030*. https://www.statista.com/statistics/1305696/apparel

Statista. (2022b). *Sales share of sustainable clothing items within the global apparel market from 2013 to 2026*. https://www.statista.com/forecasts/1307848/worldwide

Stoyanov, P. (2017). Corporate social responsibility and corporate image building. *Scientific Journal Economics and Finance*, *8*, 1–112.

Teng, W. (2019). Importance of corporate image for domestic brands moderated by consumer ethnocentrism. *Journal of Product & Brand Management*, *29*(3), 257–272. https://doi.org/10.1108/jpbm-09-2018-2020

The World bank. (2019). *How much do our wardrobes cost to the environment?* https://www.worldbank.org/en/news/feature/2019/09/23/costo

Triatmanto, B., Respati, H., & Wahyuni, N. (2021). Towards an understanding of corporate image in the hospitality industry East Java, Indonesia. *Heliyon*, *7*(3), e06404. https://doi.org/10.1016/j.heliyon.2021.e06404

Vătămanescu, E.-M., Dabija, D.-C., Gazzola, P., Cegarro-Navarro, J. G., & Buzzi, T. (2021). Before and after the outbreak of Covid-19: Linking fashion companies' corporate social responsibility approach to consumers' demand for sustainable products. *Journal of Cleaner Production*, *321*, 128945. https://doi.org/10.1016/j.jclepro.2021.128945

Wang, C.-C. (2018). Corporate social responsibility on customer behaviour: The mediating role of corporate image and customer satisfaction. *Total Quality Management & Business Excellence*, *31*(7–8), 742–760. https://doi.org/10.1080/14783363.2018.1444985

Wong, A. K. F., & Kim, S. (2020). Development and validation of standard hotel corporate social responsibility (CSR) scale from the employee perspective. *International Journal of Hospitality Management*, *87*, 102507. https://doi.org/10.1016/j.ijhm.2020.102507

Yu, W., Han, X., Ding, L., & He, M. (2021). Organic food corporate image and customer co-developing behavior: The mediating role of consumer trust and purchase intention. *Journal of Retailing and Consumer Services*, *59*, 102377. https://doi.org/10.1016/j.jretconser.2020.102377

Zhang, J., & Cui, Y. H. (2018). Fashion corporate social responsibility, corporate image, product preference, and purchase intention: Chinese consumers' perspectives. *Journal of Fashion Business*, *22*(6), 14–24. https://doi.org/10.12940/JFB.2018.22.6.14

Regional COVID-19 cases and Bitcoin volatility: Assessment through the Markov switching prism

Dat Minh Phan[1], Sinh Duc Hoang[2], Tung Duy Dao[3], Tien Phat Pham[4]

[1] *Tomas Bata University in Zlin, Faculty of Management and Economics, Czech Republic, ORCID: 0000-0002-5909-0448, phan@utb.cz;*
[2] *International University, Vietnam National University Ho Chi Minh City, Vietnam, ORCID: 0000-0001-6382-4056, hdsinh@hcmiu.edu.vn (corresponding author);*
[3] *Vietnam Aviation Academy, Faculty of Business Administration, Vietnam, ORCID: 0000-0003-0527-7765, tungdd@vaa.edu.vn;*
[4] *Can Tho University, School of Economics, Vietnam, ORCID: 0000-0001-9472-5878, pptien@ctu.edu.vn.*

Abstract: *The 21st century has become the century of technology, which has spread to the currency market, presenting the international economic system with a new challenge – the challenge created by digital currency, which has determined a change in the rules of operation in the market. The main property of cryptocurrencies in general, and Bitcoin in particular, is constant volatility and mutual sensitivity to each other. This article aims to analyze the cryptocurrency market landscape from both short-term and long-term perspectives. Additionally, the article seeks to quantitatively assess the contradictions, trends, and patterns of price volatility in Bitcoin by employing the framework of Markov switching during the period spanning from 2020 to 2022. The Markov switching model was used in the study. In this study, the factors influencing volatility on different modes of the Markov switch are the COVID-19 pandemic and the Pearson correlation statistical method. The Chi-squared test was estimated to identify the connection between Bitcoin volatility switching modes and the COVID-19 pandemic spread. This analysis enables international investors to diversify with maximum efficiency and returns using available hedging tools. However, several open questions remain for future research. Future studies can analyze different cryptocurrencies' volatility. This research helps to assess the nature of the relationship of cryptocurrencies in statistics (the correlation of cryptocurrencies as of December 1, 2021, when no significant events in the financial market and political upheavals were recorded) and dynamics (the Markov switching models for the post-pandemic period of 2020–2022). The article contributes to understanding the interdependence and sensitivity of different cryptocurrencies in relation to each other.*

Keywords: *GARCH model, Chi-squared test, Bitcoin volatility modes, Pearson correlation method, statics and dynamics analysis.*

JEL Classification: *E41, E51, P24.*

APA Style Citation: Phan, D. M., Hoang, S. D., Dao, T. D., & Pham, T. P. (2024). Regional COVID-19 cases and Bitcoin volatility: Assessment through the Markov switching prism. *E&M Economics and Management*, *27*(2), 142–161. https://doi.org/10.15240/tul/001/2024-2-009

Introduction

In recent years, there has been a rapid development of new digital products – cryptocurrencies. During this period, Bitcoin has become a leader in the global market of cryptocurrencies. The explosive profitability and diversification opportunities worked as incentives for introducing financial derivatives into

cryptocurrencies (Kim et al., 2021a). During periods of panic in the financial markets, cryptocurrencies play the role of a potential haven where investment flows are directed (Corbet et al., 2022). Several studies indicate that the volatility dynamics between Bitcoin and major financial asset classes (gold, oil, foreign exchange, stocks, and bonds) were weak or negative before the pandemic and turned positive during the pandemic (Maghyereh & Abdoh, 2022). Unlike stock exchanges, digital currency forecasting and trading appear to be more consistent and predictable (McCoy & Rahimi, 2020). It should be pointed out that Bitcoin is the world's leader in terms of capitalization, which amounted to more than USD 138 billion. This new financial asset has great diversification opportunities for international investors, allowing the use of new and optimal hedging strategies.

Modeling can explain financial asset volatility, which is important in financial markets when forming diversified portfolios of crypto assets, increasing awareness and knowledge of market participants, and effectively controlling investment risks. The Markov switching is effective for predicting Bitcoin volatility. This model has been used in several studies to describe the volatility dynamics of Bitcoin prices (Chkili, 2021; Le & David, 2014). This method is valuable for obtaining three capabilities at once: isolating heterogeneous volatility regimes, creating a map of regime switches to determine volatility dynamics, and finding the optimal number of states to capture the heteroscedasticity of the Bitcoin regime (Chappell, 2019).

The GARCH model is of relevance too. The advantage of the GARCH model is that it combines with other models. This is what is being developed in recent research, where hybrid GARCH models are being developed that contain elements of the Markov switch calculation to account for volatility modes (Ardia et al., 2019; Walther et al., 2017). The volatility forecasts depend on the order of the GARCH models and the selected machine learning model. The Bitcoin volatility studies often show that the summation ensemble methodology based on higher-order hybrid GARCH models has proven to be a winner. This methodology improves the accuracy of volatility forecasts (Aras, 2021).

Bitcoin, Bitcoin Cash, XRP, and Ethereum show volatility that is incomparable (Hafner, 2020). Yousaf and Ali (2020) employed the VAR-DCC-GARCH model to examine the return and volatility transmission among Bitcoin, Ethereum, and Litecoin during the pre-COVID-19 and COVID-19 periods. They found that the return spillovers differed across both periods for the Bitcoin-Ethereum, Bitcoin-Litecoin, and Ethereum-Litecoin pairs (Yousaf & Ali, 2020). A problem is volatility valuation. In 2014, a structural shift in Bitcoin yields was noticed by Bariviera (2017). Bouri et al. (2019) found inconsistent results with sliding windows and static models. Some progress has been made in this area by Yin and Wang (2022) who employed the prediction model based on the intrinsic generation mechanism (chaos) of Bitcoin's daily return volatility from an econophysics perspective.

The authors suggested that chaotic artificial neural network models have a good prediction effect by comparing these models with the existing artificial neural network (ANN) models. However, not only are the properties and behavior of cryptocurrencies in the market given a lot of research but also anomalies are analysed. Firstly, anomalies in the underlying blockchain transaction network are investigated. Secondly, the price anomalies of various cryptocurrencies individually and in comparison with each other are of interest. The price correlation studies for different cryptocurrencies, such as Ethereum, Bitcoin Cash, Dash, and Monero have shown that only a few cryptocurrencies show significant price growth rates compared to Bitcoin (Meynkhard, 2020). One of the reasons for these anomalies is the manipulation of pump-and-dump prices, as this is how scammers try to force traders to buy cryptocurrencies at artificially inflated prices (pumping). This manipulation is followed by the second part of the scam, the quick sale of all assets (dumping) to make super profits. According to Li et al. (2021), such activity leads to short-term bubbles characterized by sharp increases in prices, volume, and volatility. Prices peak within minutes, followed by a reversal. These same researchers have investigated long-term pump-and-dump patterns, in which pump signals fail to reach the buy target for days or weeks.

Guesmi et al. (2019) proposed to use GARCH models as multivariate spaces to explain the volatility dynamics of Bitcoin and its indicators. They use the DCC-GJR-GARCH tool, which more optimally characterizes

the specifics of volatility modeling between Bitcoin and other assets. Thus, using Bitcoin in a portfolio consisting of gold, oil, or stocks significantly reduces the portfolio risk.

Continuing this same analysis of Bitcoin volatility dynamics, Katsiampa (2017) applies several GARCH-type models to explain the price volatility of Bitcoin. He draws a computationally sound conclusion – the component GARCH (CGARCH) model is appropriate for Bitcoin returns estimates. Twelve GARCH models were used by Chu et al. (2017) for seven cryptocurrencies. Researchers concluded that the IGARCH model with normal distributions includes fewer values of the information criteria and, hence is a better ft-model. Conrad et al. (2018) proposed the GARCH-MIDAS model to describe the causes of short-term and long-term Bitcoin volatility.

Their main conclusion is that S&P 500 volatility negatively affects the long-term volatility of cryptocurrencies. However, the S&P 500 volatility risk premium positively impacts long-term Bitcoin volatility. The scholar found that there is a significant relationship between long-term Bitcoin volatility and Baltic Dry Index. Bitcoin volatility is related to global economic activity. Urom et al. (2020) have shown that secondary volatility effects among Bitcoin and other assets are significantly amplified during extreme global market fluctuations.

In terms of the optimal formation of an investment portfolio and the achievement of the most profitable diversification, market analysts and traders tend to choose the volatility forecasting model that will most effectively describe the further fluctuation of the cryptocurrency. Several studies come to this conclusion (Malepati et al., 2019). Degiannakis et al. (2018) found that traders and investors try to forecast all their future investments in terms of uncertainty. This is necessary to assess risks, which subsequently allows for the most optimal composition of the investment portfolio and the selection of appropriate hedging instruments. Malepati et al. (2019) point out that volatility acts as a tool for measuring risk in financial markets.

Moreover, the authors suggest that the quantification of uncertainty is a key component in assessing the value of cryptocurrency in the financial market and helps to assess the degree of investment risk. A considerable body of literature exists on Bitcoin forecasting performance. Some authors suggested that forecast combination techniques outperform individual models in prediction accuracy (Wei et al., 2022). The authors selected among 295 individual prediction models three machine learning approaches, specifically, neural networks, support vector machines, and gradient boosting approach. They examined the forecasting ability of the three models and suggested that forecast combination techniques outperform individual models in prediction accuracy.

The economic situation and structural changes in the global economic system from 2020 to the present are largely shaped by the consequences arising from the COVID-19 pandemic. The increasing integration of international financial markets has been a significant factor contributing to the substantial and rapid spread of market risks (Liu et al., 2022). Therefore, it is not surprising that the COVID-19 pandemic has resulted in significant damage to virtually all sectors of global economic activity, emerging as a “black swan” event for financial transactions (Yarovaya et al., 2022). Like other asset markets, the cryptocurrency market has undergone crisis manifestations, prompting a natural interest in examining the relationship between Bitcoin volatility and the spread of the COVID-19 pandemic. In response to the crisis amid COVID-19 in the United States and Western Europe, there was an increase in the issuance of national currencies, leading to liquidity excess and heightened investor inclination to allocate funds to digital currencies, the prices of which surged (OECD, 2020). Subsequently, the ascent of cryptocurrency prices decelerated following China’s decision to implement measures prohibiting the issuance and circulation of digital currencies in the country. In 2020, as a response to the crisis arising from the COVID-19 pandemic, central banks in developed countries augmented the issuance of national currencies, resulting in an increased risk appetite among major investors and a growing interest in cryptocurrencies (Boar & Wehrli, 2021).

Of particular interest is the interplay between regional COVID-19 cases and cryptocurrency volatility. Simultaneously with the crisis manifestations of the pandemic in the economic sphere, governments sought various mechanisms to curb its impact, while investors endeavored to formulate individual strategies to capitalize on the market situation effectively. Furthermore, this novel “black swan” event is

undeniably intriguing for research as a volatility factor, given that volatility indicators are key instruments for forecasting and studying the functioning of Bitcoin in the financial asset market.

Hence, the objective of this article is to analyze the cryptocurrency market landscape from both short-term and long-term perspectives. Additionally, it aims to quantitatively assess the contradictions, trends, and patterns of Bitcoin price volatility through the lens of Markov switching from 2020 to 2022. The focus of the research is specifically placed on the impact of the COVID-19 pandemic on Markov switching regimes, ultimately enabling investors to ascertain portfolio composition, discern Bitcoin price dynamics, and determine risk levels. In this context, the COVID-19 pandemic may function as a litmus indicator of high or low Bitcoin volatility in the future. Despite some studies attempting to investigate the volatility properties of Bitcoin using various model types, there exists a gap in the analysis of the specific influence of COVID-19 on Bitcoin volatility and the Markov switching of its volatility regimes. Addressing this gap will contribute to expanding existing scholarly research and providing crucial information to financial analysts, international investors, and risk managers regarding risk assessment, securities valuation, risk management, and portfolio allocation.

1. Theoretical background

Bitcoin was designed as a peer-to-peer monetary system and to function as a currency, it should be stable and supported by the government. At the same time, the price volatility of Bitcoin is extreme and can be up to 10 times higher than the volatility of exchange rates, which negatively affects its investment opportunities (Baur & Dimpfl, 2021). As for the analysis of Bitcoin behavior studies, it should be noted that there is no definitive concept of the nature of Bitcoin and cryptocurrencies. Several authors, for example, indicate that Bitcoin is a commodity, that has the same properties as gold (Rambaccussing & Mazibas, 2020), other authors (Dyhrberg, 2016) indicate that Bitcoin is the same monetary unit as the dollar; therefore, performs all functions of money. The author points out that, in this vein, the main function is moneymaking.

The onset of the COVID-19 pandemic has heightened research interest in the issue of cryptocurrency volatility. The pandemic not only spread at an unprecedented speed but also assumed truly global proportions, covering more than 30 countries, regions, and territories in just a month and a half. Almost immediately, in response to the economic consequences of the pandemic, studies began to emerge on its impact on cryptocurrencies. Researchers have concluded that cryptocurrency market volatility exhibits a swift response to news reports related to COVID-19 (Baek et al., 2020). For instance, there is evidence supporting the notion that news containing panic-inducing information about the consequences of COVID-19 increased cryptocurrency volatility. Studies have explored the correlation between mortality statistics and the heightened market volatility exacerbated by a sense of panic (Chen et al., 2020).

The correlation method in modern research shows a strong relationship among cryptocurrencies. Thus, for example, the level of correlation between Bitcoin and other cryptocurrencies has grown since the beginning of 2017 and somewhat halted its growth in mid-2018. High growth is proved by research that found a correlation between cryptocurrencies that use the proof of work mechanism to verify transactions compared to those that use other cryptographic algorithms (Lahajnar & Rozanec, 2020). In addition, the authors identified a strong positive relationship between the 20 influential cryptocurrencies, with most of the correlation coefficients exceeding 0.7 (Davies, 2021). Other studies indicated a high positive correlation between cryptocurrencies and their volatility index across all investment horizons (Agyei et al., 2022). A fundamentally important discovery was made by Akyildirim et al. (2020a), revealing a strong positive relationship between financial market stresses and cryptocurrency correlations that change over time. These correlations increase significantly during periods of high stress in financial markets. In this case, fear of contagion in financial markets and volatility increase affect new financial products – cryptocurrencies (Akyildirim et al., 2020b).

Jiang et al. (2018) and Mensi et al. (2019) suggested shaping volatility modeling by introducing additional factors. In this paper, the researchers talk about the long-term memory factor. At the same time, Mensi et al. (2019) analyzed two cryptocurrencies and found evidence for the Bitcoin market's long-term memory. Models investigated by scientists that

include a long-term memory factor have modifications like FIGARCH and hyperbolic GARCH (HYGARCH). Moreover, Charles and Darné (2019) found that the FIGARCH model shows the best performance in the sample for a lot of virtual currencies.

Soylu et al. (2020) focused directly on volatility, and not only on Bitcoin, but compared two other cryptocurrencies to Bitcoin and used GARCH family models. Their modeling was based on three separate models for each currency. Researchers looked at the long-term memory factor in volatility. However, GARCH models were not compared with Markov switch and FIGARCH. Bitcoin volatility research should consider this comparison. Several related studies (Katsiampa, 2019; Pal & Mitra, 2019; Tan et al., 2021) considered volatility between Bitcoin prices and commodity and financial markets.

Modern publications analyze the role of the pandemic in predicting the conditional volatility of five important cryptocurrencies – Bitcoin, Dash, Ethereum, Litecoin, and XRP. Based on the application of the asymmetric TGARCG model, studies revealed a significant role of pandemic indicators in predicting conditional volatility for all five cryptocurrencies. These findings will help investors adopt the right strategies and optimize trading operations (Apergis, 2022).

Pesaran and Timmermann (2007) considered a cross-validation method for selecting the window size under a single discontinuity. The cross-validation method is about an estimate including a breakpoint that improves the trade-off between variance and bias. Examples of different window selections include Fang et al. (2018) discussing the long memory phenomenon in Bitcoin markets and the CSI 300 including a sliding window (200 observations). Markov models are used to understand the highly speculative, loosely regulated, and decentralized cryptocurrency market. Giudici and Abu Hashish (2020) studied Bitcoin prices' switch between "bullish," "stable," and "bearish" modes. Koki et al. (2022) considered returns for three highly capitalized cryptocurrencies: Bitcoin, Ripple, and Ether. Like Giudici and Abu Hashish (2020), they established that the invisible Markov structure differentiated between "bullish," "stable," and "bearish" modes for the Bitcoin series; for ether and ripple, it parted periods with different numbers of risk and return. Kim et al. (2021b) employed the invisible Markov model to see how cryptocurrency markets conduct and react to social attitudes under different modes.

At the same time, Dyhrberg (2016) suggested that Bitcoin hedging can be considered using GARCH models. Baur et al. (2018) continued Dyhrberg's (2016) study. The researchers found that cryptocurrencies' returns, volatility, and correlation differ from gold and the U.S. dollar, Bouri et al. (2019) modeled long-term volatility employing semi-parametric and parametric methods. Their data confirm shocks' constancy and no return to the average in level series; they also find Bitcoin dynamics' structural changes. Cheikh et al. (2020) shared this view, using the smooth transition GARCH model, they found evidence of an asymmetric inverted response for most cryptocurrencies. Good news largely impacts volatility compared to bad news. The present study uses time series and asymmetry coefficient and compares GARCH models with FIGARCH and Markov switch that employ long-term memory (no research considered this before). The present study considers an effective model for Bitcoin volatility prediction. Studying the interrelationship of various cryptocurrencies, the authors use a high-frequency analysis of the correlation of futures contracts through the effectiveness of Bitcoins. Ultimately, they found that significant consequences for pricing are associated with both fraudulent activities and regulatory concerns in the markets (Akyildirim et al., 2020a). The analysis of correlations between key cryptocurrencies, stock indices, bonds, and gold prices contributes to more efficient management of cryptocurrency portfolios (Aslanidis et al., 2019).

Thus, some studies have attempted to explore the relationship between cryptocurrencies and the volatility properties of Bitcoin using different types of models. Nevertheless, researchers have not arrived at a definitive conclusion regarding the exclusive effectiveness of employing a particular analytical tool. Each model has its proponents ready to advocate for its applicability in forecasting cryptocurrency volatility. As previously mentioned, a significant body of work is dedicated to the application of models from the GARCH family, which have proven effective in forecasting the volatility of traditional financial instruments. However, it is emphasized that asymmetric

GARCH models such as EGARCH, APARCH, and TS-GARCH outperform standard GARCH modeling in terms of forecast accuracy when it comes to currency forecasts, including cryptocurrencies (Amirshahi & Lahmiri, 2023). Early researchers of cryptocurrency volatility asserted that the classical GARCH model with a sudden intensity of returns is well-suited for analyzing extreme price movements, indicative of an immature market. This modeling approach was suitable for analyzing Bitcoin volatility in 2014 when the cryptocurrency market was essentially in its nascent stages but has since undergone substantial changes (Mostafa et al., 2021). Later researchers, identifying a set of superior models and employing over 1000 GARCH models for forecasting the volatility of popular cryptocurrencies, concluded that standard GARCH models are insufficiently effective in modeling their volatility primarily due to the existing long-memory effect. Simultaneously, criticism extended to the consideration of the challenge of forecasting short-term daily cryptocurrency volatility. In this context, it is demonstrated that comparing forecasts of realized Bitcoin volatility reveals that HAR models outperform GARCH models based on daily data (Bergsli et al., 2022).

However, despite a substantial body of critical research, none of it specifically addressed the impact of COVID-19 on Bitcoin volatility and the Markov switching models of its volatility post-pandemic. The net mutual correlation among cryptocurrencies in a static context has not been explored in the post-pandemic period. Additionally, the analysis of interrelationships among cryptocurrencies in both short-term and long-term perspectives, along with a quantitative assessment of contradictions, trends, and patterns in Bitcoin price volatility and Markov switching from 2020 to 2022, emerges as a pertinent and nontrivial task.

2. Research methodology

The GARCH model allows for the description of the conditional variance of financial income series (Bollerslev, 1986). GARCH model with Markov switching is the main calculation method. The choice of modeling is predicated on the inadequacy of standard GARCH models, as previously mentioned, in effectively capturing cryptocurrency volatility. The refinement of the model is necessitated by existing long-memory effects in cryptocurrencies, regime-switching, and multifractality. Moreover, combined forecasts enhance predictions compared to those obtained from individual models, and regime-switching models can assist in addressing the challenge of accounting for structural changes in the cryptocurrency market (Panagiotidis et al., 2022).

This model is as follows (Equation (1)):

$$y_t = v_{st} + a_{1,st}\, y_{t-1} + a_{2,st} y_{t-2} + \\ + a_{3,st} y_{t-3} + a_{n,st} y_{t-n} + \varepsilon_t,\ \varepsilon_t \sim N(0,\sigma_{st}^2) \quad (1)$$

From the basics of modeling theories, one can say that models with Markov switching were developed by Goldfeld and Quandt (Goldfeld & Quandt, 1965). These dynamic measurement models are used to analyze time series using time-varying parameters that correspond to the state the process is in. The autoregressive model with order p, AR( ), N states for probable modes, $s_t \in \{1, 2, 3, ..., N\}$, is MS( ) – AR($p$) and is shown in the Equation (1).

Autoregressive models are characterized by the estimation of mode changes, which is done by likelihood function maximization with the EM algorithm, where “E” are integrals and “M” are equations with no analytical solution. The Markov switching heteroskedasticity model is more flexible when it describes financial series, in which conditional mean structure discontinuities and unconditional variance of the data generation process are common. To analyze the volatility of Bitcoin, the study chose a model that describes the volatility of Bitcoin prices. For this purpose, the study used a Markov switching-GARCH model with two states, which has the form of a system of equations as follows:

$$z_t = \begin{cases} a_0 + \beta z_{-1} + \varepsilon_t, & s_t = 0 \\ a_0 + a_1 + \beta z_{-1} + \varepsilon_t, & s_t = 1 \end{cases} \quad (2)$$

where: $\beta < 1$, and ε_t is contrasted to zero average and variance σ_ε^2.

This is the easiest system AR (1), i.e., the standard process with mean values $\alpha_0/(1-\beta)$, if $s_t = 0$. If $s_t = 0$, the process switches to a state s_t from 0 to 1. Based on the above, one can say that the model describes two basic states of the unobservable variable s_t. The resulting indicator z_t can control distributions with both zero state s_t and a single state, while it is s_t that is the switch between these modes.

Descriptive statistics for the original time series present: mean (0.17), SD (0.82622), asymmetry (−1.877), and kurtosis equal to 20.88. Fig. 1 depicts the series of returns and prices. Information is crucial as volatility is primarily a parameter that characterizes the dynamics of price changes, reflecting the breadth of the price movement range over a fixed period. Therefore, the value of this parameter aids in assessing how rapidly the price changes during the current period in comparison to the preceding ones.

There are low prices for 2013–2017. Then, they increase and reach a maximum

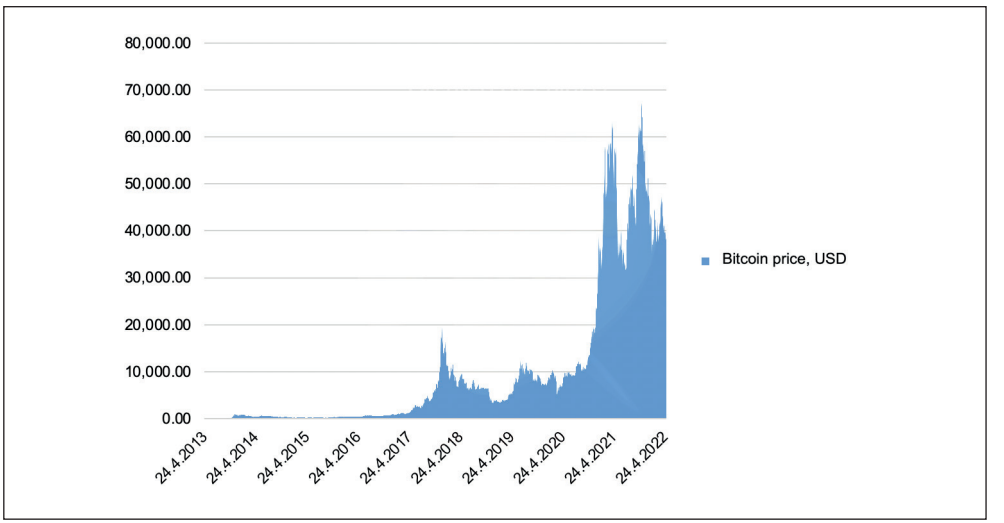


Fig. 1: Evolution of Bitcoin prices (April 2013–April 2022)

Source: own (based on Investopedia (2023))

in 2021–2022. However, the series has peaks and is not stable. The series further fluctuates from USD 20,000 to USD 60,000. Returns show volatility clustering, which advocates the option of GARCH models to depict Bitcoin market volatility dynamics.

The overall volume of Bitcoin purchases has increased since 2019, reaching its peak in 2021. Understanding this phenomenon may be grounded in the consideration of external socio-economic factors. During this period, a pivotal external factor could be attributed to COVID-19. Given that one of the distinctive features of the cryptocurrency market is that significant events lead to heightened investor enthusiasm (Liu & Tsyvinski, 2021), manifestations of the pandemic could have increased the demand for Bitcoin, coinciding with price growth (Fig. 1) and an elevation in market capitalization. The mean Bitcoin return is positive and equals 0.1773%, while the volatility, which is measured by the standard deviation, showed high values and amounted to 8.2%. The asymmetry statistics showed a negative result, which may indicate frequent small gains and a few large losses.

The Jarque-Bera test statistic is significant at 1%, and this finding is confirmed by the deviation from the Gaussian distribution. The Engle test shows heteroskedasticity for returns of up to 5 lags and stimulates using GARCH models. Panel B shows the unit root tests, i.e., Phillips-Perron (PP) and extended Dickey-Fuller (ADF) tests. The two tests are valid at 1% significance. Consequently, the null hypothesis of the unit root for the studied series can be rejected.

However, the reasons for increased volatility for 2020–2022 must be studied. For this, an exogenous influence factor was the COVID-19 data

set. Fig. 1 shows the unctioning trend in the markets. It was decided to use beincrypto.com to obtain data on the Markov-switching Bitcoin volatility for 2019–May 2022. UNICEF data on COVID-19 incidence were used. The Chi-squared test for several EECCA countries was used to test the claim. Fig. 2 depicts data on the quantity of sick people (the COVID-19 incidence) in Armenia, Azerbaijan, Belarus, Moldova, Kyrgyzstan, Kazakhstan, Tajikistan, and Uzbekistan. The rationale for the research sample is elucidated by the fact that the countries comprising the Commonwealth of Independent States (CIS) today represent the post-Soviet space with developing economies. These countries lack surplus funds in their state budgets, prompting their governments, following the dissolution of the socialist system, to seek financial resources outside the national economy. Furthermore, after the global financial crisis and the decline in global oil prices in 2020–2021, the issue of compensating for the decline in budgetary revenues has become even more pressing for them. Simultaneously, it is essential to note that in the CIS countries, a financial market is only beginning to emerge against the backdrop of the decentralization of financial instruments. The potential of CIS countries is of interest in terms of the future dynamics and trends in the development of the financial market. Therefore, it seems expedient to test the proposed model on the cryptocurrency market in the region of developing countries in Asia.

Fig. 2 shows disease growth dynamics in the analyzed countries; incidence increased in November 2020. One can consider the connection between Bitcoin exchange rate volatility and the incidence in China, as this state was the first to face the disease growth. The lockdown was in the regions with high disease levels and not the whole country; this should be analyzed with the Chi-squared tool.

Below is the Pearson correlation analysis between cryptocurrencies in the short- and long-term perspective. The empirical data on the prices of the top fifteen financial instruments as of the beginning of December 2021 were used for a static analysis of the relationships between cryptocurrencies (Fig. 3).

Fig. 3 demonstrates a staggering price gap for different cryptocurrencies, from USD 48,700 for Bitcoin (BTC) to 0.58 for Crypto.com coin

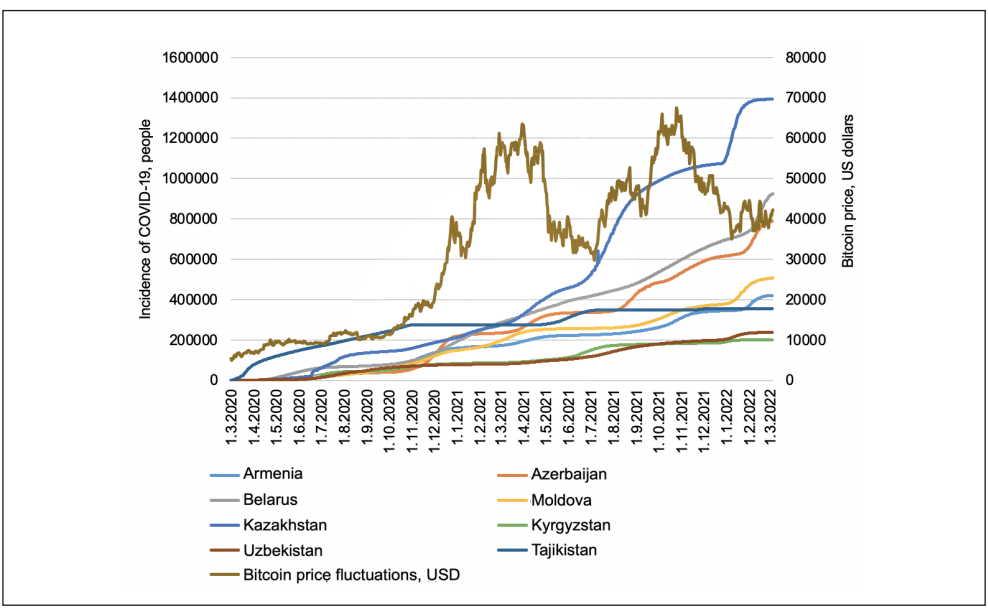


Fig. 2: Bitcoin fluctuations and COVID-19 incidence 2020–2022

Source: own (based on WHO (2023))

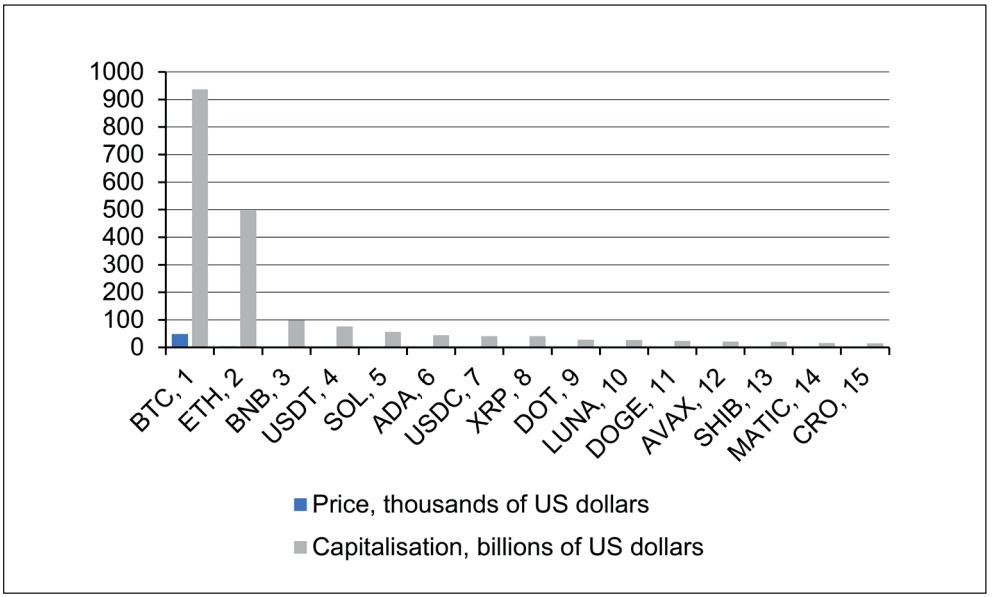


Fig. 3: Cryptocurrency prices and market capitalization

Source: own (based on CoinMarketCap (2023))

(CRO), and a 60-fold gap in their capitalization (937.2 and USD 14.98 billion for the respective cryptocurrencies). An overview of cryptocurrency prices in the context of capitalization shows their relationship and follows the main cryptocurrency – Bitcoin.

3. Research results

Conditional volatility is tested first. Two popular tests are applied, i.e., Robinson's semi-parametric Gaussian criterion (GSP) and logarithmic periodogram regression test (GPH). The estimation is shown in Fig. 4.

There are some high volatility periods. There are two periods of Bitcoin market sharp spikes: November 2020–January 2021 and November 2021–January 2022. As Bitcoin demand is not seasonal, due to similar periods in 2019–2020 and 2018–2019, one must add the COVID-19 disease peak and related restrictions.

Tab. 1 depicts the evaluation and tests for the Markov switching GARCH model.

All parameters of the standard GARCH model that have been calculated are positive and greater than 0. Thus, Bitcoin returns current conditional volatility is influenced by its past shocks and past conditional volatility. The coefficient β is seen as high and close to 1, namely, there is Bitcoin market volatility. Conditional variance is stationary as the sum of GARCH and ARCH coefficients is less than one. This outcome is consistent with several previous studies. Katsiampa (2019) studied the cryptocurrency market volatility dynamics. He showed that the studied market is volatile.

There are two mode types: a mode of low volatility (mode 1), and a mode of high volatility (mode 2). As for conditional variance, Bitcoin volatility is almost 3 times higher in mode 2 compared to mode 1. Mode 1 is more stable compared to Mode 2. In 2021, there was a maximum of 267 days in mode 2, and 72 days in 2022. The probability of staying in the high volatility mode is 0.9908, which is a mean duration of 108 days. There are turbulent and alternating stable periods. The high volatility mode is less stable. The Markov switching model allows for identifying different volatility modes.

The study points to the likely impact of switching volatility modes and COVID-19 incidence as the period of pandemic peaks stabilizes the Bitcoin exchange rate in the high

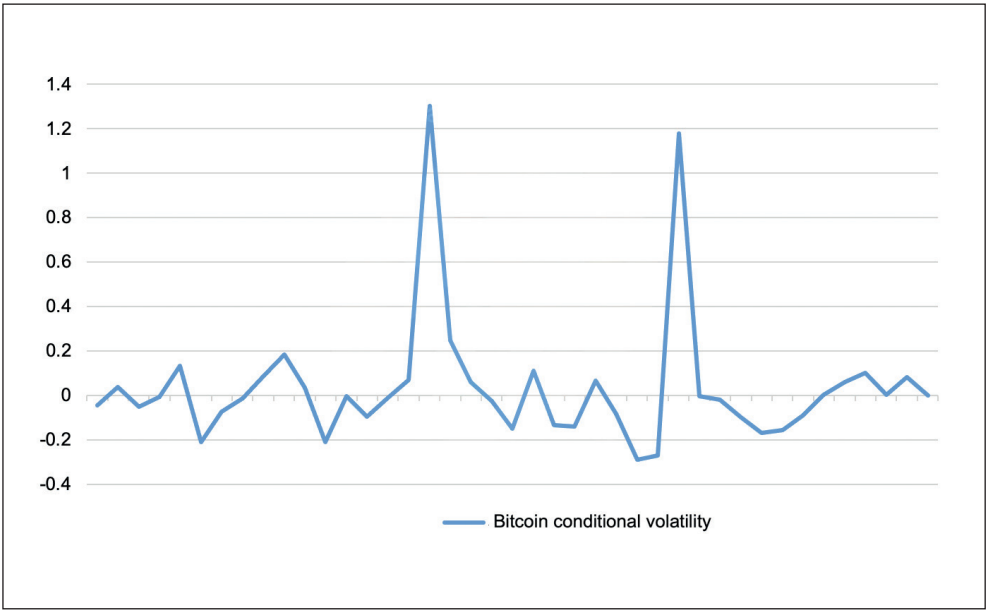


Fig. 4: Bitcoin conditional volatility estimation

Source: own (based on the data of Bitcoin prices from Binance (2023) and CoinMarketCap (2023))

Tab. 1: Evaluating Markov switching GARCH model

Indicators	GARCH model
μ	0.172011523
ω	0.824857467
α	0.024581282
β	0.311707841
Student *t*-test	20.404472740
Standard error	0.037759143
Multiple *R*	0.993627458
***R*-square**	0.987295525
Normalized *R*-square	0.986236819

Source: own

mode of volatility. The Chi-squared test results are shown in Tab. 2.

In Kazakhstan and Azerbaijan, the Chi-squared test is bigger than the tabulated value; therefore, Bitcoin volatility and COVID-19 are linked (correlation ranges from 0.80 to 0.99). If the correlation is below 0.5 (Kyrgyzstan), it is considered low. As for Armenia, Moldova, Tajikistan, Uzbekistan, Belarus, and Russia, no such correlation was found. Fig. 5 illustrates the number of sick people and Bitcoin volatility in Kazakhstan.

Tab. 2: Chi-squared test results

Country	Chi-squared	Critical value of Chi-squared	Chi-test (*P*) value
Armenia	628.35	847.13	0.9890
Azerbaijan	3,304.75		0.5175
Belarus	134.40		0.9915
Kazakhstan	1,974.62		0.8601
Kyrgyzstan	308.97		0.2137
Moldova	752.90		0.9893
Russia	127.80		0.9996
Tajikistan	189.21		0.7008
Uzbekistan	157.43		0.9787
China	1,976.29		0.9987

Source: own (based on WHO (2023))

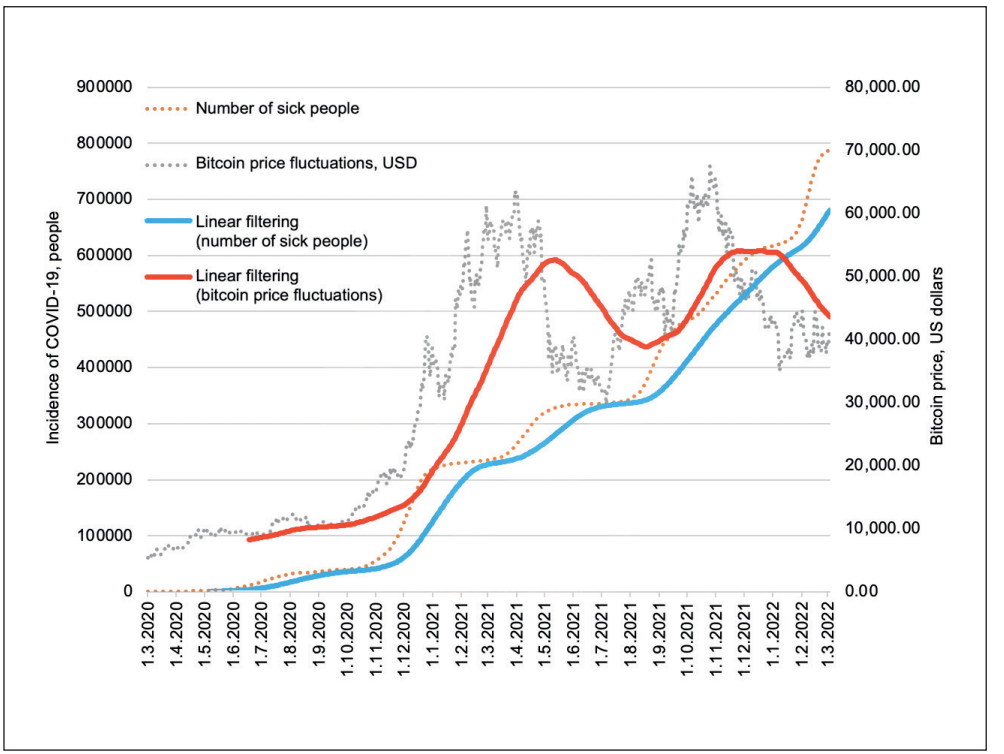


Fig. 5: Comparing the dynamics of Bitcoin volatility and the number of sick people in Kazakhstan for March 2020–March 2022

Source: own (based on the data of Bitcoin prices from Binance (2023), CoinMarketCap (2023), and WHO (2023))

The graph of disease dynamics partially coincides with the graph of volatility dynamics (Fig. 6). To analyze the figure, a trend with linear filtering was used, which allows evaluation of the link between the number of sick people and Bitcoin fluctuations, which shows that at the start of the pandemic incidence slightly increased and Bitcoin was in a low-volatility mode (March 2020–June 2020). Nevertheless, growing morbidity and the introduction of COVID-19 restrictions by countries from November 2020 to May 2021 defined a Bitcoin quote's highly volatile mode. Fig. 6 depicts the number of sick people and Bitcoin volatility in Azerbaijan.

