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Mapping the Global Research on Healthcare Management in the Context of Sustainable Development

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Abstract

The aim of this paper is to enhance the comprehension of the worldwide landscape of scientific publications centred on healthcare management within the framework of sustainable development to discern potential opportunities for undertaking more influential and substantial future research within the examined domain. This study employs scientific articles published within the scientific journals indexed in the Scopus database. Relevant documents were sought by utilising the keywords 'sustainab*', 'healthcare', and 'management' in the titles of articles. A total of 740 articles published from 2000 to 2023 (up to August 8) were selected for analysis. The study employed various bibliometric methods to analyse and visually represent the collected data. Biblioshiny, VOSviewer 1.6.16 software toolkits, and Scopus analytical tools were utilised for the bibliometric analysis. The acquired outcomes were integrated, and potential avenues for future research were discussed. The bibliometric analysis disclosed a noticeable upward trend in research concerning healthcare management in the context of sustainable development. The theoretical implications of this paper encompass a more profound comprehension of patterns and developments in the scientific literature. The practical implications extend to guiding the execution of bibliometric analyses and offering insights for prospective research endeavours. It is important to note that the conclusions drawn from this study are confined to data derived from the Scopus database. Future studies should consider incorporating a broader range of data sources for a more comprehensive analysis.

Key words

bibliometric analysis, biblioshiny, healthcare management, sustainability, scientific output.

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Introduction

Human rights encompass a comprehensive collection of fundamental entitlements inherent to all individuals. These rights are categorised into two main groups: civil and political. In the context of healthcare, human rights are closely linked to advocating for equitable opportunities, healthcare access, and the advancement of sustainable and responsible conduct. The realisation of numerous human rights, such as the right to life and healthcare, requires a sustainable environment (Hussain et al., 2021; Kwilinski, 2023; Letunovska et al., 2023; Polcyn et al., 2022; Arefieva et al., 2021). It stands to

mention that sustainability has been defined in various ways across different contexts. Most definitions imply an emphasis on approaches that yield favourable outcomes for both the present and future human and natural environments (Chen et al., 2021; Dzwigol, 2021; Szczepańska-Woszczyna & Kurowska-Pysz, 2016; Spicka et al., 2019). Sustainability encompasses the persistent balance of social, environmental, economic, and institutional elements within human society, as well as all components of the non-human environment (Lyulyov et al., 2023). Enriquez-Puga et al. (2009) noted that sustainability is characterised by the capacity of human activity to be conducted without depleting the accessible resources and causing harm to the environment, thereby preserving the ability to meet the needs of future generations without compromise.

The United Nations Conference on Environment and Development, also known as the 'Earth Summit' (Rio de Janeiro, 3–14 June 1992), marked a pivotal moment in history as it witnessed the signing of some of the most significant global environmental agreements (UN, 2023). Notably, the event spotlighted Agenda 21, an extensive action plan on a global scale. The primary objective of Agenda 21 was to actualise the idea of sustainable development by fostering the prudent utilisation of resources while concurrently facilitating economic growth.

In 2015, world leaders embraced the United Nations' 17 Sustainable Development Goals (SDGs) to tackle global challenges such as climate change, poverty, inequality, etc. (UN, 2015a). At the same time, population health is considered to be fundamental to sustainable development. Therefore, a discernible trend is emerging wherein the utilisation of SDGs is being incorporated into strategies within the realm of healthcare services (Schwartzman and Zucchi, 2021; Dementyev et al., 2021). This integration allows for the alignment of performance metrics with multiple SDGs, emphasising SDG 3, "Health and Well-being". SDG 3 focuses explicitly on ensuring healthy lifestyles and promoting well-being. It entails ambitious objectives encompassing the mitigation of diseases and mortality rates and enhancing health access and pharmaceutical provisions.

Within the WHO European Region, the role of health in sustainable development is delineated by three fundamental documents: the 2030 Agenda for Sustainable Development (UN, 2015b), Health 2020 – the European policy for health and well-being (WHO, 2013), and the roadmap adopted in 2017 by the WHO Regional Office for Europe to execute the 2030 Agenda (WHO, 2017). These documents establish a structure for national leaders to develop collaborations with development partners, domestic stakeholders, and civil society. This collaborative effort aims to achieve universal health and well-being and advance prosperous societies.

Healthcare systems serve as primary barriers in safeguarding populations against different hazards. Although healthcare facilities are susceptible to environmental strains, they could also contribute to adverse environmental effects, consequently impacting health. Healthcare, being one of the significant sources of environmental pollution, yields adverse effects on health due to its contribution to environmental degradation. According to the statistical data (WHO, 2023), healthcare accounts for over 4.4% of total global climate emissions. In turn, India generated over 33 ths. tonnes of medical waste during the seven months of the COVID-19 pandemic (Narang & Vij, 2021), in the United States, the collective greenhouse gas emissions produced by healthcare organisations saw a rise of around 6% between 2010 and 2018 (Eckelman et al., 2020), in the previous decade, the annual carbon footprint of the National Health Service England has surged to 21 million tonnes (NHS, 2010). Therefore, the healthcare sector must exhibit proactive leadership in decarbonisation, reshaping its growth trajectory to attain zero emissions, enhancing resilience, and fulfilling worldwide health objectives. Indeed,

environmentally sustainable healthcare facilities are prepared to anticipate, respond to, manage, recover from, and adjust to climate-induced shocks and pressures. Concurrently, they mitigate detrimental environmental consequences while capitalising on prospects to rehabilitate and enhance the environment, safeguarding the health and well-being of future generations.

Healthcare sectors worldwide may differ due to historical, economic, and cultural factors, but they share common functions related to service delivery, resource development, financing, and management (WHO, 2017). Ensuring the efficient and effective delivery of healthcare services is crucial in mitigating emerging diseases and fostering the health and well-being of populations. Numerous healthcare systems worldwide are dedicated to optimising resource utilisation and enhancing processes by fostering collaborative and integrated operations among all relevant stakeholders. Therefore, given today's social and economic challenges, the effective performance of these functions requires a strong focus on effective management.

In the past few decades, research on healthcare management has grown exponentially. However, the preliminary scientific literature review showed that until recently, only a limited number of systematic literature review papers have addressed the intersection of healthcare management and sustainability issues. Thus, the availability of reviews centred on healthcare management in the context of sustainable development is scarce. Therefore, considering the available literature gap and building upon the knowledge from existing scientific studies, the aim of this paper is to deepen the understanding of the global profile of scientific publications focusing on healthcare management in the context of sustainable development to identify the opportunities for conducting more impactful future research in the investigated field. The initial data for this study were collected from the extensive multi-disciplinary Scopus database. The search for relevant publications was conducted using the keywords 'sustainab*', 'healthcare', and 'management' in the titles of articles. The research provides a comprehensive overview of academia's interest in developing this study area. The study's theoretical contributions lie in identifying future research directions to advance the theory of healthcare management in the context of sustainable development.

This paper is structured as follows: the introduction section presents the research problem and the importance of analysing the scope of scientific literature concerning healthcare management in the context of sustainable development; the literature review section presents the initial findings of the scientific literature analysis on the subject under investigation; the methodology section outlines the materials and methods used to achieve the research aim; result section provides the findings of the bibliometric analysis; conclusion section discusses the main conclusions derived from the study and offers suggestions for future research directions.

1. Literature review

Recently, there has been a resurgence of interest among both practitioners and researchers in examining the influence of management on the performance of health systems and organisations (Dzwigol, 2022a; Miśkiewicz, 2019). Healthcare management is considered to be a scientific discipline offering guidance to the leadership of healthcare facilities (Cevik Onar et al., 2017). It encompasses various research fields, where the main ones are healthcare systems, public health systems, hospitals, and their networks. Noteworthy here, healthcare managers encompass a range of individuals, including senior doctors, nurses, allied specialised health professionals, and those responsible for overseeing general practitioner practices and hospitals (Wyatt, 2015).

Within healthcare facilities, a diverse array of challenges arises. Concerning the literature on these issues, Dwivedi et al. (2003) noted that the conversion of raw clinical data into contextually pertinent information stands as a prominent challenge in healthcare. Progress in information technology and telecommunications has enabled healthcare institutions to address the complex task of translating substantial volumes of medical data into clinically relevant insights. From a managerial standpoint, the above challenges have compelled healthcare stakeholders to explore alternative healthcare management concepts to mitigate information overload (Dzwigol, 2022b).

Prompted by the economic crisis, political decision-makers and managers strive to re-establish control over healthcare system costs by refocusing efforts on managing inputs (Smilianov et al., 2020; Dzwigol, 2019). Health organisations face imposed limitations on staff recruitment or replacement, adjusted purchasing policies, and explorations of new technologies. However, this renewed focus on inputs and resource management carries certain drawbacks (Lega et al., 2013). Firstly, cost-containment strategies do not inherently lead to significant structural changes in the operational methods adopted by healthcare professionals and administrative personnel within these organisations. Secondly, cost management policies could impact both high- and low-performing organisations within the same healthcare system (Dacko-Pikiewicz, 2021; Szczepańska-Woszczyna & Gatnar, 2022). Furthermore, if these cost-cutting measures are applied uniformly, it could significantly undermine the principle of universality. Without fundamental shifts in the approach to delivering healthcare services, these cuts may predominantly affect factors such as access, equitable treatment, and overall service quality. Considering the above, Lega et al. (2013) indicated that any healthcare system, whether predominantly funded through taxes, social insurance or operates in a market-based model, has grappled with the sustainability challenge. In this context, sustainability refers to the ability to uphold quality and comprehensive service provision while ensuring affordability.

According to the Alliance for Natural Health (2010), sustainable healthcare could be defined as an intricate system encompassing various approaches to restore, manage, and enhance human health. This system is ecologically rooted, economically, socially, and environmentally viable over the long term. It operates in harmony with both human well-being and the broader environment, ensuring fairness and minimising disproportionate impacts on key components of the healthcare system (Kharazishvili & Kwilinski, 2022; Kwilinski et al., 2020; Szczepańska-Woszczyna et al., 2022; Zhanibek et al., 2022). Recently, the scientific literature has been expanding the scope of research on sustainability in healthcare management. There is an avenue of research in sustainable healthcare management that has centred on facilitating organisational change within the dynamic healthcare landscape (Szczepańska-Woszczyna, 2018; Trushkina et al., 2021; Trzeciak et al., 2022; Szczepanska-Woszczyna & Bogaczyk, 2023). This application of management theories and practices has explored the ways in which an organisation's vision, mission, and strategy can be realigned to align with a sustainability agenda (Punnakitikashem & Hallinger, 2019; Szczepańska-Woszczyna & Gajdzik, 2016; Dacko-Pikiewicz, 2019; Dzwigol, 2023).

Certain initiatives aimed at reshaping healthcare organisations to align with a sustainability agenda have prominently focused on embracing the triple bottom line framework, which encompasses the social, environmental, and economic dimensions of sustainable development (Szczepańska-Woszczyna et al., 2021; Kwilinski et al., 2023; Chen et al., 2023). These programs emphasise the necessity of involving various healthcare stakeholders in defining and attaining sustainability objectives that cover all three dimensions (Ramirez et al., 2013).

The acknowledgement of the interrelated nature of sustainability challenges has prompted increased attention towards how the healthcare system influences sustainability on community and organisational levels. An illustration of this is the emergence of 'disinvestment' as a subject of interest, largely spurred by policy initiatives undertaken by the National Health Service in the UK (Daniels et al., 2013). In the context of the bibliometric review conducted in this paper, the authors acknowledge the existence of previous bibliometric reviews in related fields. These reviews have covered topics such as green and sustainable healthcare (Berniak-Woźny & Rataj, 2023; Moskalenko et al., 2022b; Lyulyov et al., 2015), healthcare sustainability (Singh et al., 2023), sustainable business models in healthcare (Rashdan & Csepy, 2019; Dzwigol et al., 2023a, 2023b; Kwilinski et al., 2022; Letunovska et al., 2022), measuring sustainability in healthcare systems (AlJaberi et al., 2017), role of management in increasing the performance and sustainability of healthcare (Lega et al., 2013; Melnychenko, 2019; Moskalenko et al., 2022a; Spicka, 2018), creating continuous improvement in healthcare sector (Morell-Santandreu et al., 2020), telemedicine in healthcare sustainability (Kwilinski, 2019; Palozzi et al., 2020a; Palozzi et al., 2020b; Kwilinski et al., 2019; Melnychenko, 2021), technology for sustainable healthcare (Nti et al., 2023). However, it's noteworthy that, to the authors' knowledge, only one of the previous reviews has examined the healthcare management literature for 1994-2018 through the lens of sustainability (Punnakitikashem & Hallinger, 2019). This gap in the existing literature serves as the impetus for the current bibliometric review, allowing for a broader exploration of healthcare management in the context of sustainability.

2. Methodology

This section presents the procedures used for reviewing and analysing the investigated scientific documents.

2.1 Research design

Utilising data sourced from the Scopus scientific database, this study analysed publications on healthcare management within the framework of sustainable development until August 8, 2023. The choice of using the data from the Scopus database is due to its extensive recognition and influence as a multidisciplinary citation database. According to Elsevier (2022), the Scopus database encompasses a vast repository of over 84 million documents and engages roughly 18 million researchers worldwide, associated with approximately 95 thousand institutions. Hence, the utilisation of data from Scopus enables a comprehensive evaluation of worldwide research productivity, offering a crucial perspective on healthcare management in the context of sustainable development.

In this study, bibliometrics and knowledge visualisation techniques were employed to explore the interrelation between articles and keywords, presenting a comprehensive analysis of emerging trends and potential research prospects in the examined research area (Soliman et al., 2021; Dubina et al., 2020; Ziabina et al., 2023). The study encompassed an examination of the dynamic of publication activity, key research trends, influential scholars and their collaborations, as well as the contributions of journals, affiliations, and countries towards the development of the investigated subject. It stands to be mentioned that the principal advantage of employing bibliometric analysis lies in its capacity to offer a quantitative and unbiased literature assessment, thereby minimising subjective influences from the authors. The bibliometric R package and VOSviewer 1.6.16 software toolkit were utilised to carry out the bibliometric analysis. The initial stage involved searching, collecting, and preprocessing relevant articles about the research theme (Figure 1). Subsequently, various bibliometric techniques were

employed to scrutinise and visually represent the findings. Ultimately, the outcomes were synthesised, and future avenues for research were deliberated upon.

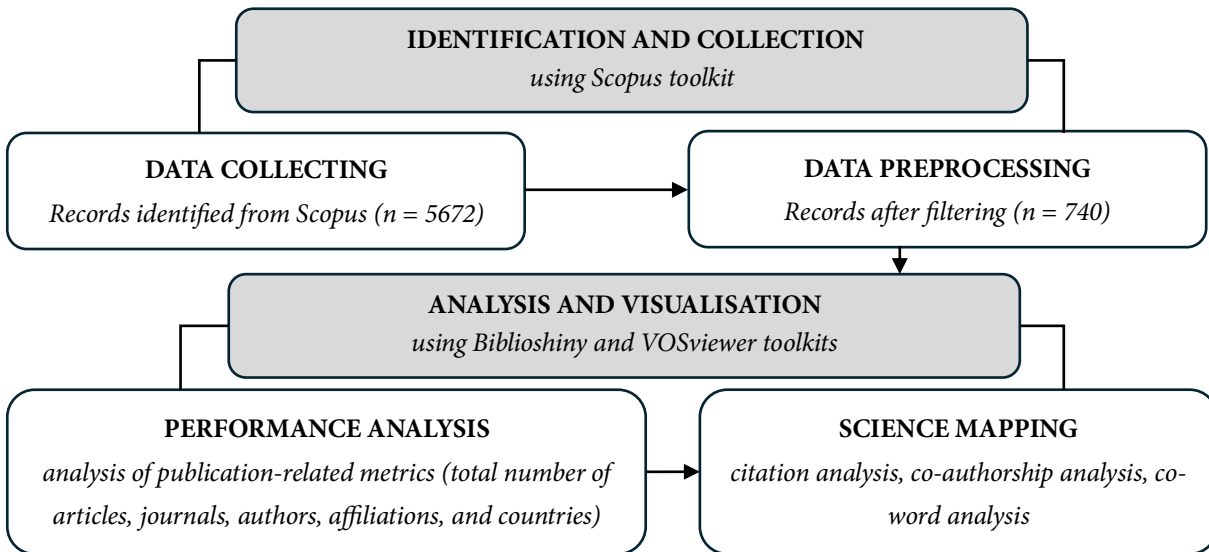


Figure 1. Research design

Source: developed by the authors.

2.2 Identification and collection of data

This study undertook an extensive bibliometric analysis of worldwide scholarly publications centred on healthcare management in the context of sustainable development. The primary dataset was sourced from the interdisciplinary Scopus database, with the latest access performed on August 8, 2023. The selection of the Scopus database was driven by its comprehensive coverage of scientific journals spanning diverse subject fields (Falagas et al., 2008). After choosing the databases, the subsequent phase involves refining the research criteria. The data search procedure is detailed in Table 1, illustrating a multi-stage process.

Table 1. Data collection steps in Scopus database

Nº	Query	Description	No. of articles
1	TITLE	healthcare AND management AND sustainab*	5672
2	PUBYEAR	1999 > PUBYEAR < 2023 (till August 8)	5431
3	LIMIT-TO SUBJAREA	Business, Management and Accounting AND Social Sciences AND Economics, Econometrics and Finance	1337
4	LIMIT-TO DOCTYPE	Article	1302
5	LIMIT-TO PUBSTAGE	Final	775
6	LIMIT-TO LANGUAGE	English	740

Source: developed by the authors.

The search was executed using the keywords 'healthcare,' 'management,' and 'sustainab*'. The Boolean operator 'AND' was employed to encompass all of the keywords mentioned above and their compounds, while the '*' operator was used to encompass various word endings such as sustainable, sustainability, etc. To ensure the inclusion of pertinent publications, the search outcomes were confined to distinct subject fields: 1) Business, Management and Accounting, 2) Social Sciences, and 3) Economics, Econometrics, and Finance. The research encompassed publications spanning from the year

2000 to August 8, 2023. Notably, the initial dataset consisted of 5,672 publications. However, after applying filtering criteria, the number of publications for the subsequent bibliometric analysis was reduced to 740 (Table 1).

Table 2. The main characteristics of the filtered dataset

Description	Results
Timespan	2000-2023 (up to August 8)
Documents (articles)	740
Single-authored documents	101
Multi-authored documents	639
Average citation per document	13.39
Document average age	5.54
Annual growth rate, %	15.94
References	34766
Sources	376
Authors' keywords	2300
Authors	2279
Authors of single-authored documents	98
Co-authors per document	3.33
International co-authorship, %	23.38

Source: developed by the authors.

After the filtering procedure, the analysis was carried out on a comprehensive sample of 740 articles, comprising 101 single-authored articles and 631 articles with multiple co-authors (Table 2). These articles originate from 376 distinct sources. The dataset involves a cumulative count of 2279 authors, with 98 authors contributing solely to single-authored articles. The occurrence of international co-authorship stands at 23.38%. On average, each article is authored by approximately 3 scholars. The average age of the documents is calculated to be 5.54 years, while the annual growth rate amounts to 15.94%. The average citation per article is 13.39. In turn, the total number of references of considered documents is 34766.

3.3 Data analysis and visualisation

Following Casado-Belmonte et al. (Casado-Belmonte et al., 2021), the performance analysis centres around productivity (publication-related metrics), primarily gauged by the number of publications. In order to assess the primary trends associated with the subject under investigation, this study employed productivity metrics. The productivity metrics encompassed the annual growth rate of publication activity. To calculate the annual growth rate of publication activity, the formula established by Shi et al. (2019) was utilised:

$$AGR_{ij} = \frac{N_i - N_j}{N_j} \times 100\% \quad (1)$$

where AGR_{ij} – the annual publication growth rate, N_i – the number of articles within the current year; N_j – the number of articles in the previous year ($i-1$).

Additionally, the performance analysis incorporates the number of citations and the h-index, further enhancing the evaluation of performance at the journal, author, and affiliation levels. The

overarching objective is to offer an up-to-date portrayal of the research domain by identifying the pivotal works that constitute its intellectual foundation.

The science mapping of the scrutinised literature was established through a distance-based technique called co-citation analysis. This approach facilitated the visualisation of collaborative ties between scholars on a global scale, shedding light on the collaborative patterns within the research area. The citation analysis was employed to identify the most influential articles and explore the interconnections among the analysed articles. Meanwhile, the co-authorship analysis unveiled the social interactions among authors across different countries. The co-citation analysis was instrumental in delineating the most extensively developed research themes by authors. In contrast, the co-word analysis facilitated trend analysis of these themes and the exploration of their interrelationships.

The utilisation of co-word network analysis and clustering methodologies enabled the delineation of thematic categories associated with the investigated keywords. The study discerned discrete themes within the research area by scrutinising the connections and co-occurrences among keywords.

These themes were visually presented in a two-dimensional diagram, organised into four quadrants (upper-right, upper-left, lower-left, and lower-right) (Corte et al., 2019). The examination of the two-dimensional diagram yields the following interpretations for each quadrant:

- 1) upper-right quadrant possesses the keywords with substantial significance and influence in the subject area (motor themes). These keywords correspond to well-established and crucial focal points within the research field.
- 2) upper-left quadrant keywords indicate the niche themes with limited significance when considered in the broader context of the entire research field.
- 3) lower-left quadrant keywords display emerging or waning research-related themes. These keywords reflect areas that are currently gaining traction or diminishing in relevance within the research field.
- 4) lower-right quadrant comprises keywords that represent fundamental and foundational themes essential to the analysed scientific domain (basic themes). They may serve as core concepts or key focal points of research.

The authors employed the keyword-based method as the analytical framework to generate the thematic map that visually portrays the prominent themes identified within the analysed scientific literature.

3. Research results

This section presents the findings of the bibliometric analysis conducted on the knowledge base pertaining to healthcare management in the context of sustainable development. The subsequent discussion sequentially addresses the research questions outlined above.

3.1 Descriptive trends in the investigated scientific literature

Table 3 presents the main annual productive indicators of published articles, such as the number of articles, the annual publication growth rate, the relative growth rate of publication activity, the average total citations per article, and the average total citations per year. The expansion rate of considered articles on healthcare management within the framework of sustainable development from 2000 to 2023 (up until August 8) is proved in Table 3. Considering the number of articles, the increasing trend of publication activity in the investigated field has been noticed since 2015, which could be caused by adopting the UN 17 SDGs in 2015. Thus, the annual publication growth rate indicator shows

that the number of articles in 2015 increased by 118% compared to 2014 (37 and 17 articles, respectively). Moreover, upon examining the citation count, it became evident that the year 2020 recorded the highest citation count (1473), accompanied by an average citation ratio of 20.2 per article.

Table 3. Analysis of publication activity on healthcare management in the context of sustainable development in Scopus database (2000-2023)

Year	NA	AGR (%)	NC	MTCA	MTCY
2000	2	-	102	51.0	2.1
2001	6	200	121	20.2	0.9
2002	3	-50	51	17.0	0.8
2003	1	-67	1	1.0	0.1
2004	7	600	87	12.4	0.6
2005	4	-43	64	16.0	0.8
2006	7	75	79	11.3	0.6
2007	12	71	429	35.8	2.1
2008	9	-25	160	17.8	1.1
2009	14	56	358	25.6	1.7
2010	16	14	168	10.5	0.8
2011	15	-6	352	23.5	1.8
2012	26	73	344	13.2	1.1
2013	22	-15	354	16.1	1.5
2014	17	-23	342	20.1	2.0
2015	37	118	612	16.5	1.8
2016	47	27	1067	22.7	2.8
2017	37	-21	472	12.8	1.8
2018	53	43	860	16.2	2.7
2019	86	62	1208	14.1	2.8
2020	73	-15	1473	20.2	5.0
2021	85	16	786	9.3	3.1
2022	101	19	327	3.2	1.6
2023	60	-41	94	1.6	1.6

Notes: NA – Number of articles; AGR – the annual publication growth rate, %; MTCA – Average total citations per article; MTCY – Average total citations per year.

Sources: developed by the authors.

The findings showed the scholarly inclination toward selecting esteemed journals for disseminating their research results on healthcare management in the context of sustainable development. Table 4 presents the TOP-5 most productive sources of investigated articles, such as the Switzerland journal 'Sustainability' and the UK journals 'Journal of Cleaner Production', 'International Journal of Health Care Quality Assurance', 'Facilities', and 'Journal of Health Organization and Management'.

It is notable for highlighting that all the journals under consideration possess a substantial impact factor (ranging between Q1 and Q2), signifying their credibility and trustworthiness. Journal of Cleaner Production, Facilities, and Sustainability are some of the most prestigious journals within a subject area 1) environmental science (miscellaneous), 2) architecture, and 3) geography, planning and development, respectively. Journal of Health Organization and Management and International Journal of Health Care Quality Assurance present 25-50% group in the subject area of business, management and accounting. Among the assessed journals, the highest count of investigated articles and documents emerged in the Switzerland journal 'Sustainability', which was included in the Scopus database in 2009. According to the analysis of data on SJR, Table 4 demonstrates that among the

considered journals, the average article of the Journal of Cleaner Production has the biggest scientific influence on the global scientific discussion. Moreover, in terms of CiteScore rankings for 2022, it is evident that the articles of this journal were the most frequently cited from 2019 to 2022. The International Journal of Health Care Quality Assurance had the most expanded international research collaboration network in line with the international collaboration. Thus, researchers from several countries elaborated on 33.3% of articles in this journal from 2000 to 2023 (up to August 8).

Table 4. TOP-5 most productive sources of investigated articles 2000-2023 (up to August 8)

Sources	NA	SJR 2022	Cite Score	IC	h-index	Publisher	Country	Scopus cov.years
Sustainability	78	0.664	5.8	31.5	136	MDPI AG	Switzerland	2009 to pr.
Journal of Cleaner Production	16	1.981	18.5	32.3	268	Elsevier Ltd.	UK	1993 to pr.
International Journal of Health Care Quality Assurance	14	0.529	4	33.3	54	Emerald Publishing	UK	1988 to pr.
Facilities	12	0.547	4.7	18.2	52	Emerald Publishing	UK	1983 to pr.
Journal of Health Organization and Management	11	0.417	2.6	23.4	48	Emerald Publishing	UK	2003 to pr.

Note: NA – Number of articles; IC – international collaboration, %.

Sources: developed by the authors.

3.2 Leading countries and international scientific collaborations

According to the Scopus database (Figure 2), the TOP-10 most productive countries investigating the issues of healthcare management in the context of sustainable development were the USA (360 articles), the UK (254 articles), Italy 210 (articles), India (136 articles), Australia (104 articles), China (98 articles), Malaysia (80 articles), Netherlands (66 articles), Sweden (64 articles), and Canada (60 articles).

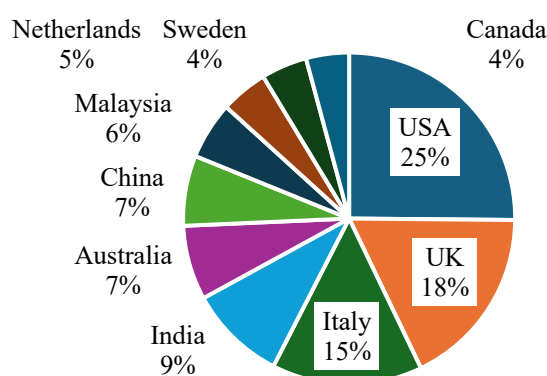


Figure 2. Network visualisation of worldwide co-authorship, 2000-2023 (up to August 8)

Sources: developed by the authors.

The co-authorship map was constructed to discern global scholarly collaborations. The primary criterion was set at a minimum of 5 documents per country. Consequently, 28 out of the total 99 countries satisfied this criterion. As a result, the co-authorship network map based on countries reveals the presence of four distinct clusters (Figure 3):

- *the first cluster (red colored)* is led by the UK, which has contributed 100 publications cited 2103 times. This cluster demonstrates strong collaboration among EU countries (France, Greece, Italy, Netherlands, Poland, and Portugal), the UK, and South Africa.
- *the second cluster (green colored)* encompasses 8 countries (Australia, Brazil, Canada, Denmark, Germany, Norway, Spain and Sweden). It is noteworthy that Australia stands out with the highest number of publications (35 articles cited 563 times).
- *the third cluster (blue colored)* showcases a close interconnection among scholars from China, Finland, Malaysia, Pakistan, Saudi Arabia, Taiwan, and Turkey. In turn, this cluster is headed by Malaysia, which contributed 29 documents cited 213 citations.
- *the fourth cluster (yellow colored)* is anchored by USA (136 papers cited 2279 times). This cluster underscores collaboration among researchers from India, Iran, South Korea, UAE, and USA.

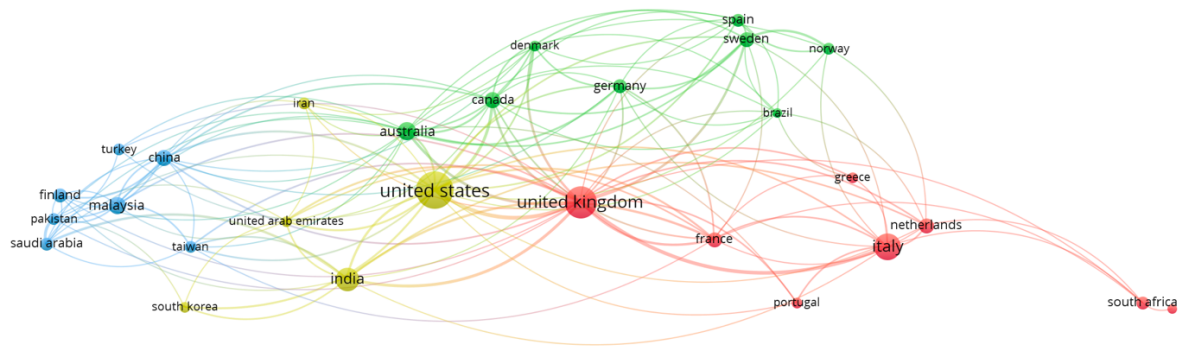


Figure 3. Visualisation of co-authorship network by countries, 2000-2023 (up to August 8)

Sources: developed by the authors using the VOSviewer tools.

3.3 Analysis of influential authors, affiliations and documents

Regarding the most productive authors who have significantly contributed to the advancement of the examined subject between 2000 and 2023 (up to August 8), it is relevant to highlight authors who have authored a minimum of four publications. Table 5 shows seven authors most significantly contributed to the development of the analysed topic. These authors represent six affiliations (University of Ferrara, Institute for Sustainability and Innovation in Structural Engineering, Aston Business School, Faculty of Medical Sciences of the University of the West Indies, Universidade do Minho, and Università degli Studi di Salerno), four countries (Italy, Portugal, UK, and Jamaica) and two regions (Europe and Caribbean).

With regard to the number of articles, up to 2023 (August 8), the Italian scholar Vagnoni Emidia had published the biggest number of articles on the investigated topic among the others (5 articles cited 121 times). It stands to be mentioned that the research on healthcare management in the context of sustainable development consists of 10% of the scholar's publication background. On the other hand, the author mostly specialising in this topic is Cavicchi Caterina, who devoted 25% of publications to the issues of healthcare management in the view of sustainable development. In this view, it's appropriate to mention that all authors have a great scientific interest in research on sustainability.

Table 5. The most influential scholars, according to Scopus, 2000-2023 (up to August 8)

Nº	Authors	NA/TP	NC/TC	h-index	Country / Affiliation
1	Vagnoni Emidia	5/50	121/819	16	University of Ferrara / Italy

2	Bragança Luís	4/126	99/1830	23	Institute for Sustainability and Innovation in Structural Engineering / Portugal
3	Cavicchi Caterina	4/16	94/182	7	University of Ferrara / Italy
4	Dey Prasanta Kumar	4/213	40/5910	46	Aston Business School / UK
5	Hariharan Seetha- raman	4/119	40/1052	19	Faculty of Medical Sciences of the University of the West Indies / Jamaica
6	Mateus Ricardo	4/102	99/1595	25	Universidade do Minho / Portugal
7	Saviano Marialuisa	4/35	105/645	17	Università degli Studi di Salerno / Italy

Notes: NA – Number of articles; TP – Total number of publications; NC – Number of citations; NC – Total number of citations.

Sources: developed by the authors based on the Scopus data.

In general, the most productive scholar on the global scientific stage is Dey Prasanta Kumar from Aston Business School in the UK. Dey Prasanta Kumar published 213 publications that were cited 5910 times. However, the investigated topic took up less than 2% of the research.

Considering scholars' h-indexes, it could be supposed that the most influential researcher is Dey Prasanta Kumar (46 points), followed by Mateus Ricardo (25 points) and Bragança Luís (23 points). Besides, it is noteworthy to point out that most of the authors commenced their publications on the investigated subject within the first two, starting from 2015. This trend serves as an indicator of the increasing recognition and popularity of the field of sustainability in healthcare management among academics after world leaders embraced UN SDGs.

Table 6. The most relevant affiliations, 2000-2023 (up to August 8)

Nº	Affiliation	NA/TP	No. of authors	Dom. sub. area	Country
1	Università degli Studi di Salerno	10/39252	4731	Engineering	Italy
2	University of Ferrara	7/41399	6666	Medicine	Italy
3	Bucharest University of Economic Studies	7/7097	2458	Business, Manage- ment and Accounting	Romania
4	The University of Manchester	6/211922	33477	Medicine	UK
5	Tilburg University	6/23891	2584	Social Sciences	Netherlands
6	Università degli Studi di Napoli Federico II	6/135174	23692	Medicine	Italy
7	Monash University	6/175552	23874	Medicine	Australia
8	Erasmus Universiteit Rotterdam	6/43600	4984	Medicine	Netherlands
9	Sapienza Università di Roma	6/211771	39064	Medicine	Italy
10	Aston Business School	6/3359	348	Business, Manage- ment and Accounting	UK

Notes: NA – Number of articles; TP – Total number of publications.

Sources: developed by the authors based on the Scopus data.

The number of articles generated by a specific affiliation serves as an indicator of the level of scientific engagement and proficiency in tackling healthcare management in the context of sustainable development. Consequently, this study's subsequent stage involved examining the documents based on their affiliations of origin. The findings indicate the involvement of 160 affiliations in the exploration of healthcare management in the context of sustainable development. In turn, the TOP-10 most prolific affiliations based on the count of documents dedicated to studying the issue are presented in Table 6. As determined by the count of published documents within the refined Scopus dataset, the field of medicine holds a prominent position as the dominant subject area for 6 out of the TOP-10 most significant affiliations globally. It is noteworthy to mention that four out of the ten organisations are based in Italy (Università degli Studi di Salerno, University of Ferrara, Università degli Studi di

Napoli Federico II, and Sapienza Università di Roma), per two from the Netherlands (Tilburg University and Erasmus Universiteit Rotterdam), and UK (Aston Business School and The University of Manchester), per one from Romania (Bucharest University of Economic Studies) and Australia (Monash University).