The linear filtering trend illustrates comparable disease and Bitcoin volatility trends as well. There are peak growth periods (April 2021 and October 2021) and peak decline periods (July 2021 and September 2021). Yet the peaks of morbidity and switching of volatility modes do not match. In the high volatility mode, the COVID-19 morbidity changes its tendency a few times: from November 2020 to January 2021 (rapid morbidity growth with a low Bitcoin volatility state). This is also true for other study periods. One should note that the charts wave-like match each other in the spots of increasing and decreasing Bitcoin prices and the number of cases.

Chi-square for China is 1,976.29 and the tabular value is 847.125. There is a disparity between 1,976.29 > 847.125, meaning the number of COVID-19 episodes in China correlates with the volatility of Bitcoin. To examine the relationship in detail, the authors built a graph with a linear filtering method (Fig. 7).

The calculations lead to the conclusion that the quotation and volatility of Bitcoin are not characterized by a dependency on cases of COVID-19. As a conjecture, this can be clarified by the fact that the Chinese government did not implement total isolation for the entire country but instead intensified quarantine restrictions for regions with the highest infection rates. This measure aimed to preserve the functioning of the economic sector in areas

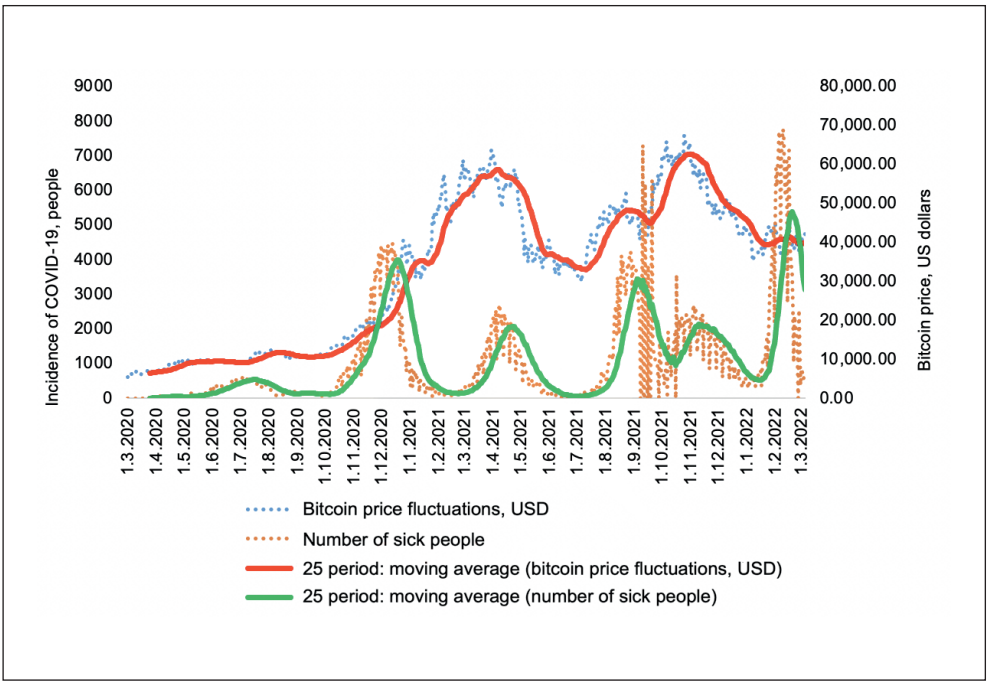


Fig. 6: Comparison of Bitcoin volatility dynamics and the number of patients in Azerbaijan for the period March 2020–March 2022

Source: own (based on the data from Binance (2023), CoinMarketCap (2023), and WHO (2023))

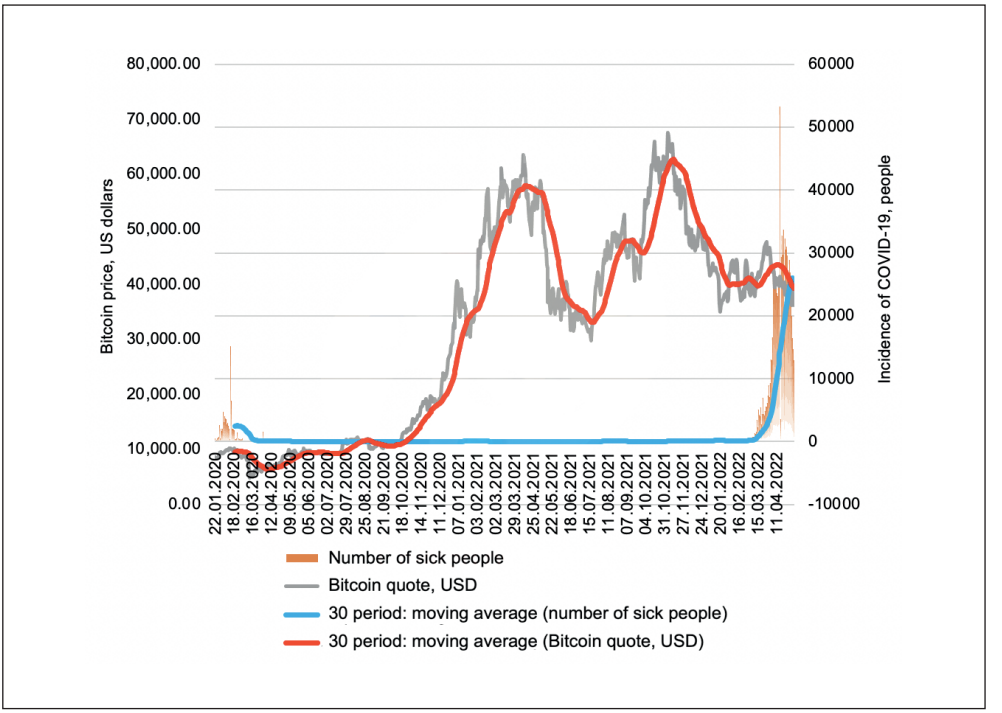


Fig. 7: Comparison of the Bitcoin volatility dynamics and the quantity of ill people in China for January 2020–March 2022

Source: own (based on the data from Binance (2023), CoinMarketCap (2023), and WHO (2023))

where the infection rate was not as high. However, it is noteworthy that subsequently, impediments to entrepreneurial development due to the pandemic created long-term challenges for China's economic growth (Li & Li, 2023). The analysis used the daily price (start and end of the day) and weekly returns of 11 significant cryptocurrencies on financial markets tied to the USD exchange rate as of December 1, 2021: Bitcoin, Ethereum, Binance Coin, Tether, Cardano, XRP, USDC, Dogecoin, Litecoin, Tron, Bitcoin Cash. Tether and USDC (CoinMarketCap, 2023).

The formula used to calculate the correlation coefficient is:

$$r = P_{closing}\,(t_1) - P_{closing}\,(t_1{-}1)\,/P_{closing}\,(t_1{-}1) \quad (3)$$

where: t – a unit of time; $P_{closing}(t_1)$ – the closing price of the cryptocurrency at the start of the day; $P_{closing}(t_1{-}1)$ – the closing price of the cryptocurrency at the end of the day.

The correlation matrix of the daily prices of cryptocurrencies from the short-term perspective is presented in Tab. 3.

The correlation analysis of the cryptocurrencies presented in the Tab. 3 indicates a positive (moderate) correlation among them. In this case, Bitcoin, due to its market capitalization, has a significant impact on the cryptocurrency market. Therefore, the matrix presented is the correlation between Bitcoin and other currencies. The most strongly correlated with Bitcoin are Ethereum, Litecoin, and TRX, with investors who consistently and risk-free invest in their purchases and optimize their portfolios. There is a strong positive correlation among Binance Coin, Tron, Cardano, and Bitcoin Cash, and a low negative correlation between Tether, and USDC. Moderate positive correlation is present for XRP and Binance Coin, and between XRP, Ethereum, and Litecoin.

The following is a correlation matrix between weekly returns over the long-term perspective (Tab. 4).

Tab. 3: Correlation matrix between daily prices of cryptocurrencies (1 day; 12/1/2021)

	BTC	ETH	BNB	USDT	ADA	XRP	USDC	DOGE	LTC	TRX	BCN
BTC	–										
ETH	0.86	–									
BNB	0.81	0.84	–								
USDT	0.05	0.12	0.14	–							
ADA	0.78	0.80	0.81	0.02	–						
XRP	0.44	0.45	0.45	−0.01	0.55	–					
USDC	0.15	0.09	0.12	−0.12	0.11	0.12	–				
DOGE	0.77	0.76	0.73	−0.02	0.75	0.72	0.20	–			
LTC	0.86	0.87	0.85	0.16	0.80	0.49	0.16	0.75	–		
TRX	0.85	0.84	0.83	0.11	0.79	0.52	0.11	0.82	0.89	–	
BCN	0.81	0.78	0.76	0.08	0.76	0.52	0.07	0.76	0.86	0.81	–

Source: own (based on the data from Binance (2023) and CoinMarketCap (2023))

Tab. 4: Correlation matrix of weekly cryptocurrency returns (1 week; 12/1/2021)

	BTC	ETH	BNB	USDT	ADA	XRP	USDC	DOGE	LTC	TRX	BCN
BTC	–										
ETH	0.86	–									
BNB	0.77	0.76	–								
USDT	−0.28	−0.16	0.01	–							
ADA	0.70	0.66	0.76	−0.03	–						
XRP	0.73	0.62	0.62	−0.32	0.66	–					
USDC	−0.03	0.04	0.05	0.32	0.01	−0.01	–				
DOGE	0.85	0.79	0.68	−0.37	0.65	0.79	0.00	–			
LTC	0.88	0.82	0.81	−0.21	0.74	0.74	0.01	0.81	–		
TRX	0.77	0.73	0.66	−0.32	0.56	0.66	−0.06	0.77	0.76	–	
BCN	0.81	0.75	0.62	−0.45	0.48	0.70	−0.01	0.80	0.81	0.73	–

Source: own (based on the data from Binance (2023) and CoinMarketCap (2023))

Comparing the correlation analysis in the short and long term, it becomes clear that the relationship between the prices of Bitcoin and other cryptocurrencies is significantly stronger in the short term, although in the range from 0.05 to 0.89. Ethereum and Litecoin are strongly correlated with Bitcoin. In addition, there is a strong correlation between Binance Coin, Tron, Cardano, and Bitcoin Cash. A negative correlation has been found between Tether and USDC. Moreover, the correlation between cryptocurrencies is much stronger during price declines than during their increase, reducing investment portfolio diversification's effectiveness.

4. Discussion

The COVID-19 pandemic implications for cryptocurrency markets are troubling in terms of risk management and investment. Bitcoin

price volatility information can adversely impact financial market participants. Furthermore, this study examines how the COVID-19 pandemic affects the correlation between COVID-19 infections and Bitcoin volatility. However, this paper considers the BTCF market for empirical analysis, given its certain benefits. As expected by the authors of this study, Corbet et al. (2021) affirmed in their study how Chinese financial markets reacted first to the onset of the COVID-19 pandemic in Wuhan and the ensuing lockdown of the cities. Researchers have suggested identifying the impact of shifts in cryptocurrency markets with indices reflecting the effect of COVID-19 on Chinese financial markets, as measured by real-time investor sentiment. Their study, however, is based on contrasting the effect of COVID-19 and traditional flu on financial market indicators, while the current study is based on the effect of COVID-19 on Bitcoin volatility, i.e., the study describes a narrower area.

The comparative correlation analysis in both short-term and long-term perspectives reveals that the association between Bitcoin prices and those of other cryptocurrencies is significantly stronger in the short-term horizon. However, as recent studies show, as market volatility and financial stress increase, correlations become stronger (Akyildirim et al., 2020a). Ethereum and Litecoin exhibited a close association with Bitcoin. The findings demonstrate a robust correlation among Binance Coin, Tron, Cardano, and Bitcoin Cash, while a negative correlation is observed between Tether and USDC. This conclusion extends prior research that forecasted the conditional volatility of several major cryptocurrencies such as Bitcoin, Dash, Ethereum, Litecoin, and XRP (Apergis, 2022). It reaffirms the assertion that optimizing investment portfolios requires information on the interrelationships among cryptocurrencies, as well as the patterns or contradictions in their alignment with the primary currency, Bitcoin. Our study on cryptocurrency correlations in 2021–2022 aligns with research conducted in earlier periods, such as 2017–2018, where strong correlations between cryptocurrencies were identified based on proof-of-work mechanisms (Lahajnar & Rozanec, 2020), including significant correlations among 20 cryptocurrencies with coefficients exceeding 0.7 (Davies, 2021). An intriguing regularity was discovered by Akyildirim et al. (2020a): a strong positive correlation exists between financial market stresses and cryptocurrency correlations, which change over time. Increased volatility consistently amplifies the interdependence among cryptocurrencies (Akyildirim et al., 2020b).

The study has advanced approaches to the utilization of GARCH models and showcased their capabilities, thereby extending the postulates formulated earlier. Thus, Baur et al. (2018) and Katsiampa (2017) support the conclusions concerning the usage of autoregressive conditional heteroskedastic (GARCH) models and their versions in the single-mode form to simulate Bitcoin volatility. Kodama et al. (2017), on the contrary, stressed the applicability of Markov-switching autoregressive models to Bitcoin. The researchers thus confirmed the Markov-switching GARCH model to be the most effective model. Tiwari et al. (2018) proposed to use long memory parameter estimates with overlapping windows every 300 observations of daily returns when modeling with a Markov switching GARCH model, or to enter a complementary long memory parameter, which completely supports the selection of the model. Zargar and Kumar (2019) used non-intersecting quarterly rolling windows of about 100 days. Ardia et al. (2019) examined volatility by using sliding windows of 1,000 daily logarithmic returns but utilizing these Markov-switching models can provide more precise and better results, which has already been confirmed by the study. Conrad et al. (2018) proposed various approaches to simulating and projecting the volatility of the Bitcoin market. Their results show that the Bitcoin market is characterized by long memory, mode switching, and multifractality. The present study did not investigate this aspect, that is, the long memory factor was not included in the model because the study objective was to determine the effect of the exogenous pandemic factor on Bitcoin volatility. However, the present study authors agree with the second part of the results of Conrad et al. (2018), which show that multifractal Markov switching processes are superior to all other models of the GARCH family in modeling Bitcoin market volatility on both long and short timeframes. American scientists support the conclusions regarding the use of autoregressive conditional heteroscedastic (GARCH) models and their versions in single-mode form for modeling the volatility of Bitcoin (Baur et al., 2018; Katsiampa, 2017). In addition,

the analysis of the volatility of cryptocurrencies often uses the summation ensemble methodology based on hybrid GARCH models, which enhances the accuracy of volatility forecasts (Aras, 2021).

An important next step in this study may be to check the hypotheses by Mensi et al. (2019), who observed that incorporating a long-term memory factor into the conditional variance greatly improves the forecasting of cryptocurrency prices. Dyhrberg (2016) shared the same idea. The author found that a structural change and long-memory volatility model, such as FIGARCH with gaps, is better than every other model in characterizing and forecasting the volatility of futures and spot oil prices. This research format was not used in this article. Still, it can be effective for future studies for comparison because the GARCH model with Markov switching is the basic model for studying Bitcoin volatility, which was investigated without any additional elements introduced (Chkili et al., 2012; Sosa et al., 2019). Some researchers demonstrated that long-run memory is considerably reduced when regime change is considered (Charles & Darné, 2019; Mensi et al., 2019). Their findings show that the evidence of long memory attenuates in magnitude and/or statistical significance when a series of gap-adjusted returns is used.

Conclusions

This work attempts to determine a proper model to depict Bitcoin price volatility dynamics using Markov switching GARCH, and mode switching is driven by volatility clustering, which is considered using raw time series as an example. This analysis assists investors and portfolio managers in gaining an accurate valuation of assets and selecting possible diversification opportunities that Bitcoin acquired. This provides the best hedging strategies by selecting suitable derivatives and value-at-risk valuations.

It has been revealed that two switching volatility modes are possible: i) mode 1 – low volatility; and ii) mode 2 – high volatility. One exogenous factor affecting Bitcoin switching modes was the COVID-19 morbidity growth factor. This is because the increase in Bitcoin value, number of transactions, and capitalization occurred at the start of the pandemic. The study showed that of all the countries analyzed, only in Kazakhstan did the pandemic influence the switching of volatility modes of Bitcoin quotes more. In Azerbaijan, the peaks and drops of the incidence match the Bitcoin price peaks, but the volatility switch from low to high does not rely on the prevalence of COVID-19 in the country. One should note that the effect of COVID-19 on Bitcoin volatility differs considerably by region, according to the government measures taken to control the disease.

Correlation analysis of cryptocurrencies revealed a positive moderate correlation among them, with Bitcoin exerting a stronger influence on other currencies due to its market capitalization. The most strongly correlated with Bitcoin are Ethereum, Litecoin, and TRX. There is a strong positive correlation between Binance Coin, Tron, Cardano, and Bitcoin Cash, and a low negative correlation between Tether and USDC. A moderate positive correlation is present for XRP and Binance Coin and among XRP, Ethereum, and Litecoin. A comparative analysis of the correlation coefficients of cryptocurrencies in the short- and long-term perspective showed that the price correlations of Bitcoin and other cryptocurrencies are much stronger in the short term perspective.

The following guidelines are suggested as directions for future research work: i) develop and model investment strategies with more than two modes; ii) model these investment strategies using MS, MS-ARCH, or MS-GARCH models with non-uniform likelihood functions in each mode; iii) use asymmetric models in Bitcoin volatility parameters and the likelihood functions; and iv) include the effects of financial transaction costs, as well as other market risks not included here, such as slippage (or fluctuations in the exercise price), foreign exchange risk, or any other risk or impact due to the influence of exogenous variables or events not included in the used MS model.

Hence, as a theoretical contribution, this research can be characterized as an additional contribution to the literature on the application of Markov Switching (MS) models to actively manage investment portfolios in cryptocurrency markets. Additionally, it is anticipated that the research findings will contribute to further exploration of the advantages of active investing utilizing MS GARCH models.

The practical implications of this research hold significance for financial strategic planning. They are directed towards investment management professionals, as the use of constant-dispersion MS models and MS-GARCH

models enables the attainment of alpha or excess returns compared to a passive strategy. This provides the opportunity for one or multiple investors to denominate funds in dollars. The study introduces an approach for cryptocurrency market participants that aids in better understanding the manifestations of cryptocurrency volatility associated with the occurrence of "black swan" events and facilitates the adoption of more informed and effective strategies amidst market turbulence. Such a combined approach, involving the use of the MS-GARCH model, enhances forecasts and thereby minimizes risks associated with unfounded decisions. In conclusion, the anticipated results are economically significant, as accurate volatility forecasts provide crucial information for portfolio allocation decisions and risk management. While the promising outcomes of this study are encouraging, the direct positive impact of the proposed calculation may be more effectively expanded by considering other exogenous factors and incorporating multi-modality in the presence of dynamic price changes.

Future research endeavors should delve into the causes behind the observed divergent behavior in the volatility of various cryptocurrencies and assess whether MSGARCH models outperform GARCH models in forecasting volatility across different cryptocurrencies. Additionally, it is imperative to expand the list of examined countries, investigate the correlation between Bitcoin volatility and the spread of the COVID-19 pandemic, and explore this factor's impact on other cryptocurrencies.

References

Agyei, S. K., Adam, A. M., Bossman, A., Asiamah, O., Owusu Junior, P., Asafo-Adjei, R., & Asafo-Adjei, E. (2022). Does volatility in cryptocurrencies drive the interconnectedness between the cryptocurrencies market? Insights from wavelets. *Cogent Economics & Finance*, *10*(1), 2061682. https://doi.org/10.1080/23322039.2022.2061682

Akyildirim, E., Corbet, S., Katsiampa, P., Kellard, N., & Sensoy, A. (2020a). The development of Bitcoin futures: Exploring the interactions between cryptocurrency derivatives. *Finance Research Letters*, *34*, 101234. https://doi.org/10.1016/j.frl.2019.07.007

Akyildirim, E., Corbet, S., Lucey, B., Sensoy, A., & Yarovaya, L. (2020b). The relationship between implied volatility and cryptocurrency returns. *Finance Research Letters*, *33*, 101212. https://doi.org/10.1016/j.frl.2019.06.010

Amirshahi, B., & Lahmiri, S. (2023). Hybrid deep learning and GARCH-family models for forecasting volatility of cryptocurrencies. *Machine Learning with Applications*, *12*, 100465. https://doi.org/10.1016/j.mlwa.2023.100465

Apergis, N. (2022). COVID-19 and cryptocurrency volatility: Evidence from asymmetric modelling. *Finance Research Letters*, *47*, 102659. https://doi.org/10.1016/j.frl.2021.102659

Aras, S. (2021). Stacking hybrid GARCH models for forecasting Bitcoin volatility. *Expert Systems with Applications*, *174*, 114747. https://doi.org/10.1016/j.eswa.2021.114747

Ardia, D., Bluteau, K., & Rüede, M. (2019). Regime changes in Bitcoin GARCH volatility dynamics. *Finance Research Letters*, *29*, 266–271. https://doi.org/10.1016/j.frl.2018.08.009

Aslanidis, N., Bariviera, A. F., & Martínez-Ibañez, O. (2019). An analysis of cryptocurrencies conditional cross correlations. *Finance Research Letters*, *31*, 130–137. https://doi.org/10.1016/j.frl.2019.04.019

Baek, S., Mohanty, S. K., & Glambosky, M. (2020). COVID-19 and stock market volatility: An industry level analysis. *Finance Research Letters*, *37*, 101748. https://doi.org/10.1016/j.frl.2020.101748

Bariviera, A. F. (2017). The inefficiency of Bitcoin revisited: A dynamic approach. *Economics Letters*, *161*, 1–4. https://doi.org/10.1016/j.econlet.2017.09.013

Baur, D. G., & Dimpfl, T. (2021). The volatility of Bitcoin and its role as a medium of exchange and a store of value. *Empirical Economics*, *61*(5), 2663–2683. https://doi.org/10.1007/s00181-020-01990-5

Baur, D. G., Dimpfl, T., & Kuck, K. (2018). Bitcoin, gold and the US dollar – A replication and extension. *Finance Research Letters*, *25*, 103–110. https://doi.org/10.1016/j.frl.2017.10.012

Bergsli, L. Ø., Lind, A. F., Molnár, P., & Polasik, M. (2022). Forecasting volatility of Bitcoin. *Research in International Business and Finance*, *59*, 101540. https://doi.org/10.1016/j.ribaf.2021.101540

Binance. (2023). *Popular cryptocurrencies*. https://www.binance.com/ru-UA

Boar, C., & Wehrli, A. (2021). *Ready, steady, go? – Results of the third BIS survey on central bank digital currency* (BIS paper No. 114). Bank for International Settlements. Monetary and

Economic Department. https://www.bis.org/publ/bppdf/bispap114.pdf

Bollerslev, T. (1986). Generalized autoregressive conditional heteroskedasticity. *Journal of Econometrics*, *31*(3), 307–327. https://doi.org/10.1016/0304-4076(86)90063-1

Bouri, E., Gupta, R., & Roubaud, D. (2019). Herding behaviour in cryptocurrencies. *Finance Research Letters*, *29*, 216–221. https://doi.org/10.1016/j.frl.2018.07.008

Chappell, D. (2019). Regime heteroskedasticity in Bitcoin: A comparison of Markov switching models. *SSRN Electronic Journal*, *14*(65), 621–641. https://doi.org/10.2139/ssrn.3290603

Charles, A., & Darné, O. (2019). Volatility estimation for cryptocurrencies: Further evidence with jumps and structural breaks. *Economics Bulletin*, *39*, 954–968.

Cheikh, N. B., Zaied, Y. B., & Chevallier, J. (2020). Asymmetric volatility in cryptocurrency markets: New evidence from smooth transition GARCH models. *Finance Research Letters*, *35*, 101293. https://doi.org/10.1016/j.frl.2019.09.008

Chen, C., Liu, L., & Zhao, N. (2020). Fear sentiment, uncertainty, and Bitcoin price dynamics: The case of COVID-19. *Emerging Markets Finance and Trade*, *56*(10), 2298–2309. https://doi.org/10.1080/1540496x.2020.1787150

Chkili, W. (2021). Modeling Bitcoin price volatility: Long memory vs Markov switching. *Eurasian Economic Review*, *11*(3), 433–448. https://doi.org/10.1007/s40822-021-00180-7

Chkili, W., Aloui, C., & Nguyen, D. K. (2012). Asymmetric effects and long memory in dynamic volatility relationships between stock returns and exchange rates. *Journal of International Financial Markets, Institutions and Money*, *22*(4), 738–757. https://doi.org/10.1016/j.intfin.2012.04.009

Chu, J., Chan, S., Nadarajah, S., & Osterrieder, J. (2017). GARCH modelling of cryptocurrencies. *Journal of Risk and Financial Management*, *10*(4), 17. https://doi.org/10.3390/jrfm10040017

CoinMarketCap. (2023). *Today's cryptocurrency prices by market cap*. https://coinmarketcap.com

Conrad, C., Custovic, A., & Ghysels, E. (2018). Long- and short-term cryptocurrency volatility components: A GARCH-MIDAS analysis. *Journal of Risk and Financial Management*, *11*(2), 23. https://doi.org/10.3390/jrfm11020023

Corbet, S., Hou, Y. G., Hu, Y., Larkin, C., Lucey, B., & Oxley, L. (2022). Cryptocurrency liquidity and volatility interrelationships during the COVID-19 pandemic. *Finance Research Letters*, *45*, 102137. https://doi.org/10.1016/j.frl.2021.102137

Corbet, S., Hou, Y. G., Hu, Y., Oxley, L., & Xu, D. (2021). Pandemic-related financial market volatility spillovers: Evidence from the Chinese COVID-19 epicentre. *International Review of Economics & Finance*, *71*, 55–81. https://doi.org/10.1016/j.iref.2020.06.022

Davies, G. (2021). *A short history of cryptocurrencies* [Blog entry]. Davies Blog. https://daviescoin.io/blog/

Degiannakis, S., Filis, G., & Hassani, H. (2018). Forecasting global stock market implied volatility indices. *Journal of Empirical Finance*, *46*, 111–129. https://doi.org/10.1016/j.jempfin.2017.12.008

Dyhrberg, A. H. (2016). Bitcoin, gold and the dollar – A GARCH volatility analysis. *Finance Research Letters*, *16*, 85–92. https://doi.org/10.1016/j.frl.2015.10.008

Fang, W., Tian, S., & Wang, J. (2018). Multiscale fluctuations and complexity synchronization of Bitcoin in China and US markets. *Physica A: Statistical Mechanics and Its Applications*, *512*, 109–120. https://doi.org/10.1016/j.physa.2018.08.051

Giudici, P., & Abu Hashish, I. (2020). A hidden Markov model to detect regime changes in cryptoasset markets. *Quality and Reliability Engineering International*, *36*(6), 2057–2065. https://doi.org/10.1002/qre.2673

Goldfeld, S. M., & Quandt, R. E. (1965). Some tests for heteroscedasticity. *Journal of the American Statistical Association*, *60*(310), 539–547. https://doi.org/10.1080/01621459.1965.10480811

Guesmi, K., Saadi, S., Abid, I., & Ftiti, Z. (2019). Portfolio diversification with virtual currency: Evidence from bitcoin. *International Review of Financial Analysis*, *63*, 431–437. https://doi.org/10.1016/j.irfa.2018.03.004

Hafner, C. M. (2020). Testing for bubbles in cryptocurrencies with time-varying volatility. *Journal of Financial Econometrics*, *18*(2), 233–249. https://doi.org/10.1093/jjfinec/nby023

Investopedia. (2023). *Investopedia.com*. https://www.investopedia.com/

Jiang, Y., Nie, H., & Ruan, W. (2018). Time-varying long-term memory in Bitcoin market. *Finance Research Letters*, *25*, 280–284. https://doi.org/10.1016/j.frl.2017.12.009

Katsiampa, P. (2017). Volatility estimation for Bitcoin: A comparison of GARCH models.

Economics Letters, *158*, 3–6. https://doi.org/10.1016/j.econlet.2017.06.023

Katsiampa, P. (2019). An empirical investigation of volatility dynamics in the cryptocurrency market. *Research in International Business and Finance*, *50*, 322–335. https://doi.org/10.1016/j.ribaf.2019.06.004

Kim, A., Trimborn, S., & Härdle, W. K. (2021a). VCRIX – *International Review of Financial Analysis*, *78*, 101915. https://doi.org/10.1016/j.irfa.2021.101915

Kim, K., Lee, S.-Y. T., & Assar, S. (2021b). The dynamics of cryptocurrency market behavior: Sentiment analysis using Markov chains. *Industrial Management & Data Systems*, *122*(2), 365–395. https://doi.org/10.1108/imds-04-2021-0232

Kodama, O., Pichl, L., & Kaizoji, T. (2017). Regime change and trend prediction for Bitcoin time series data. In *CBU International Conference Proceedings on Innovations in Science and Education* (Vol. 5, pp. 384–388). https://doi.org/10.12955/cbup.v5.954

Koki, C., Leonardos, S., & Piliouras, G. (2022). Exploring the predictability of cryptocurrencies via Bayesian hidden Markov models. *Research in International Business and Finance*, *59*, 101554. https://doi.org/10.1016/j.ribaf.2021.101554

Lahajnar, S., & Rožanec, A. (2020). The correlation strength of the most important cryptocurrencies in the bull and bear market. *Investment Management and Financial Innovations*, *17*(3), 67–81. https://doi.org/10.21511/imfi.17(3).2020.06

Le, C., & David, D. (2014). Asset price volatility and financial contagion: Analysis using the MS-VAR framework. *Eurasian Economic Review*, *4*(2), 133–162. https://doi.org/10.1007/s40822-014-0009-y

Li, H., & Li, X. (2023). The COVID-19 pandemic's impact on the Chinese economy. *China Currents*, *22*(1), 1–10.

Li, T., Shin, D., & Wang, B. (2021). Cryptocurrency pump-and-dump schemes. *SSRN Electronic Journal*, 3267041. https://doi.org/10.2139/ssrn.3267041

Liu, Y., & Tsyvinski, A. (2021). Risks and returns of cryptocurrency. *The Review of Financial Studies*, *34*(6), 2689–2727. https://doi.org/10.1093/rfs/hhaa113

Liu, Y., Wei, Y., Wang, Q., & Liu, Y. (2022). International stock market risk contagion during the COVID-19 pandemic. *Finance Research Letters*, *45*, 102145. https://doi.org/10.1016/j.frl.2021.102145

Maghyereh, A., & Abdoh, H. (2022). COVID-19 and the volatility interlinkage between bitcoin and financial assets. *Empirical Economics*, *63*(6), 2875–2901. https://doi.org/10.1007/s00181-022-02223-7

Malepati, V., Challa, M. L., & Kolusu, S. N. R. (2019). Stock market volatility modeling and forecasting with a special reference to BSE Sensex. In R. Biswas & M. Michaelides (Eds.), *Research in Finance* (Vol. 35, pp. 105–118). Emerald Publishing Limited. https://doi.org/10.1108/s0196-382120190000035005

McCoy, M., & Rahimi, S. (2020). Prediction of highly volatile cryptocurrency prices using social media. *International Journal of Computational Intelligence and Applications*, *19*(04), 2050025. https://doi.org/10.1142/s146902682050025x

Mensi, W., Al-Yahyaee, K. H., & Kang, S. H. (2019). Structural breaks and double long memory of cryptocurrency prices: A comparative analysis from Bitcoin and Ethereum. *Finance Research Letters*, *29*, 222–230. https://doi.org/10.1016/j.frl.2018.07.011

Meynkhard, A. (2020). Effect of Bitcoin volatility on altcoins pricing. In *Advances in Intelligent Systems and Computing. Software Engineering Perspectives in Intelligent Systems. CoMeSySo 2020* (Vol. 1294, pp. 652–664). Springer International Publishing. https://doi.org/10.1007/978-3-030-63322-6_55

Mostafa, F., Saha, P., Islam, M. R., & Nguyen, N. (2021). GJR-GARCH volatility modeling under NIG and ANN for predicting top cryptocurrencies. *Journal of Risk and Financial Management*, *14*(9), 421. https://doi.org/10.3390/jrfm14090421

OECD. (2020). *Policy responses to coronavirus (COVID-19). The territorial impact of COVID-19: Managing the crisis across levels of government*. https://www.oecd.org/coronavirus/policy-responses/the-territorial-impact-of-covid-19-managing-the-crisis-across-levels-of-government-d3e314e1/

Pal, D., & Mitra, S. K. (2019). Hedging bitcoin with other financial assets. *Finance Research Letters*, *30*, 30–36. https://doi.org/10.1016/j.frl.2019.03.034

Panagiotidis, T., Papapanagiotou, G., & Stengos, T. (2022). On the volatility of cryptocurrencies. *Research in International Business and Finance*, *62*, 101724. https://doi.org/10.1016/j.ribaf.2022.101724

Pesaran, M. H., & Timmermann, A. (2007). Selection of estimation window in the presence of breaks. *Journal of Econometrics*, *137*(1), 134–161. https://doi.org/10.1016/j.jeconom.2006.03.010

Rambaccussing, D., & Mazibas, M. (2020). True versus spurious long memory in cryptocurrencies. *Journal of Risk and Financial Management*, *13*(9), 186. https://doi.org/10.3390/jrfm13090186

Sosa, M., Ortiz, E., & Cabello, A. (2019). Bitcoin conditional volatility: GARCH extensions and Markov switching approach. In J. Choi & B. Ozkan (Eds.), *International Finance Review* (Vol. 20, pp. 201–219). Emerald Publishing Limited. https://doi.org/10.1108/S1569-376720190000020020

Soylu, P. K., Okur, M., Çatıkkaş, Ö., & Altintig, Z. A. (2020). Long memory in the volatility of selected cryptocurrencies: Bitcoin, Ethereum and Ripple. *Journal of Risk and Financial Management*, *13*(6), 107. https://doi.org/10.3390/jrfm13060107

Tan, C.-Y., Koh, Y.-B., Ng, K.-H., & Ng, K.-H. (2021). Dynamic volatility modelling of Bitcoin using time-varying transition probability Markov-switching GARCH model. *The North American Journal of Economics and Finance*, *56*, 101377. https://doi.org/10.1016/j.najef.2021.101377

Tiwari, A. K., Jana, R. K., Das, D., & Roubaud, D. (2018). Informational efficiency of Bitcoin – An extension. *Economics Letters*, *163*, 106–109. https://doi.org/10.1016/j.econlet.2017.12.006

Urom, C., Abid, I., Guesmi, K., & Chevallier, J. (2020). Quantile spillovers and dependence between Bitcoin, equities and strategic commodities. *Economic Modelling*, *93*, 230–258. https://doi.org/10.1016/j.econmod.2020.07.012

Walther, T., Klein, T., Thu, H. P., & Piontek, K. (2017). True or spurious long memory in European nonEMU currencies. *Research in International Business and Finance*, *40*, 217–230. https://doi.org/10.1016/j.ribaf.2017.01.003

Wei, M., Sermpinis, G., & Stasinakis, C. (2022). Forecasting and trading Bitcoin with machine learning techniques and a hybrid volatility/sentiment leverage. *Journal of Forecasting*, *42*(4), 852–871. https://doi.org/10.1002/for.2922

WHO. (2023). *WHO coronavirus (COVID-19) dashboard*. https://covid19.who.int/

Yarovaya, L., Matkovskyy, R., & Jalan, A. (2022). The COVID-19 black swan crisis: Reaction and recovery of various financial markets. *Research in International Business and Finance*, *59*, 101521. https://doi.org/10.1016/j.ribaf.2021.101521

Yin, T., & Wang, Y. (2022). Nonlinear analysis and prediction of Bitcoin return's volatility. *E&M Economics and Management*, *25*(2), 102–117. https://doi.org/10.15240/tul/001/2022-2-007

Yousaf, I., & Ali, S. (2020). The COVID-19 outbreak and high frequency information transmission between major cryptocurrencies: Evidence from the VAR-DCC-GARCH approach. *Borsa Istanbul Review*, *20*, S1–S10. https://doi.org/10.1016/j.bir.2020.10.003

Zargar, F. N., & Kumar, D. (2019). Long range dependence in the Bitcoin market: A study based on high-frequency data. *Physica A: Statistical Mechanics and Its Applications*, *515*, 625–640. https://doi.org/10.1016/j.physa.2018.09.188

Digital payments as an indicator of financial inclusion in Euro Area countries

Tamara Petrikova[1], Kristina Kocisova[2]

[1] *Technical University of Kosice, Faculty of Economics, Department of Banking and Investments, Slovakia, ORCID: 0000-0002-3094-1114, Tamara.Petrikova@tuke.sk;*

[2] *Technical University of Kosice, Faculty of Economics, Department of Banking and Investments, Slovakia, ORCID: 0000-0003-0784-441X, Kristina.Kocisova@tuke.sk (corresponding author).*

Abstract: *The process of digitisation in the financial sector is developing through the systematic introduction of computer systems, the establishment of Internet connectivity and the use and ownership of various information and communication devices. Information and communication technologies can increase the desired degree of financial inclusion in a country by increasing the availability of various financial services. This study examines the individual attributes that can affect financial inclusion in the Euro Area countries in 2021. Our analysis applies a probit model to data from the World Bank Global Findex database, focusing on digital payments as a proxy for financial inclusion. The main finding highlights that higher income, higher education, female gender, and younger age groups are associated with an increased propensity to engage in digital payments. Notably, our expectation of a non-linear relationship between age and digital payments is confirmed, as evidenced by the application of the Robin Hood algorithm. Specifically, we observe a positive correlation between age and digital payment usage. However, this trend reverses beyond a specific breakpoint, approximately around the age of 40, leading to a subsequent decline in digital payment activity. Furthermore, our research shows that individuals who utilised alternative payment methods alongside cash before the COVID-19 pandemic are likelier to engage in higher digital payments. Additionally, a tendency for higher adoption of digital payments coincides with countries that achieved a higher Digital Access Index (DAI), an indicator assessing the degree of digitalisation in a country. Furthermore, it is associated with countries among the Euro Area's founding members.*

Keywords: *Financial inclusion, made and received digital payments, individual characteristics, Internet, mobile ownership, U-shaped relationship.*

JEL Classification: *G21, O16, P34.*

APA Style Citation: Petrikova, T., & Kocisova, K. (2024). Digital payments as an indicator of financial inclusion in Euro Area countries. *E&M Economics and Management, 27*(2), 162–182. https://doi.org/10.15240/tul/001/2024-5-004

Early Access Publication Date: *January 23, 2024.*

Introduction

In early 2020, with the onset of COVID-19, the global population was attracted and forced to use advanced digital technologies. It catalysed a rapid adoption of technology across various sectors. Kabakova and Plaksenkov (2018) assert that technological advancements rank among the foremost factors contributing to enhanced financial inclusion in numerous countries. Moreover, the pandemic, as noted by Demirgüç-Kunt et al. (2022), profoundly influenced the utilisation and nature of various banking services, fostering concerted efforts towards global financial inclusion. They highlight that the crisis accelerated the surge in online purchases of banking products, which,

in many cases, led to a notable shift away from in-branch transactions towards exclusive online interactions.Consequently, more individuals are now opting for and executing transactions via the Internet, mobile applications or ATMs. This digital revolution, spurred by the pandemic, has revolutionised access to financial services while simultaneously lowering the costs associated with digital transactions for individuals and businesses. As digital payments become more common and the costs continue to decline, many private enterprises have switched to electronically making payments to employees, suppliers, or for tax obligations. Furthermore, this shift has positively impacted governance, as social programs now channel transfers directly to their beneficiaries, reducing leakage and minimising delays in the process. The transition to digital payments has made financial operations more efficient and increased transparency, as funds flow directly from national budgets to individuals, reducing corruption opportunities.

Demirgüç-Kunt et al. (2022) state that the prevalence of digital payments has exhibited significant growth in developing economies, with the share of adults engaged in making or receiving digital payments rising from 35% in 2014 to 57% in 2021. In high-income countries, the share is nearly 95%, while on a global scale, approximately 64% of adults participate in digital payment transactions. According to the definition, digital payments include using a mobile money account, a debit or credit card, a mobile phone or the Internet to make a payment from an account, send money to relatives (or friends) or pay bills. Access to digital payments leads to the financial inclusion of non-financial companies and individuals while boosting resilience and growth on the micro and macro levels. Financial inclusion represents using formal financial services, contributing to the prerequisite of financial development. Information and communication technologies (ICT) have helped the banking sector and countries to become digital, especially with the gradual introduction of mobile phones, the Internet, and various digital services. Adopting diverse ICT platforms engenders a heightened interest in utilising financial accounts for digital payments. It extends to a broader spectrum of financial services, including savings or borrowing through various types of loans. There are still many opportunities to increase the use of financial accounts for digital payments, increasing financial inclusion. For instance, one way to progress involves employing financial accounts to facilitate digital payments for essential utilities such as water and electricity or fully transitioning merchant payments into digital formats. Additionally, digitalising wage disbursements and government payments directly into financial accounts can encourage individuals to save while reducing the time and costs of receiving such payments.

Studying digital payments as an indicator of financial inclusion is important for several reasons. 1) Digital payments serve as a tangible gouge of financial inclusion, offering insights into how individuals can access and utilise formal financial services. By examining digital payment behaviour, researchers and policymakers can assess the inclusiveness of financial systems. 2) Digital payments are emblematic of financial services' accessibility and convenience. A high prevalence of digital payments suggests that financial services are readily available and user-friendly, making them more accessible to a broader population segment. 3) The ability to make digital payments is closely linked to individuals' capacity to engage in economic activities. People who can transact digitally are better positioned to participate in the formal economy, receive wages electronically, make purchases, and access credit, all of which are vital for economic growth and development. 4) Digital payments can enhance financial resilience. Individuals who use digital payment often have the resources to manage more effectively with financial shocks, as they can access their funds and conduct transitions remotely, reducing the risk of financial exclusion during crises. 5) Digital payments can lower transaction costs for both individuals and businesses. It can lead to more efficient financial transactions, facilitating economic growth and reducing the financial burden on users. 6) Digital payments are more transparent and secure than traditional cash transactions. It can reduce the risk of fraud, corruption, and theft, ultimately contributing to financial stability and security. 7) Analysing digital payment data provides policymakers with valuable insights into financial behaviour. This data can inform the development of targeted policies aimed at enhancing financial inclusion, improving the efficiency of the financial system, and fostering economic development. 8) Understanding digital payment adoption can help

identify gaps in access to digital infrastructure and financial services, highlighting areas where interventions are needed to bridge the digital divide and ensure that all population segments can benefit from digital financial services. Studying digital payments as an indicator of financial inclusion allows for a comprehensive assessment of financial inclusion in a given region or country. It sheds light on the extent to which financial services are accessible, affordable, and user-friendly, ultimately contributing to economic development, reducing poverty, and improving the financial well-being of individuals and communities.