Table 7. TOP-10 representative papers, 2000-2023 (up to August 8)

Nº	Title	Author(s)	NC	Year
1	The impact of green human resource management practices on sustainable performance in healthcare organisations: A conceptual framework (Mousa and Othman, 2020)	Mousa, S.K., Othman, M.	206	2020
2	Progressing in the change journey towards sustainability in healthcare: The role of 'Green' HRM (Pinzone et al., 2016)	Pinzone, M., Guerci, M., Lettieri, E., Redman, T.	206	2016
3	Emergence of Big Data Research in Operations Management, Information Systems, and Healthcare: Past Contributions and Future Roadmap (Guha and Kumar, 2018)	Guha, S., Kumar, S.	129	2018
4	A hybrid multi-criteria decision making method approach for selecting a sustainable location of healthcare waste disposal facility (Chauhan and Singh, 2016)	Chauhan, A., Singh, A.	127	2016
5	Blockchain technology, improvement suggestions, security challenges on smart grid and its application in healthcare for sustainable development (Khan et al., 2020)	Alam Khan, F., Asif, M., Ahmad, A., Alharbi, M., Aljuaid, H.	119	2020
6	Sustainable healthcare and environmental life-cycle impacts of disposable supplies: A focus on disposable custom packs (Campion et al., 2015)	Campion, N., Thiel, C.L., Woods, N.C., ...Landis, A.E., Bilec, M.M.	101	2015
7	AMEE Consensus Statement: Planetary health and education for sustainable healthcare (Shaw et al., 2021)	Shaw, E., Walpole, S., McLean, M., ... Tun, S., Woollard, R.	99	2021
8	Exploration of social sustainability in healthcare supply chain (Hussain et al., 2018)	Hussain, M., Ajmal, M.M., Gunasekaran, A., Khan, M.	99	2018
9	Healthcare supply chain management; strategic areas for quality and financial improvement (Kwon et al., 2016)	Kwon, I.-W.G., Kim, S.-H., Martin, D.G.	89	2016
10	The healthcare sustainable supply chain 4.0: The circular economy transition conceptual framework with the corporate social responsibility mirror (Daú et al., 2019)	Daú, G., Scavarda, A., Scavarda, L.F., Portugal, V.J.T.	76	2019

*Note: NC –Number of citations.

Sources: developed by the authors.

To identify the most impactful articles within the research scope addressing healthcare management in the context of sustainable development, this study pinpointed the most cited articles within the Scopus database (Table 7). Delving into the more specific research domains of the most impactful articles within the research scope, it is appropriate to mention a common interest among these articles in building the sustainable healthcare system. Moreover, Shaw et al. (2021) highlighted that the education of the interprofessional healthcare workforce plays a significant role in promoting sustainable development and planetary well-being. Daú et al. (2019) noted that the convergence of the triple bottom line, Industry 4.0, and corporate social responsibility facilitates the shift from a linear model to a circular model. This convergence can potentially enhance the sustainability of the healthcare supply chain within the context of Industry 4.0. According to the findings, the article titled ‘The impact of green human resource management practices on sustainable performance in healthcare organisations: A conceptual framework’ (Mousa & Othman, 2020) holds significant importance in investigating the analysed subject, with a citation count of 206 in the Scopus database. This study extends the analysis of the importance of applying green human resource management practices at healthcare

facilities. This paper offers scholars a deeper comprehension of green human resource management practices within the context of developing countries and provides empirical evidence regarding the impact of these practices on employee behaviour, aiming to promote sustainable performance. Moreover, in this line, the second most cited article (206 citations) titled 'Progressing in the change journey towards sustainability in healthcare: The role of 'Green' HRM' (Pinzone et al., 2016) found that green human resource management practices play a significant role in fostering voluntary environmentally conscious behaviours at a collective level. Guha and Kumar (2018) focused their study on analysing the utilisation of big data analytics within the realms of information systems, operations management, and healthcare, delving into the existing applications of big data and exploring the prospective future potentials in these domains. On the other hand, while blockchain technology has garnered significant attention from various stakeholders, largely attributed to its robust implementation in the realm of digital currencies, blockchain technology finds myriad applications across various sectors, including healthcare, the automation industry, the energy sector, and security. In this line, Khan et al. (2020) found out that the contribution of custom four-layered blockchain models has been remarkable in areas like precision medicine and clinical trials within the healthcare domain. Kwon et al. (2016) delved into strategic domains through which the healthcare supply chain could enhance operational efficiency. The scholars assert that foundational supply chain principles should be harnessed to establish a "supply chain community surplus," thus leveraging resources to enhance the quality of care. In this line, Hussain et al. (2018) verified that while focusing on individual stakeholder groups is crucial, conducting a comprehensive analysis encompassing the perceptions of all stakeholders regarding the components of a socially sustainable supply chain would yield greater advantages. This approach would aid hospital managers in effectively addressing the expectations of all parties involved and achieving a balanced outcome. Among the TOP-10 most cited articles, two articles were dedicated to analysing healthcare waste disposal in terms of sustainable development. Thus, Chauhan and Singh (2016) focused on the problem of locating healthcare waste, while Campion et al. (2015) highlighted that healthcare institutions can make informed efforts to streamline disposable custom packs by employing tools and strategies such as life cycle assessment and design for the environment.

3.4 Keyword co-occurrences in the investigated topic

This study delves into the core co-occurring terms by leveraging cluster identification, aiming to restructure and amalgamate the existing literature more effectively. Figure 4 visualises keyword co-occurrence, generating a map that delineates the primary scientific clusters within the scope of the analysed literature from 2000 to 2023 (up to August 8). The network map of keyword co-occurrences was constructed by analysing the links, total link strengths, and the number of occurrences of authors' keywords. A minimum co-occurrence threshold of 5 was applied, resulting in the inclusion of 77 keywords out of a total of 2307. This map highlights the connections among various keywords, offering insights into the principal themes and focal points within the scientific literature concerning healthcare management in the context of sustainable development. A comprehensive exploration of the clusters and their interconnections enhances the comprehension of pivotal scientific research trends and the interrelationships among different subject matters within the investigated scientific literature.

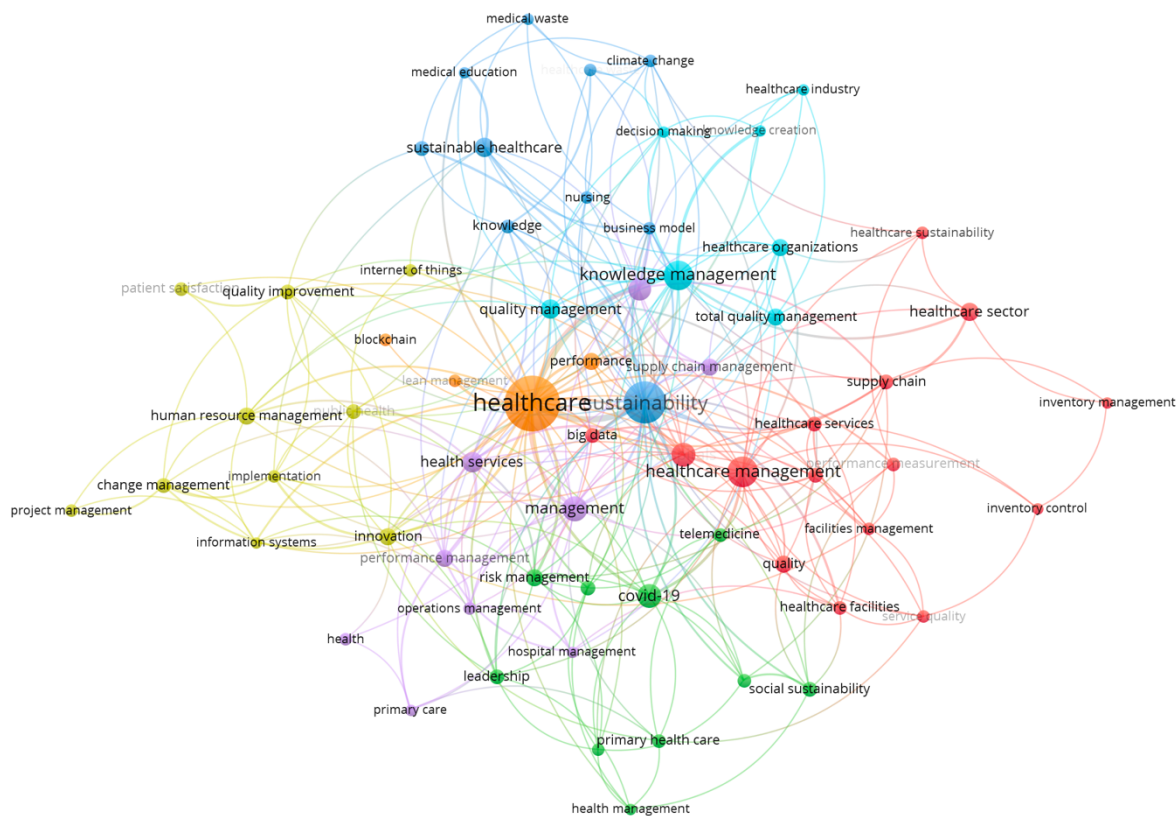


Figure 4. Network visualisation of keyword co-occurrences according to Scopus data, 2000-2023 (up to August 8)

Source: developed by the authors.

Thus, Figure 4 presents a network visualising of seven thematic clusters that aggregate the authors' keywords. The foremost clusters identified are as follows: 1) red – healthcare management; 2) green – COVID-19; 3) blue – sustainability; 4) yellow – innovation; 5) purple – management; 6) cyan – knowledge management; 7) orange – healthcare. It is appropriate to mention that the cluster names were designed based on the keyword situated within the central node, which exhibits stronger connections with the other keywords within the cluster.

The biggest (red) cluster is titled 'healthcare management', since this keyword is characterised by the biggest number of links, occurrences and highest total link strength. Considering other pertinent nodes within this cluster, 'healthcare services', 'service quality', 'big data', 'hospitals', and 'healthcare sustainability' emerge as significant and interlinked keywords.

Indeed, the quality of healthcare services considerably impacts both patient satisfaction and value of healthcare delivery. Boakye et al. (2017) concluded that the influence of perceived value on satisfaction and behavioural intention is evident in the fact that enhancing perceived benefits and minimising perceived costs results in repeated actions and lays the foundation for a retention strategy in healthcare management.

Evolution and shifts within health services underscore the significance of competition, fostering a drive to elevate the quality standards across healthcare facilities. Throughout these processes, the system's foremost requisites involve attaining the desired quality and upholding the integrity of the

system's environment. In this context, the measurement and ongoing enhancement of service quality hold paramount importance for healthcare centres in their endeavour to deliver superior service to patients. Erdebilli and Özdemir (2022) highlighted that the assessment of performance and the execution of corresponding measures significantly impact the service quality within a hospital that is in a critical state, especially during COVID-19.

Concerning the literature on big data in healthcare management, Dash et al. (2019) noted that to offer effective solutions for enhancing public health, healthcare providers need comprehensive infrastructure to collect and analyse big data systematically. Effectively managing, analysing, and interpreting this extensive data can be transformative, ushering in new possibilities for modern healthcare. Through robust integration of biomedical and healthcare data, contemporary healthcare organisations have the potential to revolutionise medical treatments and personalised medicine approaches. Moreover, big data has the potential to contribute significantly by reducing the complexity of supply chain stages, broadening economic margins, and simplifying the sustainable strategising of intelligent healthcare investments (Moro Visconti and Morea, 2019).

Fang et al. (2023) noted that the sudden surge in COVID-19 cases has placed immense pressure on the healthcare system, subjecting it to unprecedented challenges. In this scenario, healthcare management emerges as a complex yet vital process to oversee and coordinate all information and resources effectively. Therefore, there is an increasing need to enhance the capabilities of urban systems and establish an open data city framework to ensure dependable information and data sharing, particularly in areas like medical and testing data. This endeavour will bolster public awareness and elevate healthcare services to a more effective level.

The second (green) cluster is designed around the keyword COVID-19. Other noteworthy keywords that garner attention within this cluster are risk management, social sustainability, telemedicine, and healthcare supply chain.

The unexpected outbreak of COVID-19 has triggered scientific interest in this topic worldwide. Mishra et al. (2021) highlighted that efficient healthcare management has played a pivotal role in fostering a healthier society. Taking affirmative steps within distinct research, technology, and management domains holds significant potential to strengthen the worldwide response to healthcare burdens such as COVID-19. Sun et al. (2021) suggested that it is improbable that healthcare delivery will revert entirely to its pre-COVID state. Therefore, there is a need to swiftly enact measures to safeguard patients and healthcare providers from infections. One of the possibilities to improve healthcare efficiency is considered to be telemedicine. However, the successful deployment of telemedicine requires robust evidence, including findings from clinical trials, to effectively inform the smooth integration of telemedicine into standard healthcare practices (Maiga and Arinaitwe, 2017). It is crucial for ensuring the safety and quality of virtual care provided. The outlined guidelines offer indispensable elements for policymakers, researchers, and the informatics community to consider. These guidelines represent a vital phase within a broader initiative to evaluate the ethical, regulatory, and operational dimensions of telemedicine as a healthcare delivery platform.

Kanokphanvanich et al. (2023) emphasised that the pandemic crisis and its ensuing global uncertainties have undoubtedly inflicted substantial repercussions on the healthcare supply chain. It has prompted scholars, healthcare executives, and policymakers to intensify their attention on ensuring the sustainability of the healthcare supply chain. Healthcare supply chains constitute a distinct realm, as their primary aim is to preserve lives rather than maximise profits (Senna et al., 2020). Borgonovi

(2017) underscored that discussions about sustainability challenges often focus primarily on the economic dimension, overlooking the equally crucial social and political aspects. However, the healthcare systems are strained not solely due to their cost but because scientific and technological advancements are expanding opportunities for a more significant population segment. Considering risk management in healthcare, Ferrari et al. (2017) emphasised the significance of risk managers, who are accountable for ensuring the quality and safety of healthcare services, gaining paramount importance within both public and private hospitals.

The third (blue) cluster is built around the keyword 'sustainability'. Assessing sustainability in healthcare systems is a multifaceted and intricate matter, encompassing numerous criteria and sub-criteria (AlJaberi et al., 2017). This complexity demands deconstructing the issue into a series of components organised within a multi-level hierarchical framework.

Other salient keywords that draw attention within this cluster are 'healthcare waste management', 'sustainable healthcare', and 'education'. Considering the keyword 'healthcare waste management', Puška et al. (2022) emphasised that the proper disposal of healthcare waste stands as a critical concern for global environmental sustainability. Since the volume of healthcare waste is growing daily, it underscores the imperative of appropriately managing and disposing of this type of waste.

It stands to be mentioned that the third cluster has a close relation to the sixth (cyan) cluster titled 'knowledge management'. Other pertinent nodes within this cluster are 'knowledge creation', 'decision making', 'healthcare organisation', 'healthcare industry', 'quality management', and 'totally quality management'.

Gonçalo and de Borges (2010) distinguished two types of healthcare organisations: traditional organisations (using information) and learning organisations (resting on knowledge creation). Here-with, the scholars pointed out that organisational knowledge is considered a strategic asset for healthcare services characterised by high complexity. Therefore, medical specialities are expected to collaborate harmoniously and be willing to exchange knowledge.

Considering the decision-making in healthcare, Suha and Sanam (2023) noted that healthcare decision-making is a complex process that necessitates collaboration among different stakeholders. Therefore, ensuring the sustainability of these decisions is crucial for meeting the needs of healthcare facilities. Moreover, Harris et al. (2017) highlighted the necessity of providing health service personnel with access to education, training, expertise, and support to facilitate evidence-based decision-making. It is crucial for effectively implementing and evaluating the changes resulting from such decisions.

The fourth (yellow) cluster is designed around the keyword 'innovation', including other important keywords such as 'human resource management', 'public health', and 'change management'. In the contemporary landscape, innovation has become an integral component of any service, crucial for maintaining competitiveness. The effectiveness and acceptability of innovation development in hospitals hinge on the effectiveness of its management, which must be aligned with the context of healthcare quality (Tonjang & Thawesaengskulthai, 2022). This alignment is crucial since quality serves as a guiding philosophy in life-related environments, including healthcare.

Healthcare organisations face persistent pressure to adjust to evolving circumstances and various internal and external burdens. In this view, job proactivity and vitality assume significance in dynamic environments. For instance, Tummers et al. (2015) mentioned that employees with high vitality are better equipped to handle change due to their increased energy levels. Nevertheless, it is still unclear the means by which organisations can foster proactivity and vitality. Therefore, the above triggers

scholars to bridge human resource management and change management by examining how human resource management practices can encourage job proactivity and vitality.

The fifth (purple) cluster is focused on the keyword 'management'. The keywords with high link strength included in this cluster are as follows: 'health services', 'operations management', 'performance management', and 'sustainable development'. Comprehending customers' service expectations, formulating processes, establishing standards to fulfil those expectations, delivering accurate service communication, and recruiting and training suitable front-line staff all shape perceptions of service quality (Parasuraman et al., 1985). These efforts collectively aim to minimise the gap between expectations and experiences and foster positive customer experiences. In this line, performance management is widely recognised as one of the most pivotal functions within human resource management (Kennedy et al., 2019). The foundation of performance management lies in establishing consistent and dependable hiring processes to identify front-line staff who possess a strong commitment to service, exceptional customer service skills, and a positive outlook on receiving feedback to enhance their performance. Considering the keyword 'operations management', Villa (2021) highlighted the growing role of operations management in healthcare. It is indispensable for effectively managing the movement of both patients and supplies with efficiency, responsiveness, and adaptability. Thus, a new wave of scholars specialising in healthcare operations management is investigating current and relevant healthcare subjects through the utilisation of modern methodological approaches (Dai & Tayur, 2020).

At last, the smallest (orange) cluster titled 'healthcare' includes three more keywords: 'blockchain', 'lean management', and 'performance'. Lean healthcare management is considered to be an innovative approach to process healthcare management. Lean management acts as a foundational framework for harnessing innovation across healthcare projects (Abuhejleh et al., 2016). Therefore, more lean experts explore the feasibility of applying the established principles of lean management, known for enhancing efficiency and process-oriented quality assurance in industries, to the control, support, and core processes within the healthcare sector (Helmold et al., 2022; Abuhejleh et al., 2016). Another keyword requiring consideration is 'blockchain'. Villarreal et al. (2023) noted that blockchain technology is emerging as a prominent solution in the healthcare ecosystem, offering a means to achieve equilibrium and enhance various aspects of the industry. Blockchain technology is well-suited for open-source interoperability beyond the financial sector, but the intricate interplay between technological intricacies and practical outcomes remains uncertain (Usharani et al., 2022). Therefore, blockchain has garnered significant attention from both scholars and practitioners across various business domains. In turn, scholarly academics in the healthcare sector try to explore the potential of blockchain technologies, focusing particularly on their diverse applications in the field of medicine.

3.5 Research trends

To enhance the analysis of the keyword evolution, the analysed period of publication activity was divided into three sub-periods (2000-2014 – before embracing UN SDGs (the initial period provided a baseline for understanding pre-SDG research trends), 2015-2019 – since embracing UN SDGs till COVID-19 (this phase offered insights into how the global agenda for sustainable development influenced research themes within healthcare management and sustainable development, 2020-2023 (up to August 8) – the modern period capturing the most recent developments in research). This subdivision allows for a more detailed examination of how keyword trends have evolved over time within specific time intervals. By doing so, the study can capture nuances and shifts in the usage and relevance of keywords within different phases of the chosen period, providing a more comprehensive

understanding of the development trends in healthcare management in the context of sustainable development.

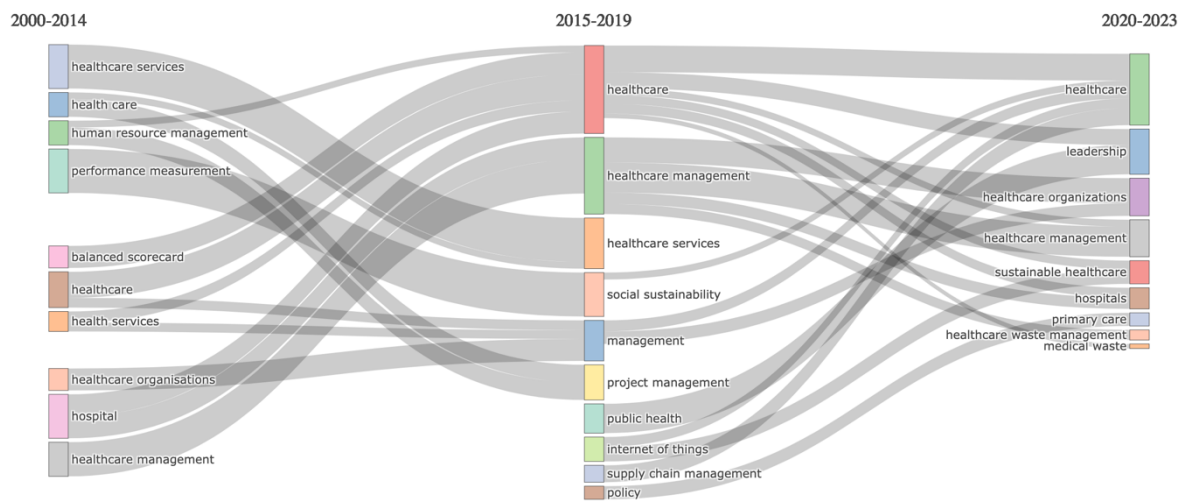


Figure 5. Thematic evolution of the investigated keywords, 2000-2023 (up to August 8)

Source: developed by the authors.

Figure 5 presents the evolution of keywords of the analysed articles in three different stages (2000-2014, 2015-2019, and 2020-2023). Thus, the findings show that before the UN SDGs were embraced, the analysed articles on healthcare management in the context of sustainable development were focused on healthcare services, human resource management, performance measurement, healthcare organisations, etc. From 2015 to 2019, the research topics shifted slightly to the analysis of social sustainability, project management, public health, the Internet of Things, supply chain management, etc. Since 2020, scholars have investigated healthcare management issues considering healthcare waste management, leadership, sustainable healthcare, hospitals, primary care, medical waste, etc.

Table 8 presents the thematic evolution of the investigated keywords by sub-periods. The thematic evolution table is designed using the authors' keywords. The thematic development of the researched keywords was conducted by categorising and arranging the keywords into specific themes, thereby visually depicting the primary subjects covered in the analysed literature in the particular sub-period. The thematic map showcases various topic areas within the research field, offering a comprehensive view of the research landscape and aiding in comprehending the breadth of the research being conducted. The map's structure assists in identifying essential, motor, emerging or declining, and niche themes, contributing to a deeper understanding of the overall field of study. Thus, Table 8 shows that during the first sub-period (2000-2014), the primary themes in the studied scope of scientific literature were healthcare services and healthcare. The well-established and significant themes within the research field were human resources management, health care, and health management. While considering the broader context of the entire research field, the themes with limited significance were hospital and sustainability. In turn, the emerging research-related themes were healthcare management and performance measurement.

Table 8. Thematic evolution table of the investigated keywords by sub-periods, 2000-2023 (up to August 8)

Period	Themes		Period	Themes	
2000-2014	<u>Niche themes</u> Hospital Sustainability	<u>Motor themes</u> Human resource management Health care Health management	2020-2023	<u>Niche themes</u> Primary healthcare	<u>Motor themes</u> Hospitals Public health Climate change Medical waste Sustainable healthcare Blockchain Big data Artificial intelligence Smart healthcare
	<u>Emerging/declining themes</u> Healthcare management Performance measurement	<u>Basic themes</u> Healthcare services Healthcare		<u>Emerging/declining themes</u> Innovation Healthcare management Healthcare waste management Quality improvement	<u>Basic themes</u> Telemedicine COVID-19 Sustainability Sustainable development Knowledge management Risk management
2015-2019	<u>Niche themes</u> Internet of Things Case management Primary healthcare Healthcare services	<u>Motor themes</u> Supply chain management Social sustainability Corporate social responsibility	2020-2023	<u>Emerging/declining themes</u> Innovation Healthcare management Healthcare waste management Quality improvement	<u>Basic themes</u> Telemedicine COVID-19 Sustainability Sustainable development Knowledge management Risk management
	<u>Emerging/declining themes</u> Information management	<u>Basic themes</u> Healthcare management Public health Sustainability Quality management Sustainable development			

Source: developed by the authors.

After embracing the UN SDGs and till COVID-19 (2015-2019), the primary themes were expanded into healthcare management, public health, sustainability, quality management, and sustainable development. The widely recognised and substantial themes were supply chain management, social sustainability, and corporate social responsibility. The themes with marginal significance were the Internet of Things, case management, primary healthcare, and healthcare services. In turn, information management presents the emerging research-related themes in the investigated scope of scientific literature. In the current period of scientific activity (from 2020 till 2023, August 8), the central themes in the examined domain of scientific literature are telemedicine, COVID-19, sustainability, sustainable development, knowledge management, and risk management. The extensively recognised and momentous themes are hospitals, public health, climate change, medical waste, sustainable healthcare, blockchain, big data, artificial intelligence, and smart healthcare. On the other hand, the themes related to primary healthcare lose their significance. Herewith, progressive research-linked themes within the scoped-out scientific literature are innovation, healthcare management, healthcare waste management, and quality improvement.

Conclusions

The findings underscore the upward trajectory of research concerning healthcare management within the realm of sustainable development. To comprehensively investigate this trend, this study harnessed bibliometric methodologies. A distinct advantage of bibliometrics is its capacity to deliver a quantitative, unbiased evaluation of global scholarly discourse, mitigating the subjective inclinations of individual authors. This approach ensures a meticulous and structured literature examination fortified by rigorous bibliometric scrutiny. Furthermore, the study integrated visualization techniques to

holistically appraise emergent patterns and potential avenues for future research in the studied domain. Merging bibliometric analysis with visualization, the study offers a comprehensive methodology for scrutinizing scientific output in healthcare management within the realm of sustainable development, providing objective insights and delineating uncharted trajectories for further exploration.

The performance analysis evidences an observable surge in publication activity within the investigated field, particularly since 2015. The annual publication growth rate indicator indicates a significant increase in the number of articles from 2014 to 2015, with a growth rate of 118% (37 articles in 2015 compared to 17 articles in 2014). This upward trend could be attributed to the adoption of the UN SDGs in the same year. Furthermore, a comprehensive analysis of citation counts unveils that the year 2020 recorded the highest citation count, totalling 1473 citations, accompanied by an average citation ratio of 20.2 citations per article. This illustrates the increasing recognition and impact of research conducted within the realm of healthcare management in the context of sustainable development.

The Swiss journal "Sustainability" emerges as the most prolific source indexed in the Scopus database concerning the study of healthcare management within the framework of sustainable development. Based on the obtained results, the exploration of healthcare management in the context of sustainable development engaged a total of 160 affiliations. Among these affiliations, the most productive was Università degli Studi di Salerno, which published a remarkable 10 documents on the subject. On average, each affiliated institution contributed roughly 5 articles between 2000 and August 8, 2023, indicating a moderate level of participation per establishment in the domain of healthcare management research.

The analysis outcomes divulged that a cumulative 99 countries have participated in the inquiry into healthcare management within the sustainable development context. Among these countries, the TOP-10 in terms of published articles include the USA (360 articles), UK (254 articles), Italy (210 articles), India (136 articles), Australia (104 articles), China (98 articles), Malaysia (80 articles), Netherlands (66 articles), Sweden (64 articles), and Canada (60 articles). Furthermore, the co-authorship analysis classified countries into four distinct clusters of collaborative authorship: 1) among EU countries (France, Greece, Italy, Netherlands, Poland, Portugal), the UK, and South Africa; 2) among Australia, Brazil, Canada, Denmark, Germany, Norway, Spain, and Sweden; 3) among China, Finland, Malaysia, Pakistan, Saudi Arabia, Taiwan, and Turkey; 4) among India, Iran, South Korea, UAE, and the USA.

In the realm of prolific authors significantly contributing to the advancement of the subject under examination from 2000 to August 8, 2023, the findings underscore the noteworthy contributions of Italian scholar Vagnoni Emidia. With an impressive portfolio of 5 articles, her work has garnered 121 citations. However, it's worth noting that the study of healthcare management within the context of sustainable development constitutes only 10% of her publication focus. In contrast, Cavicchi Caterina emerges as a specialist extensively dedicated to this topic, with an 25% of her publications delving into healthcare management within the sphere of sustainable development. This signifies a strong commitment to research in this domain. Besides, it's worth to highlight that all the authors exhibit a pronounced scientific interest in the area of sustainability.

This study highlights the work by Mousa and Othman (2020), entitled "The impact of green human resource management practices on sustainable performance in healthcare organizations: A conceptual framework." This paper has garnered substantial recognition as a seminal contribution, evidenced by its 206 citations in the Scopus database. Such acclaim underscores its profound impact and sway

within the investigated field. This research extends the discourse on the significance of applying green human resource management practices within healthcare establishments. The paper furnishes scholars with an enriched comprehension of such practices, particularly in developing nations, and underscores their empirical significance in shaping employee behaviour and fostering sustainable performance.

In the scope of this study, a keyword co-occurrences network map was constructed by scrutinizing the connections, cumulative link strengths, and occurrences of authors' keywords. This map unveiled distinct clusters that signify diverse research trajectories within the realm of healthcare management within the realm of sustainable development.

The largest cluster highlights research avenues encompassing healthcare management intricately intertwined with healthcare services and their quality, big data applications, and the overarching concept of healthcare sustainability. A substantial portion of scholarly attention has gravitated toward this cluster. The second notable cluster echoes the profound influence of the COVID-19 pandemic on research focal points, particularly emphasizing sustainability concerns within healthcare management. This cluster delves into areas such as risk management, social sustainability, telemedicine, and the intricate dynamics of the healthcare supply chain. The third cluster revolves around the core theme of sustainability, where scholars have directed their inquiry towards topics such as healthcare waste management, sustainable healthcare practices, and education within this context. Noteworthy, this cluster shares a close relationship with the sixth cluster, titled "knowledge management," signifying a concerted exploration of issues spanning knowledge creation, decision-making processes, healthcare organization dynamics, the healthcare industry, and comprehensive quality management. The fourth cluster highlights the research on innovation in healthcare management, notably concerning facets like human resource management, public health, and change management. The fifth cluster further elucidates the academic engagement in management aspects, delving into realms of health services, operations management, performance management, and the broader framework of sustainable development. Lastly, the smallest cluster with the succinct title "healthcare" spotlights research interests that converge around blockchain technology, lean management principles, and the intricate web of performance evaluation in healthcare contexts.

To deepen the analysis of keyword evolution, the study strategically divided the period of publication activity into three distinct sub-periods (2000-2014 –prior to the adoption of the UN SDGs; 2015-2019 – encompassing the span from the adoption of UN SDGs to the onset of the COVID-19 pandemic; 2020-2023 (up to August 8) representing the contemporary period of research).

The study's findings illustrate distinct shifts in the focus of research on healthcare management within the context of sustainable development across different sub-periods. Prior to the adoption of the UN SDGs, the analysed articles primarily centred around topics like healthcare services, human resource management, performance measurement, and healthcare organizations. During the period from 2015 to 2019, there was a noticeable transition towards themes such as social sustainability, project management, public health, the Internet of Things, and supply chain management. Starting from 2020 up until August 8, 2023, the research trajectory has further evolved. Scholars have turned their attention to healthcare management issues related to healthcare waste management, leadership, sustainable healthcare, hospitals, primary care, and medical waste. This period has also witnessed a heightened emphasis on contemporary and pertinent themes, with telemedicine, COVID-19,

sustainability, sustainable development, knowledge management, and risk management emerging as central areas of scientific discourse.

During the present period of scientific activity, spanning from 2020 to August 8, 2023, the domain of scientific literature on healthcare management within the context of sustainable development has converged around several central themes. These themes include telemedicine, COVID-19, sustainability, sustainable development, knowledge management, and risk management. These concepts have garnered significant attention and are pivotal in shaping current research discourse.

Moreover, a range of themes has achieved widespread recognition and importance within the field. Notable among these are hospitals, public health, climate change, medical waste, sustainable healthcare, blockchain, big data, artificial intelligence, and smart healthcare. These themes collectively represent the forefront of discussions in healthcare management and sustainability.

Conversely, themes related to primary healthcare have experienced a decline in their significance within the current research landscape. As the field evolves, new avenues for exploration have emerged. Progressive research-linked themes, such as innovation, healthcare management, healthcare waste management, and quality improvement, are gaining prominence in the scope of scientific literature. This comprehensive analysis offers insights into the dynamics of current research trends, highlighting key areas of focus and indicating potential directions for future inquiry within the realm of healthcare management and sustainable development.

This paper carries both theoretical and practical implications by delving into the analysis and visualization of scholarly output focused on healthcare management in the context of sustainable development. The theoretical implications contribute to a heightened comprehension of patterns, interconnections, and advancements within the scientific literature concerning healthcare management in the context of sustainable development. These insights offer valuable guidance to researchers, shedding light on potential trajectories for future investigations.

From a practical perspective, the study provides a roadmap for scholars interested in undertaking bibliometric analyses of scholarly output, encompassing evaluations of scholars, affiliations, academic journals, etc. The detailed guidelines furnished in the paper could serve as a valuable resource to facilitate similar analyses across various contexts.

Moreover, this study opens doors for researchers to broaden their current horizons by leveraging the findings and insights from the bibliometric analysis. It initiates a platform for further exploration and inquiry in the realm of healthcare management in the context of sustainable development.

Nonetheless, it's imperative to acknowledge the study's limitations stemming from its exclusive reliance on data from the Scopus database. While Scopus undeniably offers a comprehensive snapshot of worldwide research activity, a broader array of data sources should be incorporated in future investigations for a more exhaustive and resilient analysis. Encompassing a wider spectrum of data sources would fortify the integrity and applicability of the findings, ultimately culminating in a more comprehensive grasp of the subject matter. This approach would bolster the validity and generalizability of the study, facilitating a more holistic comprehension of the topic of healthcare management in the context of sustainable development.

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Reference

1. Abuhejleh, A. A., Dulaimi, M., & Ellahham, S. (2016). Using lean management to leverage innovation in healthcare projects: case study of a public hospital in the UAE. *Bmj Innovations*, 2(1), 22–32.
2. AlJaberi, O. A., Hussain, M., & Drake, P. R. (2017). A framework for measuring sustainability in healthcare systems. *International journal of healthcare management*, 13(4), 276–285. <https://doi.org/10.1080/20479700.2017.1404710>
3. Alliance for Natural Health International (2010). Sustainable Healthcare – Working Towards the Paradigm Shift. https://www.anhinternational.org/wp-content/uploads/old/files/100617-SustainableHealthcare_White-Paper.pdf
4. Arefieva, O., Polous, O., Arefiev, S., Tytykalo, V., Kwilinski, A. (2021). Managing sustainable development by human capital reproduction in the system of company's organizational behavior. *IOP Conference Series: Earth and Environmental Science*, 628(1), 012039. <https://doi.org/10.1088/1755-1315/628/1/012039>
5. Berniak-Woźny, J., & Rataj, M. (2023). Towards Green and Sustainable Healthcare: A Literature Review and Research Agenda for Green Leadership in the Healthcare Sector. *International Journal of Environmental Research and Public Health*, 20(2), 908.
6. Boakye, K. G., Blankson, C., Prybutok, V. R., & Qin, H. (2017). An assessment of national healthcare service delivery: a Ghanaian illustration. *International Journal of Quality & Reliability Management*, 34(5), 649–666.
7. Borgonovi, E. (2017). Healthcare system: Issues of sustainability and economic growth. *Rivista Internazionale di Scienze Sociali*, 231–248.
8. Champion, N., Thiel, C. L., Woods, N. C., Swanzy, L., Landis, A. E., & Bilec, M. M. (2015). Sustainable healthcare and environmental life-cycle impacts of disposable supplies: a focus on disposable custom packs. *Journal of Cleaner Production*, 94, 46–55.
9. Casado-Belmonte, M. D. P., Capobianco-Uriarte, M. D. L. M., Martínez-Alonso, R., & Martínez-Romero, M. J. (2021). Delineating the path of family firm innovation: mapping the scientific structure. *Review of Managerial Science*, 15(8), 2455–2499.
10. Cevik Onar, S., Oztaysi, B., & Kahraman, C. (2017). A Comprehensive Survey on Healthcare Management. *Operations Research Applications in Health Care Management*, 23–51. https://doi.org/10.1007/978-3-319-65455-3_2
11. Chauhan, A., & Singh, A. (2016). A hybrid multi-criteria decision making method approach for selecting a sustainable location of healthcare waste disposal facility. *Journal of Cleaner Production*, 139, 1001–1010.