The evolution of digital payments poses several key questions. Firstly, which individual characteristics influence the use of digital payments in Euro Area countries? Secondly, has there been a change in the use of digital payment after the coronavirus pandemic? Thirdly, is the level of digitalisation in the country crucial for increasing financial inclusion expressed through digital payments? To address these questions comprehensively, our study aims to examine the impact of individual characteristics on financial inclusion in the Euro Area countries in 2021. Methodologically, we employ a probit model as our research framework. The dependent variable under consideration is the indicator of financial inclusion, specifically from the perspective of digital payments. Our primary control variables include age, gender, education level, and household income quintile. To address our second research question regarding changes in financial behaviour after COVID-19, we include an additional control variable designed to capture shifts in financial behaviour caused by the pandemic. In our final model, we introduce two supplementary variables: the duration of Euro Area membership and the Digital Access Index (DAI), which help us to answer the third research question. The micro-level data is taken from the Findex Global Questionnaire survey administered by the World Bank for 2021. The International Telecommunication Union publishes the data about DAI.

The remainder of this article is structured as follows. Section 1 provides an overview of the existing literature on financial inclusion. Section 2 describes the data and methodology employed in this study. Section 3 analyses digital payments in the Euro Area countries and presents our key findings. Finally, Section 4 draws conclusions from the study's findings.

1. Theoretical background

In this section, we offer a comprehensive review of the existing literature related to financial inclusion. We present the key findings from other scholars who have examined financial inclusion using different indicators across various countries and periods.

Financial inclusion, as defined by the World Bank (2022a), encompasses the provision of accessible and cost-effective financial products and services adapted to the needs of both individuals and businesses. These services include a spectrum ranging from transactions and payments to savings, credit, and insurance, all delivered responsibly and appropriately. Ozili (2021) characterises financial inclusion as ensuring that individuals, especially those facing financial difficulties, access fundamental financial services within the formal financial sector. Erlando et al. (2020) emphasise that formal financial inclusion starts with establishing a deposit account at a bank or other financial service provider, extending to the making and receiving payments, secure money storage or savings management. Moreover, financial inclusion also includes credit availability from formal financial institutions and insurance products designed to mitigate financial risks. In recent years, we have seen an increased interest in financial inclusion at political and academic levels. Scholars such as Ozili (2021) and Demirgüç-Kunt et al. (2018) emphasise its pivotal role in achieving the goals of sustainable development in the country. Lenka and Barik (2018) identify financial inclusion as a driving force behind the construction of inclusive societies and economies, while Demirgüç-Kunt et al. (2022) argue that it serves as a critical factor in poverty reduction, mitigating income inequality, and fostering inclusive economic growth. Additionally, Nagpal et al. (2020) state that enhanced financial inclusion contributes to the stability of the financial system in the country and the effectiveness of its monetary policies. However, it is essential to recognise that access to financial services is more readily available to individuals in developed nations. In contrast, individuals in developing countries often face significant barriers. Erlando et al. (2020) characterise financial inclusion as a process characterised by advances in the quantity, quality, and efficiency of financial services, each of which plays a role in simplifying lives, enhancing opportunities, and strengthening

economies on an individual level. Furthermore, Chinoda and Mashamba (2021) underscore the importance of easy access to and the utilisation of affordable financial services and products customised to diverse business and individual needs, which include transactions, payments, savings, or loans. However, they suggest that geographical location, local context, and environmental factors significantly impact the implementation of financial inclusion.

The opposite of financial inclusion is financial exclusion. One of the initial efforts to define financial exclusion can be found in the study of Leyshon and Thrift (1995), who characterise it as preventing disadvantaged individuals from accessing essential financial services. Sinclair (2001) further explains financial exclusion as the inability to access necessary financial services. Claessens (2006) highlights that financial exclusion is linked to social exclusion, meaning that access to financial services depends on factors such as education, employment status, income level, and other individual attributes. Sinclair (2013) also highlights the limited access to conventional banking services for individuals with limited incomes, particularly those residing in economically disadvantaged areas. In such cases, reliance on cash transitions becomes the norm due to the absence of direct access to formal financial services. These problems individuals face create inefficiencies that hamper economic growth and deepen poverty, primarily due to unequal access to financial resources. Many authors emphasise the imperative for governments, central banks, and regulators to understand the determinants of financial inclusion and the underlying reasons for financial exclusion. Such understanding enables the formulation of effective policy and regulatory measures to address these issues comprehensively.

Demirgüç-Kunt et al. (2022) highlight fundamental financial inclusion indicators, including financial account or mobile money account ownership, savings, borrowing, and digital payments. Key among these indicators is account ownership, as defined by the World Bank (2022b), which refers to the ownership of an individual or jointly owned account at a regulated institution, such as a bank, credit union, microfinance institution, post office, or mobile money service provider. Aurazo and Vega (2021) regard access to financial and mobile accounts as a fundamental indicator of financial inclusion, which should be universally available to every adult in the country. Such account ownership empowers individuals to utilise financial services, fostering their personal development and, at the same time, contributing to the development of their nations. Owners of accounts can send or receive money and, with access to other financial services, can withstand financial shocks more effectively compared to those without such access. From a global perspective, account ownership has shown substantial growth over the past decade. According to Demirgüç-Kunt et al. (2022), between 2011 and 2021, global account ownership increased from 51% to 76%. Notably, in European countries like Denmark, Iceland, Germany, Austria, the United Kingdom, the Netherlands, Sweden, and Ireland, reaching 100% account ownership has become commonplace. It underscores the fundamental nature of this financial inclusion indicator. The second key indicator of financial inclusion is borrowing, which includes adults who have obtained loans within the last 12 months, including through credit card usage. According to the World Bank (2022b), in 2021, 53% of adults worldwide reported having borrowed any money, with formal borrowing predominating over-borrowing from family, friends, or other sources. High-income economies like Canada (81%), USA (66%), Japan (61%) and European countries such as Iceland (73%) or Switzerland (61%) exhibit higher rates of borrowing through formal means. Savings are another indicator of financial inclusion. Individuals save for several reasons, including future expenses, education or business investments, and retirement planning. Globally, 49% of adults saved or set aside money within the last 12 months in 2021. According to the World Bank (2022b), 25% of adults in developing countries employed an account for savings, with an even larger share, 39%, using accounts for cash management.

The final indicator of financial inclusion is digital payments. Digital payments include using a mobile money account, a debit or credit card, a mobile phone and the Internet to make transactions from an account, send money to relatives or friends, or settle bills. According to Allen et al. (2016) and Demirgüç-Kunt et al. (2015), digital payments are key in advancing financial inclusion by making payment transactions easier, more accessible, and more secure. Tsatsou (2020) argues that the digital technologies facilitating access to financial

services significantly impact individuals' quality of life and social inclusion. Moreover, making and receiving digital payments through various digital technological means, as noted by Martins et al. (2014), contributes to the broader adoption of banking and financial services, particularly in emerging markets. Alter and Yontcheva (2015) state that adopting basic digital financial payment methods results in a more convenient financial ecosystem, benefiting financial institutions and individuals. According to the World Bank (2022b), the use of digital payments has reached a relatively high level globally, particularly in high-income economies where digital payments have become an integral part of daily life. As of 2021, worldwide statistics indicate that digital payments are made by 82% of the population and received by 70%, with an overall digital payment rate of 64%. However, as reported by Nandru et al. (2021), it is important to note that over 4 billion people still lack Internet access, with 90% residing in developing countries. It underlines the significance of addressing the digital divide to ensure consistent access to digital services and promote digital financial inclusion. It is often observed, as highlighted by Nuzzo and Piermattei (2020) and Aurazo and Vega (2021), that simple ownership of a bank account does not guarantee its active use, as many individuals tend to withdraw funds from their accounts and rely exclusively on cash transactions. The transition from cash to digital payments substantially benefits both payers and recipients. It enhances payment efficiency by expediting transactions and reducing associated costs. Additionally, it strengthens payment security, thereby diminishing digital payment-related crime. Furthermore, it enhances payment transparency, reducing the risk of information leakage between the payers and recipients in digital transactions.

Numerous studies have looked at financial inclusion, often drawing upon respondent-level data from the World Bank's Global Findex database, which provides a comprehensive array of fundamental financial inclusion or exclusion indicators. This database offers valuable insights into how people use information and communication technologies to engage with various financial services. Microdata allows us to examine which individual characteristics significantly impact financial inclusion in a country. The determinants of financial inclusion represent a critical area of research, as they shed light on the factors influencing individuals' access to and utilisation of formal financial services. An extensive literature review reveals several key determinants of financial inclusion: income level, education, geographical location, gender, age, employment status, digital infrastructure, regulatory environment, social networks, cultural and social norms, credit history, government initiatives, and economic stability. One of the most significant determinants is income. Higher-income levels are often associated with greater access to and utilisation of financial services. Individuals with higher incomes typically find it easier to open and maintain bank accounts, access credit, and engage in various financial transactions. The second important indicator is education. People with higher levels of education tend to have better financial literacy, which enables them to navigate the complexities of formal financial systems more effectively. Financial education programs can also enhance financial inclusion by equipping individuals with the knowledge to make informed financial decisions. Geographical factors, including urban or rural residence, can significantly impact financial inclusion. Rural areas often have fewer physical bank branches and limited access to financial services, making it more challenging for residents to engage with formal financial institutions. Gender disparities persist in financial inclusion. Women, particularly in developing countries, are often less financially included than men. Cultural and social norms and legal and regulatory barriers can hinder women's access to financial services. Age is another determinant, as younger individuals may have different financial needs and preferences than older generations. Younger populations may be more inclined to adopt digital financial services, while older individuals may prefer traditional banking. Employment status and access to a regular income source are crucial determinants of financial inclusion. Formal employment often correlates with access to payroll accounts and the ability to save and transact digitally. The availability and quality of digital infrastructure, such as Internet access and mobile phone penetration, are instrumental in promoting financial inclusion. Digital channels provide convenient and cost-effective ways to access financial services, particularly in remote or underserved areas.

Nagpal et al. (2020) underscore the role of individual characteristics in determining

disparities between those categorised as "financially excluded" and those not. Motta and Farias (2018) and Lotto (2018) concur that key individual attributes such as gender, age, employment status, income, and education play a key role in determining financial exclusion. Fungáčová and Weill (2015) examined financial inclusion in China relative to other BRICS countries in 2014. In China and other BRICS countries, a high level of financial inclusion is mainly marked by extensive usage of formal bank accounts and savings. Their analysis revealed that more frequent use of formal bank accounts and credit correlates with higher income and educational attainment, especially among older men. Similarly, Susilowati and Leonnard (2019) employed these same three primary determinants of financial inclusion in their analysis of ASEAN countries in 2014. Zins and Weill (2016) conducted a study incorporating the same three determinants but with "account ownership" as the dependent variable, including account ownership in a formal institution and mobile money account ownership. Their main findings confirmed the influence of income and education levels on the likelihood of financial inclusion, especially among older men. Furthermore, these findings align with the notion that policies designed to foster financial inclusion should be customised to target specific demographic groups, such as women and young individuals, which is supported by studies by Demirgüç-Kunt and Klapper (2013) and Nagpal et al. (2020). As highlighted by Motta and Farias (2018) and Lotto (2018), age also emerges as a significant factor in financial inclusion, with older individuals showing a higher likelihood of owning a bank account, saving, and accessing credit through formal financial institutions. In summary, the determinants of financial inclusion are multifaceted and interconnected. Understanding these determinants is crucial for policymakers, financial institutions, and researchers seeking to design effective strategies and interventions to promote greater financial inclusion, reduce disparities, and enhance the economic well-being of individuals and communities.

The analysis of financial inclusion and its determinants has predominantly focused on regions such as China, Asia, and Africa, with relatively fewer studies exploring this issue in European countries. Given the continuous growth in financial inclusion, particularly in the context of escalating digitalisation, we consider the research gap in understanding the relationship between the level of financial inclusion as measured by the "digital payments" and the socio-demographic characteristics of the respondents, including age, gender, income, and education. Our research will focus on Euro Area countries and rely on data from the World Bank's Global Findex database drawn from a questionnaire survey conducted in 2021. Regarding research methodology, we employ a probit model to analyse determinants of financial inclusion, consistent with the approaches adopted in prior studies. However, our paper introduces a novel dimension by relying on linear modelling and incorporating a non-linear approach. Quadratic regression is standardised for assessing the potential U-shaped relationship. The novelty of this paper is the introduction of the Robin Hood algorithm to set the breakpoint between the lines. Simonsohn (2018) argues that this algorithm increases the statistical power in detecting U-shaped relationship. This two-lines test offers a straightforward examination of whether the independent variable effect on the dependent variable varies in sign between high and low values of the independent variable. By employing this U-shaped analysis, we aim to determine whether increasing age always positively affects financial inclusion indicators or whether this relationship becomes reversed once a breakpoint is reached. Our model incorporates two variables serving as proxies for digital payments, which include both made and received digital payments and the utilisation of a mobile phone or Internet for payments. Additionally, age, gender, education level, and household income quintile are integrated as control variables. Compared to prior research, our contribution lies in including a control variable designed to detect shifts in financial behaviour following the COVID-19 pandemic, incorporating the number of years of Euro Area membership, and integrating the Digital Access Index. These factors enrich our analysis and provide a more comprehensive understanding of the determinants of financial inclusion in the Euro Area context.

2. Research methodology

Our dataset originates from the World Bank's Global Findex database (World Bank, 2022b), which encompasses micro-level data gathered through a survey of 127,859 adults aged 15 and above across 123 countries conducted in 2021. The database has been periodically published

every three years since 2011. Currently, it contains data from the years 2011, 2014, 2017 and 2021. It is important to note that the database includes data for 2021 specifically, as the COVID-19 pandemic disrupted the regular cycle, and data for 2020 was not made available. The comprehensive database affords insights into various indicators and access to and utilisation of formal and informal financial services. Within this dataset, we gain insights into individuals' account ownership, usage of credit or debit cards, borrowing habits, saving behaviours, and engagement in digital payment transactions facilitated through mobile phones and the Internet. Fungáčová and Weill (2015) have noted that the Findex questionnaire within this global database offers extensive and detailed information on financial inclusion based on an extensive array of inquiries. Furthermore, the database includes essential individual characteristics, such as gender, age, income, education, and employment status, further enriching the dataset's analytical capabilities.

In the study, we aim to address three main research questions. First, which individual characteristics influence the use of digital payments in Euro Area countries? Second, has there been a change in the use of digital payment after the coronavirus pandemic? Third, is the level of digitalisation in the country crucial for increasing financial inclusion expressed through digital payments?

As the dependent variable, we use the indicator of financial inclusion from the perspective of digital payments. We consider two indicators related to digital payments. In Model 1, digital payments (labelled as "digital") are defined as payments made or received digitally. The indicator takes a value of 1 when the respondent answers "yes" to one of the two questions posed in the Global Findex Questionnaire. The first question, FIN31A, inquires: "In the past 12 months, have you personally, directly made payments for electricity, water, or trash collection through a bank account or another type of formal financial institution?". The second question, labelled FIN34A, asks: "In the past 12 months, has an employer paid your salary or wages directly into your account at a bank or another type of formal financial institution?". In Model 2, digital payments ("mobile_internet") are defined as digital payments realised via mobile phone or Internet. The indicator takes value 1 when the respondent answers "yes" to question FIN5: "In the past 12 months, did you ever use a mobile phone or the Internet to make payments, buy things, or send or receive money using this account?"

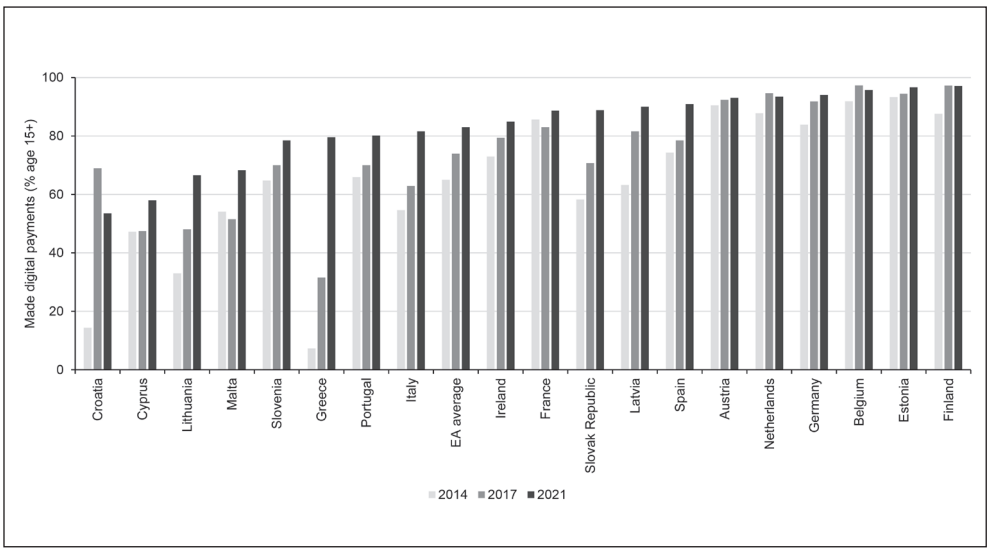


Fig. 1: **Made digital payment using a financial institution account in Euro Area countries for 2014, 2017 and 2021**

Source: own (based on World Bank, 2022b)

The first indicator of financial inclusion points to respondents who formally made payments for services. This percentage denotes individuals who have confirmed that they personally and regularly paid for water, electricity, or waste collection in the past year, paying directly from a financial institution account. An examination of this indicator at the national level reveals notable disparities within the Euro Area, as illustrated in Fig. 1, across the years 2014, 2017 and 2021. In 2021, residents of Euro Area countries demonstrated a heightened propensity to make digital payments for services using their financial accounts compared to 2014. This transformation is strongly reflected in the overall average for Euro Area countries, which has seen an increase of 18% in 2021 relative to 2014 (ascending from 65% to 83%). Exceptionally high levels of digital payment usage were observed in Finland and Estonia (97%), Belgium (96%) and Germany (94%). Notably, despite an initial low usage rate of this digital payment method in 2014 (7%), Greek respondents significantly increased their utilisation of digital options for bill payments to 82% in 2021. Similarly, a remarkable surge was observed between 2014 and 2021 in Croatia (increasing by 39%), Lithuania (increasing by 34%), Slovakia (increasing by 31%), as well as Latvia and Italy (both increasing by 27%).

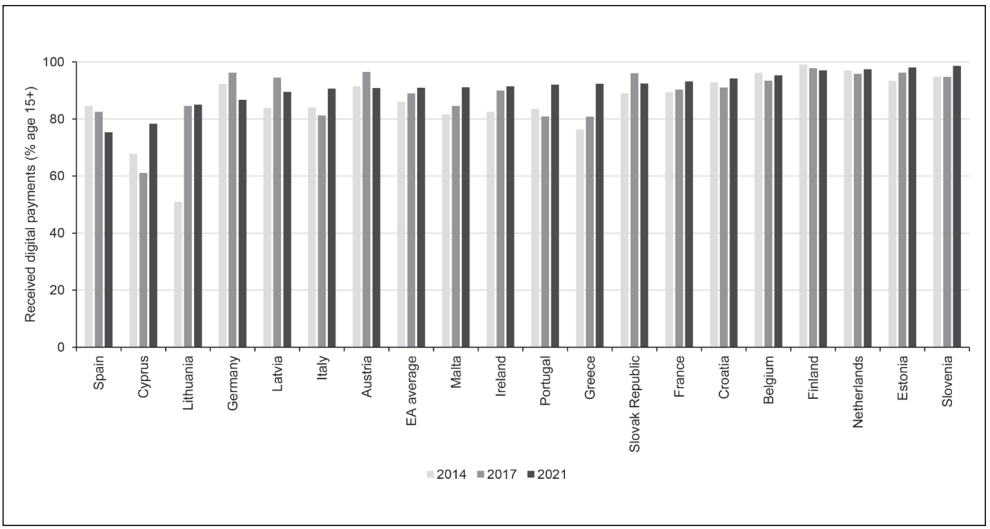


Fig. 2: **Received digital payments into a financial institution account for 2014, 2017 and 2021**

Source: own (based on World Bank, 2022b)

The second indicator, focusing on received digital payments, examines respondents who reported receiving income from their employers in the form of salaries or wages directly deposited into a financial institution account in the past year. Analysing Fig. 2, we observe relatively minor variations across Euro Area countries during the presented years. The average rate of received digital payments in Euro Area countries consistently hovered around 90% during the monitored period. Notably, in 2021, the lowest values were reported in Spain (75%), Cyprus (78%) and Lithuania (85%). The highest progress was recorded in Lithuania, where the value increased by 34% from 2014 to 2017.

The development of digitisation within the banking sector primarily revolves around the widespread adoption of mobile devices and Internet connectivity. Nowadays, nearly every individual owns a mobile phone. According to the World Bank (2022b), in 2021, a remarkable 86% of the global adult population owned a mobile phone. This trend is universal, with mobile phone ownership commonplace

in both developing economies, at 83%, and high-income economies, at 95%. Furthermore, in 2021, 63% of the world's population utilised the Internet, with the adoption rate differing between developing countries, at 57%, and high-income countries, at a higher 91%. In the Euro Area countries, mobile phones have become a widely used digital device, with ownership rates starting at 87% in Ireland and climbing even higher (Fig. 3). The overall mobile phone ownership rate across these nations averages an impressive 96%. Notably, countries like Austria, France, and Malta (100%) have the highest rates of mobile phone ownership. It begins at 85% in Cyprus, with the average Internet access rate at 91%. Residents of Nordic European countries, such as Estonia and Finland, demonstrate exceptional access

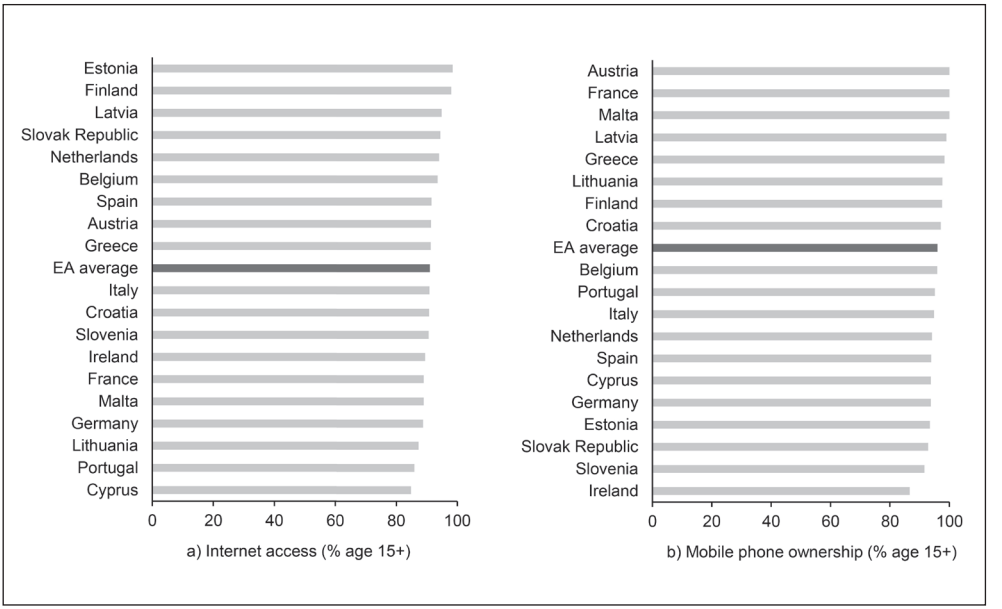


Fig. 3: Internet access and mobile phone ownership in Euro Area countries for 2021

Source: own (based on World Bank, 2022b)

to the Internet, with both nations achieving a full 100% Internet penetration rate.

The third key indicator related to digital payments sent and received (Fig. 4). This indicator represents the proportion of respondents holding an account at a financial institution who reported using a mobile phone or the Internet to make payments, purchase things, or send or receive money through their financial account. It is essential to note that data for this indicator is available for 2021 exclusively. Globally, 52% of adults with financial accounts have actively participated in digital payments via mobile phone or the Internet. Within this global figure, developing economies registered a rate of 47%, while their high-income counterparts exhibited a higher rate of 68% in 2021. The overall average for this indicator across the Euro Area countries reached 68%. However, again, it should be pointed out that the Nordic European countries, including Finland (91%), Estonia (86%), the Netherlands (80%) and Latvia (79%), stood out with the highest levels of digital payments among adults. In contrast, countries such as Croatia (46%), Portugal (54%), and France (55%) reported the lowest values for this indicator.

Our analysis uses micro-level data obtained from the World Bank's questionnaire survey and focuses on the responses of individuals in 2021. This research examines the impact of personal

Fig. 4: **Made and received digital payments via mobile phone or Internet in 2021**

Source: own (based on World Bank, 2022b)

characteristics (independent variables) on individuals' financial inclusion, as measured by the digital payments indicator (dependent variable), specifically in Euro Area countries. We employ probit regression analysis for this investigation. Regarding financial inclusion, as measured through the "digital" metric, our dataset includes 17,251 individuals who both received and sent digital payments formally, while 18,470 respondents are considered for digital payments made via mobile phone or the Internet (referred to as "mobile_internet"). The study focuses on the 19 Euro Area countries for 2021. Luxembourg is not included in our analysis due to the unavailability of data within the Global Findex database for this particular country. Comprehensive descriptive statistics and variable definitions can be found in Tab. 1.

We use the data on individuals' characteristics in the Global Findex database to examine how these different characteristics are associated with financial inclusion in Euro Area countries. We perform probit estimations to explain measures of financial inclusion and estimate the following equation:

$$FI_i = \alpha + \beta \cdot gender_i + \gamma \cdot age_i + \\ + \delta \cdot education_i + \kappa \cdot income_i + \varepsilon_i \quad (1)$$

where: *FI* – one of two financial inclusion indicators (Model 1: digital = made or received digital payment; Model 2: mobile_internet = use a mobile phone or Internet to make payment); *i* – the index for individuals. The explanatory variables belong to four groups of individual characteristics provided in the survey dataset: gender, age, education, and income. *Gender* is considered by introducing a dummy variable equal to one if the individual is a female. *Age* is defined as the number of respondents' years. *Education* is divided into two sub-groups according to the education level (primary or secondary; we omitted tertiary education as the model defined this variable as not relevant). *Income* is divided into four sub-groups according to the household income quintile (from first to fourth; we omitted the fifth income quintile as the model defined this variable as not relevant).

Within the first step to analyse the potential non-linear relationship between age and financial inclusion, we apply the Robin Hood algorithm.

Tab. 1: Descriptive statistics and definition of variables

Variable name	Label	Definition	Model	Observation	Mean	Std. dev.
Digital	Made or received digital payments	= 1 if FIN31A or FIN34A is 1 = 0 otherwise	Model 1	17,251	0.9159	0.2776
Mobile_internet	Use mobile or the Internet to make a payment	= 1 if FIN5 is 1 = 0 otherwise	Model 2	18,470	0.7197	0.4492
Gender	Gender of respondent	= 1 if female = 0 otherwise	Model 1	17,251	0.4869	0.4998
			Model 2	18,470	0.4835	0.4997
Age	Respondent age	age in a number of years	Model 1	17,251	49.7913	16.4746
			Model 2	18,470	49.6700	16.8436
Educ_primary	Respondent education level – primary	= 1 if a respondent has completed primary school or less = 0 otherwise	Model 1	17,251	0.0607	0.2388
			Model 2	18,470	0.0651	0.2468
Educ_secondary	Respondent education level – secondary	= 1 if a respondent has completed secondary school = 0 otherwise	Model 1	17,251	0.5450	0.4980
			Model 2	18,470	0.5502	0.4975
Educ_tertiary	Respondent education level – tertiary	= 1 if a respondent has completed tertiary education or more = 0 otherwise	Model 1	17,251	0.3944	0.4887
			Model 2	18,470	0.3847	0.4865
Income_q1	Within-economy household income quintile – first	= 1 if income is in the first income quintile = 0 otherwise	Model 1	17,251	0.1367	0.3435
			Model 2	18,470	0.1413	0.3483
Income_q2	Within-economy household income quintile – second	= 1 if income is in the second income quintile = 0 otherwise	Model 1	17,251	0.1665	0.3726
			Model 2	18,470	0.1664	0.3724
Income_q3	Within-economy household income quintile – third	= 1 if income is in the third income quintile = 0 otherwise	Model 1	17,251	0.1923	0.3941
			Model 2	18,470	0.1931	0.3947
Income_q4	Within-economy household income quintile – fourth	= 1 if income is in the fourth income quintile = 0 otherwise	Model 1	17,251	0.2327	0.4226
			Model 2	18,470	0.2308	0.4213
Income_q5	Within-economy household income quintile – fifth	= 1 if income is in the fifth income quintile = 0 otherwise	Model 1	17,251	0.2718	0.4449
			Model 2	18,470	0.2685	0.4432
Change	Change in payment method after the coronavirus pandemic	= 1 if the respondent used only cash to make payments before the coronavirus and now realises the payments also through the financial account or other payment methods = 0 otherwise	Model 1	17,251	0.0439	0.2048
			Model 2	18,470	0.0332	0.1791
Country EA	Euro Area membership	Number of years within the Euro Area	Model 1	17,251	18.5452	6.9187
			Model 2	18,470	18.6077	6.8809
DAI	Digital Access Index	The value of the Digital Access Index in 2021 in the country	Model 1	17,251	0.6814	0.0703
			Model 2	18,470	0.6820	0.0698

Source: own

We apply the methodology presented by Simonsohn (2018). He suggests testing the possibility of a U-shape by merely testing if the effect of *x* (age) on *y* (digital payments) changes sign for low versus high *x* values. Such a test involves computing two average slopes, which is done by estimating two regression lines, one for $x \le x_c$ and the other for $x \ge x_c$, where x_c is the breakpoint separating the two regions. One may increase statistical efficiency by simultaneously estimating both lines in a single regression, relying on what is often referred to as an interrupted regression. Specifically, interrupted regressions conform to the following general formulation:

$$y = a + bx_{low} + cx_{high} + d \times high + \mathrm{ZB}_{\mathbf{z}} \quad (2)$$

where: $x_{low} = x - x_c$ if $x < x_c$ and 0 otherwise; $x_{high} = x - x_c$ if $x \ge x_c$ and 0 otherwise; and high = 1 if $x \ge x_c$ and 0 otherwise; Z – the (optional) matrix with covariates; B_Z – its vector of coefficients.

After verifying the presence of a U-shape, we estimate the following equation:

$$FI_i = \alpha + \beta \cdot gender_i + \gamma_1 \cdot age_i + \gamma_1 \cdot (age_i)^2 + \\ + \delta \cdot education_i + \kappa \cdot income_i + \varepsilon_i \quad (3)$$

To analyse the impact of the coronavirus pandemic, we also estimate the following equation:

$$FI_i = \alpha + \beta_1 \cdot gender_i + \gamma_1 \cdot age_i + \\ + \gamma_1 \cdot (age_i)^2 + \delta \cdot education_i + \\ + \kappa \cdot income_i + \lambda \cdot change_i + \varepsilon_i \quad (4)$$

The *change* is measured as the change in the use of the payment after the coronavirus pandemic. The variable took the value 1 when the respondent used only cash to make payments before the coronavirus pandemic, and nowadays, the respondent realises the payments through the financial account or other payment methods. The variable took value 0 when the respondent used only cash to make payments before the coronavirus pandemic; now, the respondent does not use the financial account to realise payments.

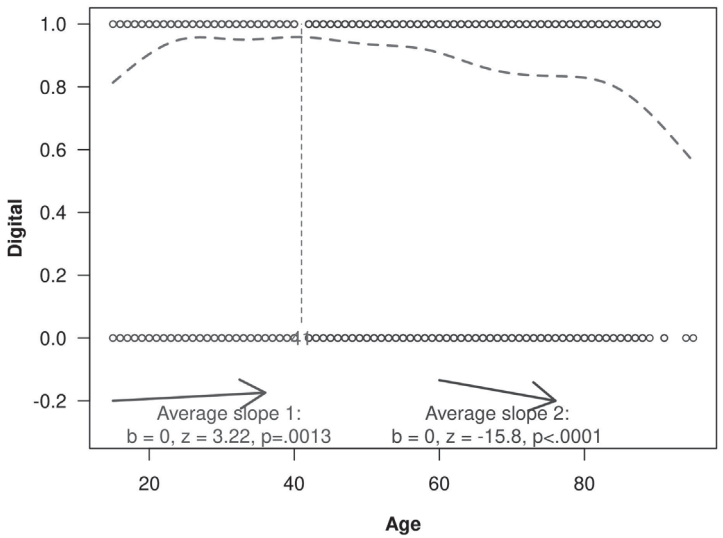
To verify the impact of digitalisation and the membership in Euro Area countries, we also estimate the following equation:

$$FI_i = \alpha + \beta_1 \cdot gender_i + \gamma_1 \cdot age_i + \\ + \gamma_1 \cdot (age_i)^2 + \delta \cdot education_i + \kappa \cdot income_i + \\ + \lambda \cdot change_i + \sigma \cdot countryEA_i + \\ + \varsigma \cdot countryDAI_i + \varepsilon_i \quad (5)$$

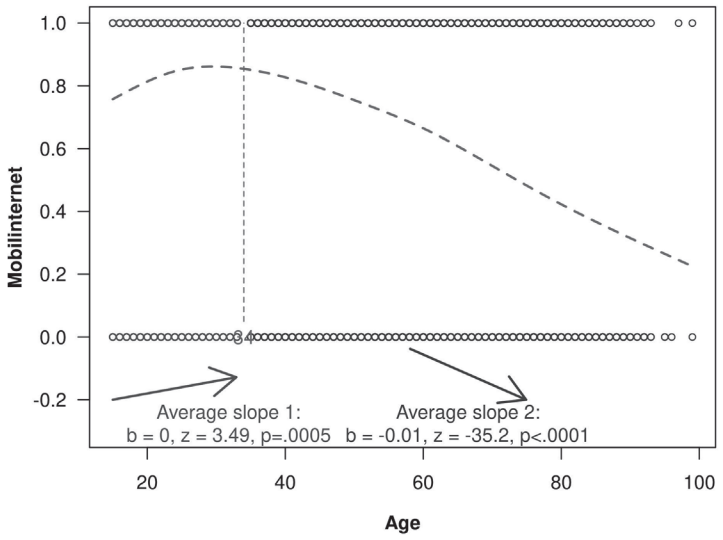
where: *countryEA* – the number of years of membership within the Euro Area; *DAI* – the level of digitalisation in the country measured by the Digital Access Index. These variables are on the country level.

3. Results and discussion

In the initial stage of our analysis, we employ the Robin Hood algorithm to investigate the potential presence of a U-shaped relationship between financial inclusion, as measured by digital payments, and the age of respondents. In this two-lines test, we focus solely on these two indicators. The test results are graphically presented in Fig. 5. As displayed, the analysis confirms the existence of an inverted U-shape between digital payments and age. It implies that digital payments tend to increase with age up to a specific breakpoint, after which the relationship shifts. In the case of the first indicator of digital payments (digital = made or received digital payment), the breakpoint is identified at 41. It signifies that up to 41, a positive association may exist between age and digital payments. However, beyond 41, we observe a negative correlation between these variables. Examining the age distribution, it is clear that over 65% of the data points fall on the side of the curve where, with increasing age, the usage of digital payments declines. Given the predominant distribution on this side, we can confidently assert the presence of a significant negative correlation, aligning with the theory of the generation effect. In the case of the second indicator of digital payments (mobileinternet = use a mobile phone or Internet to make payment), the breakpoint occurs at the age of 34. Once again, examining the age distribution reveals that over 78% of respondents are situated beyond this breakpoint, reconfirming the theory of the generation effect. The theory of the generation effect in the context of financial inclusion suggests that different generations may exhibit distinct financial behaviours and preferences, particularly concerning their adoption and use of digital financial services and technologies. The younger generation may be more comfortable and adept at using digital payment methods, mobile banking apps, and online financial services. This generation is often more digitally literate and open to using technology for financial transactions. In contrast, the older generation may face challenges in adapting to digital financial services due to lower digital literacy levels.



a) Made and received digital payments vs. age



b) Use a mobile phone or Internet to make a payment vs. age

Fig. 5: **Two-lines test**

Source: own

Based on the Robin Hood test results, we found it relevant to incorporate a quadratic term into the probit regression model. We applied the equations defined in the methodology section to analyse the impact of specified variables on digital payments in Euro Area countries. Initially, we estimated Equations (1–4) for Model 1 and subsequently for Model 2, as per the defined variables. In Model 1, the dependent variable indicates if the respondents in the past 12 months used an account at a bank or another type of formal financial institution to make a digital payment or receive payments directly into this type of account. This dependent variable was sourced from the Findex questionnaire and database, denoted by the question codes FIN31A and FIN34A. It takes value 1 when the respondent answered yes in both or one of the mentioned questions and 0 when the respondent answered no in both questions. The probit estimation results, employing digital payment as the dependent variable, are presented in Tab. 2.

We find that the use of digital payments is related to all independent variables in Equation (1) and Equation (2). It suggests that all individual characteristics are significantly associated with financial inclusion.

Women are more likely to use digital payments in all Equations (1–4), with their gender significantly increasing the probability of involvement in digital payment activities. It can be attributed to the key roles many women play within households, where they often initiate and manage financial transactions daily. Given that a substantial proportion of women own mobile phones and related devices, it enhances their accessibility to financial services. Digital payments allow women to make payments conveniently while balancing work and family responsibilities, particularly when they may not have the time to visit a physical bank branch. Consequently, digital payments can help women optimise their time management, freeing up time for more productive activities. Our analysis results align with the research by Zhongming et al. (2019), highlighting that financial technology serves as a tool for narrowing the gender gap in financial inclusion. While digital payments, whether through mobile phones, personal computers, the Internet, or cards, are not necessarily new, substantial technological investments have increased their adoption in recent years.

Notably, digital payments are a key instrument for reducing disparities between men and women, as the rate of adoption by women has increased more rapidly, particularly concerning payments initiated by women themselves.

The impact of age in Equation (1) is notably significant and carries a negative sign, signifying an inverse relationship between age and the use of digital payments. It suggests that younger generations primarily use digital payments, with a decreasing tendency among older individuals. In essence, older people use digital payments less frequently than the rest of the population. Our descriptive statistics further support this trend according to age. Specifically, we can find that the mean age of respondents who use digital payments is 47 years, whereas for those who do not, the mean age is notably higher at 57 years. Moreover, the mode value within the first group is lower (50 years) compared to the second group (65 years). As noted by Fungáčová and Weill (2015), this phenomenon can be attributed to what is commonly referred to as the "generation effect." Older individuals may exhibit unwillingness to adopt digital payment methods due to concerns about information technology usage, thereby favouring traditional payment methods like cash. It is in line with the findings of the European Central Bank (2022), which underscored differences in preferences for cash usage based on age. The study revealed that the highest proportion of individuals who preferred cash transactions belonged to the 55+ age group, indicating that older individuals were more inclined to be heavy cash users. According to Age UK (2021), many older people rely heavily on cash, with some completely dependent on it. Cutting off from cash and banking services is tantamount to social exclusion, so it is essential to maintain access to them for older demographics. Notably, those in the oldest age bracket (75+) have preferred using cash as their primary method for spending money and making payments across most of their financial needs. Cash offers them enhanced financial management capabilities and facilitates their daily budgeting. It is important to acknowledge that while age demonstrates a positive correlation with cash usage, it does not provide conclusive insights into whether this preference is only due to the natural inclination of the older population towards cash or if other factors, such as their average income or transaction sizes, play a role in driving these outcomes.

Tab. 2: Determinants of the usage of digital payments

	Equation (1)	Equation (2)	Equation (3)	Equation (4)
Intercept	2.4677***	1.7370***	1.7160***	−0.1359
	0.0620	0.1255	0.1269	0.2196
Gender	0.0507*	0.0525*	0.0585**	0.0202
	0.0288	0.0289	0.0291	0.0298
Age	−0.0137***	0.0173***	0.0171***	0.0187***
	0.0009	0.0048	0.0048	0.0049
Age2		−0.0003***	−0.0003***	−0.0003***
		0.0000	0.0000	0.0000
Educ_primary	−0.6465***	−0.6119***	−0.6180***	−0.6683***
	0.0528	0.0532	0.0538	0.0549
Educ_secondary	−0.2301***	−0.2231***	−0.2235***	−0.2672***
	0.0327	0.0328	0.0331	0.0339
Income_q1	−0.5380***	−0.5391***	−0.5475***	−0.5363***
	0.0465	0.0467	0.0471	0.0478
Income_q2	−0.3084***	−0.3108***	−0.3166***	−0.2861***
	0.0459	0.0461	0.0465	0.0473
Income_q3	−0.1484***	−0.1470***	−0.1554***	−0.1254***
	0.0460	0.0462	0.0466	0.0473
Income_q4	−0.1125**	−0.1110**	−0.1130**	−0.0915**
	0.0443	0.0445	0.0448	0.0454
Change			4.4600	4.9070
			33.3200	32.3000
Country EA				0.0184***
				0.0032
DAI				2.2990***
				0.3263
AIC	9,272.6000	9,231.6000	9,102.2000	8,754.2000
Pseudo *R2*	0.0709	0.0752	0.0884	0.1237
Loglikehood	−4,627.2800	−4,605.8000	−4,540.0800	−4,364.0900

Note: The dependent variable is made or received digital payments. We report the estimated marginal effects in the first line, and standard errors are in the second line. Asterisks denote significance at the ***99%, **95%, *90% levels.

Source: own

Hence, it is evident that national central banks are trying to enhance the financial literacy of older individuals, aiming to reduce barriers that prevent them from adopting digital payment methods. These initiatives aim to give seniors the knowledge and skills to work with digital payment platforms without fear. However, besides promoting financial literacy, it

is equally important to highlight the potential risks associated with using information technology in financial transactions. Such risks contain various cyber threats, including phishing, pharming, or other hacker attacks. In this regard, educating older individuals about the importance of protecting their personal and financial information when conducting online transactions is important. By raising awareness of these cybersecurity issues, individuals can become more vigilant and better equipped to protect themselves from potential digital threats, thus ensuring safer and more secure digital payments.

As indicated by dummy variables, the influence of education exhibits a negative correlation with the adoption of digital payments. Notably, primary and secondary education dummy variables display significant negative coefficients, with a larger impact observed for individuals with primary education. It suggests that respondents who have completed only primary education or possess lower educational qualifications tend to use digital payment methods less frequently than those with higher secondary education. We can see a negative coefficient in the case of secondary education, but the value of the coefficient is smaller than in the case of primary education. To provide a clearer perspective, in Equation (1) in Tab. 2, being primary educated decreases the probability of using digital payments by 64.65%, while secondary educated decreases the probability by 23%. Therefore, we can say that the use of digital payments increases with higher levels of education. This trend is consistently evident across all Equations (1–4) in the analysis.

The dummy variables representing different income quintiles exhibit statistical significance and negative coefficients, with larger coefficients corresponding to lower income quintiles. It indicates that respondents in lower income quintiles are less likely to use digital payment methods than those in higher income quintiles. As presented in Tab. 2, Equation (1), for the person who is in the first income quintile, the probability of using digital payments decreases by 53.8%, and if the person is in the second income quintile, it decreases the probability of using a digital payment by 30.84%. Furthermore, negative coefficients are also observed for the third and fourth income quintiles, but the value of the coefficient is smaller than in the case of the first and second income quintiles. For example, to be in the last income quintile decreases the probability of using digital payments by 11.25%. Therefore, we can say that the use of digital payments increases with income level.