12. Chen, Y., Kwilinski, A., Chygryn, O., Lyulyov, O., Pimonenko, T. (2021). The Green Competitiveness of Enterprises: Justifying the Quality Criteria of Digital Marketing Communication Channels. *Sustainability*, 13, 13679. <https://doi.org/10.3390/su132413679>.
13. Chen, Y., Lyulyov, O., Pimonenko, T., Kwilinski, A. (2023). Green development of the country: Role of macroeconomic stability. *Energy & Environment*, 0(0). <https://doi.org/10.1177/0958305x231151679>.
14. Chmielewska, M., Lotek-Waćkowska, R., Brzozowski, S., Tytko, Z., Dziok-Dmowska, K., & Hermanowski, T. (2023). The capacity to implement Lean Management in the healthcare system in Poland—results of a public consultation. *Medycyna Pracy*, 74(1), 1–8.
15. Corte, D., Gaudio, G., Sepe, F., & Sciarelli, F. (2019). Sustainable tourism in the open innovation realm: A bibliometric analysis. *Sustainability*, 11(21), 6114.
16. Dacko-Pikiewicz, Z. (2019). The selected aspects of strategic management in the city divided by the border in the context of the development of the cross-border market of cultural services [Wybrane aspekty zarządzania strategicznego w mieście podzielonym granicą w kontekście rozwoju transgranicznego rynku usług kulturalnych]. *Polish Journal of Management Studies*, 19(1), 130–144.
17. Dacko-Pikiewicz, Z. (2021). *Reputation Management and Family Business*. Routledge: London, UK.
18. Dai, T., & Tayur, S. (2020). Om Forum—Healthcare operations management: a snapshot of emerging research. *Manufacturing & service operations management*, 22(5), 869–887.
19. Daniels, T., Williams, I., Robinson, S., & Spence, K. (2013). Tackling disinvestment in health care services: the views of resource allocators in the English NHS. *Journal of health organisation and management*, 27(6), 762–780.
20. Dash, S., Shakyawar, S. K., Sharma, M., & Kaushik, S. (2019). Big data in healthcare: management, analysis and future prospects. *Journal of big data*, 6(1), 1–25.
21. Daú, G., Scavarda, A., Scavarda, L. F., & Portugal, V. J. T. (2019). The healthcare sustainable supply chain 4.0: The circular economy transition conceptual framework with the corporate social responsibility mirror. *Sustainability*, 11(12), 3259.
22. Dementyev, V., Dalevska, N., Kwilinski, A. (2021). Innovation and Information Aspects of the Structural Organization of the World Political and Economic Space. *Virtual Economics*, 4(1), 54–76. [https://doi.org/10.34021/ve.2021.04.01\(3\)](https://doi.org/10.34021/ve.2021.04.01(3))
23. Dubina, O., Us, Y., Pimonenko, T., & Lyulyov, O. (2020). Customer loyalty to bank services: The bibliometric analysis. *Virtual Economics*, 3(3), 53–66.
24. Dwivedi, A. N., Bali, R. K., Naguib, R. N. G., Baskaran, V., & Nassar, N. S. (n.d.). Tracking the healthcare management landscape: implications for integrated healthcare management and practice. Proceedings of the 25th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (IEEE Cat. No.03CH37439). <https://doi.org/10.1109/iembs.2003.1279480>
25. Dzwigol, H. (2019). Research Methods and Techniques in New Management Trends: Research Results. *Virtual Economics*, 2(1), 31–48. [https://doi.org/10.34021/ve.2019.02.01\(2\)](https://doi.org/10.34021/ve.2019.02.01(2))
26. Dzwigol, H. (2021). The Uncertainty Factor in the Market Economic System: The Microeconomic Aspect of Sustainable Development. *Virtual Economics*, 4(1), 98–117. [https://doi.org/10.34021/ve.2021.04.01\(5\)](https://doi.org/10.34021/ve.2021.04.01(5))

27. Dzwigol, H. (2022a), Comparing Idiographic and Nomothetic Approaches in Management Sciences Research. *Virtual Economics*, 5(4), 27–49. [https://doi.org/10.34021/ve.2022.05.04\(2\)](https://doi.org/10.34021/ve.2022.05.04(2))
28. Dzwigol, H. (2022b), Research Methodology in Management Science: Triangulation. *Virtual Economics*, 5(1), 78–93. [https://doi.org/10.34021/ve.2022.05.01\(5\)](https://doi.org/10.34021/ve.2022.05.01(5))
29. Dzwigol, H. (2023). The Quality Determinants of the Research Process in Management Sciences. *Virtual Economics*, 6(2), 35–54. [https://doi.org/10.34021/ve.2023.06.02\(3\)](https://doi.org/10.34021/ve.2023.06.02(3))
30. Dzwigol, H., Kwilinski, A., Lyulyov, O., & Pimonenko, T. (2023b). The role of environmental regulations, renewable energy, and energy efficiency in finding the path to green economic growth. *Energies*, 16(7), 3090.
31. Dzwigol, H., Kwilinski, A., Lyulyov, O., Pimonenko, T. (2023a). Renewable Energy, Knowledge Spillover and Innovation: Capacity of Environmental Regulation. *Energies*, 16(3), 1117. <https://doi.org/10.3390/en16031117>.
32. Eckelman, M. J., Huang, K., Lagasse, R., Senay, E., Dubrow, R., & Sherman, J. D. (2020). Health Care Pollution And Public Health Damage In The United States: An Update: Study examines health care pollution and public health damage in the United States. *Health Affairs*, 39(12), 2071–2079.
33. Elsevier (2022). Scopus. https://www.elsevier.com/_data/assets/pdf_file/0017/114533/Scopus-fact-sheet-2022_WEB.pdf
34. Enriquez-Puga A., Baker R., Paul S., Villoro-Valdes R. (2009). Effect of educational outreach on general practice prescribing of antibiotics and antidepressants: A two-year randomised controlled trial. *Scandinavian Journal of Primary Health Care*, 27, 195–201. <https://doi.org/10.3109/02813430903226530>
35. Erdebilli, B. D. R., & Özdemir, Y. S. (2022). Performance Measurement of Healthcare: A Case Study for Pilot Hospital. In International Conference on Intelligent and Fuzzy Systems (pp. 400–408). Cham: Springer International Publishing.
36. Falagas, M., Pitsouni, E., Malietzis, G., Pappas, G. (2008). Comparison of PubMed, scopus, web of science, and google scholar: Strengths and weaknesses. *FASEB Journal*, 22(2), 338–342. <https://doi.org/10.1096/fj.07-9492LSF>
37. Fang, Z., Lu, Q., Chen, L., Meng, J., Ye, Z., & Pitt, M. (2023). Creating an Open Data City for Healthcare: A Critical Review of Data Management Strategy and Development in China. *Journal of Management in Engineering*, 39(2), 03122004.
38. Ferrari, A., Odone, A., Mandelli, P., & Signorelli, C. (2017). Risk management: the new normative scenario and the role of training and education. *Acta Bio-medica: Atenei Parmensis*, 88(3), 365–374.
39. Gonçalves, C. R., & Borges, M. D. L. (2010). Healthcare services based on knowledge structure. *Journal of Health Management*, 12(4), 553–572.
40. Guha, S., & Kumar, S. (2018). Emergence of big data research in operations management, information systems, and healthcare: Past contributions and future roadmap. *Production and Operations Management*, 27(9), 1724–1735.
41. Harris, C., Allen, K., Waller, C., Dyer, T., Brooke, V., Garrubba, M., ... & Farjou, D. (2017). Sustainability in Health care by Allocating Resources Effectively (SHARE) 7: Supporting staff in evidence-based decision-making, implementation and evaluation in a local healthcare setting. *BMC health services research*, 17(1), 1–19.

42. Helmold, M., Küçük Yılmaz, A., Flouris, T., Winner, T., Cvetkoska, V., & Dathe, T. (2022). Lean Management in Healthcare and Hospitals. In *Lean Management, Kaizen, Kata and Keiretsu: Best-Practice Examples and Industry Insights from Japanese Concepts* (pp. 221-227). Cham: Springer International Publishing.
43. Hussain, H.I., Haseeb, M., Kamarudin, F., Dacko-Pikiewicz, Z., Szczepańska-Woszczyna, K. (2021). The role of globalization, economic growth and natural resources on the ecological footprint in Thailand: Evidence from nonlinear causal estimations. *Processes*, 9, 1103. <https://doi.org/10.3390/pr9071103>
44. Hussain, M., Ajmal, M. M., Gunasekaran, A., & Khan, M. (2018). Exploration of social sustainability in healthcare supply chain. *Journal of Cleaner Production*, 203, 977–989.
45. Kanokphanvanich, C., Rattanawong, W., & Vongmanee, V. (2023). A New Model for a Sustainable Healthcare Supply Chain Prioritises Patient Safety: Using the Fuzzy Delphi Method to Identify Healthcare Workers' Perspectives. *Sustainability*, 15(9), 7123.
46. Kennedy, D. M., Anastos, C. T., & Genau Jr, M. C. (2019). Improving healthcare service quality through performance management. *Leadership in Health Services*, 32(3), 477–492.
47. Khan, F. A., Asif, M., Ahmad, A., Alharbi, M., & Aljuaid, H. (2020). Blockchain technology, improvement suggestions, security challenges on smart grid and its application in healthcare for sustainable development. *Sustainable Cities and Society*, 55, 102018.
48. Kharazishvili, Y., Kwilinski, A. (2022). Methodology for Determining the Limit Values of National Security Indicators Using Artificial Intelligence Methods. *Virtual Economics*, 5(4), 7–26. [https://doi.org/10.34021/ve.2022.05.04\(1\)](https://doi.org/10.34021/ve.2022.05.04(1)).
49. Kwilinski et al., Kwilinski, A., Slatvitskaya, I., Dugar, T., Khodakivska, L., Derevyanko, B. (2020). Main Effects of Mergers and Acquisitions in International Enterprise Activities. *International Journal of Entrepreneurship*, 24, 1–8.
50. Kwilinski, A. (2019). Implementation of Blockchain Technology in Accounting Sphere. *Academy of Accounting and Financial Studies Journal*, 23(SI2), 1–6.
51. Kwilinski, A. (2023). The Relationship between Sustainable Development and Digital Transformation: Bibliometric Analysis. *Virtual Economics*, 6(3), 56–69. [https://doi.org/10.34021/ve.2023.06.03\(4\)](https://doi.org/10.34021/ve.2023.06.03(4))
52. Kwilinski, A., Lyulyov, O., Pimonenko, T. (2023). Environmental Sustainability within Attaining Sustainable Development Goals: The Role of Digitalization and the Transport Sector. *Sustainability*, 15, 11282. <https://doi.org/10.3390/su151411282>
53. Kwilinski, A., Lyulyov, O., Pimonenko, T., Dzwigol, H., Abazov, R., Pudryk, D. (2022). International Migration Drivers: Economic, Environmental, Social, and Political Effects. *Sustainability*, 14(11), 6413. <https://doi.org/10.3390/su14116413>
54. Kwilinski, A., Volynets, R., Berdnik, I., Holovko, M., Berzin, P. (2019). E-Commerce: Concept and Legal Regulation in Modern Economic Conditions. *Journal of Legal, Ethical and Regulatory Issues*, 22(Special Issue 2), 1–6.
55. Kwon, I. W. G., Kim, S. H., & Martin, D. G. (2016). Healthcare supply chain management; strategic areas for quality and financial improvement. *Technological forecasting and social change*, 113, 422–428.
56. Lega, F., Prenestini, A., & Spurgeon, P. (2013). Is Management Essential to Improving the Performance and Sustainability of Health Care Systems and Organizations? A Systematic Review and a

- Roadmap for Future Studies. *Value in Health*, 16(1), S46–S51. <https://doi.org/10.1016/j.jval.2012.10.004>
57. Letunovska, N., Abazov, R., Chen, Y. (2022). Framing a Regional Spatial Development Perspective: The Relation between Health and Regional Performance. *Virtual Economics*, 5(4), 87–99. [https://doi.org/10.34021/ve.2022.05.04\(5\)](https://doi.org/10.34021/ve.2022.05.04(5)).
 58. Letunovska, N., Offei, F. A., Junior, P. A., Lyulyov, O., Pimonenko, T., Kwilinski, A. (2023). Green Supply Chain Management: The Effect of Procurement Sustainability on Reverse Logistics. *Logistics*, 7, 47. <https://doi.org/10.3390/logistics7030047>
 59. Lyulyov, O., Chortok, Y., Pimonenko, T., & Borovik, O. (2015). Ecological and economic evaluation of transport system functioning according to the territory sustainable development. *International Journal of Ecology and Development*, 30(3), 1–10.
 60. Lyulyov, O., Chygryn, O., Pimonenko, T., & Kwilinski, A. (2023). Stakeholders' Engagement in the Company's Management as a Driver of Green Competitiveness within Sustainable Development. *Sustainability*, 15(9), 7249.
 61. Maiga, G., & Arinaitwe, I. (2017, May). A model for telemedicine adoption in remote healthcare settings. In 2017 IST-Africa Week Conference (IST-Africa) (pp. 1-8). IEEE.
 62. Melnychenko, O. (2019). Application of artificial intelligence in control systems of economic activity. *Virtual Economics*, 2(3), 30–40. [https://doi.org/10.34021/ve.2019.02.03\(3\)](https://doi.org/10.34021/ve.2019.02.03(3)).
 63. Melnychenko, O. (2021). The Prospects of Retail Payment Developments in the Metaverse. *Virtual Economics*, 4(4), 52–60. [https://doi.org/10.34021/ve.2021.04.04\(4\)](https://doi.org/10.34021/ve.2021.04.04(4))
 64. Mishra, A., Basumallick, S., Lu, A., Chiu, H., Shah, M. A., Shukla, Y., & Tiwari, A. (2021). The healthier healthcare management models for COVID-19. *Journal of Infection and Public Health*, 14(7), 927–937.
 65. Miśkiewicz, R. (2019). Challenges facing management practice in the light of Industry 4.0: The example of Poland. *Virtual Economics*, 2(2), 37–47. [https://doi.org/10.34021/ve.2019.02.02\(2\)](https://doi.org/10.34021/ve.2019.02.02(2)).
 66. Morell-Santandreu, O., Santandreu-Mascarell, C., & García-Sabater, J. (2020). Sustainability and kaizen: business model trends in healthcare. *Sustainability*, 12(24), 10622.
 67. Moro Visconti, R., & Morea, D. (2019). Big data for the sustainability of healthcare project financing. *Sustainability*, 11(13), 3748.
 68. Moskalenko, B., Lyulyov, O., Pimonenko, T. (2022a). The investment attractiveness of countries: coupling between core dimensions. *Forum Scientiae Oeconomia*, 10, 153–172. https://doi.org/10.23762/FSO_VOL10_NO2_8
 69. Moskalenko, B., Lyulyov, O., Pimonenko, T., Kwilinski, A., Dzwigol, H. (2022b), Investment Attractiveness of the Country: Social, Ecological, Economic Dimension. *International Journal of Environment and Pollution*, 69(1-2), 80–98. <https://dx.doi.org/10.1504/IJEP.2021.10050183>
 70. Mousa, S. K., & Othman, M. (2020). The impact of green human resource management practices on sustainable performance in healthcare organisations: A conceptual framework. *Journal of cleaner production*, 243, 118595.
 71. Narang, S., & Vij, D. (2021). The covid-19 pandemic: An analytical study on opportunities for circular economy practices in India's healthcare sector. *Asia Pacific Journal of Health Management*, 16(4), 236–242.

72. NHS Sustainable Development Unit (2010). Saving carbon improving future. NHS Carbon Reduction Strategy Update. Cambridge, UK. <https://www.england.nhs.uk/greenernhs/wp-content/uploads/sites/51/2021/02/NHS-Carbon-Reduction-Strategy-2009.pdf>
73. Nti, I. K., Adekoya, A. F., Weyori, B. A., & Keyeremeh, F. (2023). A bibliometric analysis of technology in sustainable healthcare: Emerging trends and future directions. *Decision Analytics Journal*, 100292.
74. Palozzi, G., Chirico, A., & Gabbrielli, F. (2020b). Cost analysis of telemedicine implementation in the lens of healthcare sustainability: A review of the literature. *Mobility Internet of Things 2018: Mobility IoT*, 451–469.
75. Palozzi, G., Schettini, I., & Chirico, A. (2020a). Enhancing the sustainable goal of access to healthcare: findings from a literature review on telemedicine employment in rural areas. *Sustainability*, 12(8), 3318.
76. Parasuraman, A., Zeithaml, V. and Berry, L. (1985). A conceptual model of service quality and its implications for future research. *Journal of Marketing*, 49(4), 41–50.
77. Pinzone, M., Guerri, M., Lettieri, E., & Redman, T. (2016). Progressing in the change journey towards sustainability in healthcare: the role of 'Green'HRM. *Journal of Cleaner Production*, 122, 201–211.
78. Polcyn, J., Us, Y., Lyulyov, O., Pimonenko, T., Kwilinski, A. (2022). Factors Influencing the Renewable Energy Consumption in Selected European Countries. *Energies*, 15, 108. <https://doi.org/10.3390/en15010108>
79. Punnakitikashem, P., & Hallinger, P. (2019). Bibliometric review of the knowledge base on healthcare management for sustainability, 1994–2018. *Sustainability*, 12(1), 205.
80. Puška, A., Stević, Ž., & Pamučar, D. (2022). Evaluation and selection of healthcare waste incinerators using extended sustainability criteria and multi-criteria analysis methods. *Environment. Development and Sustainability*, 1–31.
81. Ramirez, B., J. West, D., & M. Costell, M. (2013). Development of a culture of sustainability in health care organisations. *Journal of Health Organization and Management*, 27(5), 665–672.
82. Rashdan, O., & Csepy, G. (2019). Sustainable Business Models in Healthcare: A Scoping Review of the Quality and Quantity of Literature. In *The International Conference Finance and Sustainability* (pp. 167-176). Cham: Springer International Publishing.
83. Schwartzman, J. A., & Zucchi, P. (2021). Healthcare Managers' Perception about the Sustainable Development Goals (SDGs). *Journal of Management and Sustainability*, 11, 141.
84. Senna, P., Reis, A., Santos, I. L., Dias, A. C., & Coelho, O. (2020). A systematic literature review on supply chain risk management: is healthcare management a forsaken research field?. *Benchmarking: an international journal*, 28(3), 926–956.
85. Shaw, E., Walpole, S., McLean, M., Alvarez-Nieto, C., Barna, S., Bazin, K., ... & Woollard, R. (2021). AMEE Consensus Statement: Planetary health and education for sustainable healthcare. *Medical teacher*, 43(3), 272–286.
86. Shi, G., Liu, N., Yu, X., Zhang, H., Li, S., Wu, S., ... Li, C. (2019). Bibliometric analysis of medical malpractice literature in legal medicine from 1975 to 2018: Web of science review. *Journal of Forensic and Legal Medicine*, 66, 167–183. <https://doi.org/10.1016/j.jflm.2019.07.002>

87. Singh, S., Madaan, G., Kaur, J., Swapna, H. R., Pandey, D., Singh, A., & Pandey, B. K. (2023). Bibliometric Review on Healthcare Sustainability. *Handbook of Research on Safe Disposal Methods of Municipal Solid Wastes for a Sustainable Environment*, 142–161.
88. Smiiianov, V., Lyulyov, O., Pimonenko, T., Andrushchenko, T., Sova, S., Grechkovskaya, N. (2020). The impact of the pandemic lockdown on air pollution, health and economic growth: system dynamics analysis. *Wiadomości Lekarskie*, LXXIII(11), 2332–2338.
89. Soliman, M., Lyulyov, O., Shvindina, H., Figueiredo, R., & Pimonenko, T. (2021). Scientific output of the european journal of tourism research: A bibliometric overview and visualisation. *European Journal of Tourism Research*, 28
90. Spicka, J. (2018), How Do Agricultural Biogas Investments Affect Czech Farms?. *Central European Business Review*, 7(4), 34–60. <https://doi.org/10.18267/j.cebr.205>.
91. Spicka, J., Hlavsa, T., Soukupova, K., Stolbova, M. (2019). Approaches to estimation the farm-level economic viability and sustainability in agriculture: A literature review. *Agricultural Economics*, 65(6), 289–297. <https://doi.org/10.17221/269/2018-AGRICECON>.
92. Suha, S. A., & Sanam, T. F. (2023). Exploring dominant factors for ensuring the sustainability of utilising artificial intelligence in healthcare decision making: An emerging country context. *International Journal of Information Management Data Insights*, 3(1), 100170.
93. Sun, P., Wang, M., Song, T., Wu, Y., Luo, J., Chen, L., & Yan, L. (2021). The psychological impact of COVID-19 pandemic on health care workers: a systematic review and meta-analysis. *Frontiers in psychology*, 12, 626547.
94. Szczepańska-Woszczyna, K. (2018). Strategy, Corporate Culture, Structure and Operational Processes as the Context for the Innovativeness of an Organization. *Foundations of Management*, 10(1), 33–44.
95. Szczepanska-Woszczyna, K., & Bogaczyk, R. (2023). Organisational Climate and Employee Engagement – a Case Study of International Corporations. *Forum Scientiae Oeconomia*, 11(3), 9–29.
96. Szczepańska-Woszczyna, K., & Gajdzik, B. (2016). Competencies of engineering staff in steelworks after their restructuring. *Metalurgija*, 55(2), 271–274.
97. Szczepańska-Woszczyna, K., & Kurowska-Pysz, J. (2016). Sustainable business development through leadership in SMEs. *Engineering Management in Production and Services*, 8(3), 57–69.
98. Szczepańska-Woszczyna, K., Gatnar, S. (2022). Key Competences of Research and Development Project Managers in High Technology Sector. *Forum Scientiae Oeconomia*, 10(3), 107–130. https://doi.org/10.23762/FSO_VOL10_NO3_6.
99. Szczepańska-Woszczyna, K., Gedvilaitė, D., Nazarko, J., Stasiukynas, A., Rubina, A. (2022). Assessment of Economic Convergence among Countries in the European Union, Technological and Economic Development of Economy, 28, 1572–1588. <https://doi.org/10.3846/tede.2022.17518>
100. Szczepańska-Woszczyna, K., Muras, W., & Pikiewicz, M. (2021). Shareholders in creating the value of IT sector companies by shaping organisational culture in the context of the digital economy. In I. Stańczyk, & M. M. Stuss (Eds.), *Sustainability, Technology and Innovation 4.0* (pp. 304–316). Routledge.
101. Tonjang, S., & Thawesaengskulthai, N. (2022). Total Quality and Innovation Management in Healthcare (TQIM-H) for an Effective Innovation Development: A Conceptual Framework and Exploratory Study. *Applied System Innovation*, 5(4), 70.

102. Trushkina, N., Abazov, R., Rynkevych, N., Bakhautdinova, G. (2020). Digital Transformation of Organizational Culture under Conditions of the Information Economy. *Virtual Economics*, 3(1), 7–38. [https://doi.org/10.34021/ve.2020.03.01\(1\)](https://doi.org/10.34021/ve.2020.03.01(1)).
103. Trzeciak, M., Kopec, T.P., Kwilinski, A. (2022). Constructs of Project Programme Management Supporting Open Innovation at the Strategic Level of the Organization. *Journal of Open Innovation: Technology, Market, and Complexity*, 8, 58. <https://doi.org/10.3390/joitmc8010058>.
104. Tummers, L., Kruijen, P. M., Vijverberg, D. M., & Voesenek, T. J. (2015). Connecting HRM and change management: The importance of proactivity and vitality. *Journal of Organizational Change Management*, 28(4), 627–640. <https://doi.org/10.1108/JOCM-11-2013-0220>
105. United Nations (2015a). Department of Economic and Social Affairs Sustainable Development. The 17 Goals. <https://sdgs.un.org/goals>
106. United Nations (2023). United Nations Conference on Environment and Development, Rio de Janeiro, Brazil, 3-14 June 1992. <https://www.un.org/en/conferences/environment/rio1992>
107. United Nations. Department of Economic and Social Affairs Sustainable Development (2015b). Transforming our world: the 2030 Agenda for Sustainable Development, 1–35. <https://documents-dds-ny.un.org/doc/UNDOC/GEN/N15/291/89/PDF/N1529189.pdf?OpenElement>
108. Usharani, S., Manju Bala, P., Rajmohan, R., Kumar, T. A., & Pavithra, M. (2022). Blockchain Technology Use Cases in Healthcare Management: State-of-the-Art Framework and Performance Evaluation. *Blockchain, Artificial Intelligence, and the Internet of Things: Possibilities and Opportunities*, 117–140.
109. Villa, S. (2021). Operations Management for Healthcare Organizations: Theory, Models and Tools. Routledge Taylor & Francis Group.
110. Villarreal, E. R. D., García-Alonso, J., Moguel, E., & Alegría, J. A. H. (2023). Blockchain for healthcare management systems: A survey on interoperability and security. *IEEE Access*, 11, 5629–5652.
111. WHO Regional Office for Europe (2017). Roadmap to implement the 2030 Agenda for Sustainable Development, building on Health 2020, the European policy for health and well-being. Copenhagen. http://www.euro.who.int/_data/assets/pdf_file/0008/345599/67wd09e_SDGroadmap_170638.pdf?ua=1
112. World Health Organization (2023). Strengthening climate-resilient and environmentally friendly health systems and services. <https://www.who.int/europe/activities/strengthening-climate-resilient-and-environmentally-friendly-health-systems-and-services>
113. World Health Organization. Regional Office for Europe. (2013). Health 2020: a European policy framework and strategy for the 21st century. World Health Organization. Regional Office for Europe. <https://apps.who.int/iris/handle/10665/326386>
114. Wyatt J. (2015). Healthcare management and leadership. *Perspectives in Public Health*, 135(5), 222. <https://doi.org/10.1177/1757913915599697>
115. Zhanibek, A., Abazov, R., Khazbulatov, A. (2022). Digital Transformation of a Country's Image: The Case of the Astana International Finance Centre in Kazakhstan. *Virtual Economics*, 5, 71–94. [https://doi.org/10.34021/ve.2022.05.02\(4\)](https://doi.org/10.34021/ve.2022.05.02(4)).
116. Ziabina, Y., Kwilinski, A., Lyulyov, O., Pimonenko, T., & Us, Y. (2023). Convergence of energy policies between the EU and Ukraine under the green deal policy. *Energies*, 16(2), 998.

Psychological Well-Being and Readiness of Employees for Organizational Changes from Tertiary Education Institutions

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Abstract

The purpose of this study is to investigate the concept of psychological well-being as a crucial factor in determining an individual's readiness for organizational change. This selection is based on the importance of psychological well-being in the realm of personal resources within contemporary human resource management theory and practice. It is widely acknowledged as a universal standard for a person's positive socialization. This article examines the psychological well-being of employees at universities in Eastern Europe during the worldwide pandemic period and how it relates to their readiness for organizational change. The research utilizes the "Ready for Organizational Changes" approach and the Psychological Well-Being Scale to gather data. The results indicate that most respondents are aware of the changes being proposed, specifically the implementation of remote education. Additionally, the willingness of employees to support leadership in implementing changes and the willingness to implement innovations themselves are linked to their psychological well-being. The findings suggest that the level of psychological well-being of employees can predict their readiness for organizational changes, including the introduction of innovations. Overall, the study highlights the importance of considering the psychological well-being of employees from tertiary education institutions. By doing so, the success of these changes can be improved, as well-being has been linked to a greater willingness to embrace change and implement new ideas.

Key words

psychology, well-being, employees, change.

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Introduction

Recently, the world has undergone a significant change in working conditions and employment due to the ongoing COVID-19 pandemic. This situation has led to the rapid implementation of remote work and the digitalization of many industries, resulting in a significant shift in the way we work. This change can be considered "the largest quasiexperiment in history," as it has affected such a large proportion of the global population and has occurred at an unprecedented scale and speed (Debata et al., 2020). The term "quasiexperiment" refers to a situation where an experiment cannot be fully controlled, but observations can still be made, and conclusions can be drawn. In this case, the change in working conditions and employment is not a deliberate experiment, but the effects can still be studied. This shift has forced many companies and organizations to quickly adapt to remote work and digitalization, which has had a profound impact on employees' daily lives and routines (Courbalay et al., 2022). The pandemic has also highlighted the importance of digital skills, as increasingly more jobs require the ability to work remotely and use digital tools. It has also led to a shift in the balance of power between employers and employees, with more people now having the ability to work remotely and potentially seeking employment with companies in other locations (López Peláez et al., 2020). The digital age has brought about significant changes in all aspects of human life, including education. The COVID-19 pandemic has further accelerated these transformations, creating new challenges and tasks for personal development. On the one hand, these changes can cause tension and negatively impact a person's cognitive and creative abilities. On the other hand, they also require individuals to continuously adapt and develop in new and unfamiliar situations. The ability to navigate and thrive in this constantly evolving landscape is becoming increasingly important for personal and professional success (Zhao, 2020). The COVID-19 pandemic has further highlighted the importance of technology in education and staff well-being, as it has forced many schools and universities to shift to online learning. This has presented new challenges for students, educators and institutions, as they have had to quickly adapt to new teaching and learning modalities. Online learning requires different skills and strategies than traditional in-person classes, and many students struggle to adapt. Moreover, these global shocks have created new challenges and tasks for personal development. The changes in our life and work caused by the pandemic have led to increased levels of stress and uncertainty, which can negatively impact cognitive and creative abilities. However, it has also opened new opportunities for personal development, as individuals must be able to adapt to new situations and develop new skills to thrive in this rapidly changing world. Therefore, it is important for individuals to take an active approach to their personal development, continuously learn new skills and adapt to new situations. This will enable them to successfully navigate the digital age and to be well positioned for future opportunities and challenges (Guoyan et al., 2021).

1. Literature review

The reorganization of educational processes in universities and the integration of novel content and educational formats tied to digital technologies have elicited mixed reactions within the pedagogical community. A 2019 survey conducted by the International Association of Universities revealed a universal adoption of digital technologies in higher education, with 87% of teachers acknowledging their integration and 79% incorporating them to some extent in their practices. However, the preparedness for transformative measures was notably lower, as only 39% expressed readiness for online courses, blended learning, big data utilization, blockchains, etc. A quarter of respondents confessed to being

inadequately prepared for such future shifts, highlighting both the openness and reluctance of higher education instructors to embrace these changes, exacerbated by the abrupt introduction of distance learning during the COVID-19 pandemic. The broader issue of human adaptability to change, particularly among higher education faculty, remains insufficiently explored. Investigating the subjective factors influencing the preparedness of higher education instructors for change has gained significance in light of contemporary challenges and the quest for predictors of successful functioning and positive development in the modern era (Scherer et al., 2021). This article aims to explore psychological well-being as a subjective determinant of preparedness for organizational change. The selection of these characteristics stems from their recognized status in the realm of personal resources within modern human resource management theory and practice, with psychological well-being serving as a universal criterion for positive socialization.

The perception of organizational changes, encompassing new ideas and behaviors aligned with the evolving external environment, is investigated not only in terms of resistance but also in the context of readiness for change. While studying resistance to organizational change, the authors underscore the psychological mechanisms and behavioral indicators influencing the direction of change. Readiness, a phenomenon extensively examined in psychology, is delineated through various approaches. The activity approach views "readiness" as the condition or ability for successful activity (Holt & Vardaman, 2013). From a personal perspective, readiness manifests as a disposition toward specific behaviors and an attitude favouring active engagement (Holt et al., 2007). In an innovative framework, readiness encompasses personal, psychological, group sociopsychological, and organizational socio-economic factors that are crucial for successful innovation. From a comprehensive sociopsychological perspective, "readiness for change" or psychological readiness is portrayed as a category of subjective psychological reality resulting from volitional behavior leading to the activation of psychic resource, motivational, and energy spheres. This approach is relevant to our study because it emphasizes readiness for change's direct connection to subjective psychological reality, highlighting its reliance on individual resources rather than external factors (Wipulanusat et al., 2018). The relationships among psychological well-being, job satisfaction, and motivation are complex and multifaceted topics that have been extensively studied in the field of organizational psychology. While there is some overlap between these concepts, research has shown that they are distinct constructs that can have different effects on individuals within the workplace (Kosec et al., 2022). Psychological well-being refers to an individual's overall state of mental health and happiness. It encompasses various dimensions, such as life satisfaction, positive affect, and a sense of purpose. Research has consistently demonstrated a positive relationship between psychological well-being and job satisfaction. When employees experience high levels of psychological well-being, they are more likely to feel satisfied with their work and perceive their job as fulfilling and meaningful (Greenier et al., 2021).

On the other hand, job satisfaction specifically relates to an individual's feelings and attitudes toward his or her job. It reflects the extent to which employees are content with various aspects of their work, including the work itself, compensation, work-life balance, relationships with colleagues, and opportunities for growth. Job satisfaction is influenced by a variety of factors, such as job design, leadership style, organizational culture, and the perceived fairness of rewards and recognition. Studies have consistently shown that job satisfaction is positively associated with employee performance, organizational commitment, and overall well-being. Motivation, in the context of work, refers to the inner drive or desire to engage in work-related behaviors and achieve certain goals. While motivation

can influence job satisfaction, the relationship between the two is complex and can vary depending on various factors. Some research suggests that job satisfaction can enhance motivation by fostering a positive work environment, providing opportunities for growth and development, and recognizing employees' contributions. However, studies by Geisler et al. (2019) have shown that motivation and job satisfaction are not always strongly correlated. For example, employees may be highly motivated to achieve their goals but still experience low levels of job satisfaction due to external factors such as organizational constraints, lack of autonomy, or perceived inequities.

In conclusion, while there is a generally positive relationship between psychological well-being, job satisfaction, and motivation, it is important to recognize that these concepts are distinct and can have different effects on individuals within the workplace. Further research is needed to explore the intricate interplay between these factors and identify the specific conditions and mechanisms that influence their relationships. We rely on the definition provided by Diener (2021) to understand personal resources as being individual psychological traits that lead to greater success in various activities and a higher level of overall well-being. Personal resources refer to the individual psychological characteristics that are associated with a greater ability to successfully carry out various activities and achieve a greater level of psychological well-being. These characteristics can include self-esteem, self-efficacy, resilience, and optimism. According to the definition provided by Diener et al. (2012), personal resources are thought to be critical for individuals to navigate life challenges and achieve their goals. They also play an important role in mental health, as people who possess strong personal resources tend to be more resilient in the face of stress and adversity. Overall, personal resources are seen as a key factor in overall well-being and quality of life. From the point of view of the subject-activity paradigm of Zhurat et al. (2022), the university teacher acts as a subject of his activity. Subjectivity is represented as an ability that allows a person, showing reasonable activity, to make changes in the world around him or her, in himself or herself, creating and changing his or her image. In this sense, the subjective prerequisites of an activity can be considered personal resources of a person, stimulating his or her processes of self-regulation, self-development, and self-consciousness.