This finding aligns with previous research conducted by Demirgüç-Kunt and Klapper (2013), Fungáčová and Weill (2015), and Zins and Weill (2016), who identified a positive correlation between income and financial inclusion. Additionally, the study by Nandru et al. (2021) showed that individuals with higher educational backgrounds and incomes may associate with specific brands. Furthermore, they exhibited a propensity for online shopping, making purchases without needing physical visits to shopping malls. These individuals also use mobile phones and the Internet to realise their daily payments and regular transactions online without needing in-person visits to bank branches. Moreover, a significant portion of this demographic used their financial accounts to receive wages and other payments from the government or other authorities, which enabled them to do most of their financial transactions cashless.

It is evident from the results that individuals with lower levels of education and those with lower incomes tend to use digital payments less frequently. Additionally, this trend is consistent across all Equations (1–4) in our analysis. Moreover, older individuals and men have a reduced slope for using digital payment methods.

In our analysis of Equation (2), we examine the potential non-linear relationship between age and the use of digital payments. This investigation aimed to uncover any U-shape or inverse U-shape between these two variables. Identifying such non-linear relationships could indicate that positive and negative relations between variables also exist. It allows us to identify an optimal breakpoint around which age can enhance or reduce the use of digital payments. As demonstrated in Equations (2–4), our findings show a non-linear relation between age and the use of digital payments. It means that the use of digital payments increases with age, but after a specific breakpoint, there is a change in the relationship. As the quadratic term is negative and statistically significant, we can suppose the inverse U-shape of the function aligns with Robin Hood's two-lines test.

In Equation (3), we looked at the variable describing the shift in digital payment usage following the outbreak of the COVID-19 pandemic.

As can be seen, a positive relationship between variables is observed, but this relationship could not be considered significant. This fact is evident from Equations (3–4). Therefore, we can suppose that the impact of the COVID-19 pandemic on financial inclusion was indirect. Due to the pandemic, people have started to change their thinking and behaviour. Before the pandemic, performing work in the workplace and physically shopping in stores could be standard behaviour. However, frequent lockdowns have shown that there are other possibilities. People have learned to work from home, use their banks' online services more frequently, and make purchases over the Internet. Thus, we see a change in people's thinking that has also led to a change in their buying behaviour. What was used only minimally before the pandemic has become a regular part of the lives of the majority of the population. Thus, we can say that the pandemic has indirectly changed people's attitudes towards the use of digital payments due to changes in their thinking.

In the final Equation (4), we examine the impact of membership in the Euro Area and the level of digitalisation within the economy, as measured by the Digital Access Index in selected countries. Remarkably, both estimated coefficients are significantly positive, indicating that respondents from the countries which belong to the Euro Area for longer periods tend to use digital payments at a higher level than others. Furthermore, in countries with higher levels of digitalisation, respondents display a greater propensity for digital payment usage compared to countries with lower values of DAI.

To validate our findings, we also conducted tests using Model 2. In this model, the dependent variable indicates if the respondents have used mobile phones or the Internet within the past 12 months to make payments, purchase things, or send or receive money via their bank or financial institution account. Tab. 1 presents the dependent variable derived from the questionnaire and the Findex database, carrying the question code FIN5. The dependent variable took a value of 1 when the respondent realised payment using a mobile phone or the Internet, while 0 denotes a situation where the payment was not realised through these means. The outcomes of the probit estimations are presented in Tab. 3, in which we use digital payment realised by mobile phone or Internet as the dependent variable.

Tab. 3: Determinants of the usage of mobile phone or Internet to make payments – Part 1

	Equation (1)	Equation (2)	Equation (3)	Equation (3) without	Equation (4)	Equation (4) without
Intercept	2.0898***	1.4800***	1.4570***	2.0483***	0.5836***	1.2865***
	0.0428	0.0894	0.0904	0.0431	0.1579	0.1304
Gender	0.0568***	0.0579***	0.0634***	0.0624***	0.0574***	0.0564***
	0.0207	0.0207	0.0209	0.0209	0.0210	0.0210
Age	−0.0218***	0.0047	0.0042	−0.0214***	0.0052	−0.0220***
	0.0006	0.0035	0.0035	0.0006	0.0035	0.0006
Age2		−0.0003***	−0.0003***		−0.0003***	
		0.0000	0.0000		0.0000	
Educ_primary	−0.8202***	−0.7812***	−0.7877***	−0.8244***	−0.7878***	−0.8273***
	0.0425	0.0428	0.0433	0.0430	0.0434	0.0431
Educ_secondary	−0.3758***	−0.3685***	−0.3708***	−0.3780***	−0.3810***	−0.3881***
	0.0227	0.0228	0.0230	0.0230	0.0231	0.0230
Income_q1	−0.3570***	−0.3556***	−0.3598***	−0.3613***	−0.3617***	−0.3622***
	0.0344	0.0344	0.0347	0.0347	0.0348	0.0348

Tab. 3: Determinants of the usage of mobile phone or Internet to make payments – Part 2

	Equation (1)	Equation (2)	Equation (3)	Equation (3) without	Equation (4)	Equation (4) without
Income_q2	−0.2270***	−0.2299***	−0.2370***	−0.2346***	−0.2387***	−0.2354***
	0.0327	0.0327	0.0330	0.0330	0.0331	0.0330
Income_q3	−0.1545***	−0.1547***	−0.1637***	−0.1639***	−0.1626***	−0.1624***
	0.0314	0.0315	0.0318	0.0317	0.0318	0.0318
Income_q4	−0.0673**	−0.0660**	−0.0725**	−0.0738**	−0.0703**	−0.0714**
	0.0301	0.0302	0.0305	0.0304	0.0305	0.0304
Change			5.0150	5.0071	5.1055	5.0894
			22.8900	22.8047	22.7990	22.7261
Country EA					−0.0036	−0.0026
					0.0024	0.0024
DAI					1.3833***	1.2393***
					0.2336	0.2328
AIC	19,748.0000	19,690.0000	19,344.0000	19,397.0000	19,294.0000	
Pseudo *R2*	0.0998	0.1025	0.1184	0.1159	0.1208	0.1180
Loglikehood	−9,864.8400	−9,835.0900	−9,660.9900	−9,688.3000	−9,634.2000	−9,664.8000

Note: The dependent variable is using a mobile phone or Internet to make payments. We report the estimated marginal effects in the first line, and standard errors are in the second line. Asterisks denote significance at the ***99%, **95% levels.

Source: own

As displayed in Tab. 3, Model 2 brings consistent outcomes with Model 1. The only notable difference arises in the case of the variable "age," where a significant non-linear relation was not confirmed. Since the non-linear relationship was insignificant, we tested Equations (3–4) without incorporating the quadratic age term. The results from all estimations consistently pointed to the inverse relationship between age and financial inclusion measured using digital payments through mobile phones or the Internet. It indicates that such digital payment methods are predominantly embraced by a younger generation, with utilisation diminishing among older age groups, aligning with the theory of the generation effect.

Our analysis observed that using financial services through digital payments, direct financial access, the Internet, or mobile devices is widespread in Euro Area countries. By analysing the causes of financial exclusion, the regulatory authorities can find factors contributing to lower digital payment adoption rates in specific countries. This understanding can guide efforts to remove barriers, ultimately promoting a higher uptake of financial services. Furthermore, it plays a key role in fostering economic development within the country. This issue is connected to the broader challenge of enhancing financial literacy. Regulatory bodies must not only seek to increase the adoption of digital services but also ensure that their use is conducive to the well-being of individual users. Achieving this balance is essential to prevent excessive household indebtedness, which could jeopardise the financial stability of the households.

Through our analyses, we have identified the key characteristics that negatively impact the usage of digital payments. The most significant factor is age, with older individuals using digital payment methods, including innovative tools, to a lesser extent. This phenomenon could be attributed to various factors, including psychological barriers, financial costs, or other personal preferences that lead them to abstain

from those financial services. Consequently, the European Central Bank must adapt to conditions surrounding digital payments. As part of its overall strategy to enhance financial literacy, the central bank must tailor its efforts to specific demographics to encourage the optimal use of these services. This approach ensures that individuals can enjoy the benefits of digital payments while safeguarding against potential issues from both the clients' and the banks' perspectives.

Using the Digital Access Index (DAI) enables us to assess the nation's degree of digitalisation. Based on this knowledge, regulatory bodies and policymakers can allocate increased resources to infrastructure development, technological advancement, and innovation within the country. This strategic allocation of resources can improve accessibility to a wide range of services, get people interested in using financial services and ultimately raise residents' overall standard of living in such countries.

Therefore, the outcomes of the performed analyses can serve as recommendations for policymakers, guiding their effort to foster the expansion of financial inclusion, reduce barriers to financial exclusion, and support the increase of financial literacy. Notably, this aligns with one of the ECB's priority focus areas.

Conclusions

The landscape of financial services has undergone rapid transformation in recent decades, driven by the digitalisation of services, modernisation and technological advancements, and evolving customer preferences in accessing financial services. Antonijević et al. (2021) state that the financial sector remains highly sensitive to ongoing changes. Consequently, there is a pressing need to adapt quickly and promptly to client's requirements. Bank clients need faster, more efficient, and more convenient ways of delivering services and transactions. As mobile phones, smartwatches, and other internet-connected devices have become indispensable in most people's daily lives, new digital services have supplemented traditional transactions.

In this paper, our primary focus is examining the degree of financial inclusion in Euro Area countries based on the Global Findex database. Fungáčová and Weill (2015) highlight that financial inclusion is crucial because it helps foster economic growth. Increasing access to financial services opens up new avenues for education and entrepreneurial efforts, contributing to overall economic development.

In our study, we have employed digital payment indicators to express financial inclusion in Euro Area countries for 2021. We conducted two distinct analyses to explore the impact of individual characteristics on the level of financial inclusion through digital payments. In the first analysis, we focused on the influence of various factors on the use of digital payments made and received through financial accounts. Our finding revealed that men, older residents, less educated people, and people from poorer countries are associated with lower use of digital payments. We also observed a positive association between the COVID-19 pandemic and increased usage of digital payments among residents in the Euro Area countries. However, this effect could be considered an indirect impact due to changes in consumers' thinking and buying behaviour during and after the pandemic. Additionally, individuals from countries with longer-standing Euro Area membership exhibited a higher propensity for utilising digital payments. Furthermore, countries with higher DAI scores, indicating a higher level of digitisation, have seen an increase in digital payments. In the second analysis, which included mobile phones and Internet-based digital payments, our results remained consistent, except for the age variable. This analysis confirmed that the younger population tends to use digital payments via mobile phones and the Internet, with usage rates declining with age. The results of our analysis are in line with the theory of the generation effect. In line with this theory, it is necessary to underline the importance of recognising that different generations have different financial behaviours and preferences, particularly regarding digital financial inclusion. Policymakers, financial institutions, and FinTech companies should consider these generational dynamics when designing strategies to promote financial inclusion and ensure that individuals of all ages have access to and can benefit from digital financial services.

The bank service providers must enhance the accessibility of their services. They must invest financial resources to increase their customers' ability to use digital payments, which can reduce costs on the side of banks and the side of banks' customers. Besides increasing the range of online services, it is also important to increase resistance

to cyber risks, which are connected to the use of information technologies.

Our findings hold important policy implications for Euro Area authorities. Specifically, there is a pressing need to increase financial literacy, particularly among the older demographic. In a rapidly digitising world, the rising demand for digital payment methods exposes this group to greater vulnerability due to their limited information technology experience. Consequently, responsible authorities should prioritise efforts to enhance financial and practical IT skills among the elderly. By doing so, this demographic can make informed decisions that mitigate the adverse effects of the risks they face daily.

Acknowledgments: *Supported by grant No. 1/0444/23, "Network Analysis and Modelling of Interrelationships on International Financial Markets" of the "MINEDU of Slovak Republic."*

References

Age U. K. (2021). *Short-changed: How the decline of cash is affecting older people*. Age UK.

Allen, F., Demirguc-Kunt, A., Klapper, L., & Martinez Peria, M. S. (2016). The foundations of financial inclusion: Understanding ownership and use of formal accounts. *Journal of Financial Intermediation*, *27*, 1–30. https://doi.org/10.1016/j.jfi.2015.12.003

Alter, A., & Yontcheva, B. (2015). Financial inclusion and development in the CEMAC. *IMF Working Papers*, *15*(235), 1. https://doi.org/10.5089/9781484317556.001

Antonijević, M., Ljumović, I., & Lukić, V. (2021). Are digital financial payments constrained by the country's income: Evidence from the Global Findex database. *Anali Ekonomskog Fakulteta u Subotici*, *57*(46), 115–129. https://doi.org/10.5937/AnEkSub2146115A

Aurazo, J., & Vega, M. (2021). Why people use digital payments: Evidence from micro data in Peru. *Latin American Journal of Central Banking*, *2*(4), 100044. https://doi.org/10.1016/j.latcb.2021.100044

Chinoda, T., & Mashamba, T. (2021). Financial inclusion, bank competition and economic growth in Africa. *Journal of Economic and Financial Sciences*, *14*(1). https://doi.org/10.4102/jef.v14i1.649

Claessens, S. (2006). *Access to financial services: A review of the issues and public policy objectives*. Policy Research Working Papers. World Bank. https://doi.org/10.1596/1813-9450-3589

Demirgüç-Kunt, A., & Klapper, L. (2013). Measuring financial inclusion: Explaining variation in use of financial services across and within countries. *Brookings Papers on Economic Activity*, *2013*(1), 279–321. https://doi.org/10.1353/eca.2013.0002

Demirgüç-Kunt, A., Leora, K., Dorothe, S., & Oudheusden, P. V. (2015). *The Global Findex Database 2014: Measuring financial inclusion around the world* (Policy Research Working Paper 7255). World Bank. https://openknowledge.worldbank.org/entities/publication/f661fecd-3fc7-5a45-886e-95d6b881e278

Demirgüç-Kunt, A., Leora, K., Dorothe, S., & Saniya, A. (2022). *The Global Findex Database 2021: Financial inclusion, digital payments, and resilience in the age of COVID-19*. World Bank. https://openknowledge.worldbank.org/handle/10986/37578

Demirgüç-Kunt, A., Leora, K., Dorothe, S., Saniya, A., & Jake, H. (2018). *Global Findex Database 2017: The Global Findex measuring financial inclusion and the Fintech revolution*. World Bank. https://openknowledge.worldbank.org/entities/publication/ed800062-e062-5a05-acdd-90429d8a5a07

Erlando, A., Riyanto, F. D., & Masakazu, S. (2020). Financial inclusion, economic growth, and poverty alleviation: Evidence from eastern Indonesia. *Heliyon*, *6*(10), e05235. https://doi.org/10.1016/j.heliyon.2020.e05235

European Central Bank. (2022). *Study on the payment attitudes of consumers in the Euro Area (SPACE) – 2022*. European Central Bank Publications Office. https://doi.org/10.2866/85233

Fungáčová, Z., & Weill, L. (2015). Understanding financial inclusion in China. *China Economic Review*, *34*, 196–206. https://doi.org/10.1016/j.chieco.2014.12.004

Kabakova, O., & Plaksenkov, E. (2018). Analysis of factors affecting financial inclusion: Ecosystem view. *Journal of Business Research*, *89*, 198–205. https://doi.org/10.1016/j.jbusres.2018.01.066

Lenka, S. K., & Barik, R. (2018). Has expansion of mobile phone and internet use spurred financial inclusion in the SAARC countries? *Financial Innovation*, *4*(1), 1–19. https://doi.org/10.1186/s40854-018-0089-x

Leyshon, A., & Thrift, N. (1995). Geographies of financial exclusion: Financial abandonment

in Britain and the United States. *Transactions of the Institute of British Geographers*, *20*(3), 312. https://doi.org/10.2307/622654

Lotto, J. (2018). Examination of the status of financial inclusion and its determinants in Tanzania. *Sustainability*, *10*(8), 2873. https://doi.org/10.3390/su10082873

Martins, C., Oliveira, T., & Popovič, A. (2014). Understanding the internet banking adoption: A unified theory of acceptance and use of technology and perceived risk application. *International Journal of Information Management*, *34*(1), 1–13. https://doi.org/10.1016/j.ijinfomgt.2013.06.002

Motta, V. E. da, & Farias, L. E. G. (2018). *Determinants of financial inclusion in Latin America*. EnANPAD 2018, 16.

Nagpal, A., Jain, M., & Jain, A. (2020). Determining the role of digital technology, governance and institutions in advancing financial inclusion in BRICS nations using probit regression analysis. *Journal of Social and Economic Development*, *22*(2), 443–459. https://doi.org/10.1007/s40847-020-00112-2

Nandru, P., Chendragiri, M., & Velayutham, A. (2021). *Determinants of digital financial inclusion in India: Evidence from the World Bank's global findex database*. Research Square Platform LLC. https://doi.org/10.21203/rs.3.rs-329541/v1

Nuzzo, G., & Piermattei, S. (2020). Discussing measures of financial inclusion for the main Euro Area countries. *Social Indicators Research*, *148*(3), 765–786. https://doi.org/10.1007/s11205-019-02223-8

Ozili, P. K. (2021). Financial inclusion research around the world: A review. *Forum for Social Economics*, *50*(4), 457–479. https://doi.org/10.1080/07360932.2020.1715238

Simonsohn, U. (2018). Two lines: A valid alternative to the invalid testing of U-shaped relationships with quadratic regressions. *Advances in Methods and Practices in Psychological Science*, *1*(4), 538–555. https://doi.org/10.1177/2515245918805755

Sinclair, S. (2001). *Financial exclusion: An Introductory Survey*. CRSIS, Edinburgh College of Art, Heriot Watt University.

Sinclair, S. (2013). Financial inclusion and social financialisation: Britain in a European context. *International Journal of Sociology and Social Policy*, *33*(11/12), 658–676. https://doi.org/10.1108/ijssp-09-2012-0080

Susilowati, E., & Leonnard, L. (2019). Factors influence financial inclusion: Evidence from Indonesian micro data. *ETIKONOMI*, *18*(1), 121–132. https://doi.org/10.15408/etk.v18i1.9070

Tsatsou, P. (2020). Digital inclusion of people with disabilities: A qualitative study of intra-disability diversity in the digital realm. *Behaviour and Information Technology*, *39*(9), 995–1010. https://doi.org/10.1080/0144929x.2019.1636136

World Bank. (2022a). *Financial inclusion*. World Bank. https://www.worldbank.org/en/topic/financialinclusion/overview

World Bank. (2022b). *The Global Findex Database 2021*. World Bank. https://www.worldbank.org/en/publication/globalfindex/interactive-executive-summary-visualization

Zhongming, Z., Linong, L., Xiaona, Y., Wangqiang, Z., & Wei, L. (2019). *Closing the gender gap in financial inclusion through Fintech* (Policy Brief No. 2019-3 April). Asian Development Bank Institute.

Zins, A., & Weill, L. (2016). The determinants of financial inclusion in Africa. *Review of Development Finance*, *6*(1), 46–57. https://doi.org/10.1016/j.rdf.2016.05.001

Investigating the determinants and effects of prestige sensitivity in fashion retailing

Ivan-Damir Anic[1], Ivana Kursan Milakovic[2], Mirela Mihic[3]

[1] *The Institute of Economics, Zagreb, Department for Innovation, Business Economics and Economic Sectors, Croatia, ORCID: 0000-0003-0179-6410, danic@eizg.hr;*
[2] *University of Split, Faculty of Economics, Business and Tourism, Marketing Department, Croatia, ORCID: 0000-0003-3843-8908, ikursan@efst.hr;*
[3] *University of Split, Faculty of Economics, Business and Tourism, Marketing Department, Croatia, ORCID: 0000-0002-5768-2431, mmih@efst.hr.*

Abstract: *Targeting the prestige fashion segment enables fashion retailers to continue growing while facing a challenging environment. To attract prestige-sensitive consumers, it is important to understand their buying motivations and responses to retail actions. Thus, this paper examines the motivational predictors and effects of prestige sensitivity in fashion retailing, using the symbolic self-completion theory as a framework. It also explores the moderating role of fashion innovativeness. The data collected from shoppers of apparel products (N = 289) in Croatia were analyzed using structural equation modelling (SEM). The results show that recognition enhancement, sexual attraction, and recreation shopping motivations, which help enhance individuals' self-identity in society, drive prestige sensitivity. At the same time, fashion innovativeness significantly moderates the relationship between recreation motive and prestige sensitivity. Prestige-seeking consumers positively respond to mannequin displays, spend more time shopping, and focus more on symbolic apparel attributes while shopping. This study contributes to the self-completion theory applied in fashion retailing by developing and testing the model that links prestige sensitivity with shopping motivations, fashion innovativeness, the selection of apparel attributes, response to visual merchandising, and time expenditure. The findings provide recommendations for marketers on how to develop fashion products/prestige brands in line with the expectations of prestige-seeking shoppers, target this market segment more efficiently, and increase the effectiveness of marketing efforts.*

Keywords: *Fashion retailing, prestige sensitivity, symbolic self-completion theory, shopping motivations, shopping behavior.*

JEL Classification: *M31, M37.*

APA Style Citation: Anic, I.-D., Milakovic, I. K., & Mihic, M. (2024). Investigating the determinants and effects of prestige sensitivity in fashion retailing. *E&M Economics and Management*, *27*(2), 183–200. https://doi.org/10.15240/tul/001/2024-2-011

Introduction

Luxury apparel is a growing market segment, contributing to the manufacturing and retailing industries (Statista, 2024) since there are consumers who like to show their wealth by paying higher prices for luxury clothing brands (Maran et al., 2021). Luxury fashion brands known for their high quality, luxury, and upper-class status allow retailers to charge premium prices and increase profitability and loyalty, even in crisis, as these brands can create a sense of prestige, making consumers more inclined to continue purchasing them (Ajitha & Sivakumar, 2019; Deeter-Schmelz et al., 2000; Jain, 2020; Lai & Prendergast, 2019; Lichtenstein et al., 1993; Nyadzayo et al., 2020; Roy et al.,

2018). in light of recent economic uncertainty, luxury fashion brands are particularly resilient (Riili & Bezze, 2022). However, attracting and retaining prestige-sensitive consumers is challenging because of their distinct preferences and high expectations (Mayasari & Wiadi, 2021). Intense competition, economic fluctuations, and the growth of online sales of luxurious brands that accelerated during the COVID-19 crisis (Beauloye, 2023) challenge sale revenues and loyalty to physical fashion stores. However, physical stores still play an important role in the luxury brand market, offering a unique advantage that is missing online, including human-led personal service, in-person experience, and interaction with the retail store and product (Beauloye, 2022).

Prestige sensitivity, i.e., a consumer tendency to buy high-priced apparel brands, has been considered a major concept for understanding prestige buying behavior (Lichtenstein et al., 1993). Previous research has acknowledged that personality traits (Casidy, 2012a,b; Mulyanegara, 2011), fashion consciousness (Casidy, 2012a,b; Casidy et al., 2015). social belonging (Sung, 2019), but also some motivational factors, including the need for uniqueness, the desire to have unique goods, attain a symbolic marker of group membership, hedonic motivations, and the need for perfectionism and materialism (Lai & Prendergast, 2019; Vigneron & Johnson, 1999) drive prestige sensitivity. Furthermore, existing literature indicates that prestige-sensitive consumers have distinct shopping behaviors, emphasizing the need to acquire symbols and a prestigious self-image (Montgomery et al., 2016). Most existing studies have focused on Western cultures, while values, attitudes, and acceptance of prestige fashion products differ in non-Western cultures (Ajitha & Sivakumar, 2019; Jain, 2020; Li et al., 2012; Roy et al., 2018; Shukla, 2012). In this context, what motivates shoppers to buy prestige products and how this personality trait drives retail outcomes in different settings are less clear.

To address a gap in the literature, we apply the framework proposed by Chen-Yu and Seock (2002) and Shchudro (2011) to examine which shopping motivations related to making purchasing decisions in the store predict prestige sensitivity, considering fashion innovativeness as a moderator. We also investigate how prestige sensitivity is related to several under-researched retail outcomes, i.e., consumer response to in-store stimuli, selection of apparel attributes, and shopping time expenditure inside the fashion store. This research is based on symbolic self-completion theory, which postulates that individuals are committed to using material possessions (i.e., prestigious brands) as socially recognized symbols strongly related to what they perceive as the ideal self to protect their self-identity and communicating it to others to be accepted in the society (Braun & Wicklund 1989; Deeter-Schmelz et al., 2000; Wicklund & Gollwitzer, 1981, 1982). The data were collected from adult shoppers of fashion products in Croatia in retail stores that sell prestigious fashion brands.

Our paper contributes to the literature on prestige sensitivity within symbolic self-completion theory in three ways. First, we provide additional insights into shopping motivations that drive prestige sensitivity. Although several motives were proposed to affect prestige sensitivity, ranging from different psychological factors, needs, and desires, such as hedonism and self-expression (Mayasari & Wiadi, 2021), there is limited understanding of fashion consumption (Lee & Huang, 2020) and impact of shopping motivations. We apply the framework of shopping motivations proposed by Chen-Yu and Seock (2002) and Shchudro (2011), which include motivations that drive consumers to engage in shopping activities and make purchasing decisions, such as sexual attraction, recreation, conformity, recognition, enhancement, fashion expression, fashion and aesthetic expression, and out-of-need, which has not been researched yet. Second, our study provides new knowledge about the effects of prestige sensitivity on consumer purchasing behavior inside the store, which includes apparel selection criteria, consumers' response to visual merchandising stimuli, and time spent shopping, which have not been researched. Consumers have different expectations regarding fashion products and make purchases based on features such as price, quality, and brand (Hopfer & Istook, 2016). However, it is less clear which apparel attributes prestige-seeking consumers consider necessary in their decision-making process. We also seek to determine how prestige sensitivity is related to visual merchandising stimuli, as compared to the previous research that has

examined the effects of visual merchandising as an independent variable on emotions, consumers' attitudes, and impulse buying behavior as dependent variables (Ha & Lennon, 2010; Jain et al., 2014). Since visual merchandising plays a pivotal role in consumer in-store responses (Anić et al., 2018), exploring its relationship with prestige sensitivity will bring novelty. Finally, we examine the impact of prestige sensitivity on time spent shopping, which is insufficiently researched in the literature (Hornik, 2021). The third contribution of our study lies in providing new knowledge about the moderating effect of fashion innovativeness in the relationships between shopping motivations and prestige sensitivity, which has not been researched yet. By incorporating fashion innovativeness in the model as a moderator, we account for a key predictor of innovation adoption, which is crucial for success (Goldsmith & Hofacker, 1991).

The findings help fashion retailers targeting Croatia develop apparel products in line with consumers' expectations and increase the effectiveness of brand appeals, in-store stimuli, and advertising while targeting the prestige market segment more efficiently.

1. Theoretical framework

Our paper is based on the symbolic self-completion theory, which postulates that individuals use material possessions as socially recognized symbols related to what they perceive as the ideal self to protect their self-identity and communicate it to others (Braun & Wicklund 1989; Wicklund & Gollwitzer, 1981, 1982). When questioned, individuals substantiate their definition of themselves and clarify and protect their identity. Key concepts in this theory are a commitment to goals, symbols of completeness, and social reality (Wicklund & Gollwitzer, 1981). Goal commitment refers to personal identities or self-definitions; the symbols of completeness include material and non-material possessions used as means for identity attainment, while the social reality is created if symbols are recognized by others (Montgomery et al., 2016; Wicklund & Gollwitzer, 1981). Symbolic consumption is closely related to prestige buying behavior, as prestige-sensitive individuals are likely to buy luxury brands to signal their desired level of social standing to others (Montgomery et al., 2016).

Prestige sensitivity, a key concept in prestige fashion shopping behavior, is defined as "favorable perceptions of the price cue based on feelings of prominence and status that higher prices signal to other people about the purchaser" (Lichtenstein et al., 1993, p. 236). This concept refers to consumers' tendency to buy high-priced and expensive product brands because they bring them joy and good feelings and because they think others will notice them, as these products signal success and wealth to others and can improve social standing (Ajitha & Sivakumar, 2019; Lai & Prendergast, 2019; Li et al., 2012; Montgomery et al., 2016).

Fashion can express self-image, role, and position towards others (Miller et al., 1993), while clothing is generally used to communicate and express social information (McCracken & Roth, 1989). Thus, fashion retailing serves well for applying self-completion theory to examine prestige sensitivity (e.g., Cassidy, 2012a,b; Deeter-Schmelz et al., 2000; Montgomery et al., 2016). Luxury products enable consumers to satisfy their psychological and functional needs (Nyadzayo et al., 2020) and gain the attention of others as a form of social communication (Li et al., 2012). They can enhance self-esteem and improve one's standing in the social hierarchy (Deeter-Schmelz et al., 2000; Montgomery et al., 2016; Phau & Leng, 2008; Roy et al., 2018; Shukla, 2010). Prestige brands give consumers a sense of uniqueness (Ajitha & Sivakumar, 2019) and materialism (Montgomery et al., 2016) and help them fulfill hedonic needs (Epuran et al., 2015). In an international context, acquiring status is the major motive behind buying prestige brands, while differences exist in price quality, hedonism, and materialism (Mayasari & Wiadi, 2021; Shukla, 2012). According to some professional insights, self-expression is a vital badge of the new luxury paradigm (Beauloye, 2023). As motivations for acquiring prestige brands vary across countries, there is a need for further research in different environments.

Furthermore, past research indicates that prestige-sensitive consumers have distinct shopping patterns. Some papers suggest that they tend to buy fewer store brands (Bao & Mandrik, 2004) and seek to acquire symbols to emphasize a prestigious self-image (Montgomery et al., 2016). Luxury shoppers are brand-consistent and channel-agnostic and can assess and pick a shopping channel depending on convenience or innovations (Riili & Bezze, 2022). Despite some existing studies

examining prestige aspects, we still do not know how prestige shoppers respond to various elements of in-store stimuli and how this personal trait relates to store time expenditure.

2. Developing hypotheses

2.1 Clothing shopping motivations and prestige sensitivity

To examine which shopping motivations drive prestige sensitivity, we employ the framework proposed by Chen-Yu and Seock (2002) and Shchudro (2011), which includes several shopping motivations related to recognition, enhancement, aesthetic expression, sexual attraction, and recreation shopping motivations, arguing their relevance for the prestige-seeking behavior in a fashion retailing context. Although no study has examined the relationship between recognition enhancement and prestige sensitivity, some indirect findings suggest the potential association. Namely, recognition enhancement motivation refers to selecting a distinctive style of unusual clothes and buying well-known brands that can display an individual's personality (Shchudro, 2011). The self-completion theory postulates that individuals buy products with symbolic qualities that communicate prestigious identification to others to enhance their identity or self-image (Deeter-Schmelz et al., 2000). In addition, prestige sensitivity is associated with physical and achievement concerns (Netemeyer et al., 1995), while clothing is seen as one of the easiest ways of broadcasting one's self-image to others (Millan & Mittal, 2017). Moreover, a need to express individuality is related to a strong desire to display status through uniqueness. At the same time, possessing prestigious luxury brands can enrich consumers' sense of self (De Kerviler & Rodriguez, 2019) and empower expressions of individual identity (Beauloye, 2023). Hence,

H1: Recognition enhancement motivation is positively associated with prestige sensitivity.

A shopping motivation related to aesthetic expression refers to concerns with beauty, finding clothes that look the best, and showing that the individual is outstandingly well-dressed. Current literature has not explored the connection between aesthetic expression and prestige sensitivity. However, some indirect findings indicate the potential association. Since individuals with high prestige sensitivity are influenced by other people's opinions (Casidy & Wymer, 2018), we expect them to strive to achieve societal approval by buying clothes that will improve their appearance. In addition, public self-image drives high-prestige brand purchase behavior (Sung et al., 2019), indicating the motive to achieve a good-looking appearance. Hence,

H2: Aesthetic expression motivation is positively associated with prestige sensitivity.

Motivation related to sexual attraction refers to buying clothes that are attractive to other people. Previous studies indicate that individuals often use clothes to show sexual interest and intent (Lennon et al., 2017) and stimulate sexual consciousness and attraction. They might want to wear clothes that appeal to the other gender (Shchudro, 2011) and arouse other people's interest (Chen-Yu & Seock, 2002). Lai and Prendergast (2019) suggest that luxurious brands might signal a woman's beauty and perceived social standing. Furthermore, status consumption closely related to prestige shopping is the central motivating force of fashion innovativeness related to sexual attractiveness (Anić et al., 2018). However, the connection between sexual attraction motivation and prestige-seeking consumers is less clear. Still, it might be important because sexuality is central to building individuals' self-identity. Thus,

H3: Sexual attraction motivation is positively associated with prestige sensitivity.

Recreation motivation refers to seeking entertainment, fun, and joy in shopping (Shchudro, 2011). The hedonic motivation, closely related to recreation motivation, has often been researched in fashion retailing. It referred to personal gratification, entertainment, fun, pleasure, novelty, and rewards-seeking shopping (Hausman, 2000; Michon et al., 2015) and was shown to be associated with the purchases of expensive products, i.e., the consumption motivated by self-image, but also with careful and economically oriented shopping (Epuran et al., 2015), making the impact of recreation shopping motivation on prestige shopping even more complex. The literature further suggests that hedonic motivation stems from emotional arousal and symbols that convey the image associated with purchases of expensive products (Epuran et al., 2015). Finally, self-directed pleasure and personal fulfillment are seen as determinants of the value of new luxury consumption (Atkinson & Kang, 2022).

Thus,

H4: Recreation motivation is positively associated with prestige sensitivity.

2.2 Prestige sensitivity and the selection of apparel attributes

Consumers evaluate apparel products using several attributes when making purchasing decisions. Literature acknowledges different classifications of evaluation criteria. One classification relates to symbolic and functional apparel attributes (Abraham-Murali & Littrell, 1995). Symbolic attributes provide additional value to the product (Miller et al., 1993). In fashion retailing, they include the trendiness, image, country of origin, brand name, fashionability, sexual attractiveness, and uniqueness of clothing, and aim at fulfilling the needs for self-enhancement, role position, and ego (Hopfer & Istook, 2016; Lee & Nguyen, 2017). Some previous studies suggest that prestige-seeking consumers tend to purchase brands that emphasize symbolic attributes of the product to express their identity and increase their self-image (Mulyanegara, 2011; Phau & Leng, 2008). Thus, prestige-seeking consumers might highly value these attributes. On the other hand, functional attributes such as fit, quality, ease of care, comfort, and fiber content motivate consumers to search for products that solve externally generated consumption needs (Hopfer & Istook, 2016; Lee & Nguyen, 2017) might also be important for prestige-seeking consumers. Namely, fit and quality seem to be related to the purchase of foreign brands (Lee & Nguyen, 2017) preferred by prestige shoppers. Therefore, the following hypotheses are proposed:

H5: Prestige sensitivity is positively associated with functional apparel attributes.

H6: Prestige sensitivity is positively associated with symbolic apparel attributes.

2.3 Prestige sensitivity and consumers' response to visual merchandising

Visual merchandising, which includes interior displays, store layouts, mannequin displays, atmospherics, light, music, scents, colors, and signage, is used by fashion retailers to create an enjoyable shopping experience to attract and motivate consumers to shop. The theory suggests that consumers are more likely to make impulsive purchases when they are exposed to visual merchandising, which affects the individuals' perceptions and emotions and leads to approach behavior and purchase (Ha & Lennon, 2010; Jain et al., 2014). The more the customers enjoy the shopping experience, the more they will be engaged in browsing and the higher the number of impulsive purchases (Jain et al., 2014). Atkinson and Kang (2022) also indicate that intrinsic experiential value drives customers' intention to engage with a new luxury brand. However, it is not clear how prestige-seeking consumers respond to in-store stimuli. Considering that consumers high on prestige are hedonic-oriented and fashion-conscious and are more willing to engage in new experiences (Casidy, 2012a; Epuran et al., 2015), we assume they might be more likely to respond to visual merchandising stimuli. Hence,

H7: Prestige sensitivity is positively associated with consumer response to visual merchandising.

2.4 Prestige sensitivity and time spent shopping

Some evidence indicates that prestige sensitivity might be related to time expenditure in retail stores. Previous studies suggest that time expenditure is influenced positively by emotions (Lucia-Palacios et al., 2016; Stoel et al., 2004), recreation, self-gratification, reward-seeking motivations, and learning about new trends (Hornik, 2021; McDonald, 1994). While hedonic motivations positively affect time expenditure, utilitarian motives are negatively associated with time. There is also a notion that many shoppers today are under time pressure and tend to shop quickly and efficiently (Hornik, 2021), which makes the predictions more difficult. Since prestige-sensitive consumers are hedonic-oriented (Epuran et al., 2015) and are more excitable and emotional, we assume that prestige orientation might stimulate them to spend more time in the store shopping to find the brands that will emphasize a prestigious self-image. Hence,

H8: Prestige sensitivity is positively related to time spent shopping.

2.5 The moderating role of fashion innovativeness

Fashion innovativeness describes consumers' interest in new products and their tendency to learn about them and be the first to buy them (Goldsmith & Hofacker, 1991). Fashion innovators are more brand-sensitive, more interested in fashion brands (Beaudoin et al., 2003), less price-sensitive (Goldsmith et al.,

2005), and tend to compete for status (Lertwannawit & Mandhachitara, 2012; Rogers, 1995), and thus this trait might enhance the effect of shopping motivations on prestige sensitivity. Furthermore, the need for uniqueness is related to fashion innovativeness (Saricam & Erdumlu, 2016; Workman & Caldwell, 2007), which might enhance the impact of recognition enhancement and aesthetic expression motivations on prestige sensitivity. In addition, Anić et al. (2018) suggest that fashion innovativeness is associated with hedonic, recreation, and sexual attraction motivations. Hence,

H9: Fashion innovativeness positively moderates the effect of recognition enhancement motivation (H9a), aesthetic expression motivation (H9b), sexual attraction motivation (H9c), and recreation motivation (H9d) on prestige sensitivity.

The research model is presented in Fig. 1.

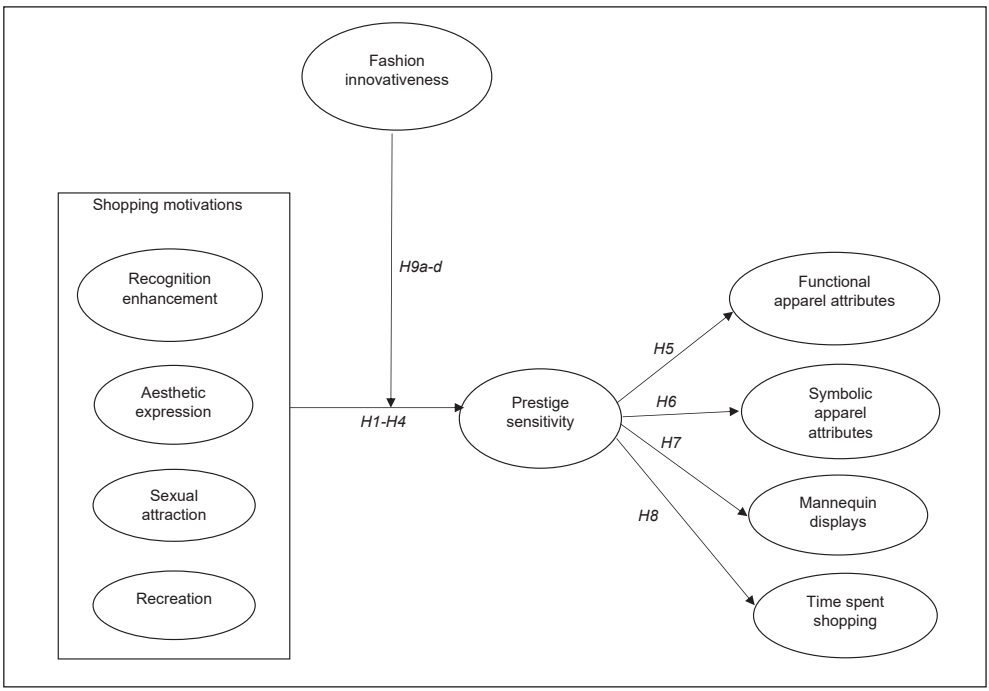


Fig. 1: Research model

Source: own

3. Research methodology

This study relies on a telephone survey (CATI). To determine the sample, we used a systematic random sampling technique by picking numbers of individuals from Croatia's telephone directory of residential and mobile phone numbers, with the target of collecting 300 surveys. The Institute of Economics, Zagreb, with four trained interviewers, collected the data from adult respondents. The interviewers were instructed about the survey and prestige sensitivity questions. They asked the respondents if they were older than 18, briefly described what prestige brands are, provided some examples of prestige fashion brands, and asked if they had been shopping for such prestige brands in the past 12 months. Only individuals who bought at least one prestige brand participated in the survey. The pre-test was carried out on 20 respondents. In total, 337 questionnaires were completed,

Tab. 1: Sample characteristics (*N* = 289)

	N	%
Gender		
Male	144	49.8
Female	145	50.2
Age (years)		
20–29	60	20.8
30–39	60	20.8
40–49	57	19.7
50–59	64	22.1
60–69	48	16.6
Education		
Primary school or less	11	3.8
Secondary school	152	52.6
College, university or more	126	43.6
Average monthly household income (HRK)		
Up to 3,000	13	4.5
3,001–4,000	22	7.6
4,001–6,000	46	15.9
6,001–8,000	52	18.0
8,001–10,000	57	19.7
10,001–13,000	55	19.0
13,0001–16,000	30	10.4
16,001–20,000	8	2.8
More than 20,000	6	2.1

Note: *HRK stands for Croatian Kuna; the exchange rate of EUR 1 to HRK is 7.48 (http://www.hnb.hr, 01.01.2021).

Source: own

out of which 48 were incomplete with missing data, and we excluded those questionnaires from further analysis, as Tabachnick and Fidell (2013) suggested. The final sample included 289 respondents and is representative and proportional to the total population in 21 Croatian counties concerning gender and age (Tab. 1).

The questionnaire was designed based on a literature review. We selected the relevant items that other scholars validated in past research. Some of the items were modified to fit the context better based on the suggestions by marketing scholars during the process of pre-testing for face and content validity. Items taken from the literature were translated from English into Croatian and then back to English.

We measured prestige sensitivity with five items taken from the sensitivity subscale of the price perception scale developed by Lichtenstein et al. (1993). This original scale measures the tendency to buy prestige products in general. We adopted the original scale to the fashion context to measure individuals' enjoyment and to feel good and attractive when buying expensive fashion brands. We asked respondents to rate their agreement

on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree).

Shopping motivations included 18 statements. Fifteen statements were taken from Chen-Yu and Seock (2002) and Shchudro (2011), while the authors developed three statements considering relevant consumer behavior theory, i.e., feeling desirable to the opposite sex, showing social standing, and looking the best when buying clothes. The items were rated on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree).