Analysis of works devoted to the problem of psychological well-being shows a variety of approaches to the interpretation and explanation of this phenomenon (Parasuraman et al., 2001). Studies of psychological well-being are widely presented in the logic of two approaches: subjective (hedonistic) and psychological (eudemonic) (Riff, 1989). Subjective well-being researchers concentrate on its affective element, emphasizing the positive facets of perception. In this approach, the overarching feature of well-being is construed as life satisfaction—a state achieved through pleasure attainment and the avoidance of displeasure, encapsulating the essence of happiness. According to Diener's (1984) framework, subjective well-being is an individual's contentment across various life spheres. A person exhibiting frequent satisfaction and infrequent unpleasant feelings is deemed to possess a high level of well-being. Conversely, an individual dominated by negative emotions, seldom experiencing joy and happiness, is considered to have a low level of subjective well-being. However, we contend that this approach has limitations, particularly in its tendency to overemphasize the emotional component, which, while undoubtedly a reliable indicator of well-being, may not capture the full spectrum of an individual's experience. Devotees of the eudemonic approach explore well-being through the lens of comprehensive self-realization within specific life circumstances and conditions, emphasizing a harmonious synthesis of social environmental needs and personal development. In modern studies of psychological well-being, attempts have been made to combine the achievements of hedonistic and

eudemonic approaches (Czerw, 2019). From the standpoint of clinical psychology, well-being is associated with the concepts of mental health, the internal picture of health (illness), life satisfaction, personal well-being, and emotional well-being. From the standpoint of humanistic, positive psychology, and developmental psychology, psychological well-being is considered from the point of view of the peak of a person's potential. Researchers working in this paradigm believe that the subjective experience of happiness is not only a positive experience, as is the feeling of a person's self-realization or self-fulfilment (Keyes, 2006). Ryff (1989), in his concept of psychological well-being, identified 6 indicators of psychological well-being: self-acceptance of a person, a positive relationship with society, environmental management, the presence of life goals, personal growth, and autonomy. The main idea of her concept is that the development of these personal components ensures the positive functioning of the personality, as well as the degree of human self-realization, which are reflected on the subjective level through the experience of satisfaction and happiness (Rusu, 2019). In our study, the psychological well-being of a person is understood as a set of psychological mechanisms for the positive functioning of the subject and a subjective assessment of the proximity of his current state to the desired state and satisfaction with the current level of life. Numerous studies by international and regional scholars and practitioners have shown that personal resources play an indirect role in psychological well-being. Based on the generalization of the research results, the following functions of personal resources were identified: buffering, filtering, and motivating, which, to some degree, are aimed at ensuring psychological well-being.

2. Methodology

To assess the psychological preparedness of educational providers for embracing innovations, we utilized the methodology known as "Readiness for Organizational Changes" (GOI) (Holt, 2007). This methodology was used to measure the participants' level of preparedness for organizational changes at their university. The research question of this study is which factors influence university teachers' readiness for organizational change. Additionally, the respondents were asked to complete an author-designed questionnaire that assessed their level of agreement with statements that described the specific changes that are being implemented within the universities. The questionnaire aimed to gather information about the teachers' perceptions of the proposed innovations and how they are being implemented in the university. This information was used to determine the employees' level of psychological readiness to introduce these changes and how it may impact their psychological well-being. The implementation of distance learning formats was assessed through a 5-point scale, where 5 corresponds to "completely agree," 4 to "agree," 3 to "Neither, I cannot define for myself," 2 to "disagree," and 1 to "entirely disagree." In addition to using the GOI methodology, the study also involved the use of an author-designed questionnaire. This questionnaire aimed to gather information about the teachers' perceptions of the proposed innovations and how they are being implemented in the university. The questionnaire used a 5-point scale to assess the teachers' level of agreement with statements that described the specific changes being implemented. The scale ranged from 5, which represented complete agreement, to 1, which represented complete disagreement.

The information gathered from the questionnaire was used to determine the teachers' level of psychological readiness to introduce the changes and how they may impact their psychological well-being. Specifically, the study aimed to understand how teachers' perceptions of the proposed innovations influenced their readiness to adopt them and how they affected their psychological well-being.

The research included 110 participants, comprising 32.9% men and 67.1% women, employed in higher educational institutions across Eastern European countries, including Bulgaria, Latvia, Estonia, Ukraine, and Serbia. These participants specialized in diverse professional domains, such as management, business, economics, sociology, psychology, entrepreneurship, and law. Within the total sample of 110 individuals, 5.4% were educators without an academic degree, 68.3% held the position of teachers with an academic Ph.D., and 10.9% were teachers with the academic title of "Doctor of Philosophy." The age distribution of the participants revealed that 23.7% were under 30 years old, 33.7% were 40-49 years old, 12.9% were 30-39 years old, and 29.8% were over 50 years old. Regarding tenure at their respective universities, 2.0% had worked for less than one year, 8.9% had 1-3 years of teaching experience, 7.9% had 3 to 5 years of experience, 26.7% had been teaching for 5 to 8 years, and the majority, constituting 54.5%, boasted more than 8 years of teaching experience. The adaptation made by Henn et al. (2016) aimed to evaluate the psychological well-being of the participants in their specific population, and the results of the adaptation may provide insights into the participants' level of psychological well-being. Data analysis was carried out using the SPSS software package. This software is commonly used for statistical analysis and is widely used in the social sciences, including psychology. The use of the SPSS software package allows the analysis of large amounts of data gathered from the psychological assessment tool. The results of the analysis provided insights into the psychological well-being of the participants, which could inform future interventions or treatments. Overall, the adaptation of the psychological assessment tool by Henn et al. (2016) and subsequent data analysis using the SPSS software package allowed for a better understanding of the psychological well-being of the specific population of participants. This information can be used to inform interventions or treatments to improve psychological well-being in this population.

3. Research results

In the initial phase, an investigation was conducted to gauge university professors' views on organizational changes, specifically the implementation of distance learning prompted by the pandemic. Additionally, an evaluation of their preparedness to execute these changes within the university context was undertaken. The study sample comprised university teachers, and the results indicated a heightened level of awareness regarding the nature of impending changes, notably the widespread adoption of distance learning. Moreover, 92% of the respondents acknowledged a clear understanding of potential risks in the absence of these changes, as depicted in Table 1.

Table 1. University professors' attitudes towards innovation

Statement, Ratio of respondents to the total number (%)	Rating				
	1 Totally disagree	2 Disagree	3 Hard to say, cannot identify for me	4 Agree	5 Totally agree
Perception of the essence of innovation is and its need at the moment	3 (3,0%)	5 (5,0%)	18 (17,8%)	26 (25,7)	49 (48,5)
Approach to innovation- working from home regime and educating students	Positive	20 (19,8%)			
	Negative	39 (38,6%)			
	Neutral	42 (41,6%)			
Existence of stamina to take a part in innovations and fostering them	17 (16,8%)	12 (11,9%)	28 (27,7%)	28 (27,7%)	16 (15,8%)
Sufficient knowledge needed to introduce innovations	3 (3,0%)	10 (9,9%)	21 (20,8%)	46 (45,5%)	21 (20,8%)
Existence of merits and behaviours required in the newly formed working environment	1 (1,0%)	7 (6,9%)	30 (29,7%)	39 (38,6%)	24 (23,8%)

Source: own elaboration in SPSS version 25.0

Table 1 outlines the respondents' perspectives on various aspects related to the perception and implementation of innovation in the educational setting. Each row represents a different dimension, and the columns reflect different response categories, ranging from "Totally disagree" (1) to "Totally agree" (5). The ratio of respondents to the total number of participants is expressed as a percentage. A notable 48.5% of respondents "Totally agree" with the importance of innovation, indicating a strong consensus on its significance. However, a substantial proportion (17.8%) find it challenging to identify or remain uncertain about the essence and need for innovation. This suggests a need for clarification or communication regarding the purpose and urgency of innovative practices. The majority (41.6%) expressed a neutral stance, while a substantial percentage (38.6%) held a negative view toward the innovation of working from home and educating students. This indicates potential resistance or dissatisfaction with the current approach to innovation in the context of remote work and student education. While a considerable percentage expressed uncertainty (27.7%) about their ability to participate in innovations, roughly equal percentages (27.7%) agreed or totally agreed. This suggests a varied level of enthusiasm or readiness among respondents to engage in innovative practices. Thus, we can conclude that university professors are ready and able to cope with the urgent task of modern reality—the transition to distance learning—although they are not encouraged by this prospect—and that their attitude toward this organizational change is rather negative.

Table 2 presents the results of diagnosing the readiness of university teachers to implement organizational changes.

Table 2. Results of diagnosing the preparedness of university teachers to implement organizational changes

Readiness for organizational change	N	Min	Max	M	Me	SD
The relevance of the change	110	0.00	62.00	37.79	40.00	13.60
Management support	110	0.00	35.00	24.87	25.00	5.54
Feasibility of changes	110	0.00	35.00	25.31	26.00	6.10
Personal attitude	110	0.00	33.00	21.16	21.00	6.21

Source: own elaboration in SPSS version 25.0

We identified three groups of university teachers by their level of readiness for organizational change:

- the first group – 18 people (17.8%)—a group of teachers with a high readiness to implement organizational changes (all values of the GOI components are higher than the medians);
- the second group – 16 people (15.8%)—a group of teachers with a low readiness to implement organizational changes (all values of the GOI components are lower than the medians);
- the third group – 67 people (66.4%), a group of teachers in which the values of the GOI components were found both below and above the medians (the group with an average GOI).

Table 3 shows the results of psychological well-being diagnostics among teachers with different levels of readiness to implement organizational changes. As the results of the study show, the general indicator of the psychological well-being of university teachers is within the average values ($M = 202.21$, $\sigma = 28.04$), which indicates the fairly positive functioning of teachers and their subjective feeling of psychological well-being. The average values of all scales of psychological well-being tend to be related to the level of readiness for organizational change: the lowest values are among teachers with a low level of readiness for organizational change, and the highest are among teachers with a high level

of readiness for organizational change. However, the differences in the means do not reach significant values.

Table 3. Features of psychological well-being for teachers with different levels of GOI

Specifications	Preparedness for organizational change							
	Low		Middle		High		The whole	
	16 ppl (15.8%)		67 ppl (66.4%)		18 ppl (17.8%)		Sample covered 101 respondents	
Psychological well-being	M	SD	M	SD	M	SD	M	SD
Autonomy	28.31	8.44	30.94	3.78	32.50	4.10	30.80	4.95
Competence	29.81	9.01	31.62	4.73	33.00	5.23	31.58	5.70
Personal growth	32.93	9.82	36.01	4.37	37.61	4.16	35.81	5.50
Positive relationship	32.31	10.89	34.25	5.93	37.44	4.30	35.51	6.82
Life goals	32.50	9.88	35.28	4.19	37.05	4.38	35.15	5.90
Self- acceptance	33.00	9.68	34.40	4.33	35.27	4.52	34.33	5.51
General indicator of psychological well-being	188.87	53.86	202.52	18.36	212.88	21.70	202.21	28.04

Source: own elaboration in SPSS version 25.0

Correlation analysis of the data on readiness for organizational change and the traits of university teachers' psychological well-being revealed significant links between them (Table 4).

Table 4. The relationship between readiness for organizational change and psychological well-being among employees

Employees		Psychological Well-being Scales						
		Autonomy	Competence	Personal growth	Positive relationship	Life goals	Self-acceptance	Total score
Scales of the readiness for organizational changes	The relevance of the changes	-0.011	0.00	0.095	0.077	0.096	-0.052	0.037
	Management support	0.142	0.168*	0.230*	0.282**	0.254**	0.203*	0.292**
	Feasibility of changes	0.042	0.262**	0.351**	0.189*	0.231*	0.232**	0.279**
	Personal attitude	0.346**	0.244**	0.128	0.072	0.168*	0.157	0.198*

Source: own elaboration in SPSS version 25.0

The correlation is significant at the 0.01 level (two-sided). ** The correlation is significant at the 0.05 level (two-sided). It was found that two scales of the organizational change readiness questionnaire (the Leadership Support scale and the Feasibility of Change scale) are related to the following parameters of psychological well-being: competence ($r_1 = 0.168^*$ and $r_2 = 0.262^{**}$, respectively, at $p < 0.05$), personal growth ($r_3 = 0.230^*$ and $r_4 = 0.351^{**}$, respectively, at $p < 0.05$), positive relationships ($r_5 = 0.282^{**}$ and $r_6 = 0.189^*$, respectively, at $p < 0.05$), life goals ($r_7 = 0.254^{**}$ and $r_8 = 0.231^*$, respectively, at $p < 0.05$), self-acceptance ($r_9 = 0.203^*$ and $r_{10} = 0.232^{**}$, respectively, at $p < 0.05$) and the general indicator of psychological well-being ($r_{11} = 0.292^{**}$ and $r_{12} = 0.279^{**}$, respectively, at $p < 0.001$).

We also found significant links between the personal attitude to organizational change subscale and personality autonomy ($r_{13} = 0.368^{**}$, $p < 0.001$) and competence ($r_{14} = 0.244^{**}$, $p < 0.001$), as well as the general level of psychological well-being ($r_{15} = 0.198^{**}$, $p < 0.05$). These data make it possible to assert that the personal attitude of university teachers toward innovations directly depends on the level of self-determination of teachers (the higher the level is, the greater the readiness for organizational changes), the ability to withstand social pressure, think and behave independently, regulate their behaviour, and the level of competence of the teacher. The belief that university management is dedicated

to change and provides support to teachers, along with teachers' evaluations of their ability to implement suggested innovations, is positively linked to various facets of psychological well-being among employees. This includes having a sense of purpose in life, feeling that their work is meaningful, having a positive self-image and having the ability to empathize and build trust with others. Additionally, teachers who feel competent and can align their personal needs and values with their work environment and who are open to new experiences are more likely to have a sense of ongoing development and potential. However, no significant correlation was found between university professors' perceptions of the appropriateness of organizational changes and their psychological well-being.

4. Discussion

Organizational changes have been taking place in Eastern European universities in recent years, specifically in regard to digitalization, distance learning, and online education. These changes were perceived by the teaching community as a global social experiment that aimed to address the challenges of the current era. It was assumed that teachers would gradually become more accepting of these changes and adapt to the new way of functioning of educational organizations (Parubchak et al., 2019). However, in March 2020, the global pandemic situation forced these changes to become mandatory and immediate. The pandemic affected all aspects of university education and created a need for rapid and massive innovation. This situation requires not only an assessment of teachers' readiness for these changes but also a prediction of the potential risks and disruptions that the educational system may face as a result. The situation created by the pandemic also forced a sudden and massive shift to online learning methods and digitalization, which may have led to various challenges and limitations. Therefore, it is important to consider the impact of the COVID-19 pandemic on the operation of destination management organizations (DMOs). These organizations play a crucial role in shaping the tourism and education industries and developing individual destinations. It should be noted that a DMO's main function is to bring together various stakeholders towards a common goal. The effectiveness of this role is dependent on the quantity and quality of the relationships the DMO has with local stakeholders and government agencies. Given this, it can be inferred that the COVID-19 pandemic, which has impacted DMOs, will also affect the functioning of the entire destination, including the businesses operating within its area (Fedyk et al., 2022). For example, the COVID-19 pandemic has caused a widespread shock with far-reaching impacts, affecting various sectors globally. The tourism industry, in particular, has seen significant and permanent changes across all its subsectors. Prior to the pandemic, the tourism industry experienced rapid growth, but the crisis brought this development to a sudden halt. Organizational changes have been taking place in Eastern European universities in recent years, specifically in regard to digitalization, distance learning, and online education. These changes were perceived by the teaching community as a global social experiment that aimed to address the challenges of the current era. It was assumed that teachers would gradually become more accepting of these changes and adapt to the new way of functioning of educational organizations (Parubchak et al., 2019). However, in March 2020, the global pandemic situation forced these changes to become mandatory and immediate. The pandemic affected all aspects of university education and created a need for rapid and massive innovation. This situation requires not only an assessment of teachers' readiness for these changes but also a prediction of the potential risks and disruptions that the educational system may face as a result. The situation created by the pandemic also forced a sudden and massive shift to online learning methods and digitalization, which may have led to various

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It is known that external factors stimulating readiness for organizational change (innovativeness, uniqueness of digital technologies caused by the development of all spheres of life, organization of the introduction of new technologies) actualize personal barriers and difficulties for teachers (Dolata, 2009). Meanwhile, the same innovations among some teachers not only reduce cognitive and labor activity but also stimulate it. This is connected, in our opinion, with the presence of a subject position in the teacher and with the development of subjectivity. Subjectivity, as an active principle, forms the basis for transformations of the surrounding world and oneself about it, acting as a condition for the progressive development of a person. This circumstance allows us to consider subjectivity as a principle of creating modern educational systems and as a condition for overcoming resistance to changes in them. Stability, self-regulation, motivation, and instrumental resources are prerequisites for a person's readiness in a situation of organizational change. This is a kind of potential, a set of personal resources, the use of which determines readiness for organizational change. Subjectivity is an integrator of these resources, determining the possibility of their use, especially in a crisis or emergency. Treating oneself as an agent helps a person to mobilize and realize himself in force majeure circumstances. It is the responsibility of the employer to implement all feasible measures to eliminate exposure to harmful biological agents and, if that is not possible, to reduce the extent of exposure through the use of advanced science and technology. Rapid and efficient identification and containment of COVID-19 outbreaks in institutions is imperative and calls for the logistic cooperation of employers and health protection services for both employers and students. Therefore, in our work, we focused on the study of readiness for organizational changes in the paradigm of subjectivity and a subjective-active approach.

Considering the subjective prerequisites of readiness for organizational changes, we paid special attention to psychological well-being as a personal resource, which, according to Stouten et al. (2018), enables a person to realize himself, while experiencing a feeling of satisfaction and happiness. At the same time, a person develops a positive relationship with society and clear life goals and values, which he or she is guided by in his or her actions and behavior. In today's rapidly evolving digital landscape, young IT-competent faculty members often find themselves dissatisfied with their status within stagnant organizations. Despite their technical expertise and valuable contributions, they may feel undervalued and underutilized (Mwesigwa et al., 2020). Consequently, these individuals may experience lower levels of psychological well-being within their current work environment. However, their dissatisfaction does not deter their motivation to seek new opportunities and make a significant change

by transitioning to organizations that prioritize digital communication as a catalyst for transformation (Moussa & Somjai, 2019). Young IT-competent faculty members recognize the immense potential of digital communication as a tool for positive change. They understand that effective digital communication strategies can enhance collaboration, streamline processes, and facilitate innovation. By leveraging digital platforms, organizations can break free from traditional hierarchies and foster a more dynamic and inclusive work culture. Moreover, young IT-competent faculty members are acutely aware of the benefits of digital communication in reaching wider audiences and promoting knowledge dissemination. They believe that embracing technology can facilitate the sharing of research findings, pedagogical best practices, and collaborative projects among peers and institutions globally. This not only enriches their own professional growth but also contributes to the advancement of the academic community as a whole. Furthermore, by embracing digital communication, organizations can attract and retain top talent. Young IT-competent faculty members are eager to work in environments that value their technical skills and provide opportunities for growth and innovation. They are motivated by the prospect of being part of forward-thinking organizations that leverage technology to enhance teaching, research, and administrative processes. Young IT-competent faculty members, while dissatisfied with their status in stagnant organizations and experiencing lower levels of psychological well-being, remain optimistic about the potential for change. They recognize digital communication as a powerful tool for transforming organizations and driving positive outcome.

By embracing digital platforms, organizations can tap into the vast potential of young IT-competent faculty members, foster collaboration and innovation, and create an environment that nurtures their well-being and professional growth. The study results indicate that teachers' personal attitudes towards the organizational changes being implemented are strongly correlated with personal factors such as autonomy, competence, and life goals. Teachers who have a positive attitude towards these changes tend to see the benefits of the new situation, such as the convenience, speed, and accuracy resulting from the digitalization of basic educational processes, access to a wide variety of information sources, the ability to replay events, and the option to repeat materials in distance learning and online education. Teachers with pronounced characteristics of subjectivity were able to predict its possible positive consequences. These teachers were distinguished by independence of judgments and actions; they were not afraid to oppose their opinions to others; they could assess themselves, other people, and the events taking place, relying on their preferences; and they had nonstandard thinking and behavior. Personality traits are seen as multiple dimensions that define a person's personality to some degree. These traits are responsible for the stability of an individual's personality across various situations and can be shaped by both genetic factors and learning experiences. They had clear goals in life, were distinguished by a sense of meaningfulness of existence, and understood the value of those events that happened in the past, occurred in the present, and will occur in the future. These teachers developed skills for the effective management of others, and they were able to overcome difficulties in realizing their own goals. The overall level of psychological well-being among these teachers was high.

Conclusions

The pertinence of changes, the notion of their timeliness, and their suitability within the framework of a particular educational institution were found to have no correlation with the psychological well-being of the respondents. None of the aspects of psychological well-being exhibited any correlation with this facet of organizational change readiness. This lack of association may be attributed to various

factors, one of which is influenced by the nature of the threats and risks posed by the global pandemic. It can be assumed that the lack of connection between the component “appropriateness of changes” and the characteristics of psychological well-being is an indicator of confusion and some disorientation of university teachers in a pandemic situation, especially in its initial stage. In addition, it is possible that the nature of the activities of a university teacher, as a whole, does not imply an assessment of any innovations as appropriate or inappropriate. At the same time, three out of four components of readiness for organizational change were found to be associated with higher education teachers’ psychological well-being. Research has indicated that psychological well-being can be regarded as a predictor of the preparedness of higher education instructors for organizational changes (Brynza, 2015). It can predict to what extent an employee is ready to implement organizational changes, but it can only do so in part and under the conditions described above. There may be other subjective prerequisites, the contribution of which to the predictive ability is commensurately greater. Perhaps additional research will reveal a willingness to implement changes due to reasons other than subjective ones. The proposed assumptions are, in our opinion, an important research task. The results obtained in the course of the study allow us to speak of the possibility of transforming individual readiness university teachers into a common desire to support changes and innovations into confidence in the success of undertakings if we take into account their resources and limitations.

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Reference

1. Bahrombekovna, D. R. (2020). Using the system "Virtual Psychologist" in determining the psychological and pedagogical readiness of students for professional education. *International Journal on Integrated Education*, 3(3), 1–4.
2. Brynza, I. (2015). Readiness for change as a psychological resource of the individual in achieving well-being. *Science and Education a New Dimension. Pedagogy and Psychology*. 3(31), 69–73.
3. Courbalay, A., Brandet, Q., Girard, D., & Gillet, N. (2022). Benefits of a Brief Physical Activity Programme on Employees’ Affective Well-being and Momentary Affective States: A Quasi-Experimental Study. *Journal of Happiness Studies*, 1–17.
4. Czerw, A. (2019). Diagnosing well-being in work context—eudemonic well-being in the workplace questionnaire. *Current Psychology*, 38(2), 331–346.
5. Debata, B., Patnaik, P., & Mishra, A. (2020). COVID-19 pandemic! Its impact on people, economy, and environment. *Journal of Public Affairs*, 20(4), e2372.
6. Diener, E., Fujita, F., Tay, L., & Biswas-Diener, R. (2012). Purpose, mood, and pleasure in predicting satisfaction judgments. *Social indicators research*, 105(3), 333–341.

7. Dolata, U. (2009). Technological innovations and sectoral change: Transformative capacity, adaptability, patterns of change: An analytical framework. *Research Policy*, 38(6), 1066–1076.
8. Holt, D. T., Armenakis, A. A., Feild, H. S., & Harris, S. G. (2007). Readiness for organizational change: The systematic development of a scale. *The Journal of applied behavioral science*, 43(2), 232–255.
9. Holt, D. T., & Vardaman, J. M. (2013). Toward a comprehensive understanding of readiness for change: The case for an expanded conceptualization. *Journal of change management*, 13(1), 9–18.
10. Geisler, M., Berthelsen, H., & Muhonen, T. (2019). Retaining social workers: The role of quality of work and psychosocial safety climate for work engagement, job satisfaction, and organizational commitment. *Human Service Organizations: Management, Leadership & Governance*, 43(1), 1–15.
11. Greenier, V., Derakhshan, A., & Fathi, J. (2021). Emotion regulation and psychological well-being in teacher work engagement: a case of British and Iranian English language teachers. *System*, 97, 102446.
12. Guoyan, S., Khaskheli, A., Raza, S. A., Khan, K. A., & Hakim, F. (2021). Teachers' self-efficacy, mental well-being and continuance commitment of using learning management system during COVID-19 pandemic: a comparative study of Pakistan and Malaysia. *Interactive Learning Environments*, 1–23.
13. Keyes, C. L. (2006). Subjective well-being in mental health and human development research worldwide: An introduction. *Social indicators research*, 77(1), 1–10.
14. Kosec, Z., Sekulic, S., Wilson-Gahan, S., Rostohar, K., Tusak, M., & Bon, M. (2022). Correlation between Employee Performance, Well-Being, Job Satisfaction, and Life Satisfaction in Sedentary Jobs in Slovenian Enterprises. *International Journal of Environmental Research and Public Health*, 19(16), 10427.
15. López Peláez, A., Erro-Garcés, A., & Gómez-Ciriano, E. J. (2020). Young people, social workers, and social work education: The role of digital skills. *Social Work Education*, 39(6), 825–842.
16. Moussa, M., & Somjai, K. (2019). Job dissatisfaction and employee turnover: A qualitative case study in Thailand. In *SAGE Business Cases*. SAGE Publications: SAGE Business Cases Originals.
17. Mwesigwa, R., Tusiime, I., & Ssekiziyivu, B. (2020). Leadership styles, job satisfaction and organizational commitment among academic staff in public universities. *Journal of Management Development*, 39(2), 253–268.
18. Parasuraman, S., & Simmers, C. A. (2001). Type of employment, work–family conflict, and well-being: a comparative study. *Journal of Organizational Behavior: The International Journal of Industrial, Occupational and Organizational Psychology and Behavior*, 22(5), 551–568.
19. Parubchak, I., Smolinska, O., & Marszałek-Kawa, J. (2019). Social Aspects of the Development of the Management Systems of Eastern European Universities in the Transformation Period. *The New Educational Review*, 58, 109–121.
20. Rusu, M. (2019). The process of self-realization—From the humanist psychology perspective. *Psychology*, 10(08), 1095.
21. Ryff, C. D. (1989). Happiness is everything, or is it? Explorations on the meaning of psychological well-being. *Journal of Personality and Social Psychology*, 57(6), 1069–1081.

22. Scherer, R., Howard, S. K., Tondeur, J., & Siddiq, F. (2021). Profiling teachers' readiness for online teaching and learning in higher education: Who's ready?. *Computers in human behavior*, 118, 106675.
23. Stouten, J., Rousseau, D. M., & De Cremer, D. (2018). Successful organizational change: Integrating the management practice and scholarly literatures. *Academy of Management Annals*, 12(2), 752–788.
24. Wipulanusat, W., Panuwatwanich, K., & Stewart, R. A. (2018). Pathways to workplace innovation and career satisfaction in the public service: The role of leadership and culture. *International journal of organizational analysis*, 26(5), 890–914.
25. Zhao, Y. (2020). COVID-19 as a catalyst for educational change. *Prospects*, 49(1), 29-33.
26. Zhurat, Y., Yanovskyi, A., Ianovska, L., Tsymbal, M., Kozyr, M., & Kokorina, L. (2022). The Problem of Subject and Subjectivity in Psychological and Pedagogical Sciences in the Context of Training Future Teachers. *Revista Romaneasca pentru Educatie Multidimensionala*, 14(1Sup1), 349–369.

Entrepreneurial Stress and Mental Well-being: Pre- and Post-COVID-19 Comparative Analysis of SMEs in Canada

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Abstract

There is no conclusive evidence to compare pre- and post-COVID-19 data to measure the performance of SMEs through the lens of mental well-being. The goal of this paper is to contribute to the existing knowledge through a comparative lens, especially considering entrepreneurial stress. This research examined the entrepreneurial stress and mental well-being of entrepreneurs in Canadian SMEs, specifically pre- and post-COVID-19. The PRISMA framework, based on the philosophy of interpretivism, was applied and 37 articles were taken into consideration for this research. The findings confirm that there is a significant increase in the entrepreneurial stress affecting the mental well-being and overall performance of Canadian SMEs, especially during and after COVID-19. Furthermore, this research confirmed that everyone's reaction to and precautions taken against entrepreneurial stress vary. Interestingly, distinct stressors such as finances, family, and work-life imbalance have evidently increased. However, the magnitude of these stressors varies for individuals. Similarly, the consequences also differ; however, emotional symptoms, followed by physical and behavioural symptoms, have noticeably been exhibited by entrepreneurs both pre- and post-COVID, while performance among SMEs has dwindled, which has brought about a higher number of entrepreneurship closures. This manuscript contributes to the existing literature from multiple facets, such as (i) through the comparative lens, (ii) enriching the literature from an advanced economy, (iii) expanding upon the theory of entrepreneurial stress, and (iv) shedding light on the importance of entrepreneurs' mental well-being. The manuscript also provides practical implications to entrepreneurs to deal with distinct types of stressors.

Key words

entrepreneurial stress, mental well-being, overall performance, SMEs.

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Introduction

Studies have confirmed that entrepreneurship is an art and science by means of which to develop a new venture by taking risks to enhance financial stability and growth while developing job opportunities (Hessels & Naudé, 2019; Diandra & Azmy, 2020). Globally, there are 582 million entrepreneurs (Kiniulis, 2022). Interestingly, Canada, being an advanced economy, is ranked 23rd among 190 economies in the World Bank annual ratings for the “ease of doing business” (Trading Economics, 2023). However, while entrepreneurial activities are relatively easier in Canada, its ranking has plunged due to the pandemic (Trading Economics, 2023). Canadian SMEs are essential contributors to the economy, employing almost two-thirds (63%) of the population and contributing 52.3% of GDP (Delgado et al., 2023; Government of Canada, 2021). Despite these crucial contributions, Canadian SMEs face major challenges that could directly or indirectly jeopardise entrepreneurs’ performance and mental well-being. SMEs are faced with rising costs, skilled labour shortage and retention challenges, rising interest rates, insurance expenditures, higher debt costs, and cost of inputs, to name but a few (Delgado et al., 2023).

Canada’s COVID-19 measures affected 52% of entrepreneurs, and 42% have shown cause for concern about the impact of COVID-19 on their employees and families. Furthermore, isolation and loneliness has increased from 21% to 28% among Canadian entrepreneurs, along with stress caused by the inability to manage funds for capital investment and operations (BDC, 2021). While entrepreneurial stress is part of the life of an entrepreneur, in the existing literature, the impact of distinct stressors such as personal, organisational, or environmental stress is nonetheless understudied. The literature at hand does not provide conclusive evidence exploring the topic of SMEs and entrepreneurial stress from the Canadian perspective; therefore, this research enriches the literature by providing details from the specific region (i.e. Canada – an advanced economy) for a better understanding of the types of stressors affecting Canadian entrepreneurial ventures. Moreover, this research provides entrepreneurial action to provide the insight depth through comparative lens and offers suggestions to deal with different types of stressors and environmental uncertainties. This research has considered the pre-and-post COVID-19 scenario to assess the performance of the Canadian SMEs and the pandemic impact on the mental well-being of the entrepreneurs, which enables the entrepreneurs to have the appropriate strategies in complex situations. The existing literature at hand had given general overview without considering the comparative aspect. Hence, this research being the first to use comparative mode for not only understanding the variables of interest, but also offer the entrepreneurial actions in such situations. The scholarly world and researchers benefit by enhancing their understanding about entrepreneurial action. The professionals’ benefit from this research by learning about the practical implications and recommendations (i.e., entrepreneurial action plan) to deal with different types of stressors and improve the existing performance.

The aim is to investigate the impact of entrepreneurial stress on the mental well-being and overall performance of the Canadian SMEs, specifically pre-and-post COVID-19.

1. Literature review

Entrepreneurs is an individual who provides or owns or initiates a service, a production, or a distribution by perceiving new opportunities or scarce of resources, for the purpose of profit earning (Holland, 2013; BDC, 2021; Haque, 2023). Thus, one could argue that entrepreneurship is the capacity to recognize new opportunity and comprehends the need and necessity for a new or unique solution. On the other hand, mental well-being is another significant variable of interest in relation to the

entrepreneurship action and progress. Plethora of studies suggest that work productivity and contentment in personal life is correlated with mental well-being (Haque, 2023; Xu & Jia, 2022). Entrepreneurs exhibit a higher level of stress in the negative events as compared to other individuals (Faizan & Haque, 2016). Various studies confirmed that COVID-19 caused enormous economical cost (Walmsley et al., 2020; Belitski et al., 2022; Delgado et al., 2023), and negatively affecting the health and well-being of the masses (Verbeke & Yaun, 2020).

During Covid-19, entrepreneurs were under extreme financial pressure as well as uncertainty (Kuckertz & Brändle, 2022) and in such circumstances, they also had to engage in crisis management (Salamzadeh & Dana, 2020), such affects hinder Entrepreneurs decisions and work tasks. The consequences of these circumstances resonated throughout entrepreneurs' decision-making processes and day-to-day work duties. The ubiquitous impact of such challenges hampered entrepreneurs' capacity to make quick and confident decisions, hindering their normal workflow and operational efficiency. The need to manage through financial insecurity, market volatility, and crisis responses substantially burdened entrepreneurs, modifying their regular business style and testing their agility in an ever-changing environment.

Interestingly, Canadian SME employees approximately 8.2 million or 67.7% labour force (Government of Canada, 2021). To put things in prospect, that is 88.3% of Canadian working in the private labour force. Approximately 43% of Canadian export is produce by SMEs. The manufacturing is 58.7% while wholesale trade is 12.6% (Government of Canada, 2021). However, with the major shift in the operations around the globe due to Pandemic, there are significant drop in the entrepreneurial actions and ventures (Table 1). There impact of COVID-19 affecting the Canadian businesses are illustrated below:

Table 1. Trends and statistics about entrepreneurship and entrepreneurial activities

Trends	Statistics	Reference
Canadian Business ownership incorporated business decline	-14.8 (decrease)	Beland et al. (2020)
Canadian Business ownership unincorporated business	10.1 (decrease)	Beland et al. (2020)
Business revenue decline	30% (decrease)	CFIB (2022)
Increased unemployment	0.8% (increase)	Kurmann et al. (2021)
Decrease labour force	2.5% (decrease)	Kurmann et al. (2021)
Self-employed work hours	11% (decrease)	Kurmann et al. (2021)

Source: developed by the authors.

Thus, this could attribute to inclined stress among the entrepreneurs. In other words, the entrepreneurs in Canada are worried about the future of their entrepreneurial ventures and actions. Nonetheless, entrepreneurs help the global economy through innovation (Archibugi et al., 1999), research and development (Feng and Chen, 2020), and inspiring individuals and corporations (Liu et al., 2022, Tari et al., 2023; Ravet-Brown et al., 2023). Robertson (2021) quoted Professor Wesley Wark from University of Ottawa that in the proper assessment of risk related to virus, the government of Canada has fallen short, and the economic suffering has escalated because government did not consider the pandemic a serious threat in the first quarter of 2020. Moreover, the Statistics Canada (2021) report stated that 7 out of 10 Canadians reported being impacted by COVID-19 whereas 2 out of 5 reported some degree of distress enhanced due to the pandemic.

In the wake of COVID-19, Canadian government initiated economic response plan that offered support to SME and corporations, such as \$25,000 per employer subsidy and filling taxes were defer

until August 21, 2020 (Government of Canada, 2020a). Moreover, income tax owing was pushed out to September 2020 and post assessment HST/GST for SME were halted (Government of Canada, 2021). SMEs were allotted \$10 billion in additional support by the Business Credit Availability Program (BCAP) through Business Development Bank of Canada (BDC) and Export Development Canada (EDC) (Government of Canada, 2020b). To allow the large banks of Canada to inject \$300 billion into the economy for additional lending by the Office of the Superintendent of Financial Institutions (OSFI) the Domestic Stability Buffer – DSB was lowered by 1.25% (Government of Canada, 2020b). Total of \$3.8 billion was provided for Temporary Business Wage Subsidy, (Government of Canada, 2020b). However, despite such supports and efforts, still the entrepreneurial actions suffered in Canada as 83% SMEs shutting down (SMEs Canada, 2022). Thus, it indicates that entrepreneurs are experiencing stress.

SME accounts for over 90% of global economy (Thorgen & Williams, 2020), and SME being one of the foundations of Canadian economy, the mental well-being of entrepreneurs is one of Canada's crucial public health issues (CMHA, 2020). While there has been focus on business ecosystem by the government, the gap between such efforts and the challenges that entrepreneurs face as individuals or in the context of social is rather noticeable especially to what extend the mental health of entrepreneurs is affected (CMHA, 2022). However, which type of entrepreneur is being more effective in the scenario of changing dynamics, is still not clearly visible from the literature at hand. Thus, one must understand the distinct types of entrepreneurs before diving into the details of their effectiveness in dealing with the stress.

Push Theory argues that some people become entrepreneurs due to lack of available employment options, job insecurity or lack of alternatives (Kirkwood, 2009) while the Pull Theory argues that some people seek personal financial growth, independence, or identify an opportunity which pulls them into entrepreneurship (Kirkwood, 2009, Mkubukeli and Cronje, 2018). However, there is no evidence regarding which type of entrepreneur deals better with the entrepreneurial stress, especially from the region specificity (Canadian context).

Interestingly, the immigrants in Canada are more likely to be entrepreneurs. Canadian industries such as Scientific, retail trade, real estate, accommodation and food services, Professional, technical services are 50% Immigrants (Table 2; AMSSA, 2016). There are various contribution factors, such as Canada's entrepreneurial immigration as well as barriers that immigrants face in getting paid employment due to their foreign credential's recognition, language barriers, professional networking, and discrimination; therefore, immigrants are self-employed involuntarily (Table 2; AMSSA, 2016).

Plethora of research confirms that entrepreneurs encounter myriad of challenges ascribable to inherent uncertainties, pressure of being the founders, success and chasing (Faizan & Haque, 2016; Haque, 2020). Interestingly, 72% of Canadian workers spend some part of workday either worrying or dealing with their personal issues, which impact Canadian entrepreneurship by approximately costing Canadian employers \$40 billion (Benefits Canada, 2022). Unaddressed stress among Canadian is one of the leading cause costings more than \$200 billion annually (Bonin et al., 2023). Entrepreneurship stress is relatively higher due higher demand requirements and long work hours (Cardon & Patel, 2015). SMEs face various challenges causing stress, including the pressure of failure, maintaining sustainability, managing talent, adhering to changing regulations, tax filing and so on (Dunkelberg, 2022). In the wake of Pandemic, these challenges further escalated (Xu and Jia, 2022). Nearly 78% SME owners are dealing with pandemic stress (CFIB, 2022). Many lives were lost while economies

were paralyzed as the estimated cost from Pandemic had accumulated to \$24 Trillion (Dunkelberg, 2022).

Table 2. Comparison of immigrant and Canadian-born entrepreneurs

Components	Immigrants	Canadian-born
Self employed	19%	15%
Private Incorporation	5.8%	4.8%
Self employed due to difficulty finding a job	33%	20%

Source: developed by the authors based on AMSSA (2016) report.

From the literature at hand, it is evident that there is no conclusive evidence regarding the impact on entrepreneurial stress on the mental well-being of the Canadian entrepreneurs pre-and-post COVID 19.

2. Methodology

Each layer of research onion represents different components of research (Saunders et al. 2016). The first layer of research onion represents philosophical stance employed in this research, which is interpretivism reflecting the useful truth to examine the relationship between research variables by exploring the hidden embedded truth (Faizan et al., 2019). Hannes et al. (2019) stated that the qualitative interpretation is gained by explaining the human opinion so the focus is on the useful truth rather than factual truth because values and norms require in-depth understanding in contrast to numerical significance (Faizan et al., 2019). This study explored the hidden and understudied phenomenon i.e., mental well-being affected by the entrepreneurial stress through qualitative method instead of mathematical objectivity. Therefore, inducement technique is more appropriate in contrast to deductive approach. This study employed inductive approach to gain qualitative perspective. Moreover, the basic research is enhancing the knowledge while applied is carried out for unique situation (Sekaran & Bougie, 2012). The nature of this research is basic that implies to enhance the existing knowledge with the aim to gain new perspective about stressors and mental well-being. These attributes are not new or unique however, the information from the Canadian context is not available. In other words, examine the phenomenon and recommend entrepreneurial action plan. Therefore, this is basic research. Moreover, this is an attempt to explore the interlinked factor, so this is more exploratory in nature rather than giving general description (i.e., descriptive research). The strategy is a case study with action research to offer the implications for improving the current situation of the SMEs in dealing with the entrepreneurial stress. Longitudinal design exceeds one year with more than one time lag (interval) whereas cross-sectional design has only one time lag and complete within a year (Sekaran & Bougie, 2012; Haque & Aston, 2016). This research completed in less than a year therefore cross-sectional design has been employed.

Secondary data is pre-existing information whereas extraction of information from raw sources is regarded as primary data (Walliman, 2011; Creswell, 2016). Since, the nature of this research is building on the existing data to assess the pre-and-post Covid impact thus, secondary data is aligned with the research objectives. Furthermore, using secondary sources is effective in maintaining reliability and credibility of the research components. In this study, the triangulation approach was employed to maintain credibility and reliability by considering peer-reviewed journals (using Scopus and WOS indexing), White-papers (government issued survey and reports), and official blogs by professionals

and experts in the field. This study considered PRISMA framework bibliographical technique to incorporate articles from credible sources (Figure 1).

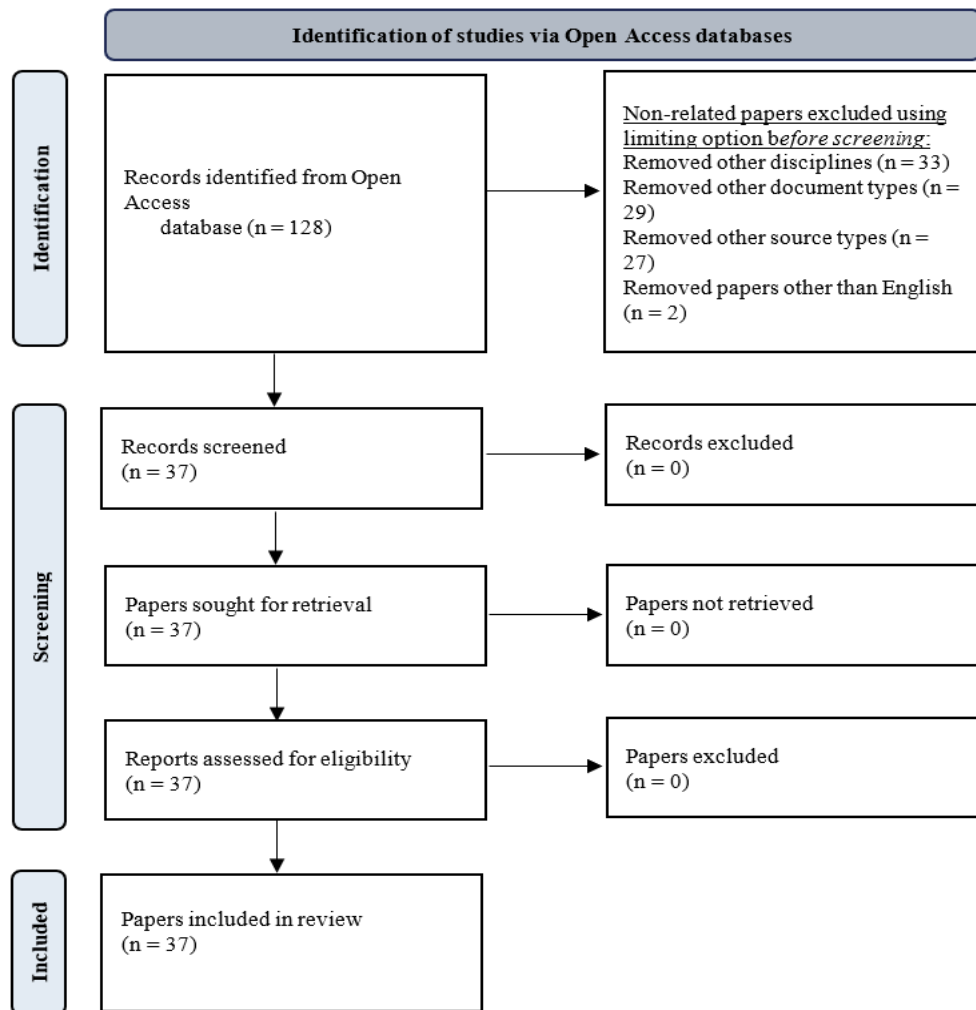


Figure 1. PRISMA Framework

Source: developed by the authors.

The PRISMA framework usage enriched the process and enabled gathered data being aligned with the objective of research. According to Haque (2022), there is no fix number of articles to use as a benchmark, however, over 30 articles provide deeper insight of the research phenomena. Through PRIMSA, total 37 articles were considered, which is sufficient to gain in-depth insight about the research variables. The use of keywords also turned out to be a productive technique in the collection process. Moreover, the use of triangulation approach was to cover all three aspects in the data collection process, i.e., ensuring the reliability, validity, and credibility of the sources. Lastly, during this study we ensured that only information available in the public domain is used while no visual or information is included without the consent of the original author or content creator. The credit has been given to the authors for citing their work.

3. Research results

Canadian entrepreneurs scored lower in contrast to the immigrant entrepreneurs in all categories. As evident, immigrant entrepreneurs are more self-employed in contrast to Canadian-born entrepreneurs (19% to 15%, Table. 3). Similarly, immigrant entrepreneurs have higher private incorporates and often start the entrepreneurial ventures because of difficulty in finding a suitable jobs in comparison to the Canadian-born entrepreneurs (Table 3). Thus, one of the major factors behind immigrant entrepreneurs starting the venture is “push factor” because of the limited job opportunities, ease of business visa, language barriers, challenges in forming professional networking, and so on (AMSSA, 2016). The studies confirmed that limited access to resources, adjustment to newer environment, language barriers, and limited awareness about dynamic environment are leading to formulate stress (AMSSA, 2016; Djamalova, 2022; Wayland, 2012). All such factors are to certain extent contributing factors in developing entrepreneurial stress.

Table 3. Comparison between immigrants and Canadian-born entrepreneurs

Components	Immigrants	Canadian-born
Self employed	19%	15%
Private Incorporation	5.8%	4.8%
Self employed due to difficulty finding a job	33%	20%

Source: developed by the authors based on the report of AMSSA (2016).

The detailed systematic analysis revealed that the higher number of SMEs in Canada is to heavy reliance of Canada on the export with the USA (OECD, 2023; World Bank, 2020). There is a significant increase in the bilateral trade during and post-COVID 19 (OECD, 2023). There has been significant increase in the SMEs shutdown due to distinct environmental challenges, thus could be a reason behind entrepreneurial stress. The report of BDC (2021) stated that one in four Canadians desired to pursue entrepreneurial venture even though Canadian entrepreneurs work 70 hours a week. The reason for such desire is embedded in need for financial independence, continuing passion, and higher flexibility that is more exciting than drawback (long working hours).

The systematic review and critical analysis of the available data revealed that distinct stressors affect the physical and mental health of the entrepreneurs in Canada. The Canadian Mental Health Association – CMHA (2023) report confirmed that entrepreneurs operating with 10 or fewer employees have higher mental health related issues. They do not have anyone to share the workload thus have higher imbalance between professional and personal lives. During COVID-19, the imbalance has exceeded further because of the shortage of skilled manpower. Various reports confirmed the consequences of stress among entrepreneurs include fatigue (62%), disturbed sleep (56%), uncertainty (51%), depression and anxiety (50%) (Figure 2; CMHA, 2023; BDC, 2021). The mental health related issues have escalated at an alarming rate. In addition to that, FP Canada Financial Stress Index (2023) report revealed significant increase in the depression and anxiety among entrepreneurs especially post COVID-19. Studies confirmed financial factors contribute towards increased stress among entrepreneurs.

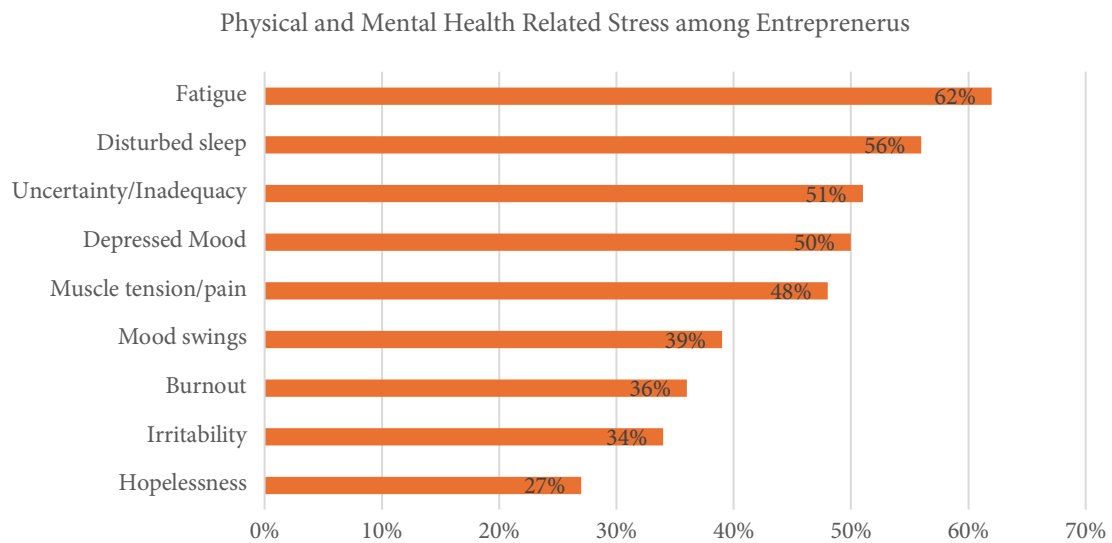


Figure 2. Physical and mental health related stress among entrepreneurs

Source: developed by the authors based on Canadian Mental Health Association – BDC, 2023.

Entrepreneurship in Canada has been severely affected by the business' shutdown during and post-COVID 19. During 2021, one in six SMEs in Canada were contemplating to shutdown operations permanently that led to 2.4 million jobs at risk with no recovery plans (Canadian Federation of Independent Business – CFIB, 2022). The entrepreneurs in Canada faced several challenges during the lockdown such as restrictions lack of workforce, and reduced sales. The survey also found that 20.8% would wait for the right conditions before starting; in contrast to only 14.3% that want to start while 7.1% were planning to take up a business venture (TEO Toronto, 2020). As evident from the official reports, 45% entrepreneurial shutdown, 32% reduction in operations, 12% reduction in support from the government, and 29% governmental increased restrictions led to impact the physical and mental well-being of the entrepreneurs in Canada (Figure 3).

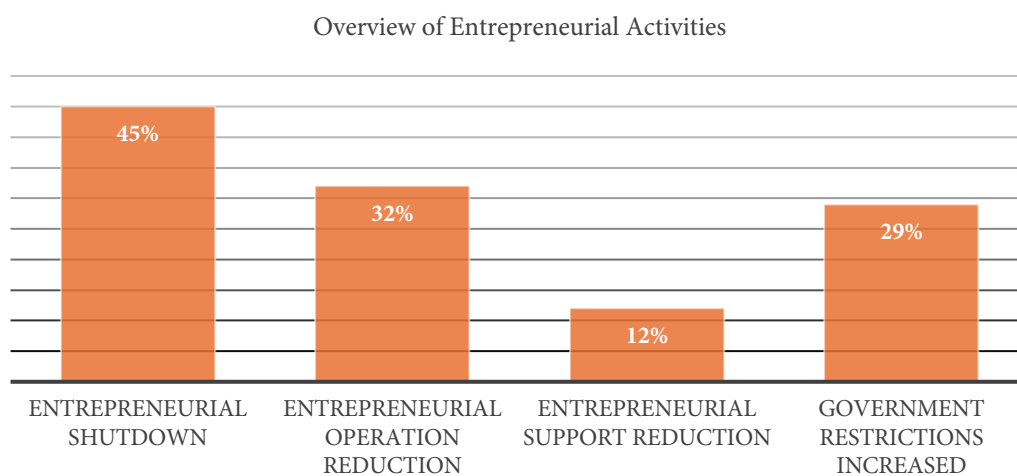


Figure 3. Recent Challenges faced by Entrepreneurs in Canada

Source: developed by the authors.

According to the work of Haque (2023), occupational stress is a reality that does not only affect the professional life but extend its impact even after the office hours. On the other hand, the work of Messabia et al., (2022) revealed that due to COVID-19, SME owners were facing higher level of stress, anxiety, and uncertainty due to significant financial loss, workforce issues & unplanned closure. The mental and physical well-being of the personnel remain critical aspect for the organizations (Haque, 2023). According to survey mental health challenges increased from 38% to 45% among business owners with 54% business owners' main concern is work-life balance, that's a 10% increase while over half of business owners are struggling due to inflation (BDC, 2021). The entrepreneurial stress inclined in Canadian SMEs due to smaller revenue (CMHA, 2022).

Although 37 articles were examined but only 10 articles that contained stressors are discussed to compute Word Cloud. The major themes depicted from those articles are presented in the Table 4.

Table 4. Secondary sources and key findings

No.	Title, authors, and years	Key Findings
Article 1	Relationship between Occupational Stress and Organisational Commitment (Haque & Aston, 2016)	Contrasting gender demonstrate distinct stressors, financial issues, depression, anxiety
Article 2	Innovation System in a Global Economy. Technology Analysis & Strategic Management (Archibugi et al., 1999)	Economic growth and development, financial vulnerability, global economy
Article 3	Entrepreneurship and process studies (Hjorth et al., 2015)	Distinct stressors, aching, physical and behavioural symptoms
Article 4	Going Alone: The mental health and well-being of Canada's Entrepreneurs (CMHA, 2022)	Work-life-balance, distinct stressors, anxiety, depression, economic growth
Article 5	Ease of Doing Business in Canada (Trading Economics, 2023)	Financial loss, manpower issues, Anxiety, aching and pain, economic constraints, manpower issues, financial loss, manpower issues, COVID-19, SMEs
Article 6	Migration Matters (AMSSA, 2016)	Mental issues, fatigue, sleep deprivation, aching and pain, work-life-balance, Anxiety, depression
Article 7	Managing restaurants during the COVID-19 crisis: Innovating to survive and prosper (Messabia et al., 2022)	COVID-19, behavioural symptoms, physical symptoms, anxiety and depression, financial loss, manpower issues, sleep deprivation
Article 8	Canadian Federation of Independent Business, (CFIB, 2022)	Entrepreneurial stress, work-life-balance, aching, pain, mental issues, financial constraints, distinct stressors
Article 9	Canadian Entrepreneur Mental Health and Well-Being Report (BDC, 2021)	Fatigue, financial loss, stressors, economic behaviour, COVID-19, SMEs
Article 10	GEM Canada 2021 Report (GEM, 2021)	Economic constraints, fatigue, sleep deprivation, aching and pain, economic constraints, manpower issues, anxiety, depression, stressors, economic growth and development, financial vulnerability

Source: developed by the authors.

The critical evaluation revealed that distinct stressors affect the entrepreneur's physical and mental well-being. The significant issue remains distinct stressors, indicating that not all entrepreneurs are affected by only one type of stressors in same magnitude, followed by depression and anxiety as another key components (Figure 4). COVID-19 has played significant role in further increasing the stress of the entrepreneurs. Thus, present study opposes the work of Coulombe, DeJardin and Luc (2022). Plethora of research confirmed that sleep deprivation, work-life-imbalance, and fatigue are the

consequences faced by entrepreneurs (BDC, 2021; GEM, 2021; Messabia et al., 2022; CFIB, 2022; CMHA, 2022; Trading Economics, 2023) has been confirmed through present findings.



Figure 4. Key themes emerging from the literature at hand

Source: developed by the authors.

The detailed systematic review confirmed that the three most common causes of stress include financial stress (increased by 4%, post-COVID), family stress (increased by 5%, post-COVID), and work life imbalance (increased by 9%, post-COVID) (Figure 5).

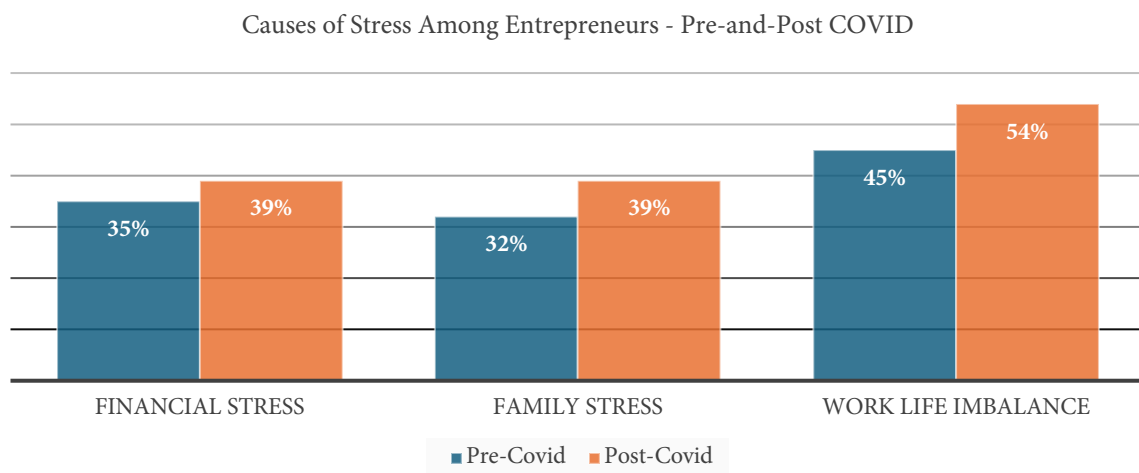


Figure 5. Causes of Stress among Entrepreneurs – Pre-and-Post COVID

Source: developed by the authors.

Moreover, 54% entrepreneurs confirmed that stress has significantly impact on the work life balance, which has increased by 9% during COVID. Therefore, our findings support the work of BDC (2021) and Wilson (2023) whereas oppose the previous work of Coulombe et al. (2022). In addition to that, TEC Canada report showed that women entrepreneurs have higher stress in contrast to their counterparts, especially the single mothers have higher work life imbalance. Females are more stressed due to personal factors such as family and financial stress, therefor, our findings are aligned with the previous work of Faizan and Haque (2016) and Haque et al. (2018). There is indirect hint

towards increased work life imbalance., which is further exceeded due to COVID-19 as entrepreneurs are finding it difficult to strike a fine balance between professional work and personal life eventually leading to long working hours. The family stress has inclined among entrepreneurs after COVID. The comparison of consequences of stress pre-and-post COVID has been carried out to further assess the impact on the mental well-being.

There are distinct consequences of stress confirmed by plethora of research (Stranks, 2005; Haque & Aston, 2016; Imran et al., 2018; Faizan et al., 2019). Nonetheless, in general for entrepreneurs, the consequences vary in its magnitude. These were not presented before. Thus, the detailed systematic review confirmed that increased in all types of consequences, namely, emotional consequences (increased by 10%, post-COVID), behavioural (increased by 4%, post-COVID), and physical (increased by 2%, post-COVID) respectively (Figure 6).

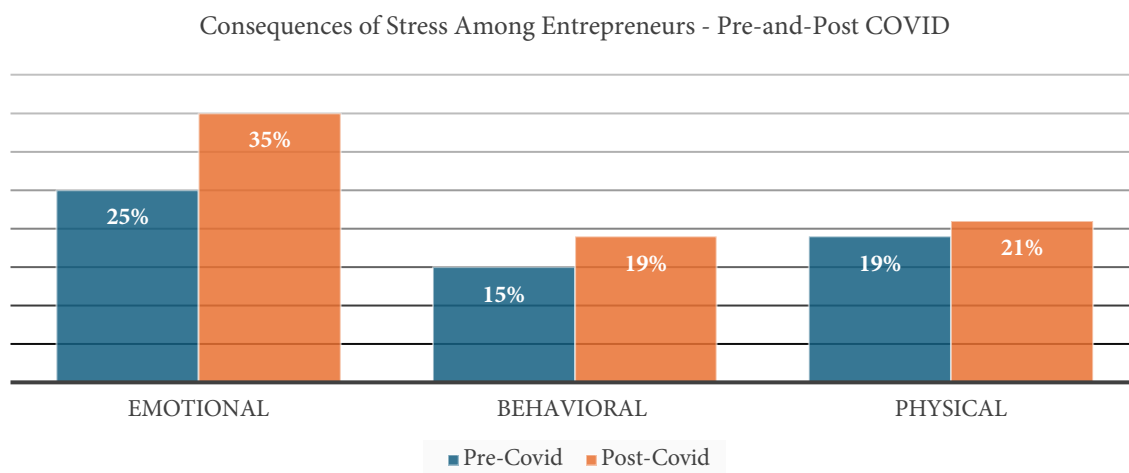


Figure 6. Consequences of Stress among Entrepreneurs – Pre-and-Post COVID

Source: developed by the authors.

The work of Haque et al. (2020) showed that the consequences of stress vary for contrasting gender (male and female), however from the lens of entrepreneurship, there is no conclusive evidence. It could be attributed since SMEs are smaller in size thus lacks moral and emotional support from specialized department, which could be a reason for higher emotional symptoms. Findings revealed that anxiety and depression are the critical emotional consequence exhibited by the entrepreneurs. Reports suggested that among entrepreneurs, mental and emotional health problems develop the feelings of loneliness and isolation. We found that workload sharing is next to zero among the entrepreneurs causing higher imbalance among professional work and personal lives during COVID-19. Shortage of workforce has led to severe physical and behavioural consequences among these entrepreneurs. Extensive reports confirmed that entrepreneurs have formed habits of eating lesser, less, or disturbed sleep pattern, consumption of medications, smoking cigarettes, and excessive caffeine intake. These habits reflect behavioural consequences. Moreover, pain and aching, loss of sex drive, and dizziness, showing physical consequences. Therefore, the systematic review confirmed the findings of BDC (2021), CFIB (2022), GEM (2021), and CMHA (2022) whereas oppose the findings of Coulombe et al. (2022). In other words, the consequences of stress differ for entrepreneurs in both pre-and-post COVID-19.

Additionally, between 2020-2021, 28% entrepreneurs in Canada reported the mental health conditions being adversely affected. An alarming 78% entrepreneurs stated do not wish to seek help of professional occupational therapists to deal with stressors. Hence, it could be attributed that causes and consequences of stress negatively impact on the mental well-being of entrepreneurs and overall performance of the SMEs. Approximately 83% SMEs shutdown during the COVID also has indirectly led to increase the entrepreneurial stress.

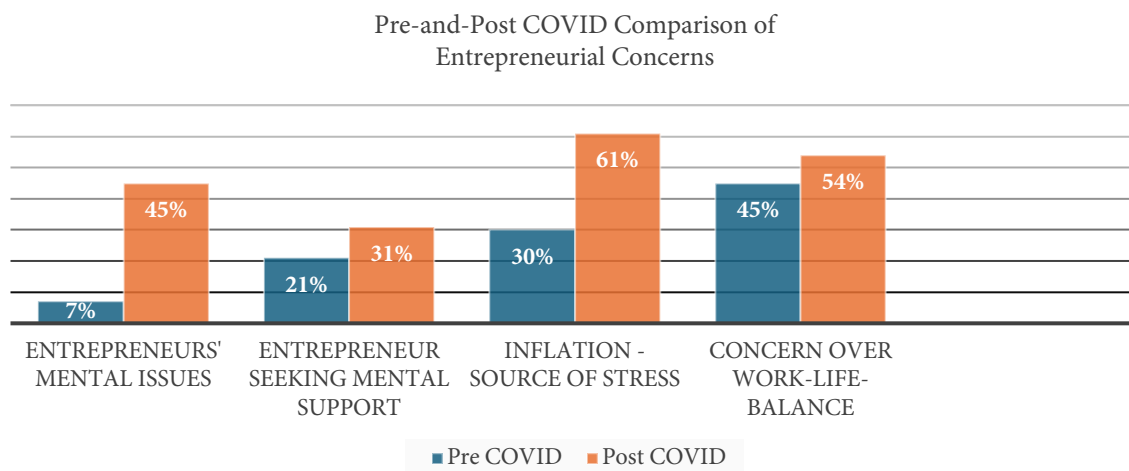


Figure 7. Comparison of Entrepreneurial concerns – Pre-and-Post COVID

Source: developed by the authors.

The comparison revealed that inflation and work-life-balance have greater impact on the entrepreneurs. These factors have contributed to difficulty in seeking help because professional support services are not always affordable. Not only entrepreneurs but also the employees are deprived from mental health support services because they need to pay from their own pocket. Although, private insurance options are available, but these options are not affordable to all. Post COVID-19 entrepreneurs have struggled to manage business due to inflation. Cost of living and operating business in inflation are challenging tasks that is creating distinct stressors. In last 12 months, there has been an 18% hike in transportation cost and raw material whereas the equipment is 16% up by interest. The big companies have the capacity to pre order material for longer periods, but SMEs find it challenging to afford or risk bulk orders. According to survey, 42% of Canadian start-ups fail due to lack of need for the product and services that start-ups offer, while 29% fail due to depleting capital and 23% failure is caused by not having the right team (CBInsights, 2021). Moreover, competition also hurts start-ups while 19% of start-ups closed due to being outcompeted. It is also evident that 17% product are inferior in quality and same percentage of start-ups shut down due to wrong business model (Grant Thornton, 2022). Interestingly, one in five start-ups fail in Canada which is about 20% in first year and 60% within the first three years (CBInsights, 2021). According to BDC (2021), 17% men entrepreneurs worry about their reputation while seeking mental health in comparison to 8% women entrepreneurs. Moreover, 40% men worry about the cost associated with mental health care in contrast to 30% women entrepreneurs (CMHA, 2022).

Conclusions

The conclusion is drawn that distinct stressors affect the mental well-being of the entrepreneurs in Canada and overall performance of SMEs. The most common stressors include financial stressors, family stressors, and work-life imbalance. There are significant increase stressors during and after COVID-19. The pandemic has adversely affected the mental well-being of the entrepreneurs and overall performance of the SMEs. The surveys of BDC (2021) and CHMA (2023) confirmed that higher number of SMEs shutdown while 45% entrepreneurs confirmed mental health and well-being negatively affected. Thus, we contradict the work of Coulombe et al. (2022) that COVID has not been the reason for change in work-life-imbalance. COVID-19 pandemic has made it difficult for the entrepreneurs to balance professional and personal life, therefore, 64% entrepreneurs stated being unsatisfied with their current mental well-being. Depression and anxiety are evident among the entrepreneurs, especially after COVID therefore our findings opposed the work of Coulombe, Dejardin and Luc (2022). The mental well-being of the entrepreneurs in SMES is negatively affected as there are reports of sleep deprivation, work-life-imbalance, and fatigue being the frequent consequences. Hence, present findings conclude in support of recent studies (BDC, 2021; GEM, 2021; Messabia et al., 2022; CFIB, 2022; CMHA, 2023; Trading Economics, 2023).

The pandemic has been the source of stress, anxiety, isolation, and has crippled the world economy. Statistics Canada (2021) survey confirmed that out of 10, at least 7 Canadians reported being impacted by COVID-19, which is 70%. Moreover, 2 out of 5 reported some level of distress (Statistics Canada, 2021). Hence, it is concluded that the COVID-19 pandemic repercussion for economies and health system were extremely severe and devastating. Based on the findings, we conclude that entrepreneurs in Canada were already dealing with stress while the COVID-19 pandemic further affected and enhanced the negative impact on the entrepreneurs. During COVID-19 lockdown, isolation and social distancing put a greater strain on entrepreneurs especially due to lack of support from mental well-being of professionals and the cost associated with the treatment. Thus, it is concluded that COVID-19 has impacted entrepreneurs and SMEs significantly during and after COVID, which means findings support the survey of CMHA (2020), BDC (2020), GEM (2021), and CMHA (2022).

We concluded that inflation and work-life-balance are the biggest concern for entrepreneurs. The financial stress has been the biggest burden and hurdle for the Canadian entrepreneurs to perform their daily duties and balance their work-and-life. However, the magnitude in terms of impact on the entrepreneurs differs to large extent. While seeking professional help is not affordable for many SMEs. We conclude that stress has three major consequences such as behavioural, physical, and emotional symptoms demonstrated by the entrepreneurs at the Canadian SMEs. We also concluded that female entrepreneurs were more prone to experience mental well-being challenges, especially demonstrating higher emotional consequences. On the other hand, males demonstrate higher physical and behavioural consequences. Thus, the magnitude of stressors varies for distinct entrepreneurs. Sleep deprivation is another contributing factor that has been affecting the health and mental well-being of the entrepreneurs. Although best practices were adopted with the available limited resources to address things adequately, however, this research is also not free of limitations like any other research. Some of these limitations are potential bias despite several steps taken, no funding or grant, data sources and availability, limited use of statistical tools to gain mathematical objectivity, and so on.

The selection of papers was based on the axiological stance and so does the selection of SMEs in Canada, which reflects the potential bias in the selection process. The future researchers shall consider

more rigorous mechanism for the selection of papers. During this research, no financial grant or funding was available therefore personal limited resources were used to gather data from open access sources. Some of the reports required payment to be purchased were not accessed. Moreover, the findings are based on secondary sources, as there are no direct primary sources included. Future researchers shall consider the direct interviews and survey from the entrepreneurs, which would enrich the data. It would have given direct/firsthand information from the professionals. Future researchers shall consider the use of primary data, especially longitudinal design because it would bring more concrete evidence. In addition to that, the respondents in two different time-lag responses would be more useful in measuring the magnitude. Furthermore, in this study statistical tools like SPSS or PLS SEM modeling were not used so the findings have limitation of gaining mathematical objective. Future studies shall consider the statistical significance by incorporating the statistical data (in order words, the numeric expression/quantification of the relationship between entrepreneurial stress and mental well-being and overall performance of the SMEs could not be established). However, the future researchers have greater opportunity to consider these limitations and build on it to have more comprehensive approach. Following are the recommendations:

Mental Support App - Based on the project findings, it is recommended that there should be an online app for the entrepreneurs. This app would not only provide 24/7 support to deal with mental well-being, but also assess and monitor the entrepreneurial actions from time-to-time. Hence, it would be beneficial in suggesting alternative plans to different types of entrepreneurs facing distinct stressors. It shall contain a depression hub to understand the symptoms and strategies to tackle with it. Professional occupational therapists – From the systematic review, it is evident that despite governmental support in terms of tax relaxation and loan interest ease, there is no professional occupational therapist available to provide professional consultancy and support in terms of mental health and well-being. The entrepreneurial action is to offer the additional support to such individuals. This step is pivotal however the cost is higher therefore many SMEs do not offer such support to its staff. Nonetheless, the government being the important stakeholder and having more power over the process could make a policy for the SMEs to ensure there is a way to use the public certified professional therapist for individuals facing mental health issues. This would also help the entrepreneurs to avail the expert advice from those professionals in managing their personal and professional work life balance. Such entrepreneurial action would help the entrepreneurship in Canada a long run, especially the indigenous entrepreneurs would benefit. The depression and suicide rate are higher among indigenous community in Canada as compared to rest of the population. Thus, this entrepreneurial action would help entrepreneurs from distinct communities. Perhaps, the government can provide some subsidies to the SMEs for using professional occupational therapist or might offer the grant to develop a department for creating awareness about mental issues and offer solutions.