We measured fashion innovativeness with the domain-specific innovativeness scale developed by Goldsmith and Hofacker (1991). It includes nine items describing individuals' interest in new and original fashion items. The scale indicates consumers' desire to look at new fashion and learn about it and the tendency to be the first to buy new and original fashion products when they appear. We used a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree).

We asked respondents to indicate the importance of 16 apparel attributes that are relevant for purchasing fashion products, such as quality, price, fit, fashionability, natural fiber content, brand name, appearance, styling, image, and care/maintenance. The items were rated on a Likert scale from 1 (not at all important) to 5 (very important). Measures of consumers' tendency to respond to visual merchandising, based on Kim (2003), include window displays, mannequin displays, promotional signage, and floor merchandising. We added music and store personnel to the original items. The items were measured using a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree).

We examined the perceived time consumers spend browsing, evaluating merchandise, selecting items, and waiting at a counter to purchase. The respondents were asked how much time, on average, they spent in the store shopping for clothing products, coded as (1) less than one hour, (2) 1–3 hours, (3) 4–6 hours, and (4) more than six hours.

Before the main data analysis, we checked data for common method bias. To assess common method variance (CMV), we have performed several (ad-hoc and post-hoc) procedures. At the beginning of the survey, respondents were informed that there were no right or wrong questions and that participation was confidential. Then, during data analysis, particularly multi-collinearity check, VIF values achieved the recommended thresholds, i.e., VIF values below 3.3. Further, we have conducted Harman's single-factor test, and the results indicated that the total variance extracted by one factor was below the suggested threshold of 50%. Hence, all tests performed suggest that CMV does not disrupt our model assumptions, i.e., that our data is free from common method bias.

4. Research results

4.1 Descriptive statistics

The data were analyzed in SPSS (v23) and AMOS for descriptive insights and to perform confirmatory factor analysis (CFA) and

Tab. 2: Descriptive statistics

Variable	Mean	Standard deviation
Enhancement motivation	2.168	1.078
Aesthetic motivation	2.771	1.140
Sexual attraction motivation	3.107	1.192
Recreation motivation	3.600	1.299
Fashion innovativeness	2.328	0.975
Prestige sensitivity	1.857	1.055
Functional product attributes	4.611	0.554
Symbolic product attributes	2.631	1.095
Mannequin displays	2.226	1.118

Source: own

structural equation modeling (SEM). Descriptive statistics research results (Tab. 2) show that the respondents in the sample were below average prestige-sensitive (M = 1.85) and fashion innovative (M = 2.32), and they scored low on the response to mannequin displays (M = 2.22). Regarding the shopping motivations, the respondents did not score high on buying clothes to enhance their status (M = 2.16) or improve their aesthetic appeal (M = 2.77). However, they scored moderately high on buying clothes for recreation (M = 3.60) and slightly less on buying clothes to be sexually attractive (M = 3.10). Regarding product attributes, respondents valued functional attributes more (M = 4.61) than symbolic attributes (M = 2.63). Most respondents (59.9%) purchased up to five clothing items during 12 months. Unplanned purchases were about 2.7 items on average. Individuals (53.6%) spent between one to three hours in the store, 38.8% less than one hour, and 7.6% more than three hours.

4.2 Confirmatory factor analysis (CFA)

A confirmatory factor analysis was employed to assess the scales' reliability, validity, and unidimensionality. The measurement model was created based on the relevant principles (Kline, 2011) using the maximum-likelihood method for parameter estimation. The CFA shows that the measurement model has a good fit ($X2$/df = 359.329/231 = 1.556, TLI = 0.956, CFI = 0.966, IFI = 0.966, RMSEA = 0.044), which also confirms the unidimensionality of the measures. We excluded several items from the analysis due to low factor loadings, including two items from the prestige sensitivity scale, eight items from shopping motivation, six items from the fashion innovativeness scale, and eleven items from apparel attributes and visual merchandising. The final measurement model relied on high (>0.6) and significant factor loadings. CFA results (Tab. 3) indicate that the measurement scales show the characteristics of reliability and convergent validity.

Tab. 3: CFA results – Part 1

Factor/items	Factor loadings	Composite reliability (CR)	The average variance extracted (AVE)	Cronbach alpha
Recognition enhancement motivation (ENH)				
I buy clothes to express who I am	0.874	0.821	0.696	0.817
I buy clothes that show my social standing*	0.793			
Aesthetic expression motivation (AES)				
I spend much time finding the garment that looks best on me	0.772	0.717	0.559	0.716
Looking the best you can is worth the effort*	0.722			
Sexual attraction motivation (SAT)				
I want my clothes to appeal to the other gender sex	0.848	0.897	0.744	0.895
When buying attractive clothes, I feel more desirable to the opposite sex*	0.906			
Dressing to appeal to the other gender is important to me	0.831			
Recreation motivation (REC)				
I enjoy shopping for clothes	0.938	0.892	0.737	0.885
Shopping for clothes put me in a good mood	0.917			
Shopping for clothes is boring (*r*)	0.701			

Tab. 3: CFA results – Part 2

Factor/items	Factor loadings	Composite reliability (CR)	The average variance extracted (AVE)	Cronbach alpha
Fashion innovativeness (FI)				
I like to buy fashions that look fresh, new, and original	0.653	0.749	0.500	0.744
If I heard that a new fashion was available in a store, I would be interested enough to buy it	0.783			
I like to buy fashions put out by brand new designers	0.679			
Prestige sensitivity (PS)				
Buying a high-priced brand makes me feel good about myself	0.905	0.911	0.775	0.906
Buying the most expensive brand of a product makes me feel classy	0.929			
I enjoy the prestige of buying of a high-priced brand	0.801			
Functional apparel attributes (FAA)				
Quality	0.657	0.820	0.603	0.809
Comfort	0.815			
Fit	0.756			
Symbolic apparel attributes (SAA)				
Brands	0.796	0.767	0.622	0.766
Image	0.781			
Mannequin displays (MA)				
I get an idea of what I want to buy after looking through mannequin display	0.735	0.874	0.700	0.854
When I see clothing featuring a new style or design on a mannequin display, I tend to buy it	0.907			
When I see clothing that I like on a mannequin display, I tend to buy it	0.859			

Note: Sources for ENH, AES, SAT and REC were taken from Chen-Yu and Seock (2002) and Shchudro (2011), PS from Lichtenstein et al. (1993), FI from Goldsmith and Hofacker (1991), FAA and SAA from (Shchudro, 2011), MA from Kim (2003), while items marked by * were developed by the authors based on the relevant literature, i.e., theory.

Source: own

Moreover, the CFA shows that the measurement scales have achieved discriminant validity (Tab. 4).

4.3 Structural equation modelling and testing the hypotheses

Structural equation modelling was covariance-based (CB-SEM), whereas two models were assessed, constrained (without moderator – Model 1) and unconstrained (with moderator – Model 2) model, both showing good model fits (Tab. 5). The parameters were analyzed using the maximum-likelihood method. Model 1 encompassed main effects with moderating effects fixed to 0, while Model 2 included main and moderating effects freely

Tab. 4: Discriminant validity

Factor	ENH	AES	SAT	REC	FI	PS	FAA	SAA	MA
ENH	0.834								
AES	0.233**	0.747							
SAT	0.206**	0.254**	0.862						
REC	0.197**	0.422**	0.202**	0.858					
FI	0.344**	0.414**	0.276**	0.422**	0.707				
PS	0.327**	0.186**	0.268**	0.165**	0.478**	0.880			
FAA	0.091	0.210**	0.156**	0.226**	0.141*	0.162**	0.776		
SAA	0.250**	0.322**	0.286**	0.129*	0.434**	0.553**	0.184**	0.788	
MA	0.281**	0.233**	0.165**	0.332**	0.272**	0.236**	0.140*	0.147*	0.836

Note: *Correlation is significant at the 0.05 level; **correlation is significant at the 0.01 level; ENH – recognition enhancement; AES – aesthetic expression; SAT – sexual attraction; REC – recreation; FI – fashion innovativeness; PS – prestige sensitivity; FAA – functional apparel attributes; SAA – symbolic apparel attributes; MA – mannequin displays.

Source: own

Tab. 5: SEM results – Part 1

	Model 1 (constrained model)		Model 2 (unconstrained model)	
	Std. estimate	*p*-value	Std. estimate	*p*-value
Main effects				
H1: Recognition enhancement motivation → Prestige sensitivity	0.163	0.000	0.181	0.000
H2: Aesthetic expression motivation → Prestige sensitivity	−0.050	0.309	−0.054	0.261
H3: Sexual attraction motivation → Prestige sensitivity	0.138	0.000	0.130	0.002
H4: Recreation motivation → Prestige sensitivity	0.063	0.164	0.107	0.027
H5: Prestige sensitivity → Functional apparel attributes	0.183	0.007	0.182	0.007
H6: Prestige sensitivity → Symbolic apparel attributes	0.886	0.000	0.888	0.000
H7: Prestige sensitivity → Mannequin displays	0.279	0.000	0.277	0.000
H8: Prestige sensitivity → Time spent shopping	0.659	0.000	0.674	0.000

Tab. 5: SEM results – Part 2

	Model 1 (constrained model)		Model 2 (unconstrained model)	
	Std. estimate	***p*-value**	**Std. estimate**	***p*-value**
Moderating effects				
H9a: Fashion innovativeness × Recognition enhancement motivation → Prestige sensitivity			0.075	0.070
H9b: Fashion innovativeness × Aesthetic expression motivation → Prestige sensitivity			−0.059	0.178
H9c: Fashion innovativeness × Sexual attraction motivation → Prestige sensitivity			−0.079	0.054
H9d: Fashion innovativeness × Recreation motivation → Prestige sensitivity			0.107	0.022
Model properties				
χ2/D.F.	190.594/103		259.725/151	
ΔΧ2/ΔD.F.			69.131/48	
RMSEA	0.054		0.050	
TLI	0.944		0.933	
CFI	0.958		0.952	
IFI	0.959		0.953	

Source: own

estimated. We created moderating variables as interaction terms concerning the fashion innovativeness variable and shopping motivation predictors. Fashion innovativeness was tested as a relevant predictor of prestige sensitivity (β = 0.386, *p*-value 0.000). Given the significant model change, we used Model 2 for hypotheses testing (Tab. 5).

The results show that shopping motives related to recognition enhancement, sexual attraction and recreation shopping positively influence prestige sensitivity, supporting hypotheses *H1*, *H3* and *H4*. In contrast, the link with aesthetic motivation is not statistically significant, rejecting hypothesis *H2*. Furthermore, prestige sensitivity is positively related to the selection of symbolic apparel attributes but also functional attributes, and to mannequin displays, and time spent shopping (supporting hypotheses *H5*, *H6*, *H7*, *H8*). In addition, fashion innovativeness positively moderates the relationships between shopping recreation and prestige sensitivity (supporting hypothesis *H9d*). However, fashion innovativeness does not significantly moderate the relationship between recognition enhancement, aesthetic expression, sexual attraction motivations and prestige sensitivity, rejecting hypotheses *H9a*, *H9b* and *H9c* ($p > 0.05$).

5. Discussion

This study contributes to the literature by developing and testing the model that examines motivational predictors of prestige sensitivity and its effects on buying behavior inside fashion stores. The results show that three out of four shopping motivations are positively associated with prestige sensitivity, including recognition enhancement, sexual attraction, and recreation. This is in line with the symbolic self-completion theory indicating that individuals who are prestige sensitive are committed to acquiring expensive clothing brands as material possession and symbols strongly related

to what they perceive as the ideal self to protect their self-identity and communicate it to others to be recognized in the society (Casidy et al., 2012a; Deeter-Schmelz et al., 2000). We found that they are driven by the need to acquire the distinctive style of unusual clothes and well-known brands to display personality (recognition enhancement) and to arouse sexual interest in other people (sexual attraction), which is crucial for building individuals' self-identity. These consumers shop for prestigious apparel brands for entertainment, fun, and joy.

Contrary to expectations, aesthetic expression is not significantly associated with prestige sensitivity, which can be explained by the notion that a beautiful and well-dressed appearance is not exclusively linked to acquiring the symbols (brands), impressing others, and enhancing self-identity but can be internally oriented motivation. In addition, nice and modern clothing does not necessarily need to be followed by expensive brands. This is supported by findings indicating that Croatian consumers, especially women, like to dress and groom nicely (Đaić, 2013) and have a great aesthetic sense (RTL, 2018), but many of them shop on sales due to low income (Hendal, 2020).

A further contribution of our study is the examination of fashion innovativeness as a moderator in the relationship between shopping motivations and prestige sensitivity. The findings show that fashion innovativeness moderates significantly and positively the effects of recreation motivation on prestige sensitivity. We confirmed that innovative consumers are hedonic-oriented shoppers looking for entertainment and fun. However, fashion innovativeness does not significantly moderate the relationship between aesthetic expression, sexual attraction, recognition enhancement motivations, and prestige sensitivity. Contrary to expectations, our results show that fashion innovativeness does not moderate the relationship between aesthetic expression motivation and prestige sensitivity. It cannot enhance the impact of motivations that are not closely related to improving prominence and status on prestige sensitivity. We see the reason for this in the explanation that having a good appearance could be internally motivated and not significantly connected to prestige sensitivity. This can be even more expressed in the case of fashion innovators due to their greater need for individuality or uniqueness (Saricam & Erdumlu, 2016; Workman & Caldwell, 2007).

Our results did not support the moderating effect of fashion innovativeness on the sexual attraction-prestige sensitivity relationship. It seems that the motivation for seeking sexual attraction is driven by individual preferences, attractiveness, and relationship characteristics and need not be influenced by the degree to which an individual is attracted to innovative fashion brands. Although the centrality of possessions to consumer's life and materialism related to status is proposed to be correlated with fashion innovativeness (Gautam & Sharma, 2018; Goldsmith et al., 2013), the insignificant moderating impact of fashion innovativeness on the recognition enhancement and prestige sensitivity link can be explained by the fact that some individuals may be highly fashion-innovative and view luxury brands as a means of self-expression. In contrast, others may prioritize the status or prestige associated with these brands regardless of fashion innovativeness.

Our study also contributes to the theory by clarifying the effects of prestige sensitivity on buying behavior inside retail stores. The results show that prestige sensitivity positively relates to symbolic and functional apparel attributes, whereas the impact is more substantial for symbolic attributes. Prestige-seeking consumers attain their goal by acquiring famous, well-known clothing brands that convey the desired image and represent the symbol for enhancing their self-identity (i.e., symbolic apparel attributes), which is in line with self-completion theory and past research (Mulyanegara, 2011; Phau & Leng, 2008). We also found that for prestige-seeking consumers, some functional and intrinsic aspects of apparel, such as the quality of the product, comfort in clothing, and fit, are also important but less important than the symbolic ones. It might be concluded that prestige-seeking consumers look for a product that signals the prominence and status of others, but they also want some basic features. Hence, prestige-sensitive shoppers perceive symbolic and functional aspects of apparel as complementary attributes.

A further contribution of our paper is investigating how prestige-sensitive consumers respond to in-store stimuli and how much time they spend shopping. The findings indicate that these consumers positively respond only to mannequin displays, as factor analysis generated only this factor among several visual merchandising items. As prestige-sensitive

consumers are goal-oriented, it is reasonable to discover that they engage more intensively with mannequin displays that highlight the unique collections of the store and satisfy the need for uniqueness.

Lastly, prestige sensitivity is positively associated with time spent shopping, suggesting that individuals with high prestige sensitivity will spend more time in the store. This can be explained by the fact that prestige-seeking consumers are hedonic, emotional, and fashion-conscious shoppers (Casidy, 2012a; Epuran et al., 2015). They are more likely to enjoy browsing, searching for desired brands, evaluating, and buying them.

Conclusions

Our study adds to the self-completion theory in fashion retailing by providing deeper and novel insights into underexplored shopping motivations and prestige-seeking behavior. The analysis showed that prestige-seeking individuals are highly motivated, goal-oriented, and driven by recognition enhancement, sexual attraction, and recreation motivations. These motivations lead consumers to acquire expensive fashion brands acting like status symbols that help them enhance their self-identity to be recognized in society. While in the store, consumers strive to find famous and well-known brands that display the desired image (symbolic apparel attributes) while having good quality, comfort, and fit (functional apparel attributes). Prestige-seeking consumers are more likely to respond positively to mannequin displays and spend more time searching for desired products in the store. This study enhances self-completion theory with new constructs of shopping motivations (recognition, sexual attraction, and recreation) and varying effects of fashion innovation across the relationships between shopping motivations and prestige sensitivity. A similar approach was not found in the existing literature.

The results provide several managerial implications for the retailers that offer prestige fashion brands. Considering the motivations of prestige-seeking consumers, retailers should carry famous, well-known, prestigious brands of high quality that provide comfort in the correct sizes. In selling prestigious brands, innovations, and quick changes are extremely important. New extravagant, easily recognizable, sexually attractive clothes must be introduced and promoted regularly. Furthermore, retailers should design an in-store shopping environment that is more fun and entertaining. In this sense, visual merchandising, video, and social media can be used creatively to create a good mood for shopping. Retailers must know that mannequin displays have the strongest effect on prestige-seeking consumers. They can be used to promote new prestigious brands that elicit emotions and convey the desired image to consumers. Eye-catching mannequin displays should inform prestige-seeking consumers about new fashions and styles and stimulate them to browse the store and consider purchasing them. In addition, advertising should promote recognizable brands.

This study has several limitations. Although the applied sampling method helps prevent bias and ensures representativeness, it may result in difficulty accessing a preferred population. Namely, the study results indicate that most subjects (2/3 of individuals) are characterized by low to intermediate levels of prestige sensitivity. However, we believe we achieved the correct and adequate results concerning the utilized data collection method and given the explanation provided to the respondents by the interviewers.

Furthermore, the analysis did not consider actual total and impulsive consumer purchases. Future studies might expand the model with variables such as satisfaction, loyalty, purchase intentions, and actual and unplanned purchases. We also found that only mannequin displays were stable in the sample among visual merchandising stimuli, so future research might further test the applicability of this construct. Researchers might also examine the patterns of consumers' behavior concerning prestige brands across different brands and fashion products and various store types (e.g., department stores, discount stores, and specialty stores). Future studies might test this model across different cultures. Despite these limitations, our study is original and offers valuable insights into prestige-seeking consumers' motivations and shopping behavior.

Acknowledgments: *This work was made as part of the project "Determinants of Strengthening Technological Capabilities of Different Sectors" at the Institute of Economics, Zagreb and funded/co-funded within the National Recovery and Resilience Plan 2021–2026 – NextGenerationEU.*

References

Abraham-Murali, L., & Littrell, M. A. (1995). Consumers' conceptualisation of apparel attributes. *Clothing and Textiles Research Journal*, *13*(2), 65–74. https://doi.org/10.1177/0887302x9501300201

Ajitha, S., & Sivakumar, V. J. (2019). The moderating role of age and gender on the attitude towards new luxury fashion brands. *Journal of Fashion Marketing and Management: An International Journal*, *23*(4), 440–465. https://doi.org/10.1108/jfmm-05-2018-0074

Anić, I.-D., Mihić, M., & Kursan Milaković, I. (2018). Antecedents and outcomes of fashion innovativeness in retailing. *The Service Industries Journal*, *38*(9–10), 543–560. https://doi.org/10.1080/02642069.2017.1408799

Atkinson, S. D., & Kang, J. (2022). New luxury: Defining and evaluating emerging luxury trends through the lenses of consumption and personal values. *Journal of Product & Brand Management*, *31*(3), 377–393. https://doi.org/10.1108/jpbm-09-2020-3121

Bao, Y. & Mandrik. (2004). Discerning store brand users from value consciousness consumers: The role of prestige sensitivity and need for cognition. *Advances in Consumer Research*, *31*(1), 707–712.

Beaudoin, P., Lachance, M. J., & Robitaille, J. (2003). Fashion innovativeness, fashion diffusion and brand sensitivity among adolescents. *Journal of Fashion Marketing and Management: An International Journal*, *7*(1), 23–30. https://doi.org/10.1108/13612020310464340

Beauloye, F. E. (2022). *Why digital-native luxury brands are opening physical stores*. Luxe Digital. https://luxe.digital/business/digital-luxury-reports/digital-luxury-ecommerce-brands-open-physical-stores/

Beauloye, F. E. (2023). *The future of luxury: 7 trends to stay ahead in 2023*. Luxe Digital. https://luxe.digital/business/digital-luxury-trends/luxury-future-trends/

Braun, O. L., & Wicklund, R. A. (1989). Psychological antecedents of conspicuous consumption. *Journal of Economic Psychology*, *10*(2), 161–187. https://doi.org/10.1016/0167-4870(89)90018-4

Casidy, R. (2012a). An empirical investigation of the relationship between personality traits, prestige sensitivity, and fashion consciousness of Generation Y in Australia. *Australasian Marketing Journal*, *20*(4), 242–249. https://doi.org/10.1016/j.ausmj.2012.05.012

Casidy, R. (2012b). Discovering consumer personality clusters in prestige sensitivity and fashion consciousness context. *Journal of International Consumer Marketing*, *24*(4), 291–299. https://doi.org/10.1080/08961530.2012.728506

Casidy, R., Nuryana, A. N., & Hati, S. R. H. (2015). Linking fashion consciousness with Gen Y attitude towards prestige brands. *Asia Pacific Journal of Marketing and Logistics*, *27*(3), 406–420. https://doi.org/10.1108/apjml-09-2014-0136

Casidy, R., & Wymer, W. (2018). A taxonomy of prestige-seeking university students: Strategic insights for higher education. *Journal of Strategic Marketing*, *26*(2), 140–155. https://doi.org/10.1080/0965254x.2016.1182573

Chen-Yu, J. H., & Seock, Y. (2002). Adolescents' clothing purchase motivations, information sources, and store selection criteria: A comparison of male/female and impulse/no impulse shoppers. *Family and Consumer Sciences Research Journal*, *31*(1), 50–77. https://doi.org/10.1177/1077727x02031001003

Đaić, V. (2013). *Evo na što Hrvati najviše troše!* [Here's what Croatians spend the most on!]. DREVNIK.hr. https://dnevnik.hr/vijesti/hrvatska/evo-na-sto-hrvati-najvise-trose---277719.html

De Kerviler, G., & Rodriguez, C. M. (2019). Luxury brand experiences and relationship quality for Millennials: The role of self-expansion. *Journal of Business Research*, *102*(2), 250–262. https://doi.org/10.1016/j.jbusres.2019.01.046

Deeter-Schmelz, D. R., Moore, J. N., & Goebel, D. J. (2000). Prestige clothing shopping by consumers: A confirmatory assessment and refinement of the Precon scale with managerial implications. *Journal of Marketing Theory and Practice*, *8*(4), 43–58. https://doi.org/10.1080/10696679.2000.11501879

Epuran, G., Gârdan, I. P., Gârdan, D. A., & Bumbas, F. (2015). Hedonic value of clothing products. *Industria Textila*, *66*(3), 164–168.

Gautam, V., & Sharma, V. (2018). Materialism, fashion involvement, fashion innovativeness and use innovativeness: Exploring direct and indirect relationships. *Theoretical Economics Letters*, *8*(11), 2444–2459. https://doi.org/10.4236/tel.2018.811158

Goldsmith, R. E., Flynn, L. R., Goldsmith, E. B., & Kim, W.-M. (2013). Fashion innovativeness and materialism. *Journal of Global Fashion Marketing*, *4*(4), 266–283. https://doi.org/10.1080/20932685.2013.817142

Goldsmith, R. E., & Hofacker, C. F. (1991). Measuring consumer innovativeness. *Journal*

of the Academy of Marketing Science, *19*(3), 209–221. https://doi.org/10.1007/bf02726497

Goldsmith, R. E., Kim, D., Flynn, L. R., & Kim, W.-M. (2005). Price sensitivity and innovativeness for fashion among Korean consumers. *The Journal of Social Psychology*, *145*(5), 501–508. https://doi.org/10.3200/socp.145.5.501-508

Ha, Y., & Lennon, S. J. (2010). Online visual merchandising (VMD) cues and consumer pleasure and arousal: Purchasing versus browsing situation. *Psychology & Marketing*, *27*(2), 141–165. https://doi.org/10.1002/mar.20324

Hausman, A. (2000). A multi-method investigation of consumer motivations in impulse buying behavior. *Journal of Consumer Marketing*, *17*(5), 403–419. https://doi.org/10.1108/07363760010341045

Hendal. (2020). *As many as 63% of respondents buy the same brands as before coronavirus*. https://progressive.com.hr/wp-content/uploads/2020/11/Top-brendovi-23.jpg

Hopfer, E. N., & Istook, C. (2016). The importance of apparel attributes among young Mexican-American female. *Journal of Textile and Apparel Technology and Management*, *10*(1), 1–15.

Hornik, J. (2021). The temporal dimension of shopping behavior. *Journal of Service Science and Management*, *14*(01), 58–71. https://doi.org/10.4236/jssm.2021.141005

Jain, S. (2020). Assessing the moderating effect of subjective norm on luxury purchase intention: A study of Gen Y consumers in India. *International Journal of Retail & Distribution Management*, *48*(5), 517–536. https://doi.org/10.1108/ijrdm-02-2019-0042

Jain, V., Takayanagi, M., & Malthouse, E. C. (2014). Effects of show windows on female consumers' shopping behaviour. *Journal of Consumer Marketing*, *31*(5), 380–390. https://doi.org/10.1108/jcm-04-2014-0946

Kim, J. (2003). *College students' apparel impulse buying behaviours in relation to visual merchandising* [Master's thesis]. University of Georgia.

Kline, R. B. (2011). *Principles and practice of structural equation modeling*. Guilford publications.

Lai, S. M., & Prendergast, G. (2019). How men interpret women's luxury brand signals. *Journal of Fashion Marketing and Management: An International Journal*, *23*(2), 209–223. https://doi.org/10.1108/jfmm-02-2018-0025

Lee, J., & Nguyen, M. J. (2017). Product attributes and preference for foreign brands among Vietnamese consumers. *Journal of Retailing and Consumer Services*, *35*(March), 76–83. https://doi.org/10.1016/j.jretconser.2016.12.001

Lee, S. H., & Huang, R. (2020). Exploring the motives for online fashion renting: Insights from social retailing to sustainability. *Sustainability*, *12*(18), 7610. https://doi.org/10.3390/su12187610

Lennon, S. J., Adomaitis, A. D., Koo, J., & Johnson, K. K. P. (2017). Dress and sex: A review of empirical research involving human participants and published in refereed journals. *Fashion and Textiles*, *4*(1), 14. https://doi.org/10.1186/s40691-017-0101-5

Lertwannawit, A., & Mandhachitara, R. (2012). Interpersonal effects on fashion consciousness and status consumption moderated by materialism in metropolitan men. *Journal of Business Research*, *65*(10), 1408–1416. https://doi.org/10.1016/j.jbusres.2011.10.006

Li, G., Li, G., & Kambele, Z. (2012). Luxury fashion brand consumers in China: Perceived value, fashion lifestyle, and willingness to pay. *Journal of Business Research*, *65*(10), 1516–1522. https://doi.org/10.1016/j.jbusres.2011.10.019

Lichtenstein, D. R., Ridgway, N. M., & Netemeyer, R. G. (1993). Price perceptions and consumer shopping behavior: A field study. *Journal of Marketing Research*, *30*(2), 234–245. https://doi.org/10.2307/3172830

Lucia-Palacios, L., Pérez-López, R., & Polo-Redondo, Y. (2016). Cognitive, affective and behavioural responses in mall experience: A qualitative approach. *International Journal of Retail & Distribution Management*, *44*(1), 4–21. https://doi.org/10.1108/ijrdm-05-2014-0061

Maran, T., Liegl, S., Moder, S., Kraus, S., & Furtner, M. (2021). Clothes make the leader! How leaders can use attire to impact followers' perceptions of charisma and approval. *Journal of Business Research*, *124*, 86–99. https://doi.org/10.1016/j.jbusres.2020.11.026

Mayasari, L., & Wiadi, I. (2021). Purchasing massive prestige brands: The exploration of consumers' value perceptions. *ASEAN Marketing Journal*, *9*(1), 1–17. https://doi.org/10.21002/amj.v9i1.4447

McCracken, G. D., & Roth, V. J. (1989). Does clothing have a code? Empirical findings and theoretical implications in the study of clothing as a means of communication. *International*

Journal of Research in Marketing, *6*(1), 13–33. https://doi.org/10.1016/0167-8116(89)90044-x

McDonald, W. J. (1994). Time use in shopping: The role of personal characteristics. *Journal of Retailing*, *70*(4), 345–365. https://doi.org/10.1016/0022-4359(94)90004-3

Michon, R., Chebat, J.-C., Yu, H., & Lemarié, L. (2015). Fashion orientation, shopping mall environment, and patronage intentions: A study of female fashion shoppers. *Journal of Fashion Marketing and Management*, *19*(1), 3–21. https://doi.org/10.1108/jfmm-09-2012-0055

Millan, E., & Mittal, B. (2017). Consumer preference for status symbolism of clothing: The case of the Czech Republic. *Psychology & Marketing*, *34*(3), 309–322. https://doi.org/10.1002/mar.20990

Miller, C. M., McIntyre, S. H., & Mantrala, M. K. (1993). Toward formalizing fashion theory. *Journal of Marketing Research*, *30*(2), 142–157. https://doi.org/10.2307/3172824

Montgomery, R. D., Schwarz, B. J., & Mitchell, M. A. (2016). Examining the cross-cultural dimensionality of prestige sensitivity: An empirical analysis of Chinese and American millennials. *Journal of East-West Business*, *22*(2), 118–143. https://doi.org/10.1080/10669868.2016.1155522

Mulyanegara, R. (2011). The effects of consumer personality on fashion consciousness and prestige sensitivity. *Asian Pacific Advances in Consumer Research*, *9*, 363–366.

Netemeyer, R. G., Burton, S., & Lichtenstein, D. R. (1995). Trait aspects of vanity: Measurement and relevance to consumer behaviour. *Journal of Consumer Research*, *21*(4), 612–626.

Nyadzayo, M. W., Johnson, L. W., & Rossi, M. (2020). Drivers and outcomes of brand engagement in self-concept for luxury fashion brands. *Journal of Fashion Marketing and Management: An International Journal*, *24*(4), 589–609. https://doi.org/10.1108/jfmm-05-2018-0070

Phau, I., & Leng, Y. S. (2008). Attitudes toward domestic and foreign luxury brand apparel: A comparison between status and non status seeking teenagers. *Journal of Fashion Marketing and Management: An International Journal*, *12*(1), 68–89. https://doi.org/10.1108/13612020810857952

Riili, V., & Bezze, L. (2022). *4 trends that will define the future of luxury and fashion*. Think with Google. https://www.thinkwithgoogle.com/intl/en-emea/consumer-insights/consumer-journey/trends-fashion-luxury/?utm_source=luxe.digital

Rogers, E. M. (1995). *Diffusion of innovation*. The Free Press.

Roy, S., Jain, V., & Matta, N. (2018). An integrated model of luxury fashion consumption: Perspective from a developing nation. *Journal of Fashion Marketing and Management: An International Journal*, *22*(1), 49–66. https://doi.org/10.1108/jfmm-04-2017-0037

RTL. (2018). *Hrvatice se jako vole uređivati i većina ih ima dobar smisao za estetiku* [Croatians are like oxen and most of them have a good sense of aesthetics]. RTL.

Saricam, C., & Erdumlu, N. (2016). Modeling and analysis of the motivations of fast fashion consumers in relation to innovativeness. *Autex Research Journal*, *16*(4), 205–213. https://doi.org/10.1515/aut-2015-0057

Shchudro, O. (2011). *Age differences in women's shopping for clothes behaviour* [Bachelor's thesis]. Gotland University, School of the Humanities and Social Science.

Shukla, P. (2010). Status consumption in cross-national context: Socio-psychological, brand and situational antecedents. *International Marketing Review*, *27*(1), 108–129. https://doi.org/10.1108/02651331011020429

Shukla, P. (2012). The influence of value perceptions on luxury purchase intentions in developed and emerging markets. *International Marketing Review*, *29*(6), 574–596. https://doi.org/10.1108/02651331211277955

Statista. (2024). *Luxury apparel – Worldwide*. https://www.statista.com/outlook/cmo/luxury-goods/luxury-fashion/luxury-apparel/worldwide#revenue

Stoel, L., Wickliffe, V., & Lee, K. H. (2004). Attribute beliefs and spending as antecedents to shopping value. *Journal of Business Research*, *57*(10), 1067–1073. https://doi.org/10.1016/s0148-2963(03)00016-x

Sung, E. C., Calantone, R., & Huddleston, P. (2019). Motivators of prestige brand purchase: Testing cultural (in)stability of measures over time across the United States, Poland, and South Korea. *Journal of International Consumer Marketing*, *32*(1), 15–32. https://doi.org/10.1080/08961530.2019.1642172

Tabachnick, B. G., & Fidell, L. S. (2013). *Using multivariate statistics* (6th ed.). Pearson Education.

Vigneron, F., & Johnson, L. W. (1999). A review and a conceptual framework of

prestige-seeking consumer behavior. *Academy of Marketing Science Review*, *2*(1), 1–15.

Wicklund, R. A., & Gollwitzer, P. M. (1981). Symbolic self-completion, attempted influence, and self-deprecation. *Basic and Applied Social Psychology*, *2*(2), 89–114. https://doi.org/10.1207/s15324834basp0202_2

Wicklund, R. A., & Gollwitzer, P. M. (1982). *Symbolic self-completion*. Erlbaum Hillsdale.

Workman, J. E., & Caldwell, L. F. (2007). Centrality of visual product aesthetics, tactile and uniqueness needs of fashion consumers. *International Journal of Consumer Studies*, *31*(6), 589–597. https://doi.org/10.1111/j.1470-6431.2007.00613.x

Exploring travel agencies customers' loyalty motives throught machine learning analysis

Andrzej Dudek[1], Daria E. Jaremen[2], Izabela Michalska-Dudek[3], Pavlina Pellesova[4]

[1] *Wroclaw University of Economics and Business, Faculty of Economics and Finance, Department of Econometrics and Computer Science, Poland, ORCID: 0000-0002-4943-8703, andrzej.dudek@ue.wroc.pl;*
[2] *Wroclaw University of Economics and Business, Faculty of Management and Business, Department of Marketing and Tourism Management, Poland, ORCID: 0000-0001-8726-7573, daria.jaremen@ue.wroc.pl;*
[3] *Wroclaw University of Economics and Business, Faculty of Management and Business, Department of Marketing and Tourism Management, Poland, ORCID: 0000-0003-2804-6513, izabela.michalska-dudek@ue.wroc.pl (corresponding author);*
[4] *Silesian University in Opava, School of Business Administration in Karvina, Department of Tourism and Leisure Activities, Czech Republic, ORCID: 0000-0002-2595-923X, pellesova@opf.slu.cz.*

Abstract: *This article focuses on identifying the directions of changes in the decision-making process of purchasing package travels and the motives determining this purchase, as well as the impact of these motives on the affective, behavioral and global loyalty of travel agency customers during the COVID-19 pandemic. To achieve the research goal, a literature review and field research were conducted. In the case of secondary sources, the content analysis method was used to examine them, while data from primary sources (N = 1,508) were collected using an indirect survey technique (CAWI). The data analysis was carried out using machine learning – the variable importance method and the random forest algorithm. The obtained results allowed us to conclude that during the period of threat of the COVID-19 virus pandemic, tourist packages had been purchased less frequently, and buyers either had limited their trips to domestic trips or had adapted their travel destinations to the changing pandemic situation. The most important motivators that determined the choice of a travel agency during the COVID-19 pandemic were an attractive offer, a wide selection of package travels, previous positive experiences and trust in the organiser. It was also confirmed that in the face of the pandemic threat, buyers of package travels had been loyal to travel agencies. The use of machine learning allowed for more in-depth analyses and identification of motives that had a key impact on the development of buyer loyalty during the pandemic. The factors identified in the study encouraging buyers of package travels to maintain long-term relationships with their suppliers are belief in the value of the travel agency's offer, trust in the travel agency, individual approach travel agency employees, efficient service in the travel agency, and a wide selection of package travels.*

Keywords: *Tourist package, travel agency, customer behavior, random forest, COVID-19 pandemic.*

JEL Classification: *D12, Z31, Z33.*

APA Style Citation: Dudek, A., Jaremen, D. E., Michalska-Dudek, I., & Pellesova, P. (2024). Exploring travel agencies customers' loyalty motives throught machine learning analysis. *E&M Economics and Management*, *27*(2), 201–220. https://doi.org/10.15240/tul/001/2024-2-012

Introduction

The sale of organised tourist trips offered by tour operators constitutes one third of global tourism revenues (Statista, 2021). These trips are called many names, e.g., tourist packages, package holidays, tourist services packages, and

package travels (according to Directive (EU) 2015/2302 of the European Parliament and of the Council of November 25, 2015, on package travel and linked travel arrangements, amending Regulation (EC) No. 2006/2004 and Directive 2011/83/EU of the European Parliament and of the Council and repealing Council Directive 90/314/EEC). Similarly to the entire tourism industry, travel agencies have also been affected by the COVID-19 pandemic in 2020–2022. As a result, in the first year of the pandemic (2020) compared to 2019, sales of package travels decreased by 64%. Tourists gave up traveling most often under the pressure of legal restrictions prohibiting movement and crossing state borders. The effect of reduced demand for international trips was obvious and easiest to observe and estimate. Many researchers, however, assumed that in addition to the forced cancellation of travel, the pandemic had had a much broader impact on the behavior of tourists, including buyers of package travels. All the more so because information published by the internet platform Wasza.turystyka.pl in 2021 from interviews with representatives of tour operators and travel agents, as well as private conversations of the authors of the article with practitioners, signaled that the impact of the pandemic had not been limited to the decline in the number of organised trips, but also had affected other aspects of traveling (distance, length of stay, the method of transport, accommodation conditions) and on the decision-making process itself to purchase package travel and the expectations expressed by customers towards the service in travel agencies (Waszaturystyka, 2020, 2021). For this reason, the authors concluded that a more thorough understanding of the behavior of buyers of package travels was interesting both for scientific reasons and may have had a utilitarian value for representatives of travel agencies.

The main aim of the article was to identify the directions of changes in the decision-making process of purchasing package travel and the motives determining this purchase, as well as the impact of these motives on the affective, behavioral and global loyalty of travel agency customers during the COVID-19 pandemic.

There are four research questions asked:

RQ1: Was the decision-making process for purchasing package travels during the COVID-19 threat different from before the pandemic?

RQ2: What motivators determined the choice of a package travel supplier (tour operator) during the COVID-19 pandemic?

RQ3: Were purchasers of package travels loyal to travel agencies during the COVID-19 pandemic threat?

RQ4: Did the identified reasons for choosing a package travel supplier influence the loyalty of travel agency customers?

The data needed to solve the research problem undertaken in the article was collected from both secondary and primary sources. In the off-the-desk research, the method of systematic content analysis of secondary sources was used. In the case of primary research, data was obtained using a selected indirect survey method, namely a computer-assisted web interview.

1. Theoretical background

1.1 Loyalty of package travel buyers

Customer loyalty is one of the most important long-term goals for all businesses, including tour operators. Tour operators' benefits from buyer loyalty are clear. Customers make repeat purchases of a particular tour operator's service packages and, at the same time, they adopt an attitude favorable to the provider and the brand it offers (in tourism, the brand name is usually identical to that of the tour operator). Loyal buyers very often step into the role of a brand guardian, an ambassador and even a defender, which has positive connotations, especially in times of crisis. Indeed, as Rundle-Thiele (2006) notes, loyalty is a buyer's commitment to persist in a relationship with a supplier for better or worse. An exceptionally loyal customer does not seriously consider alternative brands and, moreover, often ignores other suppliers (Devece et al., 2015). The brand to which the buyer is loyal has a leading position and appears first in his or her mind when making a purchase decision (Han et al., 2011), thus achieving loyalty at the cognitive level (Caruana, 2002). Some researchers, such as Reichheld and Schefter (2000), argue that, from the customer's perspective, brand loyalty is a more important factor in the choice of supplier than price, while Chaudhuri and Holbrook (2001) and Rowley (2005) add that loyalty reduces the price sensitivity of the buyer.

The term "loyal" can be understood in many ways (Morgan, 1999), and its definition has

evolved over time (Campo & Yagüe, 2008). In the marketing literature, customer loyalty is usually defined as either behaviours (Newman & Werbel, 1973) or attitudes towards a brand (Bendapudi & Berry, 1997) or a mixture of both dimensions (Day, 1969; Dick & Baśu, 1994; Goldberg, 1981; Gremler & Brown, 1996; Jacoby & Chestnut, 1978; Oliver, 1999). In the first sense, known as behavioural, loyalty to a tour operator refers to a buyer's behaviour of repeatedly buying package travel from the same brand (e.g., Gonçalves & Sampaio, 2012). Loyalty interpreted in this way is primarily expressed in the frequency and volume (value) of purchases, which translates into the supplier's market share (Richard & Zhang, 2012). However, it does not answer the question of the reasons and motives explaining this repeat purchase (Dick & Baśu, 1994). In contrast, the rationale for loyalty, at least the psychographic one, is contained in the affective approach. In this view, loyalty is the result of buyers' emotions associated with a tour operator's brand, buyers' subjective feelings and their attitude towards the brand, which is expressed in conscious attachment to the brand and a desire to continue a transactional relationship with a particular supplier (Chen & Tsai, 2008). Affective loyalty also includes buyers' preferences, trust in the supplier, commitment to the relationship (Devece et al., 2015) and recommendation of the brand to other potential buyers (Konecnik & Gartner, 2007). The literature sources emphasise that loyalty is a function of thought (mental) processes involving evaluation (valuation) and the buyer's decision based on internal considerations (Andreassen & Lindestad,1998). Taking into account the two dimensions of loyalty mentioned above, Oliver (1999) stresses that loyalty expresses the deep-rooted obligation of the buyer to repurchase or recommend the brand in the future despite the influence of environmental (situational) factors and the marketing efforts of suppliers. Many other researchers present a mixed approach to the concept of loyalty. Among them, Gremler and Brown (1996) claim that the loyalty of a service buyer is the degree to which the customer repeats purchasing behavior with the service provider has a positive attitude towards him and considers using only this supplier when the need for a given service arises (for a tourist package). These combined dimensions yield what is known as global (mixed) loyalty, which is the product of attitudes and actions (Dick & Basu, 1994; Oliver, 1999). In a structured way, global loyalty is defined by Andreassen and Lindestad (1998), who state that it is a non-random (subjective), behavioural response (i.e., purchase), expressed over time by a decision-making individual, to one or more alternative brands among a set of such brands. It should also be mentioned here that recently, in the case of tourist packages, buyer loyalty is increasingly being considered in the context of the Internet, because the activities of travel agencies are undergoing dynamic digitisation. Statista (2021) reports that 70% of sales of organised tourist trips are sold in e-commerce. The loyalty of online travel package buyers results from their favorable attitude towards online shopping and repeat purchases in the online channel (Anderson & Srinivasan, 2003).

In fact, understanding the above-mentioned loyalty perspectives is important for the conceptualisation of research and the construction of an instrument measuring customer loyalty, because each of these interpretations has different consequences for the assessment of motives and ways of measuring loyalty (Gonçalves & Sampaio, 2012; Mazurek-Kusiak, 2020). Behavioral loyalty is usually measured by the frequency of purchases. Although, according to Devece et al. (2015), in the case of purchases of tourist packages, this is not an ideal measure due to the fact that, in essence, the packages are purchased rather sporadically (once or twice a year), not often, which is the result of their high cost and strict dependency on the use from the package from the client's free time (holiday), which is usually limited. A better measure would, therefore, be repeat purchases. An analysis of the literature provides important insight that is a trend in the study of behavioral loyalty, focusing on the level of customer intention/readiness to repeat the purchase (Amaro & Duarte, 2015; Del Bosque et al., 2006). The study of affective loyalty involves measuring buyer attitudes, which may result in repeat purchases. This measurement is much more complex and includes, among others: measuring satisfaction, brand preference over other brands, and the customer's tendency to recommend the supplier to others. In this approach, the measure may be the probability that customers will express positive opinions about the travel agency, recommend it to others and encourage others

to purchase the services of this agency, and the probability that customers will consider a given tour operator as the supplier of first choice when they have a need to use a tourist package (Richard & Zhang, 2012).

In studies on tourists' loyalty, an important role also play the factors that encourage people to be loyal, i.e., the determinants of loyalty. In the case of these studies, loyalty factors of tourism package buyers. The analysis of the achievements of previous researchers on this issue, including 30 relevant articles, deliberately selected from the Scopus and Web of Science databases, published over the last

Tab. 1: Determinants of travel agency customer loyalty considered in previous studies

Determinants of loyalty	Researchers
Satisfaction	Del Bosque et al. (2006), Lee et al. (2011), Setó-Pamies (2012), Major and McLeay (2013), Prause et al. (2013), Lai (2014), Silva and Gonçalves (2016), Yang et al. (2017), Rizal et al. (2020), Cetin (2020), Atsiz et al. (2021), Mursid and Wu (2022), Santos et al. (2022)
Perceived value of services/ relational benefits	Conze et al. (2010), Senders et al. (2013), Lai (2014), Roger-Monzó et al. (2015), Silva and Gonçalves (2016), Ronsana et al. (2018), Dudek et al. (2019), Albayrak et al. (2020), Mursid and Wu (2022)
Perceived quality of service/relationships/ communication quality of website/system	Lee and Cunningham (2001), Campo and Yagüe (2008), Huang (2008), Thi Phuong Thao and Swierczek (2008), Lee et al. (2011), Setó-Pamies (2012), Major and McLeay (2013), Lai (2014), Moisescu and Gica (2014), Roger-Monzó et al. (2015), Devece et al. (2015), Silva and Gonçalves (2016), Abou-Shouk and Khalifa (2017), Dudek et al. (2019), Albayrak et al. (2020), Rizal et al. (2020), Cetin (2020), Elgarhy (2022)
Trust in the supplier	Huang (2008), Setó-Pamies (2012), Prause et al. (2013), Lai (2014), Devece et al. (2015), Silva and Gonçalves (2016), Ronsana et al. (2018), Albayrak et al. (2020), Rizal et al. (2020), Santos et al. (2022)
Prices/transaction costs	Lee and Cunningham (2001), Campo and Yagüe (2008), Thi Phuong Thao and Swierczek (2008), Senders et al. (2013), Elgarhy (2022)
Emotional involvement of customers/customer identification with the company	Richard and Zhang (2012), Prause et al. (2013), Lai (2014), Yang et al. (2017), Elgarhy (2022)
Provider's brand and its image	Richard and Zhang (2012), Dudek et al. (2019)
Corporate social responsibility (CSR)	Moisescu and Gica (2014), Akbari et al. (2020)
Experience and its dimensions	Cetin (2020)
Expectations	Del Bosque et al. (2006), Lee et al. (2011)
Motivations/goals for travelling	Lee et al. (2011), Mody et al. (2017)
Perception of brand	Mody et al. (2017)
Customer orientation	Yang et al. (2017)
Complaints	Lee et al. (2011)
Loyalty programmes	Elgarhy (2022)

Source: own

three decades, provides many valuable tips for studying the determinants of loyalty (Tab. 1). Firstly, the most frequently mentioned motivators for being a loyal customer are the perceived quality and perceived value of services, satisfaction, and secondly, trust in the supplier, price of services, emotional involvement, supplier's image, as well as corporate social responsibility and buyer's experience. Individual studies analysed many other loyalty factors, e.g., loyalty programs, complaint handling, travel motivations and consumer expectations.

It should be noted that a systematic increase in the number of studies conducted in the area of factors shaping loyalty focuses on the determinants of buyers' loyalty to travel agencies (agents and tour operators) operating in an e-commerce environment (Abou-Shouk & Khalifa, 2017; Albayrak et al., 2020; Huang, 2008; Rizal et al., 2020; Ronsana et al., 2018; Silva & Gonçalves, 2016). Their results clearly point to new factors specific to the online environment, such as buyers' involvement in social media, website design, quality of service in functional and hedonic terms, interactional and transactional benefits for the customer, as well as online interactions with other current and potential buyers.

The above literature review from two highly rated databases of scientific publications indicates that over the last 30 years, only 30 articles have appeared on the issues of the drivers of customer loyalty in travel agencies. This means that, on average, 1 article related thematically was published in one year and this is not an impressive number. It should be admitted that in the period under study, it is possible to indicate years in which the interest in the mentioned problem was greater (3–4 articles in 2017, 2020 and 2022), but it passed relatively quickly, and no clearly dominant directions of research on the loyalty of buyers of package travels emerged. In view of the development of new information and communication technologies and the emergence with them of the unlimited possibility for individual travellers to organise their own trips (bypassing the intermediaries), customer retention by package travel suppliers (travel agencies) is now becoming a more important task than it was before the Internet revolution. And the limited research so far, often selectively treating the problem of customer loyalty factors of travel agencies, confirms the need to conduct further research and a more comprehensive approach to identifying and organising these determinants.

Additionally, the analysis of the determinants of travel agency customer's loyalty in light of previous research has allowed the final conceptualisation of the research problem addressed in this study, as well as the operationalisation of the research and the construction of an appropriate measurement instrument that takes into account the scientific achievements of other researchers.

1.2 COVID-19 and the loyalty of buyers of package travels in the light of previous research

In order to confirm the research gap regarding the issue of shaping the loyalty of buyers of tourist service packages in a pandemic situation, a systematic review of the literature on the impact of COVID-19 on the behavior of travel agency customers was conducted. In the process of selecting articles accepted for the review, the databases of scientific publications most valued by the academic community were used first, i.e., Web of Science (WoS) and Scopus, and then the list of articles was supplemented with publications that were presented by the Google Scholar search engine on the 50 pages exposed first. The selection of literature was done according to a specific categorisation key and an assumed filter. The following selection criteria were used: period of publication (2020–2023), language of publication (English), access (full-text) and, type of publication (article in a scientific journal or chapter(s) in a scientific monograph) and nature of publication (research or review). The categorisation key narrowed the search to titles, abstracts and keywords of publications. Databases were browsed by entering the appropriate combination of the following keywords: "loyalty," "packaged tour(s)," "package travel(s)," "tourist package(s)," "holiday package(s)," "travel agency(s)," "tour operator(s)" and "COVID-19" (Tab. 2).

A search of the databases yielded results, including a few scientific publications (Scopus – 4, and Web of Science – 11) touching on the issue of package travel buyers' loyalty under the COVID-19 pandemic. A careful analysis of the content of these publications further revealed that only two of them directly addressed the impact of the pandemic on travel agency customer loyalty. The first article of relevance, by Wu and Riantama (2022), discusses

Tab. 2: Quantitative results of the literature review

Combination	Number of papers	
	Scopus	Web od Science
Loyalty AND packaged AND tour AND COVID-19	–	–
Loyalty AND tourist AND package AND COVID-19	–	–
Loyalty AND holiday AND package AND COVID-19	–	1
Loyalty AND package AND travel AND COVID-19	–	1
Loyalty AND tourist/travel AND agency AND COVID-19	3	9
Loyalty AND tour AND operator AND COVID-19	1	–

Source: own

the problem of the emergence of new predictors of satisfaction – considered one of the main factors motivating buyers to be loyal. The researchers found out that such a new and relevant motive for loyalty in an emergency situation was the travel agent's reaction to the occurrence of an unexpected event that could disrupt the performance of the object of the transaction. The vision of losing the money paid to a supplier for a prepaid package travel long before the service is provided or being unable to use the purchased package were the biggest fears of tourists during the pandemic. This fear often demotivated tourists from undertaking tourist trips during the pandemic. On the other hand, Zhu et al. (2022) considered the relationship between the reliability of travel agency websites and customer loyalty. The results of their study indicated that during the pandemic period, the content presented on a supplier's website did not have a significant impact on buyers' attitudes and purchase intentions. This is because the uncertainty of the environment and the dynamics of the situation during the COVID-19 period caused this content to quickly become outdated, and as a result, customers did not pay much attention to it.

A certain paucity of results left after reviewing the Scopus and Web of Science databases prompted the authors to expand their search to other sources of information. For the penetration, Google Scholar was chosen (as the most popular browser of scholarly resources today), although not without certain imperfections, but containing a very wide selection of studies. This additional review made it possible to supplement the two earlier records with two more. In their study, Lawu et al. (2022), similarly to Wu and Riantama (2022), included among the determinants of travel agency customer loyalty the response of agencies to possible disruptions in the delivery of the purchased travel service. The researchers found out that customer loyalty during COVID-19 was influenced by so-called procedural fairness, i.e., the ways (procedures) a supplier handles problems with the delivery of a service. Implementing appropriate service standards in a service cancellation situation, on the one hand, builds a sense of security and trust in the supplier, and on the other hand, increases customer satisfaction. In contrast, the results of a study by Jasrotia et al. (2023) indicated an increase in the importance of experience-based trust in building loyalty among online travel agency customers during the pandemic. Before the pandemic, trust was not as significant a predictor of loyalty intentions.

The pandemic situation – a completely new, previously unknown condition for conducting business in tourism is an attractive testing ground and an interesting field for testing known research problems, but in the context of a new environment. New conditions may bring new insights and change current thinking about loyalty variables, they may also confirm previous findings, and their results will not be surprising. Determining whether pandemic conditions have altered loyalty factors towards the choice of travel agents warrants further research. The authors of this study seek to fill this gap.

2. Research methodology

2.1 Description of the study and characteristics of the sample

In order to achieve the established research goals, buyer research was carried out on

the issue of traveling during the COVID-19 pandemic. In the conducted survey, the basic tool was a questionnaire containing 38 questions. The research was a partial study and was carried out using an online survey on a nationwide online panel of respondents using the CAWI method. The study used a non-probabilistic sample selection – the Internet sampling method. The survey was conducted from June 1 to August 31, 2022, and ultimately included a sample of 1,508 respondents (*N* = 1,508).

The surveyed Poles (*N* = 1,508) included representatives of both sexes, and the most numerous age groups were from 36 to 45, from 26 to 35, and from 46 to 60 years of age (31.0%, respectively 27.90% and 19.2% of respondents). The majority of respondents were married (58.2%) and respondents with higher education (50.7%). Respondents' households usually consisted of 2 to 4 people (79.8% of responses in total), and every second respondent had underage children in their household. Of the respondents, 83.3% were working people. The largest group of respondents (75.7%) were respondents living in cities. Nearly half of the respondents assessed their financial situation as good, and only less than 1.3% of them thought it was very bad.

The study was characterised by a representative distribution of characteristics for the general population of Poles. Comparison of characteristics of the distribution of metric features with those available in public statistics, characteristics of the population of adult Poles allows us to conclude that that the structure of the sample in terms of gender, age, education and size of place of residence corresponds to the structure of the population of adult Poles.

The data analysis was carried out using descriptive statistics indicators and machine learning – the variable importance method and the random forest algorithm using the DATEX package of the R program.

3. Results and discussion

3.1 Analysis of the impact of the COVID-19 pandemic on the behavior of tourist packages buyers

The research results clearly confirm that the situation related to the COVID-19 pandemic has influenced Poles' tourist trips. This was confirmed by as many as 69.1% of respondents. A detailed summary of the research results is presented in Tab. 3.

Among the changes made in the method of carrying out tourist trips, the respondents most often indicated: limiting the number of tourist trips (39.6% of responses), carrying out only domestic tourist trips (27.9% of responses) and changing the destination of tourist trips (22.1% of responses). The remaining answers are presented in Tab. 4.

The above results allow to answer the first research question and provide confirmation that in the face of the threat of the COVID-19 pandemic, the behavior of purchasers of package travels has changed significantly. Travel packages at that time were purchased less frequently and buyers limited their trips to domestic trips.

The analysis of the answers provided by the respondents allowed us to answer the second research question and identify the most important themes that had guided the purchasers of package travels when choosing their organiser (Tab. 5).

Tab. 3: The impact of the COVID-19 virus pandemic on respondents' tourist trips (*N* = 1,508)

Has the COVID-19 pandemic affected your tourist travel?	Total	
	n	(%)
Definitely yes	480	31.8
Yes	562	37.3
Neither yes nor no	256	17.0
No	131	8.7
Definitely no	79	5.2

Source: own

Tab. 4: Changes in tourist travel caused by the COVID-19 pandemic (*N* = 1,508)

What changes have you made to your tourist trips due to the COVID-19 pandemic?	Total	
	n	(%)
None	55	3.6
Complete resignation from tourist trips	248	16.4
Limited to domestic travel only	421	27.9
Change of travel destination	334	22.1
Travel only by private car	254	16.8
Giving up hotels in favor of more private places to stay (e.g., separate apartments, agritourism lodgings)	199	13.2
Limiting the number of tourist trips	597	39.6
Shortening the length of tourist trips	202	13.4
Complete resignation from purchasing tourist packages organised by a travel agency	241	16.0
Different behavior	24	1.6

Note: The answers do not add up to 100% because the respondents had the possibility of making multiple choices.

Source: own

Tab. 5 Motives of loyalty to the travel agencies – Part 1

Buyers' motives of choosing a travel agency (BM; on a scale of 1–7)	Average rating importance of the motive
BM_1 – interesting/attractive tourist packages	5.68
BM_2 – a wide selection of tourist packages	5.66
BM_3 – satisfaction with previously purchased offers	5.77
BM_4 – trust	5.72
BM_5 – reputation and prestige	5.30
BM_6 – convenient location	5.29
BM_7 – belief in the value of the offer	5.53
BM_8 – favorable price–quality ratio	5.80
BM_9 – sense of security	5.75
BM_10 – special treatment of me by employees	5.14
BM_11 – service by a specially designated employee	5.15
BM_12 – attachment	5.05
BM_13 – offered loyalty program (e.g., loyalty card/club)	5.01
BM_14 – efficient/advisory service	5.62
BM_15 – individual approach of office staff	5.46
BM_16 – favorable payment terms	5.69
BM_17 – competitions and lotteries	4.48

Tab. 5 **Motives of loyalty to the travel agencies – Part 2**

Buyers' motives of choosing a travel agency (BM; on a scale of 1–7)	Average rating importance of the motive
BM_18 – prices, gifts, gadgets	4.54
BM_19 – discounts. discounts and other financial incentives	5.45
BM_20 – advertisement	4.60
BM_21 – no other travel agencies	4.12
BM_22 – convenience of purchase	5.75
BM_23 – no time	4.38
BM_24 – reluctance to change	4.41

Source: own

Among the key motives influencing the choice of a travel organiser, respondents indicated: interesting/attractive tourist packages, wide selection of tourist packages, trust, sense of security, favorable price-quality ratio, favorable payment terms, convenience, efficient advisory service and satisfaction with previously purchased offers.

It can therefore be stated that customers are looking for interesting destinations that suit their travel preferences, as well as the possibility of a wide selection and variety of organised travel options that they can tailor to their individual needs. Previous purchasing experience also plays an important role. Customers who are satisfied with previous trips are more likely to choose the same travel agency in the future, and positive experiences from previous trips can build customer loyalty and encourage them to return to the same travel agency. The credibility and reputation of the travel agency also have a significant impact on the purchasing decisions of buyers of tourist packages. Customers expect that a travel agency will provide them with a safe journey, both during the trip and during their stay there. Customers optimise their choices because they look for offers that propose a good value for the price they pay. Flexible payment options can also be an important factor for customers, especially when purchasing a holiday, which is a significant expense in the household budget. The convenience of purchasing a package travel, as well as a simple and intuitive process of booking and purchasing tourist trips, is also a factor that attracts customers. Moreover, effective and helpful customer service can be another important factor in convincing customers to choose a given travel agency.

Understanding these factors and adapting the travel agency's offer to customer needs can contribute to increasing their satisfaction and building loyalty.

3.2 Machine learning analysis

In the next part of the research (in search of the answer to *RQ4*), machine learning was used, the main goal of which is the practical application of artificial intelligence to create an automatic system capable of improving itself based on experience (data) and acquire new knowledge on this basis. Most often, machine learning is used to detect unknown patterns in data and to formulate rules, and it can be successfully used in consumer research to detect patterns or relationships and predict future consumer behavior, such as making repeat purchases.

Taking into account the criteria for selecting the algorithm, such as: the number of observations, the number of analysed variables and the values of categorical variables (number of labels) in the input data, the random forest algorithm was used in the study.

The idea of operation of this algorithm is based on classification using a group of decision trees and the biggest difference in the structure of both algorithms is the so-called bootstrap. The algorithm starts by building many decision trees (in our case, the number of trees was 50). For each tree, a random sample of observations is selected, consisting of several explanatory variables (the number of variables in each tree is the second parameter defined by the user).

Then, the information gain maximisation mechanism indicates further attributes to be divided. The final decision is made as a result of majority voting on the classes indicated by individual trees. The main advantage of the algorithm is the higher accuracy of the model than in the case of a decision tree.

Random forest is an advanced implementation of the aggregation algorithm (bagging), which uses a tree model as the base model. Each tree in the ensemble is built from samples drawn with replacement (e.g., a bootstrap sample) from the training set. When splitting a node during tree creation, the selected split is no longer the best among all predictors. Instead, the best split is selected from a random subset of predictors. Due to this randomness, the deviation of the forest usually increases slightly (relative to the deviation of one non-random tree). However, as a result of averaging, its variability also decreases – usually to the extent that more than compensates for the increase in deviation. As a result, the overall quality of the model is higher (Breiman, 2011).

The most important advantages of the random forest algorithm are: resistance to various data problems, no data, explanatory variables without significance, association of explanatory variables, a large number of explanatory variables, outliers; ability to reproduce complex dependencies more precisely than decision trees can do; resistance to overfitting; stability; ability to detect interactions between variables and the possibility of determining various costs of misclassification.

For measuring the importance, the method proposed by Fisher et al. (2019) will be used. Let us start with a collection of *n* observations related to *p* explanatory variables and a dependent variable *Y*. The matrix *X* contains these explanatory variable values, while *y* represents the observed *Y* values.

Suppose we have a model *f*( ) (in our case random forest model) generating predictions $\hat{y} = (f(x_1).f(x_2)...f(x_{1n}))'$ for *y*. A loss function $L(\hat{y}.X.y)$ measures how well the model fits the data. This function could be based on the log-likelihood (Nagelkerke, 1991) or other performance measures.

Now consider this algorithm:

Step 1. Begin by computing L^0, which represents the initial loss function value for the original data.

Step 2. For each explanatory variable X^j in the model, follow steps 3 to 5.

Step 3. Create a modified matrix, X^{*j} by rearranging the j^{th} column of *X* (i.e., by shuffling the observed values of X^j).

Step 4. Generate new model predictions, Y^{*j}, based on the adjusted data X^{*j}.

Step 5. Calculate the loss function value, Y^{*j}, for this modified data: $Y^{*j}\ L^{*j} = L(\hat{y}^{*j}.X^{*j}.y)$.

Step 6. Evaluate the importance of X^j by computing $vip^j_{Diff} = L^{*j} - L^0$ or $vip^j_{Ratio} = L^{*j}/L^0$.

The randomisation in Step 3 might lead to different outcomes, so it is recommended to repeat the procedure multiple times to gauge the variability in the calculated variable importance. Step 5 normalises the variable importance measure concerning L^0, the initial constant. This normalisation does not impact the ranking of explanatory variables based on vip^j_{Diff} or vip^j_{Ratio}. Consequently, in practice, the values of L^{*j} are often used to quantify a variable's importance (Fisher et al., 2019).

The use of the random forest machine learning algorithm and the variable importance VI method allowed for combining the output data of many decision trees to obtain a single result of determining the motives for choosing a travel agency that has the greatest impact on the loyalty of buyers of package travels.

The course of the model learning process for 3 variables (affective loyalty, behavioral loyalty, global loyalty) – subsequent iterations until the model converges. A typical run confirms that the model is not degenerate. This is also confirmed by the distribution of residuals in histogram form, which is consistent with the distribution function of a normal distribution.

3.3 The influence of motives on the loyalty of tourist package buyers

In searching of an answer to the further research questions (*RQ3* and *RQ4*), the loyalty of travel agency customers was presented in a broader perspective and the combination of the affective and behavioral approach allowed for a more complete representation of the specificity of the tourist services market and the essence of behavior manifested in repeated purchases and propagation of opinions about a given travel agency. Three approaches were proposed to explore the relationships between the variables: motives for choosing the organiser and affective loyalty, behavioral loyalty and global loyalty of travel agency customers (Tab. 6).

Tab. 6: Operationalisation phase

Variables	Symbol of variables	Question*	Categories
Loyalty of travel agency consumers (LTAC)	**Affective loyalty of travel agency customers (AL)**	Would you recommend the services of travel agency X to a friend in the future?	1 – definitely yes 2 – probably yes 3 – maybe 4 – propably not 5 – definitely not
	Behavioral loyalty of travel agency customers (BL)	Do you intend to use the services of travel agency X again in the future?	1 – I will definitely resign 2 – I will probably give up 3 – I will probably use it 4 – I will definitely use it
Buyers' motives of choosing a travel agency (BM)	**BM_1** – interesting/attractive tourist packages **BM_2** – a wide selection of tourist packages **BM_3** – satisfaction with previously purchased offers **BM_4** – trust **BM_5** – reputation and prestige **BM_6** – convenient location **BM_7** – belief in the value of the offer **BM_8** – favorable price-quality ratio **BM_9** – sense of security **BM_10** – special treatment of me by employees **BM_11** – service by a specially designated employee **BM_12** – attachment **BM_13** – offered loyalty program (e.g., loyalty card/club) **BM_14** – efficient/advisory service **BM_15** – individual approach of office staff **BM_16** – favorable payment terms **BM_17** – competitions and lotteries **BM_18** – prizes, gifts, gadgets **BM_19** – discounts, discounts and other financial incentives **BM_20** – advertisement **BM_21** – no other travel agencies **BM_22** – convenience of purchase **BM_23** – no time **BM_24** – reluctance to change	On a scale of 1–7, please rate the importance of your reasons for choosing travel agency X.	Rating on a scale from 1 to 7, where: 7 means the greatest importance and 1 the lowest weight

Note: *Questions in the survey questionnaire of buyers of travel agencies' services.

Source: own

Declarations of purchasers of package travels regarding their intention to use the services of a travel agency in the future indicate a high level of behavioral loyalty. 96.1% of consumers declare that they will definitely (41.6% of responses) or probably (54.5% of responses) use the travel organiser's offer again. In turn, declarations regarding recommending a travel agency to one's friends included 79.6% of responses (definitely 37.3% and probably 42.3%).

In the case of shaping loyalty in the affective approach, manifested in customers' promotion of positive opinions about a given travel agency, the key factors were the motives of buyers related to: belief in the value of the offer, trust, individual approach of office staff, efficient/advisory service and a wide selection of tourist packages (Fig. 1).

The occurrence of behavioral loyalty, understood as the buyer's behavior manifested

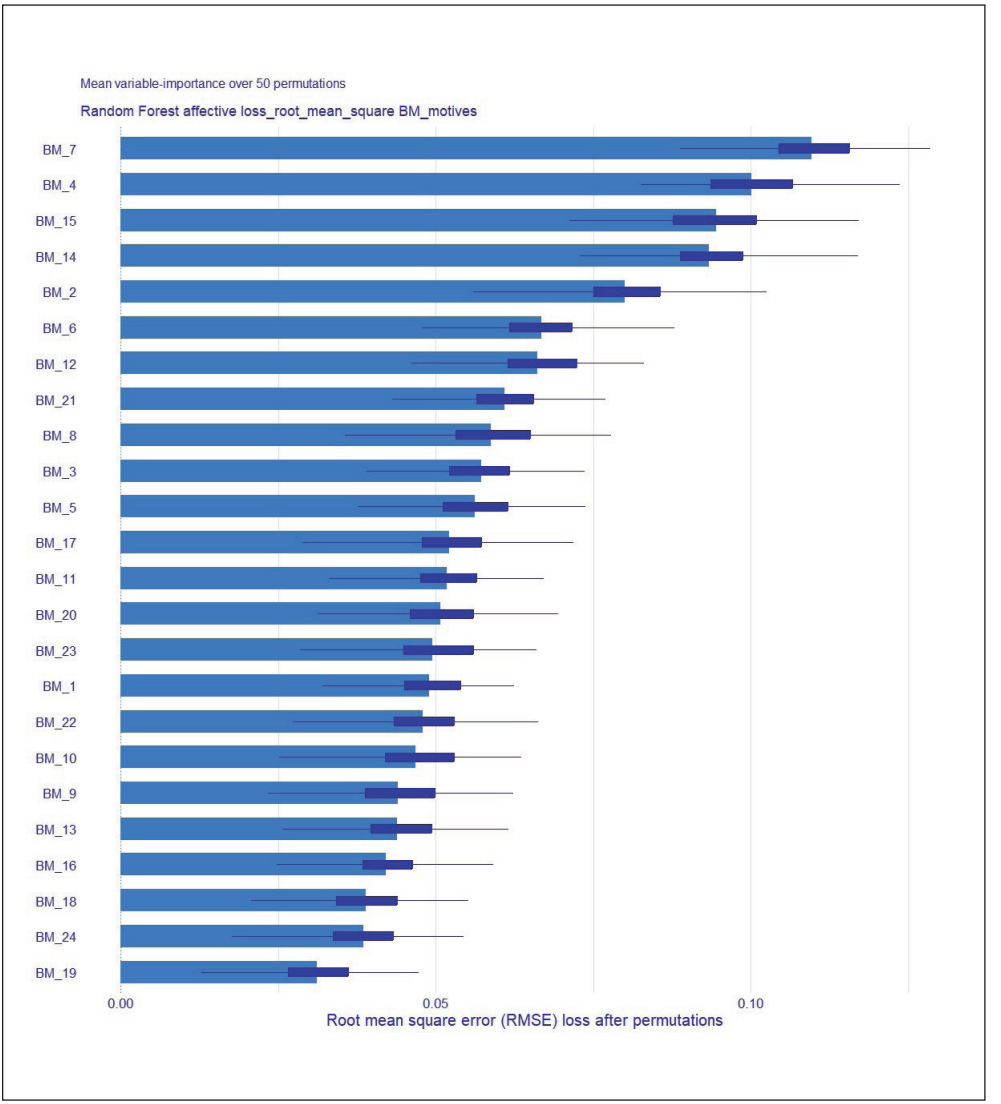


Fig. 1: **Mean explained affective loyalty (AL) variable importance in the random forest model**

Note: BM_1 – interesting/attractive tourist packages; BM_2 – a wide selection of tourist packages; BM_3 – satisfaction with previously purchased offers; BM_4 – trust; BM_5 – reputation and prestige; BM_6 – convenient location; BM_7 – belief in the value of the offer; BM_8 – favorable price-quality ratio; BM_9 – sense of security; BM_10 – special treatment of me by employees; BM_11 – service by a specially designated employee; BM_12 – attachment; BM_13 – offered loyalty program (e.g., loyalty card/club); BM_14 – efficient/advisory service; BM_15 – individual approach of office staff; BM_16 – favorable payment terms; BM_17 – competitions and lotteries; BM_18 – prizes, gifts, gadgets; BM_19 – discounts, discounts and other financial incentives; BM_20 – advertisement; BM_21 – no other travel agencies; BM_22 – convenience of purchase; BM_23 – no time; BM_24 – reluctance to change.

Source: own (based on DALEX package of R program)

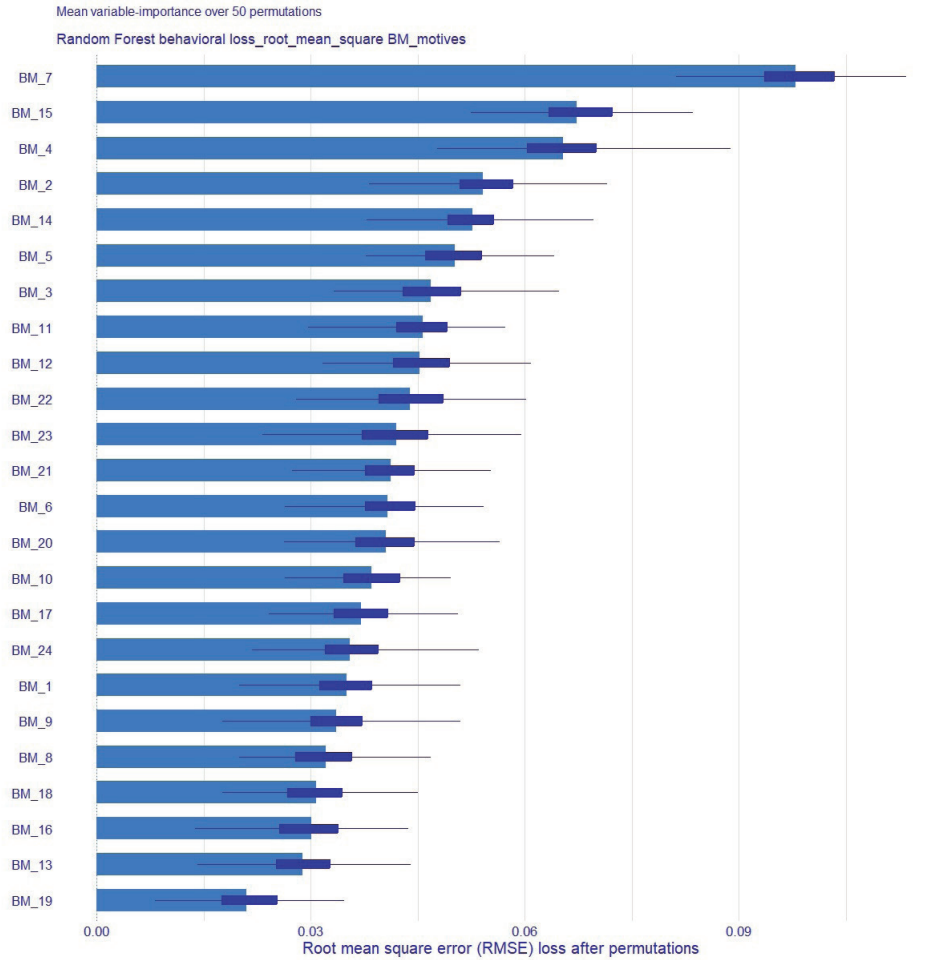


Fig. 2: **Mean explained Behavioral Loyalty (BL) variable importance in the random forest model**

Note: BM_1 – interesting/attractive tourist packages; BM_2 – a wide selection of tourist packages; BM_3 – satisfaction with previously purchased offers; BM_4 – trust; BM_5 – reputation and prestige; BM_6 – convenient location; BM_7 – belief in the value of the offer; BM_8 – favorable price-quality ratio; BM_9 – sense of security; BM_10 – special treatment of me by employees; BM_11 – service by a specially designated employee; BM_12 – attachment; BM_13 – offered loyalty program (e.g., loyalty card/club); BM_14 – efficient/advisory service; BM_15 – individual approach of office staff; BM_16 – favorable payment terms; BM_17 – competitions and lotteries; BM_18 – prizes, gifts, gadgets; BM_19 – discounts, discounts and other financial incentives; BM_20 – advertisement; BM_21 – no other travel agencies; BM_22 – convenience of purchase; BM_23 – no time; BM_24 – reluctance to change.

Source: own (based on DALEX package of R program)

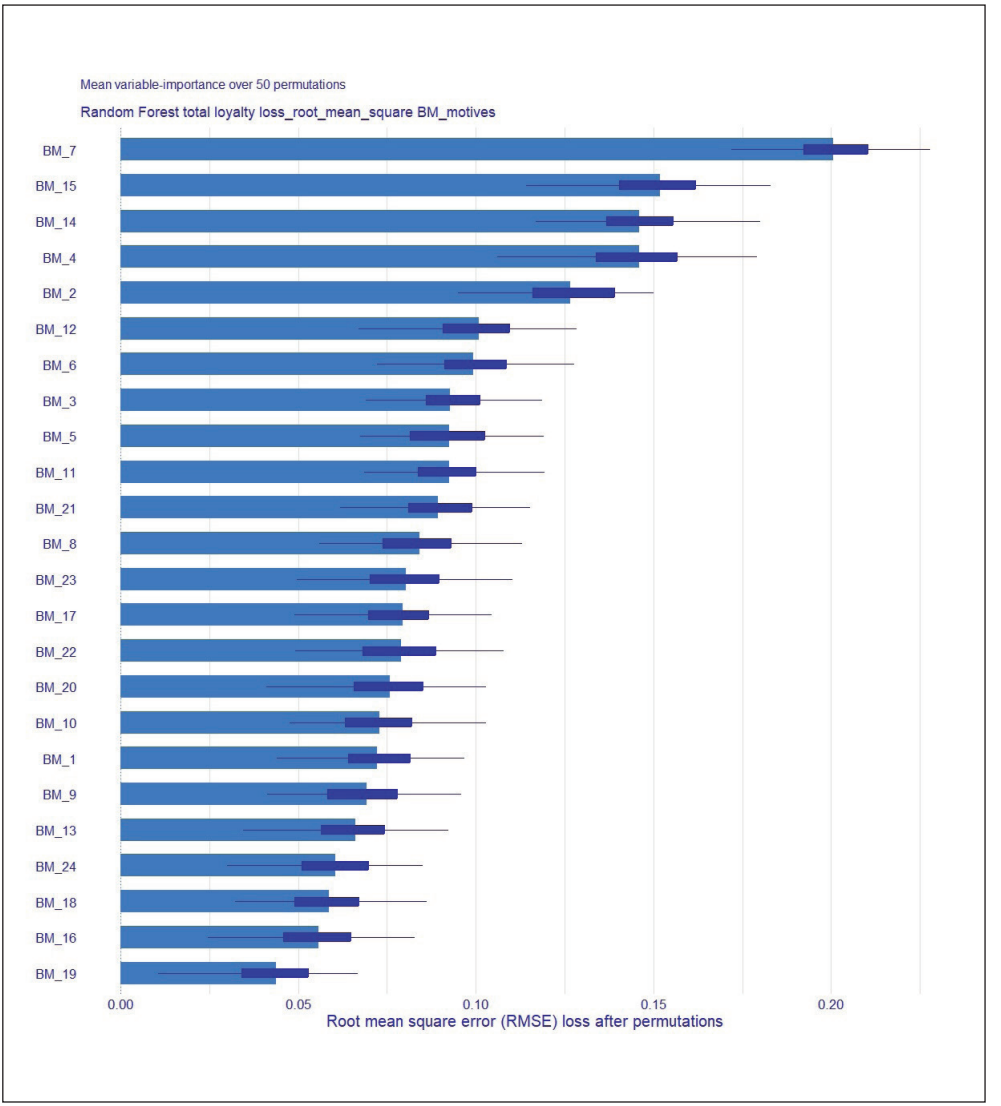


Fig. 3: **Mean explained loyalty of travel agency consumers (LTAC) variable importance in the random forest model**

Note: BM_1 – interesting/attractive tourist packages; BM_2 – a wide selection of tourist packages; BM_3 – satisfaction with previously purchased offers; BM_4 – trust; BM_5 – reputation and prestige; BM_6 – convenient location; BM_7 – belief in the value of the offer; BM_8 – favorable price-quality ratio; BM_9 – sense of security; BM_10 – special treatment of me by employees; BM_11 – service by a specially designated employee; BM_12 – attachment; BM_13 – offered loyalty program (e.g., loyalty card/club); BM_14 – efficient/advisory service; BM_15 – individual approach of office staff; BM_16 – favorable payment terms; BM_17 – competitions and lotteries; BM_18 – prizes, gifts, gadgets; BM_19 – discounts, discounts and other financial incentives; BM_20 – advertisement; BM_21 – no other travel agencies; BM_22 – convenience of purchase; BM_23 – no time; BM_24 – reluctance to change.

Source: own (based on DALEX package of R program)

in repeated purchases of package holidays in a given travel agency, was mainly influenced by the following motives of the buyers' behavior: belief in the value of the offer, trust, individual approach of office staff, efficient/advisory service, reputation and prestige, as well as a wide selection of tourist packages (Fig. 2).

However, in global terms, combining both affective and behavioral understanding of package holidays buyers' loyalty (CLTA), which manifests itself in repeated purchases and propagation of opinions about a given travel agency, the key motives of buyers were: i) belief in the value of the offer; ii) trust; iii) individual approach of office staff; iv) efficient/advisory service; and v) wide selection of tourist packages (Fig. 3).

3.4 Discussion

This study aimed to reveal the most important loyalty factors of package travels buyers during the COVID-19 pandemic. The factors were ordered according to their importance to respondents. The comparison of the obtained results of this study with the findings of previous research indicates that the key loyalty motives are confirmed in previous studies (Tab. 7). They included: belief in the value of the offer, trust, individual approach of office staff and efficient/advisory service.

Unfortunately, the individual examples of previous research on the loyalty of travel agency customers during the pandemic found in the literature review do not allow for a broad discussion of the results presented in this study. Nevertheless, they provide valuable comments. All cited publications prove that during the pandemic, changes were revealed in the motives encouraging buyers to be loyal to suppliers of package travels. While before the pandemic, many researchers considered the level of satisfaction to be the main loyalty factor, during the pandemic, the importance of factors related to trust in the travel agency, the service process, its procedures, and the personalisation of services increased. Therefore, in times of crisis, the observation made by Gounaris (2005) is valid, as he emphasised that increasing the level of customer loyalty requires travel agencies to build strong emotional bonds with customers (i.e., through trust and service provision), and not only focus on improving the satisfaction of customers.

Conclusions

The conducted research on the loyalty of purchasers of tourist packages allows to conclude that during the period of threat of the COVID-19 virus pandemic, the decision-making process of purchasing package travels has changed.

Tab. 7: Comparison of the obtained results with those of other authors

Motives*	Confirmation of research results by other authors
Belief in the value of the offer (BM_7)	Conze et al. (2010), Senders et al. (2013), Lai (2014), Roger-Monzó et al. (2015), Silva and Gonçalves (2016), Albayrak et al. (2020), Mursid and Wu (2022)
Trust (BM_4)	Huang (2008), Setó-Pamies (2012), Prause et al. (2013), Lai (2014), Devece et al. (2015), Silva and Gonçalves (2016), Albayrak et al. (2020), Rizal et al. (2020), Santos et al. (2022)
Individual approach of office staff (BM_15)	Yang et al. (2017)
Efficient/advisory service (BM_14)	Lee and Cunningham (2001), Campo and Yagüe (2008), Huang (2008), Thi Phuong Thao and Swierczek (2008), Lee et al. (2011), Setó-Pamies (2012), Lai (2014), Moisescu and Gica (2014), Roger-Monzó et al. (2015), Devece et al. (2015), Silva and Gonçalves (2016), Abou-Shouk and Khalifa (2017), Albayrak et al. (2020), Rizal et al. (2020), (2020), Cetin (2020), Elgarhy (2022)

Note: *Motives for choosing a travel agency determining the loyalty of buyers of package travels during the COVID-19 pandemic in the light of research results.

Source: own

Packaged tours were purchased less frequently, and buyers either limited their trips to domestic travel or adapted travel destinations to the changing pandemic situation.

The most important TOP10 (out of 24 variables) motivators that determined the choice of a travel agency during the COVID-19 pandemic were: favorable price-quality ratio, satisfaction with previously purchased offers, sense of security, convenience of purchase, trust, favourable payment terms, an interesting/attractive tourist packages, a wide selection of tourist packages, efficient/advisory service and belief in the value of the offer. It is noteworthy that two factors unrelated to the economic efficiency of choice ranked relatively high in this ranking. These are a sense of security (the third place), which is dependent on trust in the service provider (the fifth place).

It turned out that in the face of the pandemic threat, buyers of package travels declared loyalty to travel agencies. The study obtained a high level of loyalty, both behavioral (expressed by buyers' declared readiness to make another purchase of package travel) and affective (expressed by buyers' readiness to recommend a travel agency). This allows us to talk about the existence of a strong relationship between travel agencies and the buyers of their offers during the pandemic threat, which at the same time allows the answer to the research question *RQ3* (Were purchasers of package travels loyal to travel agencies during the COVID-19 pandemic threat?) and confirms that during the threat of the COVID-19 pandemic, buyers of package travels showed loyalty to travel agencies.

The use of machine learning allowed us to identify the reasons for choosing a travel agency, which have a key impact on the loyalty of holiday package buyers during the pandemic. These factors belong primarily to the category of loyalty motives in the customer-provider relationship (trust, individual approach of office staff) and the category of motives related to the evaluation of benefits (belief in the value of the offer, a wide selection of tourist packages and efficient/advisory service). These five motives emerged as the most important factors for each type of loyalty (affective, behavioural and total). The only difference was in the order of their occurrence. Buyers' belief in the value of the offer, trust, individual approach of office staff, efficient/advisory service and a wide selection of tourist packages determined customers' promotion of positive opinions about a given travel agency. In turn, the belief in the value of the travel agency's offer, trust in the travel agency, an individual approach of the travel agency's employees, efficient/advisory service in the travel agency, the reputation and prestige of the travel agency, as well as a wide selection of tourist packages, influenced the repeat purchase of package travels in the given office. However, the shaping of the loyalty of purchasers of package travels in a global perspective, combining both the affective and behavioral understanding of loyalty, was influenced most by belief in the value of the offer, trust, individual approach of travel agency employees, efficient service in the office that is able to advise travel and a wide selection of tourist packages. The first position in the ranking of importance was always occupied by belief in the value of the offer. It should be noted that this is a very broad and aggregate concept, and other factors may also work to influence the degree of buyer belief in the value of an offer.