ABC Model – Awareness, Balance, and Control model – Haque (2020) proposed a model to deal with stressors in the professional environment. Hence, this could be used by entrepreneurs and SMEs to incorporate in their plans when individuals are facing distinct stressors. Three step model would be an effective entrepreneurial action, by offering workshops and seminars creating awareness. Followed by educating strategies to balance work and personal commitments. There is also hybrid mode, which become prominent in COVID-19. Hence, this could be continued to bring more balance in the life of the entrepreneurs as well as their workforce. Lastly, strategies to control the physical, behavioural, and emotional consequences. One of the entrepreneurial actions could be entrepreneurs ensuring to

control their screen time. Entrepreneurs spend more time on digital platforms due to expansion of e-commerce. Sitting for too long creates physical and behavioural symptoms. Thus, entrepreneurs should take frequent breaks from the screen. A control part must also include taking notes of personal health, avoid using over limit consumption of alcohol and use of nicotine.

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Data Availability Statement: The data supporting the findings of this study are available on request from the corresponding author

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Reference

1. AMSSA (2016). *Immigration Self-Employment and Entrepreneurship*. Migration Matters - March 2016, issue 29. <https://www.amssa.org/wp-content/uploads/2020/09/InfoSheet29-Self-Employment.pdf>
2. BDC (2021). *Canadian Entrepreneur Mental Health and Well-being Report*. <https://www.bdc.ca/globalassets/digizuite/29745-well-being-study-bdc-2021.pdf>
3. Beland, L. P., Fakorede, O., & Mikola, D. (2020). Short-Term Effect of COVID-19 on Self-Employed Workers in Canada. Canadian Public Policy. *Analyse De Politiques*, 46(Suppl 1), S66–S81. <https://doi.org/10.3138/cpp.2020-076>
4. Belitski, M., Guenther, C., Kritikos, A. S., & Thurik, R. (2022). Economic effects of the COVID-19 pandemic on entrepreneurship and small businesses. *Small Business Economics*, 58(2), 593–609. <https://doi.org/10.1007/s11187-021-00544-y>
5. Benefits Canada (2022). *Benefits for Entrepreneurs*. <https://www.canada.ca/en/services/benefits/calendar.html>
6. Bonin, G., Horne, J., Halliday, K., & MacDonald, C. (2023). *The Next Frontier of Workplace Culture: How Employers Can Win on Mental Health and Wellbeing*. <https://www.bcg.com/en-ca/publications/2023/workplace-burnout-costing-canadian-companies-billions>
7. Cardon, M. S., & Patel, P. C. (2015). Is stress worth it? Stress-related health and wealth trade-offs for entrepreneurs. *Applied Psychology: An International Review*, 64(2), 379–420. <https://doi.org/10.1111/apps.12021>
8. CBInsight (2021). Business Startup Statistics Canada (2022 Update). <https://fundsquire.ca/startup-statistics-canada/#:~:text=42%25%20of%20startup%20businesses%20fail,19%25%20were%20outcompeted>
9. CFIB (2022). *Nearly four in five small businesses are still dealing with pandemic-related stress*. <https://www.cfib-fcei.ca/en/media/nearly-four-in-five-small-businesses-are-still-dealing-with-pandemic-related-stress>

10. CMHA (2022). *No more going it alone: Entrepreneurs and mental health*. <https://cmha.ca/news/no-more-going-it-alone-entrepreneurs-and-mental-health/>
11. CHMA (2020). *How can I pay for mental health care?* <https://www.heretohelp.bc.ca/q-and-a/how-can-i-pay-for-mental-health-care#:~:text=Mental%20health%20services%20provided%20through,to%20pay%20to%20see%20someone.>
12. Coulombe, S., Dejardin, M., Luc, S. (2022). Covid or not Covid? Psychological Distress and Entrepreneurial Intentions among Canadian Workers during the Pandemic. *International Review of Entrepreneurship*, 20(1), 1–20. <https://shs.hal.science/halshs-03659225>
13. Creswell, J. W. (2016). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*. 6th Edition. London, UK: SAGE.
14. Djamalova, F. (2022). *How To Succeed In Canada As A Foreign Entrepreneur*, Forbes. <https://www.forbes.com/sites/theyec/2022/05/05/how-to-succeed-in-canada-as-a-foreign-entrepreneur/?sh=72e9a9264d70>
15. Diandra, D., & Azmy, A. (2020). Understanding Definition of Entrepreneurship. *International Journal of Management, Accounting and Economics*, 7(5), 235–241.
16. Delgado, E. P., Fair, R., & Johnston, C. (2023). *Analysis on small businesses in Canada, first quarter of 2023*. [Statistics Canada]. <https://www150.statcan.gc.ca/n1/pub/11-621-m/11-621-m2023003-eng.htm>
17. Dunkelberg, W. (2022). *Small Business' Number One Problem*. [Forbes]. <https://www.forbes.com/sites/williamdunkelberg/2022/04/28/small-business-number-one-problem/?sh=13d88f3f2a08>
18. Fahimnia, B., Sarkis, J., & Davarzani, H. (2015). Green supply chain management: A review and bibliometric analysis. *International Journal of Production Economics*, 162, 101–114. . <https://doi.org/10.1016/j.ijpe.2015.01.003>
19. Faizan, R., Haque, A. U., Cockrill, A., & Aston, J. (2019). Females at Strategic Level Affecting Logistics Firms' Competitiveness: Qualitative Comparative Analysis of Contrasting Gender in Pakistan and Canada, *Forum Scientiae Oeconomia*, 7(1), 57–71.
20. Faizan, R., & Haque, A.U. (2019). Working Efficiency of Contrasting Genders under Eustress, Distress, Hyper-Stress, and Hypo-Stress, *Prabandhan: Indian Journal of Management*, 12(11), 32–46.
21. Faizan, R., & Haque, A.U. (2016). The Relationship between Societal attributes, Feminine Leadership & Management Style: Responses from Pakistan's Urban Region Female-Owned Businesses. *European Journal of Business and Management*, 8(23), 171–191.
22. FB Canada (2022). *Money is still the top source of stress for Canadians - and many feel less hopeful about their financial futures*. Cision. <https://www.newswire.ca/news-releases/money-is-still-the-top-source-of-stress-for-canadians-and-many-feel-less-hopeful-about-their-financial-futures-879224169.html>
23. Feng, B., & Chen, M. (2020). The impact of entrepreneurial passion on psychology and behavior of entrepreneurs. *Frontiers in Psychology*, 11, 1733.
24. Fetscherin, M., & Heinrich, D. (2015). Consumer brand relationships research: A bibliometric citation meta-analysis. *Journal of Business Research*, 68(2), 380–390. <https://doi.org/10.1016/j.jbusres.2014.06.010>

25. FP Canada Stress Index (2023). *Key Findings*. <https://www.fpcanada.ca/planners/2023-financial-stress-index>
26. GEM (2022). *GEM Canada 2021 Report*. <https://www.gemconsortium.org/report/gem-canada-2021-report>
27. Government of Canada (2023). *Venture Capital Catalyst Initiative*. <https://ised-isde.canada.ca/site/sme-research-statistics/en/venture-capital-catalyst-initiative>
28. Government of Canada (2021). *Key Small Business Statistics - 2021*. <https://ised-isde.canada.ca/site/sme-research-statistics/en/key-small-business-statistics/key-small-business-statistics-2021>
29. Government of Canada (2020a). *Canada's COVID-19 Economic Response Plan: Support for Canadians and Businesses*, Press Release. <https://www.canada.ca/en/departement-finance/news/2020/03/canadas-covid-19-economic-response-plan-support-for-canadians-and-businesses.html>
30. Government of Canada (2020b). *SME Profile: Social enterprises in Canada*. <https://ised-isde.canada.ca/site/sme-research-statistics/en/research-reports/sme-profile-social-enterprises-canada#s3>
31. Grant Thornton. (2022). *State of inflation: How Canadian businesses are reacting*. <https://www.grantthornton.ca/insights/state-of-inflation-how-canadian-businesses-are-reacting/>
32. Hannes, K., Lockwood, C., & Pearson, A. (2010). A comparative analysis of three online appraisal instruments 'ability to assess validity in qualitative research. *Qualitative Health Research*, 20(12), 1736–1743.
33. Haque, A. U. (2023). *Handbook of Research on Dissecting and Dismantling Occupational Stress in Modern Organizations*, IGI Publishers. <https://doi.org/10.4018/978-1-6684-6543-1>
34. Haque, A.U. (2020). *Varying Occupational Stress and Organisational Commitment within the University Staff of Contrasting Economies (Cross-Sectional Comparative Study of Middle Range Public Universities in Pakistan and the UK)*. Ph.D. Thesis, University of Wales Trinity Saint David, Lampeter, UK. <https://repository.uwtsd.ac.uk/id/eprint/1570/>
35. Haque, A. U., & Aston, J. (2016). A Relationship between Occupational Stress and Organizational Commitment of I.T Sector's Employees in Contrasting Economies, *Polish Journal of Management Studies*, 14(1), 95–105.
36. Haque, A. U., Aston, J., & Kozlovski, E. (2018). The Impact of Stressors on Organizational Commitment of Managerial and Non-Managerial Personnel in Contrasting Economies, *International Journal Business*, 23(2), 166–182.
37. Hessels, J., & Naudé, W. (2019). The Intersection of the Fields of Entrepreneurship and Development Economics: A Review towards a New View. *Journal of Economic Surveys*, 33(2), 389–403.
38. Hjorth, D., Holt, R., & Steyaert, C. (2015). Entrepreneurship and process studies. *International Small Business Journal*, 33(6), 599–611.
39. Holland, D. V., & Shepherd, D. A. (2013). Deciding to Persist: Adversity, Values, and Entrepreneurs' Decision Policies. *Entrepreneurship Theory and Practice*, 37(2), 331–358.
40. Imran, M., Haque, A.U., & Rebilas, R. (2018). Performance Appraisal Politics and Employees' Performance in Distinctive Economies, *Journal of Polish Management Studies*, 18(2), 135–150.

41. Kiniulis, M. (2022). *12 Entrepreneur Statistics You Need To Know*. [MarketingBlog]. <https://www.markinblog.com/entrepreneur-statistics/>
42. Kirkwood, J. (2009). Motivational factors in a push-pull theory of entrepreneurship, *Gender in Management*, 24(5), 346–364.
43. Kuckertz, A., & Brändle, L. (2022). Creative reconstruction: a structured literature review of the early empirical research on the COVID-19 crisis and entrepreneurship. *Management Review Quarterly*, 72, 281–307. <https://doi.org/10.1007/s11301-021-00221-0>
44. Kurmann, A., Lal'e, E., & Ta. L. (2021). *The Impact of COVID-19 on Small Business Dynamics and Employment: Real-time Estimates With Homebase Data*, International Centre for Economic Analysis. <https://iceanet.org/wp-content/uploads/2021/11/Kurman.pdf>
45. Liu, Y., Li, M., Li, X., & Zeng, J. (2022). Entrepreneurship education on entrepreneurial intention: The moderating role of the personality and family economic status, *Frontiers in Psychology*, Volume 13. <https://doi.org/10.3389/fpsyg.2022.978480>
46. Messabia, N., Fomi, P-R., & Kooli, C. (2022). Managing restaurants during the COVID-19 crisis: Innovating to survive and prosper, *Journal of Innovation & Knowledge*, 7(4), 100234. <https://doi.org/10.1016/j.jik.2022.100234>
47. Mkubukeli, Z., & Cronje, J. C. (2018). Pull and Push Elements of Entrepreneurship in South Africa: A Small-Scale Mining Perspective, *Journal of Entrepreneurship & Organization Management*, 7(3).
48. Muhuri, P. K., Shukla, A. K., & Abraham, A. (2019). Industry 4.0: A bibliometric analysis and detailed overview. *Engineering Applications of Artificial Intelligence*, 78, 218–235. <https://doi.org/10.1016/j.engappai.2018.11.007>
49. OECD (2023). *Migration Policy Debates*. <https://www.oecd.org/migration/mig/What-are-the-top-OECD-destinations-for-start-up-talents-Migration-Policy-Debates-March-2023.pdf>
50. Ponelis, S. R. (2015). Using interpretive qualitative case studies for exploratory research in doctoral studies: A case of Information Systems research in small and medium enterprises. *International Journal of Doctoral Studies*, 10, 535–550. <http://ijds.org/Volume10/IJDSv10p535-550Ponelis0624.pdf>
51. Ravet-Brown, T.É., Furtner, M., & Kallmuenzer, A. (2023). Transformational and entrepreneurial leadership: A review of distinction and overlap. *Review Management Science*. <https://doi.org/10.1007/s11846-023-00649-6>
52. Robertson, G. (2021). *Pandemic errors made Canadian COVID-19 outbreak far worse than it needed to be, committee told*. <https://www.theglobeandmail.com/canada/article-pandemic-errors-made-canadian-covid-19-outbreak-far-worse-than-it/>
53. Salamzadeh, A., & Dana, L.P. (2020) The coronavirus (COVID-19) pandemic: Challenges among Iranian startups. *Journal of Small Business & Entrepreneurship*, 33(5), 489–512.
54. Saunders, M., Lewis, P., & Thornhill, A. (2016). *Research Methods for Business Students*. 9th ed, Harlow: Prentice Hall Financial Times.
55. Sekaran, U., & Bougie, R. (2012). *Research methods for business: A skill building approach*. (6th ed.). West Sussex, UK: John Wiley and Sons.
56. SMEs Canada (2022). *Analysis on small businesses in Canada, first quarter of 2022*. <https://www150.statcan.gc.ca/n1/pub/11-621-m/11-621-m2022004-eng.htm>

57. Soliman, M., Lyulyov , O., Shvindina, H., Figueiredo, R., & Pimonenko, T. (2021). Scientific Output of the European Journal of Tourism Research: A Bibliometric Overview and Visualization. *European Journal of Tourism Research*, 28, 2801. <https://ejtr.vumk.eu/index.php/about/article/view/2069>
58. Statistics Canada (2021). *SME Profile: Social enterprises in Canada*. [Government of Canada]. <https://ised-isde.canada.ca/site/sme-research-statistics/en/research-reports/sme-profile-social-enterprises-canada>
59. Stranks, J. (2005). *Stress at Work: Management and Prevention*. Oxford: Elsevier Butterworth-Heinemann
60. Tarí, J.J., Maquieira, S.P., & Molina-Azorín, J. F. (2023). The link between transformational leadership and the EFQM model elements. *Business Process Management*. <https://doi.org/10.1108/BPMJ-10-2022-0498>
61. TEO Toronto (2020). *Business Post COVID: Is Canada Headed for a Stall in Startups and Support?* <https://www.newswire.ca/news-releases/business-post-covid-is-canada-headed-for-a-stall-in-startups-and-support--874370358.html>
62. Thorngren, S., & Williams, T. A. (2020). Staying alive during an unfolding crisis: How SMEs ward off impending disaster, *Journal of Business Venturing Insights*, 14, <https://doi.org/10.1016/j.jbvi.2020.e00187>
63. Trading Economics. (2023). *Ease of Doing Business in Canada*. <https://tradingeconomics.com/canada/ease-of-doing-business>
64. Van Burg, E., Cornelissen, J., Stam, W., & Jack, S. (2022). Advancing Qualitative Entrepreneurship Research: Leveraging Methodological Plurality for Achieving Scholarly Impact. *Entrepreneurship Theory and Practice*, 46(1), 3-20. <https://doi.org/10.1177/1042258720943051>
65. Verbeke, A., & Yuan, W. (2020). A Few Implications of the COVID-19 Pandemic for International Business Strategy Research, *Journal of Management Studies*, 58(2). 597–601. <https://doi.org/10.1111/joms.12665>
66. Xu, Z., & Jia, H. (2021). The Influence of COVID-19 on Entrepreneur's Psychological Well-Being, *Frontiers in Psychology*, 12.
67. Walliman, N. (2011). *Your Research Project: a step-by-step guide for the first-time researcher*. 3rd Edition. London: SAGE. pp 194.
68. Walmsley, T. L., Rose, A., & Wei, D. (2020). Impacts on the U.S. macroeconomy of mandatory business closures in response to the COVID-19 pandemic. *Appl. Econ. Lett.* 28, 1293–1300.
69. Wayland, S. (2012). *Winning Strategies for Immigrant Entrepreneurship in Five Communities: Final Project Report*. Workforce Planning Hamilton.
70. Wei, J., Chen, Y., Zhang, J., & Gong, Y. (2019). Research on Factors Affecting the Entrepreneurial Learning From Failure: An Interpretive Structure Model. *Frontiers in Psychology*, 10, <https://doi.org/10.3389/fpsyg.2019.01304>
71. Wilson, K. (2023). *Canadian non-profit looking to help Black food entrepreneurs start their businesses*. <https://nowtoronto.com/culture/canadian-non-profit-looking-to-help-black-food-entrepreneurs/>
72. World Bank (2020). *Doing Business 2022. Economy Profile Canada*. <https://www.doingbusiness.org/content/dam/doingBusiness/country/c/canada/CAN.pdf>

Investment instruments: The power of neural networks in predicting gold price trends

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Abstract

Precious metals, and especially gold, have been inextricably linked to the history of mankind since time immemorial. In modern times, gold has become a key factor in international trade and the global economy. Therefore, for example, oil price fluctuations can be a predictor of gold price movements. Today, gold is seen as an independent financial asset that has become a popular tool for portfolio diversification, as well as a hedge against inflation. For this reason, this topic is considered to be very important and topical worldwide, attracting the attention of a wide range of people, both from the ranks of experts and the lay public. The article's objectives are to determine the position of gold in the commodity market, measure and compare the metal's historical price development from 2000 to March 2023, and, last but not least, assess how well artificial neural networks can forecast the movement of gold's market price. Evaluating whether gold is a good financial resource multiplier or custodian is one of the partial goals. In order to achieve this goal, time series analysis will be performed using artificial neural networks. It is feasible to track how accurately artificial neural networks can forecast changes in market prices by using this technique. The results show that the most common elements influencing the historical development of the price of gold were political, economic, technological, and social aspects. Additionally, it was shown that artificial neural networks are capable of accurately predicting the course of the price of gold and, thus, mimicking the genuine price development curve. Based on the obtained results, future studies might be carried out to compare a more extensive portfolio of commodities in order to build on this work. The contribution is beneficial both on a theoretical and practical level. It can serve investors, analysts, economists, and other authors dealing with this issue.

Key words

gold, prediction, artificial intelligence, commodity market, investing.

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Introduction

Coins were the primary form of money for hundreds of years or possibly more than two millennia, with a few notable exceptions. Given that they were initially struck on a single side in the Lydian Empire, which included parts of modern-day Turkey, circa 660 BC, coins made of precious metals—

especially gold—are frequently regarded as the earliest money in history (Štúr et al., 2014). These coins were referred to as “full-value” coins because their intrinsic value, or the amount of precious metal they contained, matched their purchasing power (Revenda & Arltová, 2022). According to Gutiérrez, Franco & Campuzano (2013), genuine gold trading began in the fourteenth century. The authors go on to say that during the 19th and 20th centuries, gold was used as a means of exchange and as a financial guarantee for printed banknotes. According to Beretta & Peluso (2022), gold has long been regarded as a “haven” or “anchor of stability”. The authors also contend that although gold’s price is susceptible to financial bubbles, the metal itself is not (because of its natural scarcity). The yearly fluctuations in supply and demand have a significant impact on the stability of gold prices. Nonetheless, there are arguments that the “best bubble” has already burst or that gold could trigger a much larger bubble than tech stocks in light of the recent sharp increase in the price of gold. Due to the lengthy and intricate relationship between gold, money, and financial markets, gold is frequently brought up in conversations about money and investments (O’Connor et al., 2015). Due to its negative correlation with stocks and poor correlation with other financial assets, which make it very effective at diversifying a portfolio and lowering its inherent risk and volatility, gold can also be very helpful during stressful times (Lucey et al., 2021). According to Gürgün & Ünalms (2014), domestic investors in the majority of countries can use gold as a haven and a hedge.

Gold demonstrates strong hedging in the US, India, and a diverse function in China. Gold continues to be a valuable investment due to its status as a haven, particularly in nations like China, India, the United States, and the United Kingdom where gold is deeply ingrained in the culture. However, gold still only has a flexible function in growing countries like Malaysia and the United Arab Emirates. The US central bank has 8133.5 tons of gold, or 75.6% of all foreign reserves, making it the nation with the largest official gold reserve. The United States of America is a prominent participant in the gold mining industry, having produced 230 tons of the metal, placing it third in terms of production, after China and Australia (Ghazali et al., 2020). In recent years, China has emerged as the world’s foremost producer and the second-largest consumer of gold, with its gold market experiencing rapid growth. Although China has a long history of mining, dating back to the Xia, Shang, and Zhou dynasties, the “Silk Road” era is considered to be the mining heyday. Even though the nation “officially” states that it produced only 2 tons of gold in the nearly 40 years between 1982 and 1993, there has been a notable upsurge in production in recent years, with an annual rise of 160 tons. With more than 460 tons produced annually, China leads the world in gold output, which has increased dramatically in recent years (Pian & Santosh, 2020). According to Zhang & Wei (2010), the commodities market is primarily represented by the gold and oil markets. As a result, changes in the price of oil can forecast changes in the price of gold (Le & Chang, 2012). For a variety of reasons, it is generally challenging to characterize the price behavior of any commodity (Smiech, 2014). Like any other commodity on the market, the price of precious metals increases with increasing demand and decreases with increasing supply. Due to a variety of factors affecting supply and demand, the price of gold and silver fluctuates and evolves. As a result, everyone who invests in the financial market hopes to time the market and determine how much to purchase. The topicality of this topic results from the global importance of gold and its indisputable position on the commodity markets. This yellow metal had and still has many uses across the world. Be it its use as an indicator of wealth, the use of gold for monetary purposes, decoration and the application of gold in modern times as an integral part in the field of technology, medicine and research. The wide use of this metal is due to its extraordinary chemical and physical properties.

Nowadays, gold is increasingly used as an investment metal, as it serves as a store of value in times of economic recessions, making it an integral part of a diversified portfolio. For this reason, constant attention has been paid to the prediction of gold prices recently.

The purpose of this article is to determine the place of gold in the commodity market, measure and compare the precious metal's historical price development from 2000 to March 2023, and assess the accuracy of artificial neural networks' price predictions. Determining if this commodity may serve as an appropriate multiplier or custodian of financial resources is one of the partial goals. The following research questions are defined to fulfil the stated objectives:

1. What factors historically influenced gold prices on the commodity exchange?
2. How accurately can artificial neural networks predict the gold price time series?

The contribution of the achieved results can be viewed from several angles, both theoretical and practical. The contribution can serve as a theoretical basis for other authors who deal with the same or similar issues, as well as an informative article for potential interested parties who would like to learn more about the given issue. However, this work can bring the greatest benefit especially to potential investors, who, for example, are still deciding whether an investment in gold will lead to safe keeping, and especially to the multiplication of their financial resources, or to analysts, who will thus obtain valuable information.

The paper is further divided as follows: The paper is further divided as follows: A Literature review that provides an overview of several specific research papers dealing with gold price forecasting models. The Methodology describes data collection using the kaggle.com website and describes the application of regression analysis using neural networks, which will be evaluated using the Statistica program. In the Results section, the position of gold on the commodity market is identified, the historical development of its prices over a certain period is measured and compared, and the ability of neural networks to predict the accuracy of the gold price is analyzed. The Discussion summarizes the results and provides answers to the research questions. The Conclusion contains a summary of all findings and recommendations.

1. Literature review

Given the importance of precious metals in the financial and industrial sectors, accurate precious metal price forecasting is essential. Lin et al. (2022) adjusted the empirical mode decomposition (MEEMD) method integrated with a long-short-term memory (LSTM) neural network to achieve improved prediction accuracy for precious metal price prediction. MEEMD outperforms ensemble empirical modal decomposition (EEMD) in terms of decomposition effect, according to multi-step permutation entropy analysis. Next, the LSTM is supplied with each intrinsic mode function (IMF) that MEEMD produced in order to make predictions. The final projection results are obtained by adding the forecast values of each IMF. The MEEMD-LSTM forecasting model outperforms the conventional multi-layer perceptual neural network (MLP), support vector regression (SVR), and super learner combined forecasting model in both one-step-ahead and multi-step-ahead forecasting scenarios. To thoroughly and statistically confirm MEEMD-LSTM's best prediction performance, an ensemble test for multi-horizon model credibility is used. They further show that, depending on the training to test set ratio or the economic cycle phase, the model continues to show improved prediction accuracy. This competitive technique for forecasting the price of precious metals holds promise for connected enterprises, investors, and government organizations.

The world's gold price has garnered a lot of attention lately, and, in comparison to previous price movements, the price of gold has increased dramatically. A model to forecast the price of gold was attempted to be developed by Faruk & Hossain (2019). The period from January 1950 to January 2018 was utilized to get sample gold price data (USD per ounce). The forecasting model was constructed using the Box-Jenkin Autoregressive Integrated Moving Average (ARIMA) methodology. ARIMA (1,1,2) (1,1,2)₁₂, according to them, is the best model for predicting gold prices. Zhang & Ci (2020) concur, noting that in the past, governments, institutions, and individuals have all taken notice of changes in the price of gold. Reducing the impact of gold market swings and accurately capturing price trends are two benefits of an accurate gold price forecast. Given the complex and non-linear structure of the gold market, this is a difficult job. To forecast the price of gold, they put forth a deep belief network (DBN) model that includes a back-propagation (BP) layer with supervision for fine-tuning and limited Boltzmann machines for pretraining. Comparisons were made between the outcomes and the mathematical linear ARIMA model, the genetic algorithm optimization model for the BP neural network, and the conventional BP neural network model. With the lowest mean squared error, mean absolute error, and mean absolute error as well as the greatest directional statistics, they discovered that the suggested DBN model has outstanding prediction and directional performance. All things considered, the new DBN proves to be a more accurate gold price-predicting technique than both linear models and conventional neural networks.

In an effort to anticipate gold volatility using nation-specific indicators (GPRs), Li et al. (2023) examined the contributions of dimension reduction techniques and integrated prediction models to increase forecast accuracy. For this, several GARCH-MIDAS model extensions are employed. Initially, they discovered that the majority of nation-specific GPR indices regulate gold volatility and that, when predicting gold volatility, it makes sense to take forecast data from several nation-specific GPR indices into account. They also disclosed that combination prediction models are not as predictive as dimension reduction techniques. Furthermore, dimension reduction methods do exceptionally well in forecasting, particularly when gold volatility is minimal. Not to mention, the results remain strong even after adjusting the gold market, in-sample length, model configuration, and evaluation technique. Numerous financial operations worldwide are significantly impacted by the fluctuations in the price of gold. Creating a solid forecasting model may help shed light on the dynamics, volatility, and behavior of the gold price in addition to providing a chance to earn handsomely in the long run. In order to precisely estimate gold prices and fluctuations, Livieris et al. (2020) present a novel forecasting algorithm based on deep learning. The suggested model makes use of the effectiveness of LSTM in identifying short- and long-term dependencies, as well as the powers of convolutional layers, to extract valuable knowledge and understand the internal representation of time series data. They ran a number of tests and compared the suggested model to the most advanced deep learning and machine learning models available. Utilizing LSTM layers in conjunction with other convolutional layers has the potential to greatly enhance prediction performance, according to preliminary experimental data.

In their study, Wang et al. (2021) describe how the price creation mechanism of gold futures, a significant element of the financial market, has drawn the remarkable interest of academics and financiers. However, because gold futures price data is a time series and has chaotic, noisy, and non-stationary features, it is particularly difficult to anticipate. To solve these problems, they suggested a brand-new forecasting model called SGRU-AM, which is based on an attention mechanism (AM) and a specific recurrent unit (SGRU). The rectified recurrent unit (GRU) model known as the SGRU

modifies the memory ratio between the present and past moments by applying a 1-tanh function to the basic GRU's reset gate output. This process changes the reset gate's value range. With its long-range data collection capabilities, SGRU is able to forecast the closing price of gold futures the day after trade. Next, AM is used to alter the SGRU time dimension feature expression in order to increase prediction accuracy, learn the meaning of current local sequence features, and collect more comprehensive feature information for the model. In contrast, Pierdzioch et al. (2023) used a quasi-sampling forecasting experiment to study the predictive power of the short-term real interest rate for the volatility of gold price returns. They used US monthly data for the sample period of 1990/1 to 2022/2 to achieve this. They looked at a shadow real interest rate given the recent extension of the zero floors and a standard real interest rate predicated on sufficient federal funding. They discover that, in numerous forecasting experiment parameters, the real interest rate has a better predictive value for later realized volatility for the shadow real interest rate than for the regular real interest rate. The findings have significant ramifications for portfolio selections made by investors because gold is regarded as a safe-haven asset. Vrbka et al. (2020) state that one of the most often used prognostic techniques is the artificial neural network, which necessitates a more intricate model, employs a greater number of variables, and tends to operate non-linearly. As a result, this approach is appropriate for further modifications in the financial industry, particularly in the stock market. Neural networks yield favorable outcomes, and when solving important company indicators, they perform and are much more accurate than classical statistical techniques (Horák et al., 2023). Network drawbacks include the need for very high-quality data and the potential for artificial neural networks to behave irrationally (Rowland et al., 2021). Predictions made using neural networks can also be used to calculate the exchange rate. Vochozka et al. (2019) used artificial neural networks to predict the exchange rate, and their work produced useful and high-quality outcomes for a number of research projects. The investigation included data on currency exchange rates spanning more than nine years, totaling 3303 input data points. Using neural networks, they carried out regression and produced two sets of networks, the second of which was centered on seasonal changes. Prior to the experiment, there did not seem to be a reason to use categorical variables in the calculation. They discovered that adding more variables to the value measurement—like the year, month, day of the month, and day of the week—improved the precision and order of the time series alignment. The literature search revealed that the subject of gold as an investment was studied by a comparatively large number of scientific scholars. Numerous publications and studies have been released, and a variety of techniques have been employed. Artificial neural networks are widely utilized due to their exceptional accuracy and adaptability, enabling the computation of nearly anything. For this reason, we also selected artificial neural networks for our computations. These will be applied to RQ2, where the accuracy of neural network predictions of the gold price time series will be assessed. Then, we will forecast the price of gold for the following 30 business days. Following this estimate, a validation will be made and the discrepancy between the real and previously mentioned gold prices will be analyzed.

2. Methodology

To achieve the desired outcome, the practical part will be split into two sections. The initial stage of this work's practical part will be gathering individual secondary data utilizing the kaggle.com website. This information will be crucial in figuring out how the price of the chosen commodity, particularly the price of gold, has historically changed. In order to provide a more comprehensive historical

perspective of the price development of this precious metal, daily data for the last twenty-three years—that is, from January 4, 2000, to March 30, 2023—will be provided. The ounce will be the unit of mass and the currency for this commodity will be expressed in US dollars. Microsoft Excel data files will be created for the gold price development framework. Data files for gold will contain 5846 input data. For clarity, the created data files will therefore be edited, within which only the relevant data will be overwritten into the table, with which further actions will take place. The obtained data will be presented and evaluated both qualitatively and quantitatively, as well as graphically.

The acquisition of pertinent information appropriate for forecasting the price of the gold commodity will be required in the second stage. These will be made available once more utilizing time series from January 4, 2000, to March 30, 2023, using the kaggle.com website. After that, the data will be processed using Tibco Software Inc.'s Statistica program. As part of the need to answer RQ1, a quantile analysis will be performed with the help of the aforementioned Statistica program, which will lead to obtaining the necessary values for the precious metal, which will be: median, mode, arithmetic mean, standard deviation, range of variation and maximum and minimum value. The general mathematical formula (1) and (2) for the median:

$$\tilde{x} = \frac{x_{(N+1)}}{2}, \text{ if } N \text{ is an odd number} \quad (1)$$

$$\tilde{x} = \frac{x_{(\frac{N}{2})} + x_{(\frac{N}{2}+1)}}{2}, \text{ if } N \text{ is an even number} \quad (2)$$

$\tilde{x}$ – the median is a set of values of size N , whose elements x_i are ordered from smallest to largest.

General mathematical formula for mode (3):

$$Mod(X) = \text{the value of } x \text{ with the highest frequency} \quad (3)$$

The general mathematical formula (4) of the arithmetic mean:

$$\bar{x} = \frac{1}{n} \sum_{i=1}^n x_i = \frac{x_1 + x_2 + \dots + x_n}{n} \quad (4)$$

$\bar{x}$ – the arithmetic mean is equal to the sum of all values x_i divided by the total number of statistical units (n).

General mathematical formula (5) for standard deviation:

$$Var(X) = \frac{1}{N} ((x_1 - \bar{x})^2 + (x_2 - \bar{x})^2 + \dots + (x_N - \bar{x})^2) \quad (5)$$

$$\sigma = \sqrt{Var(X)} \quad (6)$$

Var – the square root of the variance, where $\bar{x}$ is the average value and X represents the set of values, equals the standard deviation (σ).

Time series analysis will assist in determining its evolution and, concurrently, the factors that impacted the historical price of gold by comparing similar data in chronological order. Additionally, by applying the comparison method, it will be feasible to evaluate how gold's price fluctuated more during the course of history and, concurrently, determine whether or not these variations had an impact on the price development.

MLP networks and radial basis function (RBF) networks will be employed in the artificial neural network approach to address RQ2. The MLP and RBF neural networks are graphically represented in Figures 1 and 2.

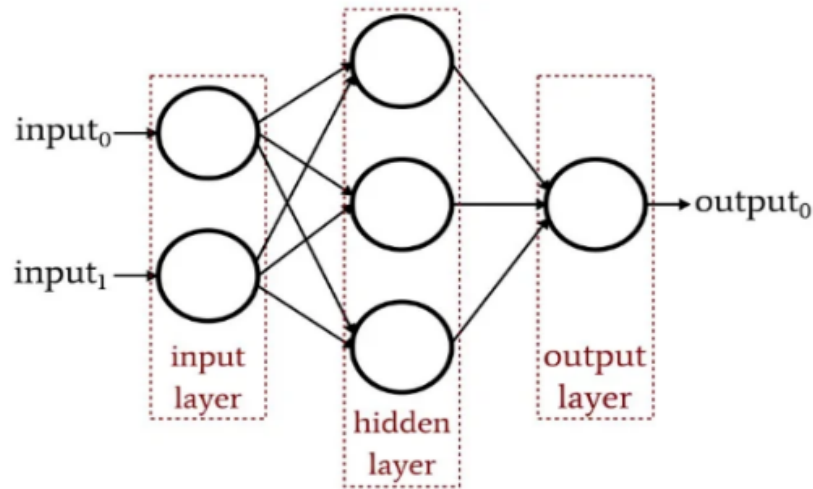


Figure 1. MLP neural networks

Source: Keim (2019).

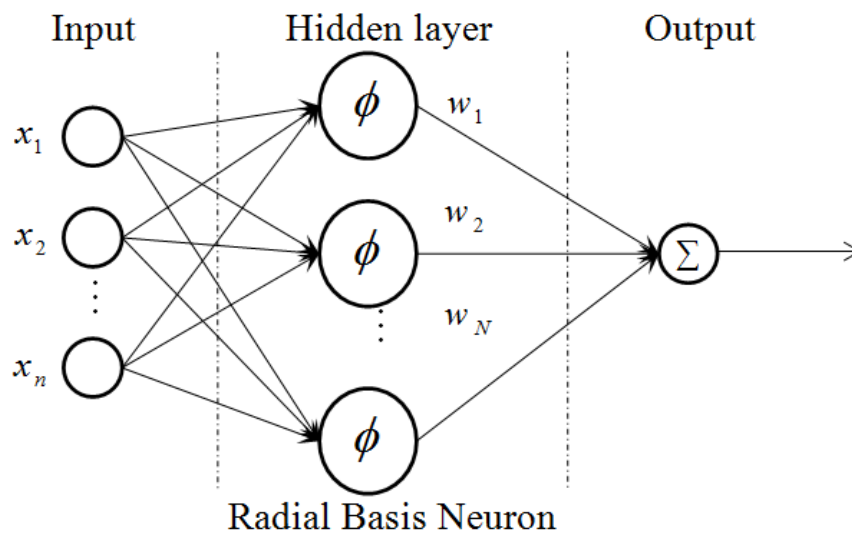


Figure 2: RBF neural networks

Source: He et al. (2019).