The study presented here enriches knowledge in the area of tourist loyalty management and tourist behaviour. The research recognises the antecedents of loyalty in an unprecedented situation – a pandemic. It contributes to multiplying the knowledge of the importance of individual loyalty motivators and their relevance depending on the situation of the environment. It proves the constant relevance of the issue of purchasing behavior and the factors determining it, as well as the need for repeated research in this area, especially in the changing conditions of operation of tourist enterprises. The originality of the research lies in the use of a new method of data analysis, i.e., machine learning. Although the results achieved are not surprising and the identified loyalty motives do not differ from those found out by previous researchers before the COVID-19, the confirmation of the findings indicates that the new method is valuable and useful. Moreover, its additional advantage is that the results obtained have a predictive value. With a high degree of probability the identified set of factors will influence the loyalty behavior of tourism package buyers in the future. This is of great importance for the utility of the research results in practice. This attribute can contribute to improving the effectiveness of future marketing decisions of companies, including travel agencies.

The results of this study may be useful for package travels providers as a source of information for planning more effective marketing strategies and crisis recovery strategies. The findings sugges focusing on the activities strengthening customer trust in the travel agency, placing an emphasis on improving the company's image and preparing appropriate standards to maintain the efficiency of service in the event of disruptions in the service provision process. Both the identification of factors and a thorough understanding of their impact on the development of buyer loyalty are important steps from the point of view of the possibility of effective implementation of marketing activities aimed at building and strengthening customer loyalty.

As trust and beliefs are built over the long term, the activities of travel agents should be oriented especially towards forming positive, strong and lasting relationships with customers. Relationship marketing tools will be useful here. The customer decides on a long-term relationship with a service provider when he or she perceives the relationship as beneficial. In the case of travel agencies, the customer benefits on the one hand from a valuable offer of travel packages and on the other from good service in the office. The offer of a travel agency is the result of the agency's cooperation with tour operators – suppliers of travel packages. Customer satisfaction with regard to the value of the offer depends on the ability of travel agencies to attract well-known travel brands, both international (e.g., TUI, Neckermann) and domestic ones (e.g., Itaka, Rainbow, Grecos), to cooperate. Travel agents should consider the widest possible cooperation with multiple tour operator brands due to the fact that customers, according to the research, are interested in a wide choice of travel packages. The satisfaction of travel agency customers also depends on the qualifications of employees, their competences and attitude to work. The respondents themselves emphasised the dependence of repeating a purchase in a travel agency and recommending the agency to other customers on the efficient advisory services and an individual approach from the agency's staff. A well-prepared staff recruitment process, constant improvement of employees, and equipping them with the right working tools are the foundations for ensuring a high level of service.

As every study, also this study is not without limitations. Firstly, the limitations concern the loyalty testing method itself. The data is declarative and refers to the future (intentions). Secondly, comparisons of the results with the findings of previous researchers must be careful because they will cover different groups of respondents, and different sets of loyalty factors, and the data was analysed using different methods. Thirdly, the research only covers a sample drawn from the Polish population, which makes it impossible to generalise the research results.

In the future, taking into account the dynamics of the environment, it is necessary to continue and repeat the study of predictors of loyalty among buyers of tourist services in search of changes that may be important for the effectiveness of taking actions to acquire and retain customers. The results of similar studies conducted in different cultural areas (countries), as well as addressing the issue of customer loyalty in online versus offline travel agencies, may be of interest.

Acknowledgments: *The research was funded by the Ministry of Science and Higher Education in Poland under the programme "Regional Initiative of Excellence" 2019–2022, project number 015/RID/2018/19, total funding amount 10,721,040.00 PLN."*

References

Abou-Shouk, M. A., & Khalifa, G. S. (2017). The influence of website quality dimensions on e-purchasing behaviour and e-loyalty: A comparative study of Egyptian travel agents and hotels. *Journal of Travel & Tourism Marketing*, *34*(5), 608–623. https://doi.org/10.1080/10548408.2016.1209151

Akbari, M., Mehrali, M., SeyyedAmiri, N., Rezaei, N., & Pourjam, A. (2020). Corporate social responsibility, customer loyalty and brand positioning. *Social Responsibility Journal*, *16*(5), 671–689. https://doi.org/10.1108/srj-01-2019-0008

Albayrak, T., Karasakal, S., Kocabulut, Ö., & Dursun, A. (2020). Customer loyalty towards travel agency websites: The role of trust and hedonic value. *Journal of Quality Assurance in Hospitality & Tourism*, *21*(1), 50–77. https://doi.org/10.1080/1528008x.2019.1619497

Amaro, S., & Duarte, P. (2015). An integrative model of consumers' intentions to purchase

travel online. *Tourism Management*, *46*, 64–79. https://doi.org/10.1016/j.tourman.2014.06.006

Anderson, R. E., & Srinivasan, S. S. (2003). E-satisfaction and e-loyalty: A contingency framework. *Psychology & Marketing*, *20*(2), 123–138. https://doi.org/10.1002/mar.10063

Andreassen, W. T., & Lindestad, B. (1998). Customer loyalty and complex services: The impact of corporate image on quality, customer satisfaction and loyalty for customers with varying degrees of service expertise. *International Journal of Service Industry Management*, *9*(1), 7–23. https://doi.org/10.1108/09564239810199923

Atsiz, O. Akova, O., & Cetin, G. (2021). Examining package tourists' experience on overall package tour satisfaction and behavioral intentions: First-time versus repeat package tourists. *Anais Brasileiros De Estudos Turisticos-Abet*, *11*, 1–18.

Bendapudi, N., & Berry, L. L. (1997). Customers' motivations for maintaining relationships with service providers. *Journal of Retailing*, *73*(1), 15–37. https://doi.org/10.1016/s0022-4359(97)90013-0

Breiman, L. (2001). Random forests. *Machine Learning*, *45*(1), 5–32. https://doi.org/10.1023/a:1010933404324

Campo, S., & Yagüe, M. J. (2008). Tourist loyalty to tour operator: Effects of price promotions and tourist effort. *Journal of Travel Research*, *46*(3), 318-326. https://doi.org/10.1177/0047287507303975

Caruana, A. (2002). Service loyalty: The effects of service quality and the mediating role of customer satisfaction. *European Journal of Marketing*, *36*(7/8), 811–828. https://doi.org/10.1108/03090560210430818

Cetin, G. (2020). Experience vs quality: Predicting satisfaction and loyalty in services. *The Service Industries Journal*, *40*(15–16), 1167–1182. https://doi.org/10.1080/02642069.2020.1807005

Chaudhuri, A., & Holbrook, M. B. (2001). The chain of effects from brand trust and brand affect to brand performance: The role of brand loyalty. *Journal of Marketing*, *65*(2), 81–93. https://doi.org/10.1509/jmkg.65.2.81.18255

Chen, C.-F., & Tsai, M.-H. (2008). Perceived value, satisfaction, and loyalty of TV travel product shopping: Involvement as a moderator. *Tourism Management*, *29*(6), 1166–1171. https://doi.org/10.1016/j.tourman.2008.02.019

Conze, O., Bieger, T., Laesser, C., & Riklin, T. (2010). Relationship intention as a mediator between relational benefits and customer loyalty in the tour operator industry. *Journal of Travel & Tourism Marketing*, *27*(1), 51–62. https://doi.org/10.1080/10548400903534899

Day, G. S. (1969). A two-dimensional concept of brand loyalty. *Journal of Advertising Research*, *9*(3), 29–35.

Del Bosque, I. A. R., San Martín, H., & Collado, J. (2006). The role of expectations in the consumer satisfaction formation process: Empirical evidence in the travel agency sector. *Tourism Management*, *27*(3), 410–419. https://doi.org/10.1016/j.tourman.2004.10.006

Devece, C., Garcia-Agreda, S., & Ribeiro-Navarrete, B. (2015). The value of trust for travel agencies in achieving customers' attitudinal loyalty. *Journal of Promotion Management*, *21*(4), 516–529. https://doi.org/10.1080/10496491.2015.1051409

Dick, A., & Baśu, K. (1994). Customer loyalty: Towards an integrated framework. *Journal of the Academy of Marketing Science*, *22*(2), 99–113. https://doi.org/10.1177/0092070394222001

Dudek, A., Jaremen, D. E., Michalska-Dudek, I., & Walesiak, M. (2019). Loyalty model proposal of travel agency customers. *Sustainability*, *11*(13), 3702. https://doi.org/10.3390/su11133702

Elgarhy, S. D. (2022). Effects of service quality, loyalty programs, pricing strategies, and customer engagement on firms' performance in Egyptian travel agencies: Mediating effects of customer retention. *Journal of Quality Assurance in Hospitality & Tourism*, *24*(6), 753–781. https://doi.org/10.1080/1528008x.2022.2077889

Fisher, A., Rudin, C., & Dominici, F. (2019). All models are wrong, but many are useful: Learning a variable's importance by studying an entire class of prediction models simultaneously. *Journal of Machine Learning Research*, *20*(177), 1-81. https://doi.org/10.48550/ARXIV.1801.01489

Goldberg, S. M. (1981). An empirical study of lifestyles correlates to brand loyalty behaviour. *Advances in Consumer Research*, *9*, 456–460.

Gonçalves, H. M., & Sampaio, P. (2012). The customer satisfaction-customer loyalty relationship: Reassessing customer and relational characteristics moderating effects. *Management Decision*, *50*(9), 1509–1526. https://doi.org/10.1108/00251741211266660

Gounaris, S. P. (2005). Trust and commitment influences on customer retention: Insights

from business-to-business services. *Journal of Business Research*, *58*(2), 126–140. https://doi.org/10.1016/s0148-2963(03)00122-x

Gremler, D. D., & Brown, S. W. (1996). Service loyalty: Its nature, importance, and implications. In B. Edvardsson, S. W. Brown, & R. E. Johnston (Eds.), *Advancing service quality: A global perspective* (pp. 171–180). International Service Quality Association, Inc., Business Research Institute.

Han, H., Kim, Y., & Kim, E.-K. (2011). Cognitive, affective, conative, and action loyalty: Testing the impact of inertia. *International Journal of Hospitality Management*, *30*(4), 1008–1019. https://doi.org/10.1016/j.ijhm.2011.03.006

Huang, L. (2008). Exploring the determinants of e-loyalty among travel agencies. *The Service Industries Journal*, *28*(2), 239–254. https://doi.org/10.1080/02642060701842316

Jacoby, J., & Chestnut, R. W. (1978). *Brand loyalty: Measurement and management*. Wiley.

Jasrotia, S. S., Mulchandani, K., & Srivastava, S. (2023). Drivers of experiential loyalty intentions towards online travel agents: A comparative analysis on pre- and post-COVID travellers. *Consumer Behavior in Tourism and Hospitality*, *18*(4), 563–586. https://doi.org/10.1108/cbth-12-2022-0200

Konecnik, M., & Gartner, W. C. (2007). Customer-based brand equity for a destination. *Annals of Tourism Research*, *34*(2), 400–421. https://doi.org/10.1016/j.annals.2006.10.005

Lai, I. K. W. (2014). The role of service quality, perceived value, and relationship quality in enhancing customer loyalty in the travel agency sector. *Journal of Travel & Tourism Marketing*, *31*(3), 417–442. https://doi.org/10.1080/10548408.2014.883346

Lawu, M. S., Santoso, I., Asbudiutomo, R. M., & Willy Gunadi, W. (2022). Service recovery in online travel agencies during COVID-19 pandemic. In *Proceedings of the International Conference on Industrial Engineering and Operations Management Istanbul* (pp. 4386–4397). IEOM.

Lee, M., & Cunningham, L. F. (2001). A cost/benefit approach to understanding service loyalty. *Journal of Services Marketing*, *15*(2), 113–130. https://doi.org/10.1108/08876040110387917

Lee, S., Jeon, S., & Kim, D. (2011). The impact of tour quality and tourist satisfaction on tourist loyalty: The case of Chinese tourists in Korea. *Tourism Management*, *32*(5), 1115–1124. https://doi.org/10.1016/j.tourman.2010.09.016

Major, B., & McLeay, F. (2013). Alive and kicking: Evaluating the overseas package holiday experience of grey consumers in the United Kingdom. *Journal of Vacation Marketing*, *19*(1), 5–18. https://doi.org/10.1177/1356766712461405

Mazurek-Kusiak, A. (2020). Determinants of the selection of travel agencies on Polish tourist services market. *E&M Economics and Management*, *23*(1), 156–166. https://doi.org/10.15240/tul/001/2020-1-011

Moisescu, O. I., & Gica, O. A. (2014). The impact of service quality on customer behavioral loyalty in the case of travel agencies from Romania. *Amfiteatru Economic Journal*, *16*(8), 1191–1204.

Morgan, R. P. (1999). A consumer-oriented framework of brand equity and loyalty. *International Journal of Market Research*, *42*(1), 1–9. https://doi.org/10.1177/147078530004200105

Mursid, A., & Wu, C. H.-J. (2022). Customer participation, value co-creation and customer loyalty: Evidence from Umrah travel agencies in Indonesia. *Journal of Islamic Marketing*, *13*(3), 628–648. https://doi.org/10.1108/jima-06-2020-0190

Nagelkerke, N. J. D. (1991). A note on a general definition of the coefficient of determination. *Biometrika*, *78*, 691–692. https://doi.org/10.2307/2337038

Newman, J. W., & Werbel, R. A. (1973). Multivariate analysis of brand loyalty for major household appliances. *Journal of Marketing Research*, *10*(4), 404–409. https://doi.org/10.1177/002224377301000408

Oliver, R. L. (1999). Whence consumer loyalty? *Journal of Marketing*, *63*(4_suppl1), 33–44. https://doi.org/10.1177/00222429990634s105

Prause, G., Mendez, M. M., & Garcia-Agreda, S. (2013). Attitudinal loyalty and trust in entrepreneurship: Building new relationships. *International Entrepreneurship and Management Journal*, *9*(4), 531–540. https://doi.org/10.1007/s11365-011-0215-y

Reichheld, F. R., & Schefter, P. (2000). E-loyalty: Your secret weapon on the web. *Harvard Business Review*, *78*(July–August), 105–114.

Richard, J. E., & Zhang, A. (2012). Corporate image, loyalty, and commitment in the consumer travel industry. *Journal of Marketing Management*, *28*(5–6), 568–593. https://doi.org/10.1080/0267257x.2010.549195

Rizal, H., Amin, H., Suddin, L., Sondoh, S. L., & Jung Ku, C. (2020). Relationship

quality and e-loyalty towards online travel agency (OTA): Social exchange theory perspective. *Jurnal Pengurusan*, *58*, 39–51. https://doi.org/10.17576/pengurusan-2020-58-04

Roger-Monzó, V., Martí-Sánchez, M., & Guijarro-García, M. (2015). Using online consumer loyalty to gain competitive advantage in travel agencies. *Journal of Business Research*, *68*(7), 1638–1640. https://doi.org/10.1016/j.jbusres.2015.02.009

Ronsana, G. G., Shihab, M. R., Syahbuddin, B. H., & Fitriani, W. R. (2018). Factors influencing customer's e-loyalty in tourism e-marketplace. In *Proceedings of 2018 International Conference on Information Technology Systems and Innovation (ICITSI)* (pp. 237–241). IEEE. https://doi.org/10.1109/icitsi.2018.8696021

Rowley, J. (2005). The four Cs of customer loyalty. *Marketing Intelligence & Planning*, *23*(6), 574–581. https://doi.org/10.1108/02634500510624138

Rundle-Thiele, S. (2006). Look after me and I will look after you! *Journal of Consumer Marketing*, *23*(7), 414–420. https://doi.org/10.1108/07363760610712957

Santos, S., Monteiro, J., Espírito Santo, P. M., Augusto, L., & Oliveira, A. (2022). The future of brand awareness and brand loyalty on travel agencies. *International Conference on Tourism Research*, *15*(1), 371–378. https://doi.org/10.34190/ictr.15.1.107

Senders, A., Govers, R., & Neuts, B. (2013). Social media affecting tour operators' customer loyalty. *Journal of Travel & Tourism Marketing*, *30*(1–2), 41–57. https://doi.org/10.1080/10548408.2013.750993

Setó-Pamies, D. (2012). Customer loyalty to service providers: Examining the role of service quality, customer satisfaction and trust. *Total Quality Management & Business Excellence*, *23*(11–12), 1257–1271. https://doi.org/10.1080/14783363.2012.669551

Silva, G. M., & Gonçalves, H. M. (2016). Causal recipes for customer loyalty to travel agencies: Differences between online and offline customers. *Journal of Business Research*, *69*(11), 5512–5518. https://doi.org/10.1016/j.jbusres.2016.04.163

Statista. (2021). *Online travel market worldwide*. https://www.statista.com/study/15218/online-travel-market-statista-dossier/

Thi Phuong Thao, H., & Swierczek, F. W. (2008). Internet use, customer relationships and loyalty in the Vietnamese travel industry. *Asia Pacific Journal of Marketing and Logistics*, *20*(2), 190–210. https://doi.org/10.1108/13555850810864551

Waszaturystyka. (2020). *Klienci, którym poświęca się czas, lepiej reagują podczas kryzysu* [Customers who are given time respond better during a crisis]. https://www.waszaturystyka.pl/klienci-ktorym-poswieca-sie-czas-lepiej-reaguja-podczas-kryzysu/

Waszaturystyka. (2021). *Agent turystyczny u progu sezonu letniego 2021 i w gąszczu covidowych zasad* [A travel agent at the threshold of the summer season 2021 amidst the maze of COVID regulations] (Podcast No. 13). https://www.waszaturystyka.pl/agent-turystyczny-u-progu-sezonu-letniego-2021-i-w-gaszczu-covidowych-zasad-podcast-13/)

Wu, W., & Riantama, D. (2022). Determining the factors affecting customer satisfaction using an extraction-based feature selection approach. *PeerJ Computer Science*, *8*, e850. https://doi.org/10.7717/peerj-cs.850

Yang, A. J.-F., Chen, Y. J., & Huang, Y.-C. (2017). Enhancing customer loyalty in tourism services: The role of customer-company identification and customer participation. *Asia Pacific Journal of Tourism Research*, *22*(7), 735–746. https://doi.org/10.1080/10941665.2017.1319398

Zhu, Z., Kim, S., & Shin, H. H. (2022). Does the website credibility of online travel agencies (OTAs) affect customers' evaluation and future intentions? *Asia Pacific Journal of Tourism Research*, *27*(8), 842–855. https://doi.org/10.1080/10941665.2022.2131444

To trust or not to trust ICT? Empirical model of relation between career readiness, trust, and distrust

Elzbieta Kowalczyk[1], Dagmara Lewicka[2], Pawel Zajac[3]

[1] *Poznan University of Economics and Business, Department of Organization and Management Theory, Poland, ORCID: 0000-0003-4611-2246, e.kowalczyk@ue.poznan.pl;*
[2] *AGH University of Krakow, Faculty of Management, Poland, ORCID: 0000-0002-6955-7371, lewicka@agh.edu.pl;*
[3] *AGH University of Krakow, Faculty of Management, Poland, ORCID: 0000-0003-4343-3458, pzajac@agh.edu.pl.*

Abstract: *In this study, the authors focus on two issues: the influence of technology trust and distrust on career readiness and the identification of these trust and distrust factors determined by the respondent's gender. To achieve this goal, the authors collected data using the survey method. The study was conducted among 871 Polish university students aged 18 to 25. Structural equation modeling was used to show potential causal dependencies between variables. The study provides valuable insight into research on trust and distrust in technology. Three groups of factors influencing career readiness were identified: catalysts (ICT trust, human-ICT competition), inhibitors (digital illiteracy, harmful ICT) and neutrals (ICT scepticism, digital anxiety). Variables in the career inhibitor category are not significant for the male respondents. The model used in the study indicates higher readiness among women in the dedication dimension, lower readiness in the engagement dimension, and no gender difference in the sacrifice dimension. The differential role of gender is confirmed in the context of career readiness. Limitations for this type of research are related to the difficulty of reaching the appropriate research sample, and thus its representativeness. In this case, thanks to a large research sample, it was possible to capture the relationships that allow for a better understanding of Generation Z.*

Keywords: *Information and communication technologies, digitalization, Generation Z, SEM.*

JEL Classification: *I23, M53.*

APA Style Citation: Kowalczyk, E., Lewicka, D., & Zajac, P. (2024). To trust or not to trust ICT? Empirical model of relation between career readiness, trust, and distrust. *E&M Economics and Management*, *27*(2), 221–239. https://doi.org/10.15240/tul/001/2024-2-013

Introduction

The dynamic development of information and communication technology (ICT), going hand in hand with the increasing dependence of humans on technology, is increasing interest among researchers in both trust and distrust in this context (McKnight et al., 2020; Wong et al., 2023). The issues of trust and distrust are increasingly becoming the focus of the sub-discipline of technology management, where humans are part of a socio-technical system (Lankton et al., 2015; McKnight et al., 2011). In this system, trust and distrust relate to the relationship between humans and technology (Liu et al., 2017; Thatcher et al., 2013). These relationships are characterized by risk and dependency. The use of technology involves risks taken by technology users. Risks are compounded by users' lack of knowledge and uncertainty regarding the consequences of technology use. On the other hand, an increasing level of dependence on technology can be observed (Ejdys, 2018).

ICT contributes to dynamic changes in society in all aspects of life, including the workplace, learning, and everyday life. These influences are increasingly felt at all levels of education, particularly in higher education institutions. As ICT enables an increasing degree of customization of learning and teaching for individual students, it is worth asking whether and how trust/distrust in ICT technology influences students' career readiness. Trust, on the one hand, helps decision-making by reducing uncertainty about the consequences of interactions and, on the other hand, enhances the desire to establish and maintain a relationship with a trusted person or object. Therefore, according to the literature, it has been assumed that ICT trust positively influences the career readiness of young adults, which is a prerequisite for a successful transition from the education market to the labour market.

As current research indicates, every relationship is also accompanied by a certain level of distrust. Defining distrust in general and with regard to technology in particular is a difficult challenge. So far, research on distrust in relation to technology is at an initial stage (Bewsell, 2012). However, the emotional perspective of distrust is worth investigating. It has important practical value. It allows attempts to better understand the fears, anxieties and barriers of technology users and develop ways to reduce them.

ICT is a driving force for change in the labour market, and technology literacy is the third fastest-growing core skill (World Economic Forum, 2023). Therefore, attitudes toward ICT, such as trust and distrust, are an essential element of career readiness and facilitate the transition from education and training to the labour market. The curriculum of students in the area of career readiness is based on the improvement of digital competencies (Hua et al., 2022; Newell & Ulrich, 2022). People refer to digital competencies to achieve goals that are important to them in an effective manner, including effective functioning in the labour market (Kowalczyk, 2022). Empirical research shows that both students and employers see a relationship between digital competencies and employability (Pirzada & Khan, 2013). The EU Commission defined these competencies in areas such as interacting through technologies, sharing information and content, engaging in online citizenship, collaborating through digital channels, netiquette, and managing digital identity (Ferrari, 2013). Trust treated as attitude (Nguyen, 2022) is necessary in all mentioned areas and according to the DigComp report, attributes are the parts of the digital competences (Vuorikari et al., 2022). We assume that achieving competence in these dimensions requires a balance between trust and distrust of ICT. In particular, we put a lot of sensitive information (e.g., personal data, CV content, copies of documents) in the digital space and, in order to keep our activities safe, we need to realistically assess the ICTs used to verify the tools used.

Therefore, it has been assumed that ICT trust positively influences the career readiness of young adults, which is a prerequisite for a successful transition from the education market to the labour market.

Given the lack of research on distrust in this context, the questions raised are whether and how ICT distrust can be a reason for career exclusion and a barrier to entry into the labour market and whether and how gender determines specific patterns of the impact of ICT trust and distrust on career readiness. This research is part of an increasingly popular trend related to eliciting value-added ICT use behaviours aimed at increasing productivity and learning outcomes.

The rest of the paper is structured as follows. The paper begins by presenting the issue of career readiness. Next, the paper delves into various studies related to trust in ICT and distrust in ICT. It then considers gender issues in relation to career readiness, ICT and trust. The paper then explains the methodology, presents the research results, discusses research limitations, and provides concluding remarks on the findings.

1. Theoretical background

1.1 Career readiness

Even before the COVID-19 pandemic, the working environment was very difficult for graduates entering the labour market due to the enormous technological variability, turbulence, outsourcing practices and remote work (Mahmud et al., 2022; Sholikah, 2021). In the post-pandemic period, as a result of, among other things, a real surge in technological changes, this problem is even greater. Research has shown that in order to increase employability and the chances of a successful career, it is important during one's education to acquire transferable

competencies, which include critical thinking, problem-solving, negotiation and decision making (Mahmud et al., 2022). Digital competencies play an instrumental role with respect to the ones mentioned above, but, importantly, they are also transferable (Kowalczyk, 2022). In addition, qualitative research conducted in France shows that a contextual factor in the form of digital transformation has an impact on the intra- and inter-organizational transferability of public sector employees' careers (Culié et al., 2021). The personal need for continuous development has already become a standard in professional functioning, and employers and training companies increasingly prepare their proposals for training in digital format; thus, it is difficult to learn, train, and develop without digital competencies these days. Although young people often have extensive experience in using technology, this experience often does not transfer to the area of education (Corrin et al., 2020). In the pandemic period especially highlighted that, digital literacy shortages resulted in digital exclusion from the labour market, and this was due to enforced technological changes which became firmly established in the world of work: from job searching, through performing and improving one's work, to receiving remuneration for it. Unfortunately, in Poland, Romania, Bulgaria, Slovakia, Hungary and Cyprus, the risk of digital exclusion in 2020 was 10% higher than in other EU countries. Several reasons for the digital exclusion of employees are observed in enterprises, the main ones being motivational barriers (42%) and mental barriers (38%) (both factors being mentioned jointly in 18% of cases), with other responses including digital illiteracy (30%), material barriers (18%), and no barriers (13%) (Lacova et al., 2022). While it is true that young people studying at universities in Poland are more digitally competent compared to the rest of society, their level of above-basic overall digital skills is comparable to that possessed by 55–64 years-old residents of the Netherlands, which has a leading position in Europe in terms of digital literacy (Eurostat, 2023a).

Career readiness is defined as useful resources in terms of labour market adaptation and willingness to undertake tasks and change status (Sampson et al., 2013). Research shows that career readiness is connected with career maturity, socioeconomic status, and one's psychological locus of control (Sholikah, 2021). Career readiness is also dependent on the ability to make the right decisions, which affect career development as well as a range of family, economic, market, and social conditions. Along with career readiness comes increased insight and adequate assessment of one's abilities, interests, and skills. Career readiness is fostered by a higher level of core self-evaluation and fewer perceived barriers, and it helps a person obtain knowledge about the labour market and adjust their educational choices accordingly (Sampson et al., 2013); on the other hand, a lower level of career readiness means a lower level of occupational knowledge (Hirschi, 2011). According to research conducted in eight OECD countries, financial advantage, which is regarded as a measure of career success, is influenced by the following (OECD, 2021a):

- Thinking about the future, which consists of career certainty (the ability to name an expected occupation in adulthood); career ambition (the expectation of working in a professional or managerial role; career alignment (the educational plans of a student can typically be regarded as appropriate for entry to their occupational expectation); and instrumental motivation towards school (a student is able to draw a connection between the education they are engaged in and a potential future in work). In all the above-mentioned aspects, there is a statistically significant correlation with internet research;
- Exploring the future (through career conversations with teachers; support from family members and friends; engaging with people in work through career talks or job fairs; workplace visits or job shadowing; application and interview skills development activities; occupationally-focused short programmes);
- Experiencing the future, e.g., through part-time work (up to 10–15 hours per week) and volunteering).

Shaping career readiness begins in the early stages of education and is designed to familiarize young people with the requirements of the world of work and support them in exploring and experiencing their chosen occupations. Although the world of work is increasingly digital (including, e.g., remote work, online recruitment and selection, online team communication, online searching and content creation) and requires ICT literacy, it is also inherently

connected with functioning in the real world (OECD, 2021b). It must be emphasized that literacy in using digital tools enhances people's careers, but it does not transfer their functioning to an autonomous, virtual environment.

In order to improve career readiness related to students' digital literacy, curricula are being developed, such as at Florida University, based on developing opportunities within identified areas of artificial intelligence literacy regardless of student discipline. Preparing graduates to address digital challenges based on digital technologies, including artificial intelligence (AI), supports the development of their professional potential and ensures faster adaptation to the challenges of the 21st century workplace (Southworth et al., 2023). There are numerous examples of using AI in everyday life – from self-driving cars to smart homes and voice assistants (Ng et al., 2021). For example, about 66,000 Alexa skills are available in the US, but only 33% of consumers think they are already using various AI platforms. It is estimated that 85 million jobs worldwide could potentially be replaced by AI and other automation technologies by 2025, and intelligent robots could replace 30% of the human workforce globally by 2030 (Nick, 2023). An International Standard Classification of Occupations study conducted in the US and Canada on regulated occupations shows that those with a future (e.g., medical care, veterinary care, IT support) are significantly less threatened by automation than those in decline (e.g., business, finance and insurance; transport and trade; sales, office support and administration; production), where this threat is significant (Mann et al., 2020). It is therefore imperative that the preparation of candidates for a career in the latter occupations should include the ability to work with machines and ICT literacy. It is necessary to use AI in the curriculum, which should be supported by enabling AI in different areas; helping students to know and understand AI; showing how to use and apply AI; creating and evaluating AI; and emphasizing AI-related ethical issues (Southworth et al., 2023).

1.2 Trust and distrust in ICT

The concept of trust is difficult to define, as it is variously understood within the scientific disciplines exploring it, i.e., psychology, sociology, economics, management, political science and others (Lewicka & Zakrzewska-Bielawska, 2020). Most research considers trust in interpersonal relationships, where one party is the trustor and the other the trustee. However, it is worth noting that trust relates to a specific context, e.g., organizational or online, and has a specific scope (Jarvenpaa et al., 2004). A party to a trust relationship is most often a person, but it can also be an institution, an intelligent device, an object that performs a function, or a technology (Lewicka et al., 2017). Of particular interest seem to be considerations of trust related to the emergence of humanoid robots, which are given a mechanical identity (Rakowska, 2021). The concept of trust is shifting to an expanding group of objects, with the assumption that at least one party to this relationship is human. Obviously, this situation raises many questions and concerns. The main one concerns the question of whether and to what extent the category of trust can be applied to the relationship between a human being and a material object. Other questions concern the antecedents of trust, its types and its consequences.

Technology trust is a particular type of trust in which an individual as a user places trust in technology (Xu et al., 2014). Previous definitions of technological trust emphasize the following aspects of the relationship between humans and technology (Lee & See, 2004): i) the expectation of help in achieving goals, i.e., usability of technology; ii) the anticipation of reliability predictability; the expectation of effectiveness and efficiency of devices from the perspective of the creators of the technology; and iii) a particular type of relationship characterized by uncertainty and vulnerability.

Research indicates that the user's level of trust in technology influences the strategy of its use (Bagheri & Jamieson, 2004). A lack of trust in the technology precludes its full use, which can lead to a decrease in productivity and a failure to exploit opportunities. The focus of technology trust is on the context of ICT. This is because people rely on them to an unprecedented degree and the digital environment is highly uncertain and risky. Interesting research contexts related to our research are: trust in online communication (Benlian & Hess, 2011), trust in government websites (Teo et al., 2008), trust in software (Lankton et al., 2014), cloud services (van der Werff et al., 2019), chatbox service (Balakrishnan & Dwivedi, 2021).

A trust construct comprising three dimensions is most used to examine technological

trust (Lankton et al., 2014): i) functionality, the degree to which an individual believes that a system or its components have the necessary functions to accomplish specific tasks or goals; ii) reliability, the degree to which the individual believes that the technology will continuously perform correctly, consistently and flawlessly; and iii) helpfulness, the degree to which the individual believes that the technology will provide adequate and responsive assistance.

It should be noted that these dimensions arose from the adaptation by analogy of the generally accepted dimensions of interpersonal trust, i.e., competence, benevolence and integrity for the purpose of trust in technology. We cannot attribute competence to ICT, but only to functionalities that help people to achieve their goals. Technical systems can show their reliability by providing functionality according to designed capabilities, consistently and continuously.

Technology cannot show benevolence, but it can respond to the needs and expectations of users and thus provide support and assistance to them. Trust in technology is also determined by individual factors such as propensity to trust, gender, and cultural factors. It is also linked to the organizational context with which the use of the technology is associated. The organizational context sets the framework using the institutional dimensions of structural confidence and situational normality, which influence the extent of trust in a given technology (Ejdys, 2018).

Trust is a positive mental state that implies a positive expectation of a partner or object, which allows one to cope with uncertainty about the surrounding world. It helps to act or to respond to various types of uncertain situations or events. Most definitions of trust indicate that, despite positive expectations, the individual is aware of the possible negative consequences of trusting. Trust is, therefore, accompanied by distrust. The question of whether trust and distrust are opposing phenomena in one dimension or whether their relationship is more complex has attracted the attention of researchers (Cho, 2006). Initially, these relationships were described as opposing states located at two opposite ends of a single continuum. In contrast to trust, where positive connotations are assumed, distrust was understood as a negative expectation resulting from the attribution of negative intentions to a person or object, linked to risk and the possibility of harm.

Although trust and distrust are defined by scholars in different ways, it is currently accepted that they are related but distinct and separate constructs. That is, lack of trust is not necessarily associated with high distrust and low distrust with high trust. However, linking the two constructs implies that they influence each other to some extent, e.g., a decrease in distrust may have positive consequences for trust, while on the other hand, a high level of distrust is likely to be a symptom of low trust in the relationship (Lewicka & Zakrzewska-Bielawska, 2022). Researchers leaning towards this view note that loss of trust is not always associated with the development of distrust. They emphasize that distrust can be reduced without inducing trust and vice versa (Ullman-Margalit, 2004). A growing group of researchers also indicate that distrust protects individuals from the negative consequences of relationships (Bewsell, 2012). It causes individuals to take protective measures and to check the consequences of the functionalities offered. Distrust refers to certain negative expectations or things that are feared. It can also be defined as an unwillingness to be vulnerable because of an expected violation (Komiak & Benbasat, 2008). Distrust defines a situation as one in which we need to protect ourselves and increase our vigilance. In this sense, it is a control mechanism that signals risk and reduces uncertainty (McKnight & Chervany, 2001). In this state, one actor has no reason to trust the other and has many reasons to be cautious and vigilant. Distrust can be considered as a mental state, a belief and feeling, and as a behaviour (Bewsell, 2012).

Based on the dimensions concerning interpersonal distrust following McKnight and Chervany (2001), the dimensions of distrust as a belief can be distinguished: i) distrusting belief competence/functional belief, based on the belief that the technology will not meet expectations regarding its functionality; ii) distrusting belief predictability, based on the belief that the technology will not be equally efficient and will not guarantee the expected standardized level of service quality over time; and iii) distrusting belief benevolence/helpfulness based on the belief that the technology is not able to satisfy the needs of a given user, e.g., the expected level of security, guarantee of privacy.

In turn, distrust as a behaviour may include behaviours aimed at reducing perceived risks,

e.g., withdrawal of reliance on technology and, in severe cases, avoidance of technology use.

The Edelman Trust Barometer indicates that although trust in the technology sector remains high, there is growing concern about the effects of rapid technological development and dynamic change, particularly among people in economically weaker countries. Annual reports indicate that people around the world are becoming increasingly distrustful of the world around them, including institutions. Among the factors causing distrust are many that are related to technology. Many respondents express concern about the future of work. These concerns are generated by factors related to technology, automation, the gig economy and the need to retrain from and learn new skills. Furthermore, 73% of global respondents worry about their data privacy, 60% agree that the use of technology to replace human workers will increase income inequality, 65% fear that technology will make it impossible to know if what people are seeing or hearing is real. The above data points to the need for increased research on distrust of technology.

1.3 Gender issues with regard to career readiness, ICT and trust

Researchers' views on career readiness between women and men are not homogenous. The research did not obtain conclusive results. On the one hand, men manifest higher levels of career readiness through career decision self-efficacy and confidence in abilities, while women identify more with their career identity. Women perceive more barriers and experience more role conflict. On the other hand, some studies (including meta-analyses) have not shown that gender is a factor influencing career self-efficacy decisions. This suggests the indirect relationship between gender and career readiness is mediated or moderated by other factors (Parietti et al., 2016). Furthermore, career choices, education and career exploration are strongly marked by direct and indirect social influences (Ikonen et al., 2020). Already, boys' early choice of a "math track" based educational pathway correlates with their greater propensity to compete and makes them more privileged in their career pathway, compared to girls choosing a "literature track" (Buser et al., 2012).

The results of studies on gender differences with regard to ICT literacy are inconclusive, but in those based on self-assessment, higher competencies of male students are often apparent (Siddiq & Scherer, 2019). This is partly due to men's overestimation of their competencies and the harsher self-assessment of women, who additionally feel that there is a cultural acceptance for their lack of competencies in this area (Kowalczyk, 2022). Women are also characterized by a greater fear of ICT, which is not, as is the case with men, modified by experience (Broos, 2005). In contrast, extensive research based on meta-analysis in which ICT literacy was measured through performance-based assessments showed that female students have higher levels of it. While this effect is relatively small, it cannot be ignored (Siddiq & Scherer, 2019). Gender differences also relate to the extent of self-expression. Women express themselves in digital media through blogs about their lives (e.g., style, family), while men write more about professional or technical issues. This greater tendency for women to self-express may be explained by the fact that they (like bloggers and vloggers in general) tend to have higher levels of neuroticism and higher (in relation to people in general) levels of extraversion (Okdie & Rempala, 2020). Also, stereotypes play an important role in gender differences as they can help explain both behaviours and declarations relating to ICT and career choices. Descriptive gender stereotypes describe what women like and what men like, while prescriptive gender stereotypes describe what each gender should like (Heilman & Parks-Sramm, 2007). It is gender stereotypes that, at least to some extent, influence women's less frequent choice of IT careers and their lower interest in technology (Luxoft Poland, 2023), as well as greater social acceptance for gaps in their digital competencies (Raluca & Phillips, 2022). Moreover, women who escape such stereotypes frequently have to face negative social evaluation.

The results of studies on gender differences in trust are also not conclusive. This is due to the multiplicity of study contexts and factors that may influence the results, such as social context, norms, societal structure and gender roles. Experimental research on gender differences in trust provides mixed results (Mukherjee, 2020). Some indicate that men are more trusting than women (Wu et al., 2020), while other studies (Bellemare & Kröger, 2007) find that women are more trusting than men.

Some studies point to factors that demonstrate the contextualization of gender trust, such as social distance, payout level, gender diversity, or lack thereof in the dyads studied (Mukherjee, 2020). Researchers in this area confirm that gender context is worth undertaking in trust research because of the practical implications for, among other things, social policy education and management.

2. Research methodology

Despite the increasing importance of ICT in everyday life and the economy, the state of research on trust and distrust in ICT is still unsatisfactory. Therefore, the following objectives were set in this study: to determine the impact of trust and distrust in ICT on the career readiness of the students surveyed and to identify gender differences in the impact of trust and distrust on career readiness. Three research questions were therefore posed:

RQ1: Whether and how does ICT trust influence career readiness?

RQ2: Whether and how does ICT distrust influence career readiness?

RQ3: Is the presumed relationship between ICT trust and ICT distrust determined by gender?

2.1 Tools

Career readiness was measured using the career readiness scale developed by Bańka (2015), which consisted of 15 items grouped into three factors using factor analysis. This scale was developed in accordance with the contextual approach, and it examines the intensity of behaviours enabling a smooth transition from the education market to the labour market. In other words, it examines a person's readiness to change their dominant role from that of a student to that of an employee.

Items forming this scale, due to the dynamics of changes – generational, technological, and caused by the pandemic – that have taken place in the labour market have been subjected to the principal components factor method which was used to analyze and uncover the underlying structure of the data. To interpret the factors that are considered relevant, an orthogonal varimax rotation of the loading matrix was performed, and the items were sorted (Abdi, 2003). All of the items of the career readiness scale were loaded onto three components, like in the earlier version of the test (Tab. 1). However, the structure of the factors was slightly different. The following three dimensions were distinguished: determination (7 items), relating to courage and perseverance in pursuit of a career; sacrifice (3 items), relating to willingness to make sacrifices and acceptance of being discriminated against in the labour market; and engagement (5 items), relating to bravery and perceiving the career as the main life value.

The same method was used to analyze issues of trust and distrust. The study was able to extract a single component of ICT trust, which includes six items related to the dimensions extracted from the literature review (Lankton et al., 2014), i.e., functionality, helpfulness, reliability,

Tab. 1: PCA results on career readiness dimension – Part 1

Items	Loadings	Communalities	MSA
Career readiness – determination (Eigenvalue 5.452; % of variance 36.35; Cronbach's alpha 0.862; KMO 0.864; Bartlett test sig. 0.000)			
I know that there will always be someone who will know more than me, but I still believe that it is not worth postponing the career of your dreams until you gain more experience	0.774	0.621	0.846
I believe that everyone should fight for their position in the labour market	0.768	0.614	0.891
I believe that anyone who wants their professional career to continue to develop should not hesitate if it is a good time to take it up	0.756	0.585	0.897
I realize that there is a lot of competition in the job market, so I believe it is important to get involved in a career as early as possible	0.754	0.582	0.871

Tab. 1: PCA results on career readiness dimension – Part 2

Items	Loadings	Communalities	MSA
When expanding career opportunities is at stake, I am ready to increase my efforts in the field of interest, even at the expense of my free time	0.640	0.596	0.908
The opportunity to make a career is an important life goal that I cannot give up	0.622	0.606	0.891
My desire to pursue a worthwhile career is so strong that there are a few factors that could deter me from this intention	0.604	0.605	0.871
Career readiness – engagement (Eigenvalue 2.482; % of variance 16.55; Cronbach's alpha 0.804; KMO 0.834; Bartlett test sig. 0.000)			
In order to meet the conditions for starting and continuing the career I am interested in, I am ready to work for some time, even for a very low salary	0.757	0.610	0.893
In order to realize my career plans, I am ready to postpone the moment of getting married until my career stabilizes	0.738	0.573	0.889
For an attractive career, I am ready to persevere even if my loved ones do not accept it	0.710	0.566	0.908
For an attractive career, I am ready to give up stability for a longer period of time, such as buying my own apartment	0.710	0.600	0.917
For an attractive career, I am ready to give up social and cultural entertainment for a long time	0.608	0.384	0.907
Career readiness – sacrifice (Eigenvalue 1.016; % of variance 6.77; Cronbach's alpha 0.707; KMO 0.671; Bartlett test sig. 0.000)			
I would rather live with the constant psychological risk of work than be stuck in poverty	0.742	0.602	0.924
I am willing to sacrifice my personal and family life for a while to gain prospects for a worthwhile career	0.604	0.641	0.912
For a good career, I am willing to endure various risks, such as the risk of being treated badly at work	0.530	0.565	0.890

Note: Extraction method – principal component analysis; rotation method – varimax; loadings below 0.53 are not presented; McDonald's omega 0.873.

Source: own

helpfulness and enjoyment of ICT (e.g., Using ICT makes me have more free time; or ICT is becoming more user friendly (intuitive)).