The MLP neural network then has the following mathematical expression (6) (Kudová, 2001):

$$(\vec{x}) = \sigma(\sum_{i=0}^n w_i x_i) \quad (6)$$

And RBF neural networks then have a mathematical expression (7) like this (Kudová, 2001):

$$y(\vec{x}) = e - \left(\frac{\|\vec{x} - \vec{c}\|}{b}\right)^2 \quad (7)$$

where $\vec{x}$ represents input values, y is output; $\vec{c}$ is centre; b – width; $\|\vec{x} - \vec{c}\|$ – the distance calculated using the Euclidean metric; $\frac{\|\vec{x} - \vec{c}\|}{b}$ – the internal potential of the RBF unit and w is the weight value.

Time series analysis will be useful, as it compares similar data in chronological order. We will utilize time series regression analysis to forecast gold prices. To use this strategy, though, the correlation coefficient—that is, the gold price's reliance on time—must first be determined. A significance threshold of 0.95 will be selected for this. There will be 5846 input data in the data files with calculations, with time acting as the independent variable and commodity price acting as the dependent variable. The processing of linear regression employing neuron architectures will come when these tasks are finished. The least squares method will be used to build 1000 neural networks in each example, of which the ten best fits for future development prediction will be retained. Time series will be separated into training, test, and validation data based on classification. Seventy percent of the training data will be used to train the neural networks. 15% more of the data will be utilized for testing and validation. The number of neurons in the hidden layer and each neuron's weight in the other layers will be determined by the training. Three layers will make up neural networks. The input layer will be the first layer. The quantity of inputs, representing the value from every day since 2000, will be included in this. The hidden layer, which makes up the second layer, will show how many hidden neurons are there and will be used to build analogies for critical computations. The output layer, which is the final and third layer, is where the final values are obtained. For the MLP hidden and output layer, we will employ the following functions: linear, logistic, Atanh, exponential, and sine. The other settings (automated network creation in the ATS tool) will remain as default. The individual function formulas are displayed in Table 1.

Table 1. Formulas of functions

Function	Definition	Range
Identity	A	$(-\infty; +\infty)$
Logistic sigmoid	$\frac{1}{1+e^{-a}}$	$(0;1)$
Hyperbolic tangent	$\frac{e^a - e^{-a}}{e^a + e^{-a}}$	$(-1;+1)$
Exponential	e^{-a}	$(0;+\infty)$
Sine	$\sin(a)$	$[0;1]$

Source: Šuleř & Machová (2020)

The mentioned least squares method is used as the error function, which is represented by the following formula (8):

$$E_{sos} = \frac{1}{2N} \sum_{i=1}^N (y_i - t_i)^2 \quad (8)$$

where N – the number of trained cases, y_i – the prediction of the target variable t_i and t_i is the target variable of the with case.

A prediction will also be made for 30 trading days ahead, where it will be determined if any of the neural networks show any price extremes. Following this prediction, a validation will be created to determine the actual and predicted prices of gold using the residual. If the expected gold price will be the same as the real one, or if it will have different values and by how much.

3. Research results

The historical evolution of gold prices from 2000 to March 2023 is shown in the results section. Additionally, the findings pertaining to the commodity's price's future impact are showcased here. The price of gold has fluctuated over time due to a number of variables, including inflation and political and economic developments. These occurrences had a big impact on how the supply and demand for gold developed concurrently. The price of gold fluctuated and went through several periods between 2000 and March 2023. Applying time series analysis, Figure 3 was created from the results, which shows the historical development of gold prices over twenty-one years.

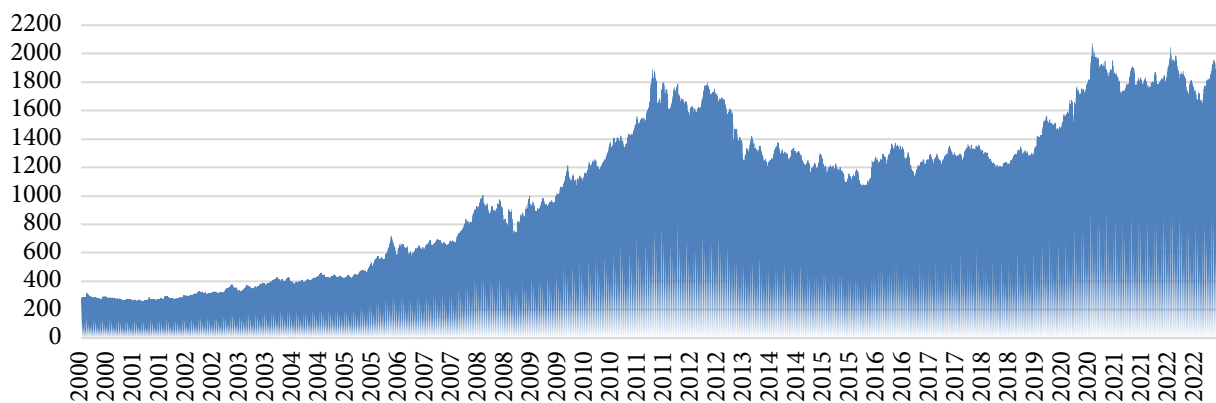


Figure 3. Historical development of gold prices from 2000 to March 2023 (in USD/oz t)

Source: developed by the authors.

Figure 3 illustrates how, from an investing perspective, prices developed over the monitored period in a generally positive manner, with very few exceptions. Prices increased. The highest price that gold ever acquired during the monitored period was the amount of 2069.4 USD/oz t reached on August 6, 2020. On the other hand, the lowest amount for which one ounce of gold could be purchased in the monitored period was 256.6 USD/oz t reached on April 2, 2001. Comparing these two values, the difference is 1812.8 USD/oz t, which is roughly a 706% increase in price, which from the investor's point of view appears to be one of the most suitable investment opportunities for the appreciation of your assets. Using the Statistica software, the fundamental statistical properties of the time series were also determined during the monitored period. These included the normality test and analyses of the data set's median, mode, arithmetic mean, standard deviation, and variation range. The results are shown in Figure 4. Throughout the examined time, the average price of gold was 1199.3 USD/oz t. The most frequent price from 2000 to March 2023 was 278.6 USD/oz t. 1058.8 USD/oz t was the average price of gold per ounce, with a 525.6 standard deviation.

The year 2000-2002 was relatively favourable for the development of gold prices. During the year 2000, gold prices were relatively stagnant. In 2001, there was a slight drop in prices, where it is possible to trace the mentioned minimum price of the monitored period, i.e. 256.6 USD/oz t. From this amount

until roughly the middle of 2002, prices rose slightly. The price of gold had a minor decline in the second half of the same year, and by the end of the year, it had reached its maximum point for the time being, or 349.7 USD.

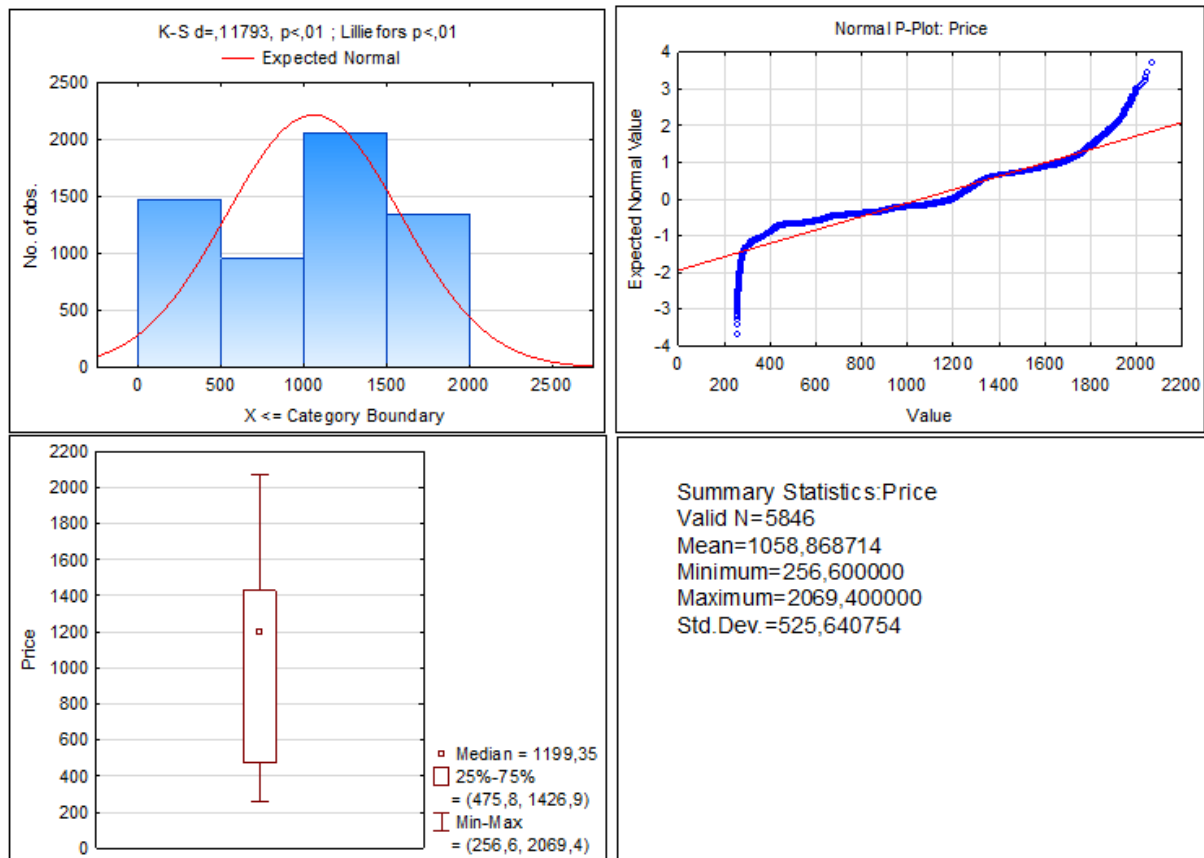


Figure 4. Basic statistical characteristics of the development of gold prices

Source: developed by the authors.

During this period, however, no factors appeared that would significantly influence the development of the prices of this investment instrument. In general, it can therefore be concluded that the price of gold did not develop considerably during the period from 2000 to 2002 and, with slight fluctuations, kept a mostly constant price, which ranged from 256.6 to 349.7 USD/oz t., and that with an average price of 288.2 USD/oz t. The beginning of 2003 followed the rise in prices from 2002. But then there was the first significant drop in prices, which reached the lowest possible price of gold, i.e. 322.2 USD/oz t, in the given year. This fall did not last long, and after a while, prices began to slowly rise again when towards the end of 2003, gold first crossed the threshold of USD 400/oz t and thus reached the highest possible price of USD 417.2/oz t. On the other hand, the average gold price did not differ much from 2002, i.e. in 2003; it acquired a moderate amount of 364.3 USD/oz t. In 2004, gold prices developed at a relatively similar pace as in previous periods. Despite slight price fluctuations, prices were mainly stagnant. Compared to 2003, the highest possible price for gold in 2004 differed only by 40.6 USD/oz t and the lowest possible price by 52.7 USD/oz t. The average price for that year was 410.4 USD/oz t. According to the data thus far, there appears to be a consistent pattern in which gold prices generally experience a small decline at the beginning of the year before rapidly rising. 2005 was the first time in history that gold prices did not fall below the 400 USD/oz t mark. Even this year, the gold

price reached a significant milestone when it attacked and broke the 500 USD/oz t mark. During this year, gold prices fluctuated negligibly, while at the end of this period, gold began to acquire a faster price growth rate. To clarify, the maximum value achieved for 2005 was 531.5 USD/oz t, and the minimum value achieved was 414.3 USD/oz t. This shows that investing in this precious metal was a very attractive year. The average value then reached the amount of 447.1 USD/oz t. 2006 was a turbulent year for gold as an investment vehicle. Prices at the beginning of the year soared at an extreme rate above the 700 USD/oz t mark, a difference of almost 200 USD/oz t compared to the highest possible amount so far in 2005. However, this amount did not have a long-term impact and immediately fell sharply below the 600 mark USD/oz t. Gold prices rose again during the rest of the year, but only below the 700 USD/oz t mark. Therefore, in 2006, gold could be purchased at the lowest possible amount of 527.8 USD/oz t, which was almost the highest 2005 possible amount per ounce of gold. The average price for 2006 was 608.2 USD/oz t. The period between 2007-2009 was one of the most significant in the development of gold prices, see Figure 5. During 2007, gold prices were largely stagnant, averaging 701.4 USD/oz t. But a turning point came at the end of that year when gold prices shot up again to record highs, and since then, gold has never traded below an amount of more than USD 700/oz t. At the beginning of 2008, with the economic crisis in full swing, prices continued to rocket and thus subsequently reached another essential historical milestone when they crossed the threshold of 1000 USD/oz t. Immediately, as in the case of the development of gold prices known, prices fell sharply again at the end of 2008, down to 705 USD/oz.t, which meant a price drop of almost 300 USD/oz.t. The year 2009 was very favourable for the development of gold prices. In the course of this year, except for minor fluctuations, prices mostly rose, and at the end of the year, they even reached another milestone, i.e. the border of 1200 USD/oz t.

When 611.4 USD/oz t was the difference between the lowest and maximum conceivable value, gold prices increased by up to 101% year over year. The price of gold in the ensuing years stayed at a maximum of \$1,000 USD/oz t.

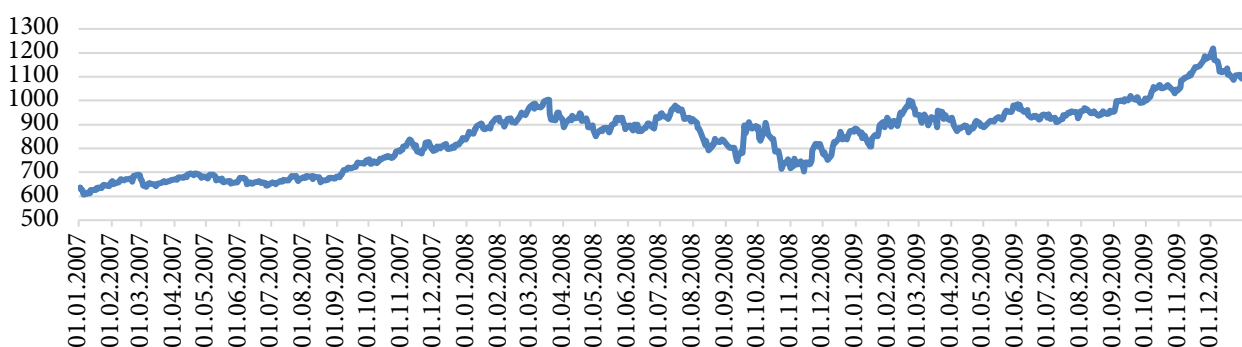


Figure 5. Historical development of gold prices during the economic crisis (in USD/oz t)

Source: developed by the authors.

From 2010 to 2012, gold became increasingly popular, increasing its investment value. At the beginning of 2010, gold traded at USD 1052.8/oz t, the lowest price for gold in years. From this amount, the price of gold increased rapidly, reaching a new maximum milestone in mid-2011, namely the amount of 1891.9 USD/oz t. However, the price of gold fell once more near the end of 2011 and stayed just below the 1800 USD/oz t level. Given that the price of gold remained within the range of 1536.6

to 1796.5 USD/oz t during 2012, the year could have been more favourable in terms of price development. A notable decline in the price of gold occurred between 2013 and 2015. The price of gold decreased by up to 61% throughout the measured period, from 1693.2 USD/oz t to 1049.6 USD/oz t. Up until the end of 2018, gold prices remained mostly unchanged since then. Consequently, the average price of gold traded for between 2013 and 2018 was USD 1269.5/oz t. With the start of the global COVID-19 pandemic in 2019, gold prices started to rise once more quickly, as seen in Figure 6.

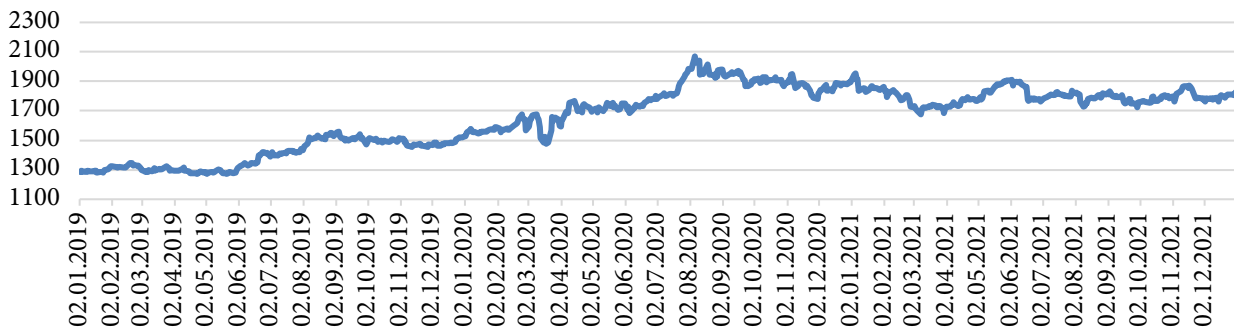


Figure 6. Historical development of gold prices during the Covid-19 pandemic (in USD/oz t)

Source: developed by the authors according to data on [Kaggle.com/Gold](https://www.kaggle.com/datasets/gold-price) (2023).

From the beginning of 2019, the price was still around 1300 USD/oz t. However, a turning point occurred around May, when prices gradually increased. In September, this precious metal again crossed the 1500 USD/oz t mark, which meant that after six years of stagnation, the first significant increase in prices. Gold maintained its increasing pace in 2020 when on August 6, it reached the highest possible price in history, i.e. 2069.4 USD/oz t, which has just been surpassed today. Since this milestone, gold prices have been falling, but not at a devastating pace, thus staying around the 1800 USD/oz mark. Based on the war conflict in Ukraine, which began at the beginning of 2022, gold prices rose again, and thus for the second time in the period monitored by us from 2000 to March 2023, they exceeded the maximum limit of 2000 USD/oz t (Figure 7).

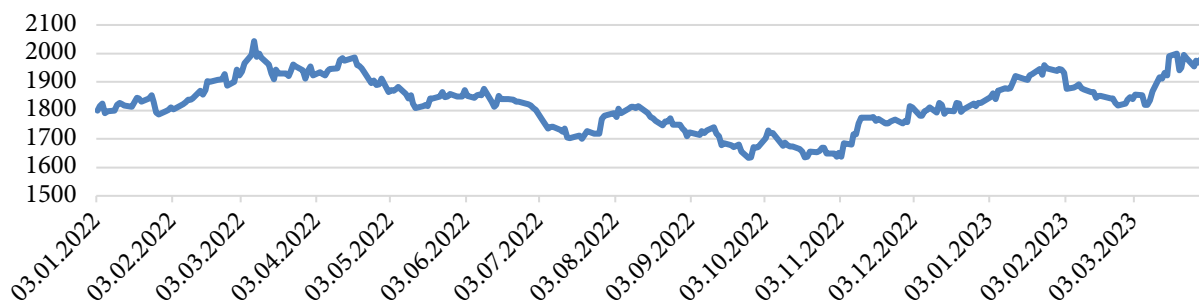


Figure 7. Historical development of gold prices during the war conflict in Ukraine (in USD/oz t)

Source: developed by the authors.

However, as the year progressed, the tradable price continued to decrease, and in 2022 it fell to the limit of 1600 USD/oz t. Towards the end of 2022, gold prices strengthened again to the limit of 1800 USD/oz t, which began to stagnate. At the beginning of 2023, the development of gold prices began to

strengthen, with which prices once again climbed to just below the tradable level of 2000 USD/oz t. A thousand neural networks were generated in accordance with the chosen procedure. An overview of the top 10 neural networks with the best parameters over the whole range of neural structures that have been developed is provided in Table 2.

Table 2. Summary of active neural networks (gold data for the period 2000-2023)

In- dex	Net. name	Training perf.	Test perf.	Validation perf.	Training error	Test error	Validation error	Training algorithm	Error function	Hidden activa- tion	Output activation
1	MLP 1-13-1	0.994971	0.994654	0.995185	1370.996	1517.278	1351.208	BFGS 1863	SOS	Logistic	Identity
2	MLP 1-15-1	0.994681	0.994785	0.994942	1450.012	1478.377	1419.372	BFGS 512	SOS	Tanh	Tanh
3	MLP 1-18-1	0.994608	0.994417	0.994843	1469.946	1583.477	1450.820	BFGS 607	SOS	Logistic	Logistic
4	MLP 1-16-1	0.994267	0.994500	0.994836	1567.147	1567.667	1448.968	BFGS 565	SOS	Tanh	Exponen- tial
5	MLP 1-18-1	0.994622	0.994575	0.994780	1465.840	1538.583	1466.187	BFGS 310	SOS	Logistic	Logistic
6	MLP 1-20-1	0.994835	0.994702	0.994995	1407.905	1501.754	1406.403	BFGS 509	SOS	Logistic	Identity
7	MLP 1-17-1	0.994582	0.994116	0.994773	1476.733	1665.180	1466.995	BFGS 312	SOS	Tanh	Sine
8	MLP 1-17-1	0.995600	0.995424	0.996026	1199.960	1296.604	1117.151	BFGS 704	SOS	Tanh	Exponen- tial
9	MLP 1-9-1	0.994691	0.994343	0.995247	1446.999	1600.613	1335.542	BFGS 8337	SOS	Tanh	Tanh
10	MLP 1-15-1	0.994661	0.994303	0.994779	1455.493	1612.432	1465.189	BFGS 325	SOS	Tanh	Tanh

Source: developed by the authors.

The table shows that only MLP networks are present, outperforming biased and inefficient RBF networks. The top ten structures were created using the BFGS (Broyden-Fletcher-Goldfarb-Shanno) variant training algorithm and had 12 to 20 neurons in the hidden layer. There is only one neuron in each of the input and output layers. At the same time, the input layer is a variable that represents time, and the output layer is also a variable, but here it is already the final price of gold. The hidden neural layers activated two functions, one of which was the hyperbolic tangent and the other a logistic function. The output layers formed the following five functions: identical, hyperbolic tangent, logistic, exponential and sine. Network performance is more closely represented by the correlation coefficient (Table 3).

Table 3. Correlation coefficients (Gold – daily data 2000-2023)

	Price	Price	Price		Price	Price	Price
1.MLP 1-13-1	0.994971	0.994654	0.995185	6.MLP 1-20-1	0.994835	0.994702	0.994995
2.MLP 1-15-1	0.994681	0.994785	0.994942	7.MLP 1-17-1	0.994582	0.994116	0.994773
3.MLP 1-18-1	0.994608	0.994417	0.994843	8.MLP 1-17-1	0.995600	0.995424	0.996026
4.MLP 1-16-1	0.994267	0.994500	0.994836	9.MLP 1-9-1	0.994691	0.994343	0.995247
5.MLP 1-18-1	0.994622	0.994575	0.994780	10.MLP 1-15-1	0.994661	0.994303	0.994779

Source: developed by the authors.

Table 3 summarizes the values of individual datasets according to particular neural networks. The goal is to identify a network whose performance is preferably the same in all sets—training, testing, and validation. The correlation coefficient, which is a measure of the datasets' performance, should equal 1 while looking for the best possible network. Given that the other two datasets confirmed the validity of the structures in the training set, all three datasets performed identically. The table shows that all neural structures and data sets have correlation coefficients higher than 0.994, indicating negligible differences between individual networks. Thus, based on these findings, there is a high degree of performance, which is further supported by the value of each individual network, which

consistently rises over the value of 0.9. More specifically, each set's coefficients always fall between 0.994 and 0.996. The detailed prediction statistics of each unique preserved MLP network are displayed in Table 4.

Table 4. Predictions statistics (Oil – daily data 2000-2023)

Statistics	1.MLP 1-13-1	2.MLP 1-15-1	3.MLP 1-18-1	4.MLP 1-16-1	5.MLP 1-18-1	6.MLP 1-20-1	7.MLP 1-17-1	8.MLP 1-17-1	9.MLP 1-9-1	10.MLP 1-15-1
Min. p. (Train)	267.839	267.268	279.277	256.600	266.532	262.971	274.674	267.570	256.399	272.107
Max. p. (Train)	1827.006	1834.998	1918.163	2019.305	1865.446	1888.018	1836.241	2008.971	1977.842	1873.402
Min. p. (Test)	267.842	267.276	279.278	256.600	266.508	262.971	274.676	267.552	256.358	272.110
Max. p. (Test)	1827.007	1834.998	1919.538	2023.698	1865.849	1888.808	1836.240	2013.038	1979.836	1873.886
Min. p. (Validation)	267.840	267.268	279.278	256.600	267.190	262.972	274.675	268.041	257.487	272.108
Max. p. (Validation)	1827.004	1834.997	1907.225	1985.641	1862.221	1881.803	1836.224	1977.803	1961.384	1869.545
Min. r. (Train)	-209.241	-210.248	-203.745	-218.071	-201.018	-185.328	-212.590	-189.865	-199.183	-202.149
Max. r. (Train)	281.875	276.613	293.624	254.185	275.481	285.974	275.194	217.608	270.766	266.816
Min. r. (Test)	-208.917	-209.936	-203.626	-211.037	-200.655	-184.926	-212.248	-189.954	-199.013	-201.883
Max. r. (Test)	251.386	246.049	250.298	201.650	244.621	254.930	244.614	186.127	227.638	235.944
Min. r. (Validation)	-196.282	-200.276	-189.970	-223.800	-188.241	-172.717	-199.711	-175.312	-185.647	-188.980
Max. r. (Validation)	234.278	229.091	215.866	172.759	228.254	238.929	227.687	171.024	197.541	219.603

Note: Min. p. – Minimum prediction; Max. p. – Maximum prediction; Min. r. – Minimum residual; Max. r. – Maximum residual.

Source: developed by the authors.

It is evident from the data in Table 4 that there is little variation in the values between different neural structures and between different sets of neural network data. While some variations exist between these files, they are not substantial enough to establish the most effective network. To elucidate and identify the most effective network, consult Figure 8, which depicts the real evolution of expected gold prices and prices produced by individual neural networks.

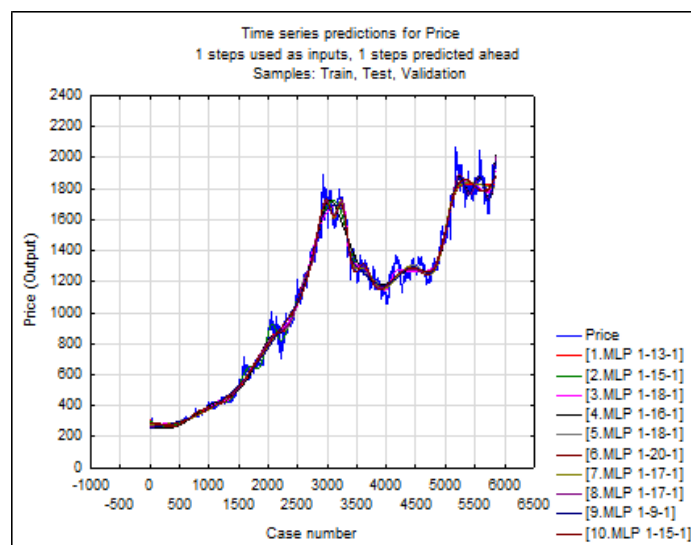


Figure 8. Development of gold prices

Source: developed by the authors.

The graph makes it evident that all of these networks forecast gold prices in a fairly similar way, with only minor variations from the actual trend in gold prices initially apparent. On the other hand, resemblance to the actual evolution of gold prices is more important than resemblance to the evolution of individual networks. The coloured curves show the top ten brain structures that have been best preserved, while the basic blue curve shows the history of the real gold price. From this vantage point, the most effective structures functioned rather precisely, allowing them to replicate the real evolution of the gold price movement curve. Even though it was the application of the most powerful neural networks according to the correlation coefficients, there is still a problem with capturing the fundamental minimum and maximum price fluctuations, which is a crucial factor in this prediction. At the beginning of the monitored period, the price prediction was accurate and did not differ from the actual price. On 30 May 2006, the first major fluctuation in the prediction occurred, but still almost negligible. Subsequently, the predicted development was again favourable until 21 December 2007, when the neural networks failed to record an increase in prices to the value of 2100 and immediately afterwards a slight decrease to 2250. During the economic crisis, when gold prices rose rapidly, neural networks proved this fact very well. On the other hand, the prediction of the neural networks differed from reality at 2900 (July 18, 2011), when gold reached its first-ever maximum price milestone. From this time on, the development of the prediction was again accurate, and the neural networks could capture even a sudden drop in prices. Prices fluctuated somewhat from April 30, 2013, to April 17, 2018. While very few neural networks were able to accurately estimate the price in this instance, the differences between their predictions and the real gold prices were negligible. Gold prices surged when the COVID-19 epidemic struck, and neural networks accurately predicted this development. During the pandemic and the war in Ukraine, the prediction was the least accurate for the entire period. At 5200 (2/9/2020) and 5600 (5/4/2022), none of the top 10 neural networks could determine the record gold price. These networks also did not record for the period from 27 January 2021 to 29 August 2022 price drops, but on a minor scale. Despite several undetected fluctuations, it was a very accurate prediction, and all these networks are applicable in practice. Following the training of the neural networks, forecasts on the movement of the gold price over the following thirty trading days were generated. Table 5 illustrates the price movement for the specified 30-day trading period.

Table 5. Gold price prediction for April – May 2023

Date	1.MLP 1-13-1	2.MLP 1- 15-1	3.MLP 1- 18-1	4.MLP 1- 16-1	5.MLP 1-18-1	6.MLP 1- 20-1	7.MLP 1- 17-1	8.MLP 1- 17-1	9.MLP 1-9-1	10.MLP 1-15-1
31.03.2023	1825.27	1802.93	1919.54	2023.70	1865.85	1888.81	1801.98	2013.04	1979.84	1873.89
03.04.2023	1825.27	1802.74	1923.67	2037.13	1867.06	1891.20	1801.81	2025.48	1985.72	1875.34
04.04.2023	1825.26	1802.67	1925.05	2041.69	1867.46	1892.00	1801.75	2029.70	1987.65	1875.83
05.04.2023	1825.26	1802.61	1926.43	2046.29	1867.87	1892.80	1801.70	2033.97	1989.56	1876.32
06.04.2023	1825.26	1802.54	1927.80	2050.94	1868.27	1893.61	1801.64	2038.27	1991.46	1876.80
10.04.2023	1825.25	1802.28	1933.32	2069.95	1869.89	1896.87	1801.42	2055.90	1998.84	1878.76
11.04.2023	1825.25	1802.21	1934.70	2074.82	1870.30	1897.69	1801.37	2060.41	2000.64	1879.25
12.04.2023	1825.25	1802.15	1936.07	2079.72	1870.70	1898.51	1801.31	2064.96	2002.42	1879.74
13.04.2023	1825.25	1802.08	1937.45	2084.67	1871.10	1899.34	1801.25	2069.55	2004.17	1880.23
14.04.2023	1825.25	1802.02	1938.83	2089.67	1871.51	1900.17	1801.20	2074.19	2005.90	1880.72
17.04.2023	1825.24	1801.82	1942.94	2104.93	1872.72	1902.68	1801.03	2088.35	2010.97	1882.20
18.04.2023	1825.24	1801.75	1944.31	2110.10	1873.13	1903.52	1800.98	2093.16	2012.61	1882.69
19.04.2023	1825.24	1801.69	1945.68	2115.33	1873.53	1904.36	1800.92	2098.01	2014.23	1883.18
20.04.2023	1825.23	1801.62	1947.04	2120.59	1873.94	1905.21	1800.86	2102.90	2015.83	1883.67
21.04.2023	1825.23	1801.56	1948.40	2125.91	1874.34	1906.06	1800.81	2107.84	2017.40	1884.17
24.04.2023	1825.23	1801.36	1952.47	2142.13	1875.55	1908.63	1800.64	2122.92	2021.97	1885.65
25.04.2023	1825.22	1801.29	1953.82	2147.63	1875.96	1909.49	1800.59	2128.04	2023.45	1886.15

Date	1.MLP 1-13-1	2.MLP 1- 15-1	3.MLP 1- 18-1	4.MLP 1- 16-1	5.MLP 1-18-1	6.MLP 1- 20-1	7.MLP 1- 17-1	8.MLP 1- 17-1	9.MLP 1-9-1	10.MLP 1-15-1
26.04.2023	1825.22	1801.23	1955.17	2153.18	1876.36	1910.36	1800.53	2133.20	2024.89	1886.64
27.04.2023	1825.22	1801.16	1956.51	2158.78	1876.77	1911.22	1800.48	2138.41	2026.32	1887.14
28.04.2023	1825.22	1801.09	1957.85	2164.42	1877.17	1912.10	1800.42	2143.67	2027.71	1887.63
01.05.2023	1825.21	1800.89	1961.85	2181.64	1878.38	1914.72	1800.25	2159.71	2031.75	1889.12
02.05.2023	1825.21	1800.83	1963.17	2187.48	1878.79	1915.60	1800.20	2165.15	2033.04	1889.62
03.05.2023	1825.21	1800.76	1964.49	2193.36	1879.19	1916.49	1800.14	2170.64	2034.30	1890.11
04.05.2023	1825.21	1800.70	1965.80	2199.30	1879.59	1917.38	1800.09	2176.18	2035.54	1890.61
05.05.2023	1825.21	1800.63	1967.11	2205.28	1880.00	1918.27	1800.03	2181.77	2036.76	1891.11
08.05.2023	1825.20	1800.43	1971.01	2223.54	1881.21	1920.95	1799.86	2198.82	2040.23	1892.60
09.05.2023	1825.20	1800.36	1972.30	2229.73	1881.61	1921.86	1799.81	2204.60	2041.34	1893.10
10.05.2023	1825.20	1800.30	1973.58	2235.96	1882.01	1922.76	1799.75	2210.44	2042.42	1893.60
11.05.2023	1825.20	1800.23	1974.86	2242.25	1882.41	1923.67	1799.70	2216.32	2043.47	1894.10
12.05.2023	1825.19	1800.16	1976.13	2248.59	1882.82	1924.58	1799.64	2222.25	2044.49	1894.59

Source: developed by the authors.

Table 5 shows how the price of gold will move from 31.3.2023 to 12.5.2023. It can be seen that none of the networks shows any extreme fluctuations. The price of all networks either rises slightly or falls slightly during the monitored period, but no price shock is visible for any of the networks. The actual price of gold throughout the observed time is shown in Table 6.

Table 6. The real price of gold

Date	The real price of gold	Date	The real price of gold
31.03.2023	1969	24.04.2023	1999.8
03.04.2023	1983.9	25.04.2023	2004.5
04.04.2023	2022.2	26.04.2023	1996
05.04.2023	2020.9	27.04.2023	1999
06.04.2023	2026.4	28.04.2023	1999.1
10.04.2023	2003.8	01.05.2023	1992.2
11.04.2023	2019	02.05.2023	2023.3
12.04.2023	2024.9	03.05.2023	2037
13.04.2023	2055.3	04.05.2023	2055.7
14.04.2023	2015.8	05.05.2023	2024.8
17.04.2023	2007	08.05.2023	2033.2
18.04.2023	2019.7	09.05.2023	2042.9
19.04.2023	2007.3	10.05.2023	2037.1
20.04.2023	2019.1	11.05.2023	2020.5
21.04.2023	1990.5	12.05.2023	2019.8

Source: developed by the authors.