Based on literature sources, a scale was created to measure distrust in ICT (Komiak & Benbasat, 2008; Lewicka & Zakrzewska-Bielawska, 2022; McKnight & Chervany, 2001). In the case of ICT distrust, five components were created (Tab. 2): harmful ICT (e.g., I am afraid that ICTs can be used to peep at and eavesdrop on people); digital anxiety (e.g., I prefer to limit my use of ICTs for fear of being cheated/exploited); digital Illiteracy (e.g., I try to avoid changing communication devices (such as mobile phones, tablets) because of the accompanying stress); human-ICT competition (e.g., I fear ICT will make humans no longer necessary for certain jobs); and ICT scepticism (e.g., There are significant risks in using ICT). Three items from ICT distrust that did not load on the appropriate component were removed. Responses were given using a 7-point Likert-type scale, where 1 meant strongly disagree and 7 meant strongly agree.

Cronbach's alpha coefficient was used to assess the reliability of the individual scales. Their values exceeding 0.7 were considered as acceptable (Taber, 2018). For the overall

test, McDonald's omega coefficients were determined, its value being acceptable (Hayes & Coutts, 2020). The Kaiser-Meyer-Olkin (KMO) test measures the common variance between the components. The KMO value between 0.8 and 1.0 indicates that the sample is adequate. KMO values between 0.7 and 0.79 are average, 0.6 and 0.69 are medium (Shrestha, 2021). The Bartlett test of sphericity checks whether variables are intercorrelated. When

Tab. 2: Results of PCA on ICT trust and distrust dimensions – Part 1

Items	Loadings	Communalities	MSA
ICT distrust – harmful ICT (Eigenvalue 7.839; % of variance 34.08; Cronbach's alpha 0.876; KMO 0.887; Bartlett test sig. 0.000)			
I am concerned that ICT is being used to manipulate people	0.829	0.728	0.901
I am concerned that ICT can be used to spy and eavesdrop on people	0.814	0.719	0.897
ICT contributes to addiction	0.733	0.604	0.935
I am concerned that ICT can be used to damage someone's image	0.708	0.571	0.946
I am concerned that ICT is significantly changing the way we live	0.655	0.655	0.928
ICT distracts people from real problems in the world	0.629	0.570	0.958
ICT distrust – digital anxiety (Eigenvalue 2.994; % of variance 13.02; Cronbach's alpha 0.851; KMO 0.856; Bartlett test sig. 0.000)			
I am afraid my superiors use ICT to control what I do	0.784	0.671	0.928
I am very concerned that someone is using technology to spy and eavesdrop on everything I do	0.774	0.717	0.913
I am afraid of websites like Google, Yahoo, and Bing because they might allow other people to hurt me	0.725	0.692	0.926
I am afraid that robots may take over the world	0.679	0.645	0.929
I prefer to limit the use of ICT for fear of being cheated/used	0.597	0.655	0.945
ICT distrust – digital illiteracy (Eigenvalue 1.656; % of variance 7.20; Cronbach's alpha 0.793; KMO 0.693; Bartlett test sig. 0.000)			
I try to avoid changing communication devices (such as mobile phone, tablet) because of the stress involved	0.822	0.742	0.888
I feel anxious when I have to learn a new operating system on my computer (e.g., changing from Windows 7 or 8 to Windows 10)	0.816	0.725	0.892
If I need to use the new ICT, I feel anxious that I will not be able to fulfil my tasks as planned	0.649	0.632	0.943
ICT distrust – human-ICT competition (Eigenvalue 1.095; % of variance 4.76; Cronbach's alpha 0.806; KMO 0.659; Bartlett test sig. 0.000)			
I fear that, thanks to the development of ICT, many people will lose their jobs	0.836	0.792	0.858
I am afraid that ICT will make a human no longer necessary in some professions	0.795	0.769	0.861
ICT security is not enough to make me feel safe using this technology	0.600	0.639	0.936

Tab. 2: Results of PCA on ICT trust and distrust dimensions – Part 2

Items	Loadings	Communalities	MSA
ICT distrust – ICT scepticism (Eigenvalue 1.071; % of variance 4.66; Cronbach's alpha 0.761; KMO 0.817; Bartlett test sig. 0.000)			
ICT meets my expectations to a small extent	0.701	0.577	0.925
I believe that ICT companies should be more sensitive to the needs of users	0.677	0.605	0.892
I am afraid that I will not complete my tasks due to the unreliability of ICT	0.620	0.574	0.917
ICT companies fail to deliver on technology functionality promises	0.582	0.514	0.928
Recommendations, even from people who are significant to me, do not increase my acceptance of ICT	0.507	0.409	0.944
The use of ICT involves significant risk	0.473	0.452	0.946
ICT trust (Eigenvalue 4.061; % of variance 0.677; Cronbach's alpha 0.904; KMO 0.900; Bartlett test sig. 0.000)			
I believe that ICT is useful.	0.843	0.711	0.870
I am pleased to be able to use ICT news, including new applications, available updates	0.841	0.708	0.886
Thanks to ICT, I do not miss what is important, and I am up to date	0.829	0.687	0.915
Using ICT helps me make good decisions	0.819	0.671	0.906
Improving my ICT competencies makes me trust these solutions more and more	0.817	0.666	0.925
ICT makes the world a better place	0.786	0.618	0.904

Note: Extraction method – principal component analysis; rotation method: varimax; loadings below 0.47 are not presented; McDonald's omega 0.873.

Source: own

analyzing the test results, *p*-values lower than the assumed significance level are considered appropriate. Components obtained within the separated groups can, therefore, be treated as correct. In each case, the obtained statistics are satisfactory.

2.2 Research group

The research was conducted among Polish university students whose education was in occupations identified by the International Standard Classification of Occupation as threatened by automation (Mann et al., 2020). On the basis of desk research, the authors assumed that their trust/distrust of ICT would be particularly important for their level of career readiness and subsequent professional success. The 871 respondents were a heterogeneous group of students aged 18 to 25 years. Women predominated in the survey, and men accounted for approximately 34% of the respondents (three people refused to disclose their gender). This is due to the overall feminization of education in Poland, with 63% of females and 50% of males aged 18 to 24 in formal education in 2021 (Eurostat, 2023b), the ratio of females to males varies by field of study and was estimated to be 6 : 4 among students in the fields of study included in the survey (Statistics Poland, 2018). Analyzing the respondents in terms of their professional work, at the time of completing the survey, 52% of them were employed, and less than 5% had an allowance or disability pension. 12% declare that they have already worked professionally but quit their job, and 3% were dismissed from work. Two people were on parental leave.

Respondents completed an online version of the questionnaire prepared in Google Forms, which comprised 43 items and a metric. The research was anonymized to ensure full confidentiality of respondents, and approval was obtained from the Research Ethics Committee.

3. Results and discussion

3.1 Results

At the initial stage, the data obtained were analyzed in terms of mean scores of the parameters studied for the whole group and separately for both genders (Tab. 3). Among the dimensions constituting career readiness, the highest score was achieved by the respondents in terms of determination, followed by sacrifice and the lowest by engagement. In addition, women scored significantly higher on the determination dimension and significantly lower on the engagement dimension. This means that they (compared to men) are hopeful and optimistic about their careers and have a sense of self-efficacy, while they perceive it less as the overriding value in life. They do not want to invest all their energy in their career.

On the scales measuring ICT distrust, gender differences were also noted. Women experienced higher levels of digital anxiety and felt more threat from human-ICT competition for jobs.

In the second step of the statistical analysis, the confirmatory factor analysis (CFA) was conducted. The authors assumed the direction of the interaction of the variables which they included in the model. The methodological approach adopted made it possible to verify these assumptions. In the tested model dimensions measuring ICT trust-distrust are causally related to three dimensions measuring career readiness. The three versions of the model were elaborated: for the general group scores and separately for each gender. Thanks to this, differences in the impact of ICT trust on men's and women's readiness for a career have been demonstrated.

The statistics values obtained for each model are similar and acceptable in each case. The best fit of the model was obtained for the full data set. The determination of the model parameters for three significantly different data sets allowed us to increase the credibility of the results obtained. The calculation was carried out using MLE estimators, and the obtained results were standardized. The quality of fit of the models to the data was assessed using typical statistics (Tab. 4).

In the next step of the research procedure, the structural equation models (SEM) were estimated. Visualization of the model is shown in Fig. 1. All constructs in the model were treated as latent variables based on items obtained earlier in exploratory analysis. The calculations were made in the STATA environment. The results of the estimation are presented in Tab. 5.

Tab. 3: Descriptive statistics

Variables Mean		Total scores		Women's scores			Men's scores			Women vs men
		Mean	S.D.	Mean	S.D.	Median	Mean	S.D.	Median	*p* (*t*-test)
Career readiness	Determination	5.18	1.07	**5.30**	**1.06**	**5.43**	**5.04**	**1.02**	**5.14**	**0.000**
	Engagement	3.88	1.34	**3.83**	**1.38**	**4.00**	**4.07**	**1.25**	**4.00**	**0.005**
	Sacrifice	4.13	1.25	4.11	1.30	4.00	4.13	1.16	4.20	0.287
ICT trust		4.74	1.25	4.75	1.23	5.00	4.74	1.27	4.83	0.706
ICT distrust	ICT skepticism	3.88	0.96	3.89	0.96	4.00	3.39	0.91	4.00	0.361
	Digital illiteracy	3.10	1.42	3.17	1.45	3.00	3.00	1.35	3.00	0.327
	Harmful ICT	4.87	1.21	4.95	1.21	5.00	4.85	1.16	4.83	0.198
	human-ICT competition	4.28	1.40	**4.45**	**1.39**	**4.67**	**3.96**	**1.34**	**4.00**	**0.000**
	Digital anxiety	3.22	1.32	**3.31**	**1.33**	**3.20**	**3.09**	**1.29**	**3.00**	**0.011**

Note: Values in bold – coefficients significantly different from zero with significance level 5%.

Source: own

It is crucial to note that the SEM analysis in general is based on correlational analysis. The correlational analysis does not establish causality but rather identifies the presence of a relationship between the variables under investigation. The direction of the relationship is determined solely by the researcher's priori assumptions. Despite its limitations, there is no clearly superior alternative to utilizing SEM analysis. Statistically identifying causality requires having data in the form of time series, which is not yet feasible in studies of this nature.

The patterns revealed in the SEM allowed the authors to categorize the independent variables. The ICT trust dimension was classified as a career catalyst. This variable explains all

Tab. 4: Model fit statistics

	Model 1 (men and women)	Model 2 (women only)	Model 3 (men only)
Absolute measures			
RMSEA	0.058	0.063	0.056
GFI	0.822	0.795	0.748
Incremental-fit measures			
CFI	0.860	0.845	0.853
TLI	0.848	0.832	0.841
Size of residuals			
SRMR	0.071	0.071	0.088

Source: own

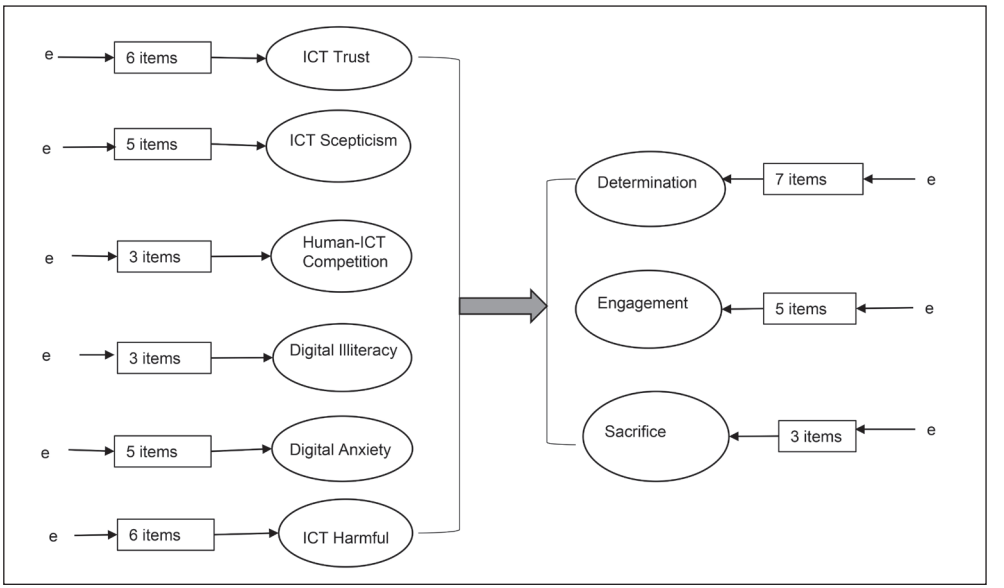


Fig. 1: Visualization of the tested structural equations model

Source: own

dimensions of career readiness. For women, ICT trust has the same effect as in the general model on career readiness. In contrast, for men, the relationship between ICT trust and engagement did not emerge.

The explanatory variable human-ICT competition is a component of the same category as above. It explains in a statistically significant way that an increase in its level contributes to greater determination towards a career goal. This relationship is observed in the overall respondents as well as in the male group. Women, although they achieve significantly higher levels of this variable, it is not a catalyst for them.

The independent variable that makes up the career inhibitors category is digital illiteracy, which statistically significantly explains the decrease in determination in the two models – general and female. The greater the perception of a lack of competence, the lower the career push, the weaker the goal orientation, which may result in difficulties in the transition from education to the labour market and passivity. However, this pattern was not apparent in men, despite the same level of illiteracy declared.

The second variable from the group of career inhibitors is harmful ICT, which statistically significantly determines a decrease in career engagement, as above, in two of the analyzed general and female models. Men do not decrease their engagement under the influence of this type of distrust, despite achieving a comparable perception with women of ICT as a tool that can be used to hurt others.

Tab. 5: The results of CFA

Standardised			Model 1 (men and women)			Model 2 (women only)			Model 3 (men only)		
Career readiness		Trust and distrust	Beta	SE	*p*	Beta	SE	*p*	Beta	SE	*p*
Determination	←	**ICT trust**	**0.29**	**0.04**	**0.000**	**0.27**	**0.04**	**0.000**	**0.34**	**0.060**	**0.000**
Determination	←	**ICT scepticism**	0.12	0.07	0.095	0.12	0.08	0.130	0.12	0.170	0.469
Determination	←	**Digital illiteracy**	**−0.25**	**0.07**	**0.001**	**−0.20**	**0.07**	**0.006**	−0.30	0.200	0.141
Determination	←	**Harmful ICT**	0.06	0.06	0.339	0.04	0.07	0.576	0.12	0.120	0.299
Determination	←	**human-ICT competition**	**0.14**	**0.06**	**0.028**	0.02	0.08	0.803	**0.23**	**0.100**	**0.022**
Determination	←	**Digital anxiety**	−0.01	0.07	0.866	0.00	0.08	0.964	−0.10	0.130	0.442
Engagement	←	**ICT trust**	**0.14**	**0.04**	**0.002**	**0.15**	**0.05**	**0.002**	0.13	0.080	0.086
Engagement	←	**ICT scepticism**	0.10	0.08	0.206	0.13	0.09	0.126	−0.35	0.220	0.102
Engagement	←	**Digital illiteracy**	−0.07	0.08	0.383	−0.10	0.08	0.221	0.37	0.260	0.156
Engagement	←	**Harmful ICT**	**−0.15**	**0.07**	**0.034**	**−0.17**	**0.08**	**0.027**	0.11	0.150	0.458
Engagement	←	**human-ICT competition**	0.08	0.07	0.267	0.05	0.08	0.531	0.05	0.120	0.678
Engagement	←	**Digital anxiety**	0.11	0.08	0.179	0.12	0.09	0.161	0.01	0.160	0.947
Sacrifice	←	**ICT trust**	**0.01**	**0.04**	**0.000**	**0.12**	**0.05**	**0.012**	**0.16**	**0.070**	**0.022**
Sacrifice	←	**ICT scepticism**	0.10	0.08	0.197	0.15	0.08	0.073	−0.32	0.190	0.096
Sacrifice	←	**Digital illiteracy**	−0.04	0.08	0.570	−0.06	0.08	0.438	0.22	0.230	0.343
Sacrifice	←	**Harmful ICT**	−0.02	0.07	0.728	−0.08	0.07	0.307	0.18	0.013	0.179
Sacrifice	←	**human-ICT competition**	0.02	0.07	0.787	−0.02	0.08	0.834	−0.02	0.110	0.867
Sacrifice	←	**Digital anxiety**	0.09	0.08	0.245	0.10	0.09	0.263	0.014	0.14	0.311

Note: Values in bold – coefficients significantly different from zero with significance level 5%.

Source: own

The authors noted yet a third category of variables-career neutral. These included ICT scepticism and ICT anxiety, in their cases there was no statistically significant effect on the career readiness dimensions in any of the models studied.

3.2 Discussion

In response to the identified research gaps, in this study the authors sought to add to the body of knowledge on two issues: the impact of trust and distrust in technology on dimensions of career readiness and the identification of those dimensions of trust and distrust that are determined by the gender of the respondent. Three groups of factors influencing career readiness were identified: catalysts, inhibitors and neutrals (Fig. 2).

The literature reports inconsistent findings on career readiness between men and women. Some show higher readiness among men, others among women, while a third testifies to a lack of gender differentiation (Parietti et al., 2016). The current study observed higher readiness among women in the dedication dimension, lower readiness in the engagement dimension and no gender difference in the sacrifice dimension. This result therefore confirms the differential role of gender in the context of career readiness.

ICT trust fosters goal determination, a sense of career-related self-efficacy and optimism. Since trust itself promotes risk-taking (Waskito et al., 2023), the ICT trust can be seen as a catalyst for enabling proactive career readiness behaviour. Its positive association with engagement indicates a kind of heroism and recognition of career as an overriding life value. According to the authors, it enables women to overcome, identified and described in earlier studies (Parietti et al., 2016), the tendency to feel role conflict and mental barriers. They can also identify more with their profession and career path.

Trust also has its dark side. It can lead to negative consequences, such as an excessive tendency to comply, which can be an invitation to abuse (Molina-Morales et al., 2011). Excessive trust may be associated with

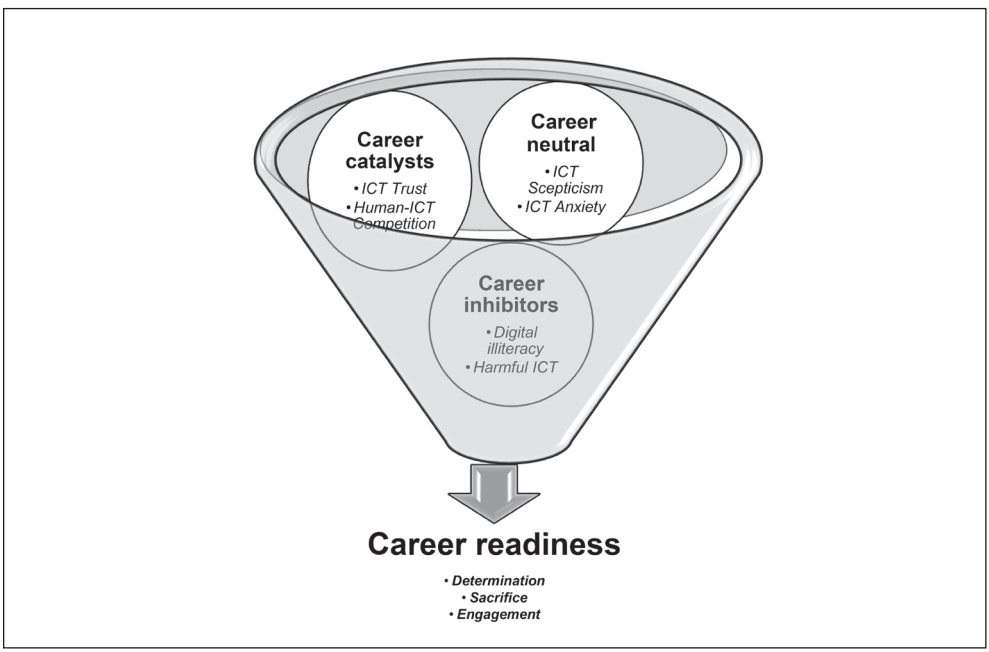


Fig. 2: **Funnel model of trust and distrust in ICT**

Source: own

a weakening of trustor control behaviour and trustee opportunistic behaviour (Lewicka, 2019). Therefore, high levels of ICT trust may result in an increased willingness to make sacrifices and acquiescence to even unethical and discriminatory labour market practices.

Human-ICT competition, on the other hand, loses its catalytic function for women, which can be explained by their fear of competition (Buser et al., 2012), and this hinders career-related action. The perception of ICT solutions as rivals to compete with and who may prove more desirable than a man for a job is stimulating and offers opportunities to gain an advantage, but mainly to men.

Digital Illiteracy in the case of women may be a derivative of their excessive self-criticism (Quirós et al., 2018). In addition, a lowered tolerance for their own incompetence, which, when they perceive it, can have negative effects on career readiness.

The second inhibitor is harmful ICT, causing the willingness to heroically fight for a career and stake everything on it to diminish with the perception of the potential danger of using ICT tools. Research suggests that the lack of confirmation of this relationship in the male model may be due to the fact that they are less vulnerable and less sensitized to unfair actions (Hashmi & Waqar, 2018). A second reason may be the gender-determined brain asymmetry and brain patterns made visible by neuroimaging methods. Female brains, having connections between the hemispheres, are predisposed to holistic judgement, appealing to intuition, and responding empathetically also towards strangers and even hostile people. Male brains are dominated by the connection between structures located on the same side, empathy is "pragmatic," shown only to people sympathetic to them (Keverne, 2017).

In summary, the variables in the category of career inhibitors are not significant for the male respondents. In the case of women, they may make the transition from the education market to the labour market more difficult, prompting them to decrease the intensity of their efforts in pursuing a career.

Relatively low levels of ICT anxiety did not affect career readiness, although the literature reports its negative association with digital skills, job and career satisfaction (Rahmani et al., 2023). The study found that women were significantly more affected by ICT anxiety, which may be explained by their use of anxiety coping strategies such as focusing on emotions or avoidance. These strategies are sometimes rated as less effective than the problem-focused strategies used by men (Mark & Smith, 2018). The results observed in the study may also be due to gender stereotypes determining men's lower willingness to admit to digital anxiety (Mark & Smith, 2018).

3.3 Limitations

Only selected variables were analyzed in the study and although the model tested was a good fit, it is not excluded that other parameters, e.g., other digital competence components, influence career readiness. Furthermore, the study group represented only selected universities and faculties, which may make it difficult to extrapolate the results to the entire population of young adults. The study did not control for individual variables, apart from gender and age, which may have an important role in shaping the relationship between confidence in technology and career readiness, e.g., experience, economic status, interests, and personality traits (especially neuroticism and extraversion).

Conclusions

The pace of change, and the difficulty in distinguishing between what is real and what is not real, intensifie the perceived fears of respondents and make them feel that technology is out of control. This fact necessitates research on trust and distrust in technology and their antecedences and implications.

Directions for future research in identifying the antecedents of trust and distrust in ICTs may concern personal characteristics (e.g., personality, digital skills, education level and truck including in curriculum AI issues, character of job and level of automation, demographic factors, digital experience); organizational characteristics (e.g., organizational support, sector, size of the organization, IT solutions used, compatibility of digital systems used, innovation readiness); or environmental characteristics (e.g., social factors, legal solutions, degree of digitalization of society).

Research on the implications of trust and distrust in ICT may cover areas such as the degree of use of digital solutions, user satisfaction with various ICT solutions, dimensions and dynamics of careers based on digital skills, digital pathologies

– e.g., technophobia and technophilia, characterized by inadequate response to digital stimuli, digital well-being or the functioning of an organization where digital solutions are introduced in personnel management.

The authors also see potential in the application of research methods and procedures involving the use of experiments, including those conducted in augmented reality and longitudinal studies giving the possibility to assess the change in trust over time depending on a set of variables, e.g., experience of use.

In the application dimension, research on ICT trust and distrust can be used to design new technological solutions so that they induce the desired attitudes towards ICT in users, preparation of programmes to promote ICT solutions among groups characterized by distrust towards digital technologies or preparation of methods and workshops to bridge the digital gap and prevent digital exclusion.

Acknowledgments: *The project financed within the Regional Initiative for Excellence Programme of the Minister of Science and Higher Education of Poland, years 2019–2023, grant No. 004/RID/2018/19, financing 3,000,000 PLN and supported by funds granted by the Minister of Science of the Republic of Poland under the "Regional Initiative for Excellence" Programme for the implementation of the project "The Poznań University of Economics and Business for Economy 5.0: Regional Initiative – Global Effects (RIGE)." Publication financed by the subvention for maintenance and development of research potential of AGH University of Science and Technology.*

References

Abdi, H. (2003). Factor rotations in factor analyses. In *Encyclopedia for research methods for the social sciences* (pp. 792–795). Sage.

Bagheri, N., & Jamieson, G. A. (2004). Human performance, situation awareness, and automation: Current research and trends. In D. A. Vincenzi, M. Mouloua, & P. A. Hancock (Eds.), *Human performance, situation awareness, and automation: Current research and trends* (pp. 54–59). Lawrence Erlbaum Associates, Inc.

Balakrishnan, J., & Dwivedi, Y. K. (2021). Role of cognitive absorption in building user trust and experience. *Psychology and Marketing*, *38*(4), 643–668. https://doi.org/10.1002/mar.21462

Bańka, A. (2015). Konstrukcja i walidacja Skali Gotowości do Kariery (SGK) [Construction and validation of the career readiness scale (CRS)]. *Czasopismo Psychologiczne. Psychological Journal*, *21*(2), 273–290.

Bellemare, C., & Kröger, S. (2007). On representative social capital. *European Economic Review*, *51*(1), 183–202. https://doi.org/10.1016/j.euroecorev.2006.03.006

Benlian, A., & Hess, T. (2011). The signaling role of IT features in influencing trust and participation in online communities. *International Journal of Electronic Commerce*, *15*(4), 7–56. https://doi.org/10.2753/jec1086-4415150401

Bewsell, G. R. (2012). Distrust, fear and emotional learning: An online auction perspective. *Journal of Theoretical and Applied Electronic Commerce Research*, *7*(2), 1–12. https://doi.org/10.4067/s0718-18762012000200002

Broos, A. (2005). Gender and information and communication technologies (ICT) anxiety: Male self-assurance and female hesitation. *CyberPsychology & Behavior*, *8*(1), 21–31. https://doi.org/10.1089/cpb.2005.8.21

Buser, T., Niederle, M., & Oosterbeek, H. (2012). *Gender, competitiveness and career choices* (NBER Working Paper No. 18576). NBER Working Paper Series. National Bureau of Economic Research. https://doi.org/10.3386/w18576

Cho, J. (2006). The mechanism of trust and distrust formation and their relational outcomes. *Journal of Retailing*, *82*(1), 25–35. https://doi.org/10.1016/j.jretai.2005.11.002

Corrin, L., Apps, T., Beckman, K., & Bennet, S. (2020). The myth of the digital native and what it means for higher education. In A. Attrill-Smith, C. Fullwood, M. Keep, & D. J. Kuss (Eds.), *The Oxford handbook of cyberpsychology* (pp. 98–114). Oxford University Press.

Culié, J.-D., Vo, L. C., & Philippe, X. (2021). L'influence de la transformation digitale sur l'évolution des carrières: Opportunités perçues et inertie structurelle au sein de collectivités territoriales [The influence of the digital transformation on the evolution]. *Politiques et Management Public*, *38*(3), 277–298. https://doi.org/10.3166/pmp.38.2021.0016

Ejdys, J. (2018). Building technology trust in ICT application at a university. *International Journal of Emerging Markets*, *13*(5), 980–997. https://doi.org/10.1108/IJoEM-07-2017-0234

Eurostat. (2023a). *Individuals' level of digital skills (from 2021 onwards)*. https://ec.europa.eu/

eurostat/databrowser/view/ISOC_SK_DSKL_I21__custom_5241706/default/table?lang=en

Eurostat. (2023b). *Participation rate of young people in formal education by sex age and labour status*. https://ec.europa.eu/eurostat/databrowser/view/EDAT_LFSE_18__custom_959098/bookmark/table?lang=en&bookmarkId=f8dd0a96-2ac7-4224-be85-5b086cbc38b8

Ferrari, A. (2013). DIGCOMP: A framework for developing and understanding digital competence in Europe. In *JRC Scientific and Policy Reports*. Joint Research Centre, Institute for Prospective Technological Studies. European Commission. https://doi.org/10.2788/52966

Hashmi, S., & Waqar, S. (2018). Perceived organizational justice and workplace reactivity among telecommunication employees: Gender as moderator. *Pakistan Journal of Psychological Research*, *33*(2), 521–540.

Hayes, A. F., & Coutts, J. J. (2020). Use Omega rather than Cronbach's alpha for estimating reliability. But.... *Communication Methods and Measures*, *14*(1), 1–24. https://doi.org/10.1080/19312458.2020.1718629

Heilman, M. E., & Parks-Sramm, E. J. (2007). Gender stereotypes in the workplace: Obstacles to women's career progress. In S. J. Correll (Ed.), *Social psychology of gender* (pp. 47–78). Elsevier.

Hirschi, A. (2011). Career-choice readiness in adolescence: Developmental trajectories and individual differences. *Journal of Vocational Behavior*, *79*(2), 340–348. https://doi.org/10.1016/j.jvb.2011.05.005

Hua, D. M., Davison, C. B., & Gondi, V. K. (2022). Enhancing student career readiness through skills infusion. *Information Systems Education Journal*, *20*(5), 27–33.

Jarvenpaa, S. L., Shaw, T. R., & Staples, D. S. (2004). Toward contextualized theories of trust: The role of trust in global virtual teams. *Information Systems Research*, *15*(3), 250–267. https://doi.org/10.1287/isre.1040.0028

Keverne, E. B. (2017). *Beyond sex differences: Genes, brains and matrilineal evolution*. Cambridge University Press.

Komiak, S. Y. X., & Benbasat, I. (2008). A two-process view of trust and distrust building in recommendation agents: A process-tracing study. *Journal of the Association for Information Systems*, *9*(12), 727–747. https://doi.org/10.17705/1jais.00180

Kowalczyk, E. (2022). Digital competences of Generation Z in the area of work and professional development. *Scientific Papers of Silesian University of Technology Organization and Management Series*, *159*, 169–182. https://doi.org/10.29119/1641-3466.2022.159.13

Lacova, Ż., Kurakova, I., Horehajova, M., & Vallusova, A. (2022). How is digital exclusion manifested in the labour market during the COVID-19 pandemic in Slovakia? *Forum Scientiae Oeconomia*, *10*(2), 129–151. https://doi.org/10.23762/FSO_VOL10_NO2_7

Lankton, N. K., McKnight, D. H., & Tripp, J. (2015). Technology, humanness, and trust: Rethinking trust in technology. *Journal of the Association for Information Systems*, *16*(10), 880–918. https://doi.org/10.17705/1jais.00411

Lankton, N., McKnight, D. H., & Thatcher, J. B. (2014). Incorporating trust-in-technology into expectation disconfirmation theory. *The Journal of Strategic Information Systems*, *23*(2), 128–145. https://doi.org/10.1016/j.jsis.2013.09.001

Lee, J. D., & See, K. A. (2004). Trust in automation: Designing for appropriate reliance. *Human Factors: The Journal of the Human Factors and Ergonomics Society*, *46*(1), 50–80. https://doi.org/10.1518/hfes.46.1.50_30392

Lewicka, D. (2019). *Zarzadzanie kapitałem ludzkim a zaangażowanie pracowników* [Human capital management and employee engagement]. Wydawnictwo C.H. Beck.

Lewicka, D., Karp-Zawlik, P., & Pec, M. (2017). Organizational trust and normative commitment. *Annales Universitatis Mariae Curie-Skłodowska, sectio H, Oeconomia*, *51*(3), 71–83. https://doi.org/10.17951/h.2017.51.3.71

Lewicka, D., & Zakrzewska-Bielawska, A. F. (2020). Interorganizational trust in business relations: Cooperation and coopetition. In A. F. Zakrzewska-Bielawska & I. Staniec (Eds.), *Springer Proceedings in Business and Economics, Contemporary Challenges in Cooperation and Coopetition in the Age of Industry 4.0* (Vol. 4, pp. 155–174). Springer International Publishing.

Lewicka, D., & Zakrzewska-Bielawska, A. F. (2022). Trust and distrust in interorganisational relations – Scale development. *PLOS ONE*, *17*(12), 0279231. https://doi.org/10.1371/journal.pone.0279231

Liu, F., Xiao, B., Lim, E. T. K., & Tan, C.-W. (2017). Investigating the impact of gender differences on alleviating distrust via electronic word-of-mouth. *Industrial Management & Data Systems*, *117*(3), 620–642. https://doi.org/10.1108/imds-04-2016-0150

Luxoft Poland. (2023). *Raport z badania społeczności IT* [IT community survey report]. https://bulldogjob.pl/it-report/2023

Mahmud, M. I., Amat, S., Abu Bakar, A. Y., Kee, C. P., & Othman, Z. (2022). The effects of career readiness course on students career decision self-efficacy during COVID-19. *Special Education*, *2*(43), 273–281. https://doi.org/10.48080/jae.v17i3.86

Mann, A., Denis, V., Ekhtiari, H., Forsyth, T., & Chambers, N. (2020). *Dream jobs? Teenagers' career aspirations and the future of work*. OECD. https://www.oecd.org/education/dream-jobs-teenagers-career-aspirations-and-the-future-of-work.htm

Mark, G., & Smith, A. P. (2018). Coping and its relation to gender, anxiety, depression, fatigue, cognitive difficulties and somatic symptoms. *Journal of Education, Society and Behavioural Science*, *25*(4), 1–22. https://doi.org/10.9734/jesbs/2018/41894

Mcknight, D. H., Carter, M., Thatcher, J. B., & Clay, P. F. (2011). Trust in a specific technology: An investigation of its components and measures. *ACM Transactions on Management Information Systems*, *2*(2), 1–25. https://doi.org/10.1145/1985347.1985353

McKnight, D. H., & Chervany, N. L. (2001). Trust and distrust definitions: One bite at a time. In R. Falcone, M. Singh, & Y. H. Tan (Eds.), *Lecture Notes in Computer Science. Trust in cybersocieties* (Vol. 224, pp. 27–54). Springer-Verlag. https://doi.org/10.1007/3-540-45547-7_3

McKnight, D. H., Liu, P., & Pentland, B. T. (2020). Trust change in information technology products. *Journal of Management Information Systems*, *37*(4), 1015–1046. https://doi.org/10.1080/07421222.2020.1831772

Molina-Morales, F. X., Martínez-Fernández, M. T., & Torlo, V. J. (2011). The dark side of trust: The benefits, costs and optimal levels of trust for innovation performance. *Long Range Planning*, *44*(2), 118–133. https://doi.org/10.1016/j.lrp.2011.01.001

Mukherjee, S. (2020). What drives gender differences in trust and trustworthiness? *Public Finance Review*, *48*(6), 778–805. https://doi.org/10.1177/1091142120960801

Newell, M. J., & Ulrich, P. N. (2022). Competent and employed: STEM alumni perspectives on undergraduate research and NACE career-readiness competencies. *Journal of Teaching and Learning for Graduate Employability*, *13*(1), 79–93. https://doi.org/10.21153/jtlge2022vol13no1art1534

Ng, D. T. K., Leung, J. K. L., Chu, S. K. W., & Qiao, M. S. (2021). Conceptualizing AI literacy: An exploratory review. *Computers and Education: Artificial Intelligence*, *2*, 100041. https://doi.org/10.1016/j.caeai.2021.100041

Nguyen, C. T. (2022). Trust as an unquestioning attitude. In *Oxford Studies in Epistemology* (Vol. 7, pp. 214–244). Oxford University Press. https://doi.org/10.1093/oso/9780192868978.003.0007

Nick, G. (2023). *101 artificial intelligence statistics* [Updated for 2023]. TechJury.

OECD. (2021a). *Career readiness in the pandemic: A summary of project findings*. Organisation for Economic Co-Operation and Development (OECD). https://doi.org/10.1787/e9544a77-en

OECD. (2021b). *Career readiness in the pandemic: Insights from new international research for secondary schools* (Vol. 44). Organisation for Economic Co-Operation and Development (OECD). https://doi.org/10.1787/8b1215dc-en

Okdie, B. M., & Rempala, D. M. (2020). Socially connecting thgrough blogs and vlogs: A social connections approach to blogging and vlogging motivation. In A. Attrill-Smith, C. Fullwood, M. Keep, & D. J. Kuss (Eds.), *The Oxford handbook of cyberpsychology* (pp. 394–412). Oxford University Press.

Parietti, M., Lower, L., & McCray, K. (2016). The career readiness of intercollegiate athletes: Is there a gender gap? *Journal of Issues in Intercollegiate Athletics*, *9*, 283–302.

Pirzada, K., & Khan, F. N. (2013). Measuring relationship between digital skills and employability. *European Journal of Business and Management*, *5*(24), 124–134.

Rahmani, D., Zeng, C., Chen, M., Fletcher, P., & Goke, R. (2023). Investigating the effects of online communication apprehension and digital technology anxiety on organizational dissent in virtual teams. *Computers in Human Behavior*, *144*, 107719. https://doi.org/10.1016/j.chb.2023.107719

Rakowska, A. (2021). *Różnorodność zasobów ludzkich w organizacji – Istota, dylematy, wyzwania* [Diversity of human resources in the organization – Essence, dilemmas, challenges]. Wydawnictwo UMCS.

Raluca, D., & Phillips, T. (2022). The gender digital gap: Shifting the theoretical focus to systems analysis and feedback loops. *Information, Communication & Society*, *26*(10), 2071–2087. https://doi.org/10.1080/1369118x.2022.2069507

Sampson, J. P., McClain, M., Musch, E., & Reardon, R. C. (2013). Variables affecting readiness to benefit from career interventions. *Career*

Development Quarterly, *61*(2), 98–109. https://doi.org/10.1002/j.2161-0045.2013.00040.x

Sholikah, M. (2021). Roles of career maturity mediating the effects of locus of control and socioeconomic status on career readiness. *International Journal of Evaluation and Research in Education (IJERE)*, *10*(3), 781–789. https://doi.org/10.11591/ijere.v10i3.21127

Shrestha, N. (2021). Factor analysis as a tool for survey analysis. *American Journal of Applied Mathematics and Statistics*, *9*(1), 4–11. https://doi.org/10.12691/ajams-9-1-2

Siddiq, F., & Scherer, R. (2019). Is there a gender gap? A meta-analysis of the gender differences in students' ICT literacy. *Educational Research Review*, *27*, 205–217. https://doi.org/10.1016/j.edurev.2019.03.007

Southworth, J., Migliaccio, K., Glover, J., Glover, J., Reed, D., McCarty, C., Brendemuhl, J., & Thomas, A. (2023). Developing a model for AI across the curriculum: Transforming the higher education landscape via innovation in AI literacy. *Computers and Education: Artificial Intelligence*, *4*, 100127. https://doi.org/10.1016/j.caeai.2023.100127

Statistics Poland. (2018). *Adult education 2016. Statistical analyses*. https://stat.gov.pl/obszary-tematyczne/edukacja/edukacja/ksztalcenie-doroslych-2016,3,3.html

Taber, K. S. (2018). The use of Cronbach's alpha when developing and reporting research instruments in science education. *Research in Science Education*, *48*(6), 1273–1296. https://doi.org/10.1007/s11165-016-9602-2

Teo, T. S. H., Srivastava, S. C., & Jiang, L. (2008). Trust and electronic government success: An empirical study. *Journal of Management Information Systems*, *25*(3), 99–131. https://doi.org/10.2753/mis0742-1222250303

Thatcher, J. B., Carter, M., Li, X., & Rong, G. (2013). A classification and investigation of trustees in B-to-C e-commerce: General vs. specific trust. *Communications of the Association for Information Systems*, *32*(1), 107–134. https://doi.org/10.17705/1cais.03204

Ullman-Margalit, E. (2004). Trust, distrust and the in-between. In R. Hardin (Ed.), *Distrust*. Russell Sage Foundation.

Van der Werff, L., Fox, G., Masevic, I., Emeakaroha, V. C., Morrison, J. P., & Lynn, T. (2019). Building consumer trust in the cloud: An experimental analysis of the cloud trust label approach. *Journal of Cloud Computing*, *8*, 6(2019). https://doi.org/10.1186/s13677-019-0129-8

Vuorikari, R., Kluzer, S., & Punie, Y. (2022). *DigComp 2.2, the digital competence framework for citizens: With new examples of knowledge, skills and attitudes*. Publications Office of the European Union. https://doi.org/10.2760/490274

Waskito, J., Kussudyarsana, K., Imronudin, I., & Linansya, W. (2023). The impact of organizational justice on the organizational citizenship behavior of contract workers in Indonesia: The role of exchange quality and multifocal trust. *Gadjah Mada International Journal of Business*, *25*(1), 72–92. https://doi.org/10.22146/gamaijb.65476

Wong, L.-W., Tan, G. W.-H., Ooi, K.-B., & Dwivedi, Y. (2023). The role of institutional and self in the formation of trust in artificial intelligence technologies. *Internet Research*, *34*(2), 343–370. https://doi.org/10.1108/intr-07-2021-0446

World Economic Forum. (2023). *Future of jobs report 2023*. https://www.weforum.org/reports/the-future-of-jobs-report-2023/

Wu, Y., Hall, A. S. M., Siehl, S., Grafman, J., & Krueger, F. (2020). Neural signatures of gender differences in interpersonal trust. *Frontiers in Human Neuroscience*, *14*, 225. https://doi.org/10.3389/fnhum.2020.00225

Xu, J., Le, K., Deitermann, A., & Montague, E. (2014). How different types of users develop trust in technology: A qualitative analysis of the antecedents of active and passive user trust in a shared technology. *Applied Ergonomics*, *45*(6), 1495–1503. https://doi.org/10.1016/j.apergo.2014.04.012

All articles in the journal have been double-blind peer reviewed by a minimum of two independent experts in the relevant field. Authors are responsible for the linguistic accuracy of their manuscripts.

Journal title: **E+M EKONOMIE A MANAGEMENT**
E&M ECONOMICS AND MANAGEMENT

Address of the editorial office
Technical University of Liberec
Faculty of Economics
Editorial Office of the E&M Economics and Management Journal
Voroněžská 13
461 17 Liberec 1
Czech Republic
Tel.: +420 485 352 345
E-mail: journal@tul.cz

The journal is published quarterly.

Subscription:
From 2024, the print format of the journal is suspended. The individual issues will be available for free in electronic form on the journal's website. The last print issue is Issue 4, Volume 26.

It is possible to order older issues only until present supplies are exhausted (20 EUR per issue).

Published by: Technical University of Liberec
Studentská 2, 461 17 Liberec 1, Czech Republic, ID no. 46747885

Production: Wolters Kluwer ČR, a. s.
U nákladového nádraží 10, 130 00 Praha 3, Czech Republic, ID no. 63077639

ISSN 1212-3609, ISSN (online) 2336-5064
www.ekonomie-management.cz