Table 6 shows that the actual price of gold was not as linear as the neural networks predicted. It can be seen here that it rose and fell again during the observed period, but not by any extreme values. It's always been in the tens of dollars, but there are also extreme price jumps. At the beginning of the monitored period, we can see that the price of gold started to rise, but on 10.4. In 2023, there was a big jump in the price, so the very next day, the price of gold rose again to almost its original value. The big price jump came on April 21, 2023, when the price of gold fell from the value of 2019 to the value of 1990. After that, the price of gold began to rise and fall again, and this was the case for almost the entire monitored period. In the observed period, there was another price jump, this time in an upward direction, specifically on 2/5/2023, when the price of gold rose from its value of 1992 to 2023. The residuals between the actual and forecast prices of gold are displayed in Table 7. It shows that the 9th neural network came out as the best, which was the only one with values that approached the value of 0. Not only its total value but also the mean and the median approach the value of 0.

Table 7. The residual between the actual gold price and the predicted one

Date	1.MLP 1- 13-1	2.MLP 1- 15-1	3.MLP 1- 18-1	4.MLP 1- 16-1	5.MLP 1- 18-1	6.MLP 1- 20-1	7.MLP 1- 17-1	8.MLP 1-17-1	9.MLP 1- 9-1	10.MLP 1- 15-1
31.03.2023	143.73	166.07	49.46	-54.70	103.15	80.19	167.02	-44.04	-10.84	95.11
03.04.2023	158.63	181.16	60.23	-53.23	116.84	92.70	182.09	-41.58	-1.82	108.56
04.04.2023	196.94	219.53	97.15	-19.49	154.74	130.20	220.45	-7.50	34.55	146.37
05.04.2023	195.64	218.29	94.47	-25.39	153.03	128.10	219.20	-13.07	31.34	144.58
06.04.2023	201.14	223.86	98.60	-24.54	158.13	132.79	224.76	-11.87	34.94	149.60
10.04.2023	178.55	201.52	70.48	-66.15	133.91	106.93	202.38	-52.10	4.96	125.04
11.04.2023	193.75	216.79	84.30	-55.82	148.70	121.31	217.63	-41.41	18.36	139.75
12.04.2023	199.65	222.75	88.83	-54.82	154.20	126.39	223.59	-40.06	22.48	145.16
13.04.2023	230.05	253.22	117.85	-29.37	184.20	155.96	254.05	-14.25	51.13	175.07
14.04.2023	190.55	213.78	76.97	-73.87	144.29	115.63	214.60	-58.39	9.90	135.08
17.04.2023	181.76	205.18	64.06	-97.93	134.28	104.32	205.97	-81.35	-3.97	124.80
18.04.2023	194.46	217.95	75.39	-90.40	146.57	116.18	218.72	-73.46	7.09	137.01
19.04.2023	182.06	205.61	61.62	-108.03	133.77	102.94	206.38	-90.71	-6.93	124.12
20.04.2023	193.87	217.48	72.06	-101.49	145.16	113.89	218.24	-83.80	3.27	135.43
21.04.2023	165.27	188.94	42.10	-135.41	116.16	84.44	189.69	-117.34	-26.90	106.33
24.04.2023	174.57	198.44	47.33	-142.33	124.25	91.17	199.16	-123.12	-22.17	114.15
25.04.2023	179.28	203.21	50.68	-143.13	128.54	95.01	203.91	-123.54	-18.95	118.35
26.04.2023	170.78	194.77	40.83	-157.18	119.64	85.64	195.47	-137.20	-28.89	109.36
27.04.2023	173.78	197.84	42.49	-159.78	122.23	87.78	198.52	-139.41	-27.32	111.86
28.04.2023	173.88	198.01	41.25	-165.32	121.93	87.00	198.68	-144.57	-28.61	111.47
01.05.2023	166.99	191.31	30.35	-189.44	113.82	77.48	191.95	-167.51	-39.55	103.08
02.05.2023	198.09	222.47	60.13	-164.18	144.51	107.70	223.10	-141.85	-9.74	133.68
03.05.2023	211.79	236.24	72.51	-156.36	157.81	120.51	236.86	-133.64	2.70	146.89
04.05.2023	230.49	255.00	89.90	-143.60	176.11	138.32	255.61	-120.48	20.16	165.09
05.05.2023	199.59	224.17	57.69	-180.48	144.80	106.53	224.77	-156.97	-11.96	133.69
08.05.2023	208.00	232.77	62.19	-190.34	151.99	112.25	233.34	-165.62	-7.03	140.60
09.05.2023	217.70	242.54	70.60	-186.83	161.29	121.04	243.09	-161.70	1.56	149.80
10.05.2023	211.90	236.80	63.52	-198.86	155.09	114.34	237.35	-173.34	-5.32	143.50
11.05.2023	195.30	220.27	45.64	-221.75	138.09	96.83	220.80	-195.82	-22.97	126.40
12.05.2023	194.61	219.64	43.67	-228.79	136.98	95.22	220.16	-202.45	-24.69	125.21
Total value	5712.81	6425.60	1972.36	-3619.01	4224.22	3248.79	6447.55	-3058.15	-55.23	3925.15
Mean	190.42	214.19	65.75	-120.63	140.81	108.29	214.92	-101.94	-1.84	130.84
Median	194.16	217.71	62.85	-138.87	144.40	107.31	218.48	-118.91	-4.64	133.69

Source: developed by the authors.

This network also had two days where their actual value was close to the most predicted value. These were specifically on 3/4/2023 and 9/5/2023. On the contrary, the 7th and 2nd neural networks did the worst, most distant from the value 0. The 1st neural network did not do much better, whose total value was around 5712. In turn, the 4th and 8th neural networks predicted a much lower price of gold than was a fact; therefore, their total value also came out negatively. The table shows that, overall, the expected price of gold for the observed time was almost off from reality.

The results obtained through this research are particularly important for economic practice, as they provide new knowledge in the field of gold price prediction, which can be perceived as very beneficial due to its indisputable importance. In general, predicting gold prices can be considered a very challenging task, which is also confirmed by this research. This is mainly due to the fact that the price of gold on the market is influenced by a number of factors, including supply and demand, speculation on the financial markets, political events and the like. Gold has long been considered one of the traditional means of investment. There are several reasons why investors consider gold as part of their investment portfolio. Gold has a long history as a store of value. For thousands of years, it has been considered a medium of exchange and storage of wealth. Its value is generally independent of monetary policies and economic cycles. A common perception of gold is as an inflation hedge. Gold often

increases in value when prices are rising, and the currency's purchasing power is falling. Investors believe holding gold can help preserve their assets' value when the currency depreciates. Gold is considered a haven in geopolitical uncertainty and financial market instability.

4. Discussion

Gold has been an important factor in human history since time immemorial. The significance of the mining and processing of this precious metal has been carried over to the present day. Its demand is increasing yearly, and the mining associated with it is increasing. However, it is necessary to consider that the occurrence of gold is rare and limited, and its deposits are not infinite. Within a few decades, it can therefore be assumed that the occurrence of this deposit will become lower and lower, thereby increasing the total value of this precious metal. Before the answers to the research questions are provided, it is possible to list several surveys dealing with similar issues. For example, a paper by Li & Diao (2013) shows the dynamics of gold prices on the New York Gold Exchange using a dataset that includes global macroeconomic indicators, financial market indices, and energy product quantities and prices. The authors extract common factors from panel data series and estimate a factor-augmented vector auto-regression for gold prices. This paper has two main contributions. First, all the factors affecting the gold market were divided into three groups, namely the gold reserve and prices of energy products, financial market indices, global macroeconomic indicators. The results show that the influence of financial market indices and macroeconomic indicators on the price of gold is negative, the influence of the gold reserve and energy product prices on the price of gold is positive. Second, they apply the FAVAR model to analyze the factors affecting the price of gold and the price trend. The aim of the study by Gasparenienė et al. (2018), in turn, was to determine whether ARIMA models are suitable for determining short-term gold price volatility. The calculations show that the ARIMA model is only suitable for short-term gold price forecasts (max. 1 year). Therefore, it is necessary to apply other models (multiregression), which can also reveal the relationship between the price of gold and its determinants. Chen et al. (2016) state that future gold price fluctuations are not only influenced by quantitative variables, but also by many non-quantifiable factors such as wars, international relations and terrorist attacks. The aim of their study is to compare the accuracy of gold price forecasts using artificial neural networks and the ARIMA model. The historical gold futures prices from 1999 to 2008 were used as training data and testing data, and the prices of 2009 were used to examine the effectiveness of the proposed model. The results of empirical analysis showed that an artificial neural network forecasted gold futures prices better than ARIMA models did.

In the study E et al. (2019) a novel combination technique is put forward based on independent component analysis (ICA) and gate recurrent unit neural network (GRUNN) methods, which called ICA-GRUNN. In the first place, due to the ICA is multichannel mixed signal analysis technique, variational mode decomposition (VMD) technique is utilized to decompose the original temporal series into virtual multichannel mixed-signal. Next, statistically independent components (ICs) are separated out from the time sequence via ICA, and then, the influence factors of the gold price are analyzed from the aspect of ICs. The results demonstrate that the fluctuation of the gold price will be interrupted by long-term trends, cyclic recurrent factors and random events. Thirdly, applying GRUNN on ICs to acquire the prediction series of independent components (ICPs) and the forecasting result of the gold price is the combination of the ICPs. Finally, comparison experiments indicate that ICA-GRUNN provides prediction with high accuracy and outperforms the benchmark methods, autoregressive

integrated moving average (ARIMA), radial basis function neural network (RBFNN), long short term memory neural network (LSTM), GRUNN and ICA-LSTM.

All of the predetermined research questions can now be answered based on the outcomes of time series analysis and the artificial neural network approach.

RQ1: What factors have historically influenced gold prices on the commodity exchange?

The first crucial aspect that has a considerable impact on how the price of this commodity develops is the existence of gold reserves and the process of extracting them. The mining capacity expanded with the discovery of new resources, which in turn boosted the availability of the material on the market and caused a decrease in price. On the other hand, when deposits were mined and production was reduced, the supply of gold on the commodity exchange fell, which caused the price to rise considerably. Economic instability and inflation are other influential factors involved in price development. For example, during the global financial crisis between 2008-2011, there was great uncertainty in the financial markets. For this reason, many investors were looking for a safe and more stable haven to keep their funds. At this moment, gold appeared with its high potential as one of the safest investments, and therefore the demand was increasing, which caused the price to rise. Also, the demand for precious metals and their corresponding price increased in tandem with inflation. According to Salisu and Adediran's research (2020), investors "pour" money into gold in order to fend off growing inflation, which drives up the metal's price.

Gold prices are influenced by global political instability and conflicts as well. For instance, prices increased on September 11, 2001, the day of the terrorist attacks on the Pentagon and the World Trade Center in New York. The invasion of Iraq in 2003, the armed conflict in Crimea between Russia and the West in 2014, the UK's exit from the European Union (Brexit), tense relations between the US and China between 2018 and 2020, the COVID-19 global pandemic that started in 2019, and the current war conflict in Ukraine are some other political instabilities and conflicts that had a significant impact on price developments. All these events have created uncertainty among investors. Thus, they became confused about the future of preserving their financial assets and began looking for more stable investment options. The demand for gold and silver thus increased again, and so did their tradable price.

The dollar influenced price development as one of the most important world currencies. Because gold is usually traded in dollars, its value tends to fall when the dollar strengthens and to rise when it weakens. Erdogdu (2017) thus confirmed that gold prices combined with the US dollar (USD) strengthened for many years. Central banks had a role in how this commodity's price evolved as well. First, the price of gold increased as a result of banks cutting interest rates, which also decreased the worth of the currency. For example, 2008, the US central bank cut its interest rates to zero. This caused an increase in inflation and, at the same time, a decrease in the dollar's value, subsequently increasing the price of this precious metal. Second, banks build up large reserves by buying gold to maintain stability if the currency collapses. This means that if banks sold these reserves, prices developed negatively, and conversely when reserves were created, prices developed positively.

The last major factor that significantly affects the price of gold is the interest of investors in these precious metals and the associated speculation. Speculators influence the development of precious metal prices for three reasons. First, speculators often buy gold for the sole purpose of holding the precious metal, thus contributing to the rise in price. Secondly, during market instability, speculators often spread so-called fake news, which causes panic among other investors, and thus the price can

rise sharply. Thirdly, speculators have the power to pique prospective investors' attention, which could raise demand and, ultimately, drive up price.

RQ2: How can artificial neural networks accurately predict the gold price time series?

The top 10 neural networks with the best potential for forecasting the movement of the gold price were chosen in order to respond to this research question. The obtained results demonstrate that just MLP-type networks were employed in the price prediction process. In this instance, it can be said that in all three sets (i.e., testing, training, and validation), the RBF networks' performance was insufficient to equal the MLP networks' 99% accuracy inside the framework of gold. The prediction accuracy of the MLP networks for gold was almost flawless, with a few exceptions, of course. The only moment when the networks showed reduced accuracy in prediction was when reaching local minimum and maximum values, where it would be necessary to train the neural networks further. The networks could analyse these local extremes, but each to a different extent and at a different time. For this reason, it is impossible to determine with precision which of the 10 MLP networks is the most accurate. Therefore, further training of these neural networks is also necessary to obtain even more accurate results.

In conclusion, it can be said that all ten of the maintained MLP networks for gold were able to accurately and without any issues replicate the real price development curve for this commodity. Therefore, they can be considered applicable and reliable in practice. This statement is also confirmed by the research of Söylemez (2020), who predicted the price of gold with different variables using artificial neural networks. The study then resulted in a model that could predict gold prices with 98.44% accuracy. Gold, through ANN, was also investigated by Brabenec et al. (2020). The purpose of their study was to predict how the price of gold would evolve in the future and ascertain whether it rises during recessions. The authors examined daily data on gold prices between 2006 and July 2020. The survey was created using five different techniques for smoothing time series: neural networks, decision trees, gradient boosted trees, linear regression, and nearest neighbours. The training data set was used to apply the algorithms, and the test data set was used to evaluate the final model. Together with a histogram of the probability density, a plot of the residuals from the test data sets, and a histogram of the training data set, the residuals of the corresponding models were displayed graphically. It was projected how the price of gold would move in the upcoming year. According to the survey results, market participants maintain the value of their assets by purchasing gold during the early stages of an economic downturn. They are compelled to sell the gold once more since they are short on cash. An analogous progression was anticipated for the upcoming timeframe. A worldwide economic downturn is likely. The need for borrowers to sell their investments will result in a sharp decline in the price of gold. Artificial neural networks and linear regression were utilized by Machová et al. (2020) to conduct a regression analysis of the evolution of the afternoon gold price on the New York Stock Exchange. Out of the 1,000 neuron architectures they produced, they retained the five that had the finest features. The curve derived from the spline function best represents the evolution of the gold price in terms of basic linear regression. Nonetheless, all five maintained neural networks produce superior outcomes.

Conclusions

In times of political crises or global economic upheavals, gold can act as a vehicle to help protect investments. The price of gold can be very volatile. While it can serve as the cornerstone of a stable portfolio, its value can fluctuate rapidly. Gold itself does not generate any returns. Its value is based largely on market supply and demand. The main way to get gold is by mining. It must be considered

that mining gold can be expensive and difficult, affecting its price. It is crucial to remember that gold's value is subject to fluctuation. Investing in gold should be done with sufficient risk awareness and as part of a broader investment plan considering individual financial goals and risk tolerance. One use of AI and machine learning in the financial sector is the prediction of gold prices with neural networks. Neural networks can analyse and detect complex patterns and patterns in historical data and use them to predict future trends. It is important to note that gold price prediction, like any financial market prediction, is not entirely accurate. The price of gold is subject to numerous variables, many of which are constantly shifting. Furthermore, while neural networks are capable of identifying patterns in data, their accuracy cannot be guaranteed under all circumstances. Prior to predicting gold prices with neural networks or other machine learning methods, it is crucial to conduct a thorough study, confirm the model's performance and dependability, and take other aspects like investment diversification and long-term investment horizon into account.

Thus, investing in commodities, especially precious metals, comes to the fore. The main goal of this work was, therefore, to identify how gold and silver stand on the commodity market, to further measure and compare their historic price development in the period from 2000 to March 2023 and, last but not least, to analyse the accuracy with which artificial neural networks can predict the price. The partial goal was to evaluate whether gold is offered as a suitable custodian or multiplier of financial resources. Research questions were already defined in the introduction to help the work reach its purpose. To answer all the research questions, a literature review was created at the beginning of the work, with the help of which suitable methods applicable to the research were found. Individual historical daily gold and silver price data from 2000 to March 2023 was collected via kaggle.com. RQ1 was subsequently evaluated using quantile analysis and time series analysis. After that, RQ2 was assessed using the Statistica software and the artificial neural network approach. A 30-trading day ahead prediction was also made where none of the networks showed extreme swings. The price of all networks rose or fell slightly during the monitored period, but no price shock was recorded for any of the networks. After the prediction, a validation of the actual gold price with the predicted one was created, from which it came out as the best MLP 1-9-1 network since it was the only one that could have the most values approaching zero. Overall, it was found that the predicted price of gold for the monitored period almost did not correspond to reality. Based on the results, it was found that during twenty-three years, the price of gold mainly increased. It goes without saying that during the historical development of the price, many fluctuations were caused by the action of many factors. With the help of research, the most common factors affecting gold prices on the commodity exchange were defined in particular: the effects of world political instability and war conflicts, as well as the influence of ever-increasing inflation and economic instability, the number of deposits with these precious metals and associated mining, monetary policy and the behaviour of central world banks, the rate of industrial use of gold and, as a last but very important influencing factor, is the very demand and supply on the commodity market. Last but not least, the application of the method of artificial neural networks proved that these networks could predict with great accuracy and thus imitate the real development of the price of gold.

Gold shows high potential and thus offers itself as a safe depository of financial assets, even in times of global instability or uncertainty. This precious metal can bridge financial crises very well and, therefore, can serve as a suitable custodian or multiplier of wealth. Therefore, it can be concluded that gold holds a high position in the commodity market, and that is why many investors increasingly include it in their investment portfolios.

A significant limitation of this research can be seen in the applied data, as it turns out that in some cases the use of a long time series for the purpose of analysis through neural networks is not always an ideal solution. The limit can also be seen in the use of a low number of types of neural networks or in the fact that no comparison with other methods was taken into account. However, it is necessary to point out that the use of several types of neural networks or several methods would not be possible to include within one article, if only because of the limited scope of the article. As for proposals for the future direction of research, it is possible, for example, to further train the best trained network on new data and thereby increase its success rate in predicting gold. Furthermore, it is possible to devote more time to working with time series delays or with the amount of input data for calculations. In the case of comparison, other neural network models (LSTM, PNN and their various variants, etc.) or completely different methods (ARIMA, VAR, etc.) can be used.

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Reference

1. Beretta, E., & Peluso, S. (2022). Gold and bubbles: an impossible binomial? A review of historical and current evidence. *Applied Economics Letters*, 29(3), 272–276. <https://doi.org/10.1080/13504851.2021.1897070>
2. Brabenec, T., Suler, P., Horak, J. & Petras, M. (2020). Prediction of the future development of gold price. *Acta Montanistica Slovaca*, 25(2), 250–262. <https://doi.org/10.46544/AMS.v25i2.11> DOI: [10.46544/AMS.v25i2.11](https://doi.org/10.46544/AMS.v25i2.11)
3. E, J. W., Ye, J. M., & Jin, H. H. (2019). A novel hybrid model on the prediction of time series and its application for the gold price analysis and forecasting. *Physica A-Statistical mechanic and its Applications*, 527 (11). <https://doi.org/10.1016/j.physa.2019.121454>
4. Erdoğan, A. (2017). The most significant factors influencing the price of gold: An empirical analysis of the US market. *Economics*, 5(5), 399–406 <https://doi.org/10.17265/2328-7144/2017.05.002>
5. Faruk, M.O., & Hossain, M. M. (2019). Forecasting Gold Price: An Application of Auto Regressive Integrated Moving Average Model. *International Journal of Applied Mathematics & Statistics*, 58(4), 115–121.
6. Gaspareniene, L., Remeikiene, R., Sadeckas, A., & Ginevicius, R. (2018). The Main Gold Price Determinants And The Forecast Of Gold Price Future Trends. *Economics and Sociology*, 11(3), 248–264. <https://doi.org/10.14254/2071-789X.2018/11-3/15>
7. Ghazali, M. F., Lean, H. H., & Bahari, Z. (2020). Does gold investment offer protection against stock market losses? Evidence from five countries. *The Singapore Economic Review*, 65(2), 275–301. <https://doi.org/10.1142/S021759081950036X>

8. Gürgün, G., & Ünalmiş, I. (2014). Is gold a safe haven against equity market investment in emerging and developing countries? *Finance Research Letters*, 11(4), 341–348. <https://doi.org/10.1016/j.frl.2014.07.003>
9. Gutiérrez, M., Franco, G., & Campuzano, C. (2013). Gold prices: Analyzing its cyclical behavior. *Lecturas de Economía*, 79(79), 113–142. <https://doi.org/10.17533/udea.le.n79a4>
10. He, H., Yan, Y., Chen T., & Cheng, P. (2019). Tree height estimation of forest plantation in mountainous terrain from Bare-Earth points using a DoG-Coupled radial basis function neural network. *Remote Sensing*, 11(11). <https://doi.org/10.3390/rs11111271>
11. Horák, J., Novak, A., & Voumik, L. CH. (2023). Healthcare Generative Artificial Intelligence Tools in Medical Diagnosis, Treatment, and Prognosis. *Contemporary Readings in Law and Social Justice*, 15(1), 81–98. <https://doi.org/10.22381/CRLSJ15120235>.
12. Chen, H. H., Chen, M. C., & Chiu, C. C. (2016). The Integration of Artificial Neural Networks and Text Mining to Forecast Gold Futures Prices. *Communications in Statistics-Simulation and Computation*, 45(4), 1213–1225. <https://doi.org/10.1080/03610918.2013.786780>
13. Kudová, P. (2001). Neuronové sítě typu RBF pro analýzu dat [BF type neural networks for data analysis]. Master's thesis, Charles University, Prague.
14. Le, T. H., & Chang, Y. (2012). Oil price shocks and gold returns. *International Economics*, 131(3), 71–103. [https://doi.org/10.1016/S2110-7017\(13\)60055-4](https://doi.org/10.1016/S2110-7017(13)60055-4)
15. Li, L. L., & Diao, C. M. (2013). Research of the Influence of Macro-Economic Factors on the Price of Gold. In 1st International Conference on Information Technology and Quantitative Management (ITQM), 17, (pp. 737–743). <https://doi.org/10.1016/j.procs.2013.05.095>
16. Li, X., Guo, Q., Liang, C., & Umar, M. (2023). Forecasting gold volatility with geopolitical risk indices. *Research in International Business and Finance*, 64. <https://doi.org/10.1016/j.ribaf.2022.101857>
17. Lin, Y., Liao, Q., Lin, Z., Tan, B., & Yu, Y. (2022). A novel hybrid model integrating modified ensemble empirical mode decomposition and LSTM neural network for multi-step precious metal prices prediction. *Resources Policy*, 78. <https://doi.org/10.1016/j.resourpol.2022.102884>
18. Livieris, I. E., Pintelas, E., & Pintelas, P. (2020). A CNN-LSTM model for gold price time-series forecasting. *Neural Computing & Applications*, 32(23), 17351–17360. <https://doi.org/10.1007/s00521-020-04867-x>
19. Lucey, B. M., Peat, M., Sevic, A., & Vigne, S. A. (2021). What is the optimal weight for gold in a portfolio? *Annals of Operations Research*, 297, 277–291. <https://doi.org/10.1007/s10479-019-03496-5>
20. Machová, V., Krulický, T., & Horák, J. (2020). Comparison of neural networks and regression time series in estimating the development of the afternoon price of gold on the New York stock exchange. *Sociálno-Ekonomická Revue*. <https://fsev.tnuni.sk/revue/papers/275.pdf>
21. O'connor, F. A., Lucey, B. M., Batten, J. A. & Baur, D. G. (2015). The financial economics of gold—A survey. *International Review of Financial Analysis*, 41, 186–205. <https://doi.org/10.1016/j.irfa.2015.07.005>

22. Pian, H., & Santosh, M. (2020). Gold deposits of China: Resources, economics, environmental issues, and future perspectives. *Geological Journal*, 55(8), 5978–5989. <https://doi.org/10.1002/gj.3531>
23. Pierdzioch, CH., Rohloff, S. & Von Campe R. (2023). On the predictive value of the (shadow) real interest rate for the realized volatility of gold-price returns. *Annals of Financial Economics*, 18(1), 22241001. <https://doi.org/10.1142/S2010495222410019>
24. Revenda, Z., & Arltova, M. (2022). Stocks, Gold and Inflation-Relationships and Contexts Over the Last 25 Years. *Politická Ekonomie*, 70(3), 288–311. <https://doi.org/10.18267/j.polek.1355>
25. Rowland, Z., Lazaroiu, G., & Podhorská, I. (2021). I Use of Neural Networks to accommodate seasonal fluctuations when equalizing time series for the CZK/RMB exchange rate. *Risks*, 9(1), 1. <https://doi.org/10.3390/risks9010001>
26. Salisu, A. A., & Adediran, I. (2020). Gold as a hedge against oil shocks: Evidence from new datasets for oil shocks. *Resources Policy*, 66, 101606. <https://doi.org/10.1016/j.resour-pol.2020.101606>
27. Smiech, S. (2014). Dissimilarity of commodity prices – the results of time series clustering, In 32nd International Conference on Mathematical Methods in Economics (MME), Olomouc: Palacky University in Olomouc, (pp. 920-925).
28. Šuleř, P., & Machová, V. (2020). Better Results of Artificial Neural Networks in Predicting ČEZ Share Prices. *Journal of International Studies*, 13, 259–278.
29. Štúr, M., Vanickova, & R., Kmecova, I. (2014). Finanční gramotnost ako základný pilier konkurenceschopnosti, In Vysoká škola polytechnická v Jihlavě, Proceedings of 6th Annual International Scientific Conference COMPETITION, (pp. 264–273), 326.
30. Vochozka, M., Horák, & J., Šuleř, P. (2019). Equalizing Seasonal Time Series Using Artificial Neural Networks in Predicting the Euro–Yuan Exchange Rate. *Journal of Risk and Financial Management*, 12(2), 1–17. <https://doi.org/10.3390/jrfm12020076>
31. Vrbka, J., Šuleř, P., Machová, V., Horák, J. (2020) . Evaluation of performance of MLP neural networks and RBF neural networks in adjusting time series of the development of the trade balance between the USA and the PRC. *Littera Scripta*, 13(2), 23–38. <https://doi.org/10.36708/Littera Scripta2020/2/3>
32. Wang, J., Li, Y., Wang, T., Li, J., Wang, H., & Liu, P. (2021). A Gold Futures Price Forecast Model Based on SGRU-AM. *IEEE Access*, 9, 146745-146754. <https://doi.org/10.1109/ACCESS.2021.3122140>
33. Zhang, P. & Ci, B. (2020). Deep belief network for gold price forecasting. *Resources Policy*, 69, 101806. <https://doi.org/10.1016/j.resourpol.2020.101806>
34. Zhang, Y. J., & Wei, Y. M. (2010). The crude oil market and the gold market: Evidence for cointegration, causality and price discovery. *Resources Policy*, 35(3), 168–177. <https://doi.org/10.1016/j.resourpol.2010.05.003>

The Nexus of Remittances and Migration: Impacts on Labour Market Dynamics through Bivariate Probit Analysis in Kosovo

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Abstract

This study investigates the labour market dynamics in Kosovo, a post-war and transitional economy, which high migration rates and substantial remittance inflows have significantly influenced. Despite the global attention paid to migration and remittances, there is a conspicuous gap in understanding their joint effects on labour markets, particularly in contexts like that of Kosovo. The research aims to analyse the interplay between migration, remittances, and labour force participation in Kosovo, and to identify how these factors collectively affect labour market dynamics across different demographic groups. Utilising 2017 data from the Millennium Challenge Corporation survey, this study employs bivariate probit techniques to address endogeneity issues in migration and remittance patterns. It provides a nuanced analysis of their impacts on labour force participation. The findings reveal that remittances can disincentivise labour force participation, contributing to a lower labour supply. This effect is more pronounced among certain demographic groups, such as women and the youth. Conversely, migration strategies have a mixed impact on labour force participation. The study suggests that remittances and migration have significant but complex effects on labour market dynamics in Kosovo. It emphasises that remittances, while bolstering household incomes, may inadvertently dampen labour force participation. This effect, coupled with the nuanced impacts of migration, suggests a need for policies that encourage the productive investment of remittances in the local economy and support labour market re-entry strategies for return migrants.

Key words

endogeneity in migration, economic development, gender disparities, bivariate probit analysis, workforce participation.

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Introduction

This research delves into the intricate dynamics between migration, remittances, and labour force participation in Kosovo, aiming to uncover these elements' nuanced effects on the labour market. Despite significant academic attention having been paid to migration and remittances globally, there re-

mains a conspicuous gap in understanding these dynamics within Kosovo's unique post-war and transitional economic context (Rozhkov et al., 2021). The originality of the investigation lies in its focused examination of a less-explored region, namely Kosovo, using the bivariate probit model, a method not previously applied extensively in this geographic context, to study these dynamics (Li et al., 2019).

The study of migration and remittances is vital in post-conflict and transitional economies such as Kosovo, where these factors play critical but underexplored roles in shaping labour market dynamics. This research is essential to bridging the gap in the existing literature by analysing the intertwined effects of migration and remittances on labour force participation and employment in Kosovo. It aims to provide academic and practical insights, informing policy interventions that leverage remittance benefits while mitigating negative impacts on the labour market. By delving into this uncharted territory, the study addresses a crucial need for comprehensive analysis, facilitating informed policymaking and contributing to sustainable economic development and labour market resilience in post-conflict settings.

This study addresses crucial policy-level problems faced by Kosovo and similar post-conflict, transitional economies: how to harness the potential of remittances and manage the implications of migration for the labour market. With high migration rates and significant remittance flows, understanding their impact on labour market dynamics is imperative for policymakers. Our research aims to provide evidence-based insights that can guide the development of strategies to enhance the positive effects of remittances on economic development and mitigate their potential adverse impacts on labour force participation. Specifically, the study seeks to inform policies that promote the productive investment of remittances and facilitate the effective reintegration of returning migrants into the labour market, thereby supporting broader economic stability and growth.

In addressing the identified policy-level problem, our study aims to provide actionable solutions that policymakers and stakeholders can implement. By leveraging the detailed analysis of migration and remittance impacts on Kosovo's labour market, we propose several policy recommendations to enhance economic resilience and labour market efficiency. These include developing targeted financial programmes to encourage the productive use of remittances in local investments, implementing comprehensive skill-upgrading initiatives for current and returning workforce members, and creating supportive infrastructure for the reintegration of migrants. Through these solutions, our study sheds light on the underlying dynamics and offers a pragmatic framework for addressing the challenges posed by migration and remittance flows, thereby contributing to formulating informed effective policies.

In response to the critical question of how our sample choice complements the policy-level problems addressed, we have carefully selected Kosovo's 2017 Millennium Challenge Corporation survey data. The primary sampling unit (PSU) for our survey was the group of geographic Enumeration Areas (EAs) as defined by the 2011 Population and Housing Census. The unit of analysis included individuals in sampled households within these EAs. A multi-stage stratified cluster randomised sampling methodology was employed, ensuring a representative sample for Kosovo's seven regions. The sample size was determined for each region, and then the EAs were stratified based on the proportion of urban/rural households within these regions. Subsequently, households within EAs were selected using simple random sampling. This sampling strategy was explicitly chosen to accurately reflect the diverse socio-economic landscapes across Kosovo, ensuring that the analysis comprehensively addresses the policy-level problem related to labour market dynamics and the impact of migration and

remittances. By selecting a representative sample that mirrors the population distribution and characteristics of Kosovo and employing the bivariate probit model, our study aims to provide relevant, actionable insights that policymakers can use to address the economic challenges faced by various demographic segments within the country (Siddiqui et al., 2018).

The bivariate probit model is particularly relevant in this study as it allows for the joint analysis of migration and remittance decisions, which are inherently linked processes (Loxha, 2019). Additionally, the bivariate probit model is suitable for analysing binary outcomes, making it an appropriate choice for studying the impact of migration and remittances on labour force participation (Zaky et al., 2014). Furthermore, the use of instrumental variable strategies in bivariate probit models, as discussed in the literature, can provide valuable insights into the identification of the model and the potential endogeneity of the variables under study (Altonji et al., 2005; Hollenbach et al., 2019). The core of this study deeply explores the key factors influencing labour force disparities, using the bivariate probit analysis model introduced by J. R. Ashford and R. R. Sowden in 1970 (Ashford & R.R, 1970).

The research gap addressed herein involves the nuanced interplay between remittances and labour force participation, mainly how this relationship manifests in an economy characterised by high migration rates and substantial remittance inflows (Bajra, 2021). Previous studies have largely overlooked the specific socio-economic conditions of Kosovo, which has experienced significant political and economic transitions. Our research fills this gap by providing empirical evidence on how remittances influence labour market behaviour in Kosovo, considering variables such as gender, age, and educational disparities (Asiedu & Chimbar, 2020; Kan & Aytimur, 2019).

By exploring these dimensions, the study aims to contribute to the broader discourse on migration and labour economics, offering insights relevant to academics, policymakers, and practitioners in Kosovo and similar transitional economies (Chami et al., 2021; Posso, 2012). The originality of our work is further underscored by its empirical approach, employing the 2017 Millennium Challenge Corporation survey data, which enables a detailed and contextually rich analysis of the labour market in Kosovo (Gapen et al., 2009).

The findings from the study are expected to shed light on the specific dynamics of remittances and labour force participation in Kosovo, providing valuable insights into the impact of migration and remittances on the labour market in a post-war and transitional economic context (Bajra, 2021). Additionally, the study's focus on variables such as gender, age, and educational disparities aligns with the literature that emphasises the importance of considering these factors in understanding labour market behaviour in the context of remittances (Kan & Aytimur, 2019; Asiedu & Chimbar, 2020).

Our research, grounded in data from the Labour Force and Time Use Survey (LFTUS) across Kosovo, aims to offer insights into labour market dynamics that, while tailored for Kosovo's unique socio-economic landscape, hold relevance for similar post-conflict and transitional economies. The comprehensive and representative survey allows our findings and policy recommendations to be cautiously extrapolated to regions with analogous socio-economic challenges, provided local conditions such as cultural norms and economic structures are carefully considered. Although our study is intrinsically linked to the Kosovar context, the methodologies and underlying principles of our analysis may serve as a guide for addressing labour market issues in comparable settings, underlining the importance of context-specific adaptations in applying our findings.

Post-1999 migration data reveal a significant increase in people leaving Kosovo, reaching its highest point in 2014 and 2015. This movement was notably marked by its unauthorised nature (Eurostat,

2019). Recent data from ASK (2022) and Eurostat (2019) show a decrease in the number of undocumented migrants after 2015, highlighting a shift towards legal migration driven by the need for family reunification, job opportunities, and educational goals (Kastrati et al., 2022). Despite Kosovo's ongoing economic growth and classification as an upper-middle-income country, many Kosovan emigrants continue to be driven by the search for better job opportunities abroad.

The majority of the Kosovan migrant population resides in Western European countries, with smaller groups living in various other parts of the world. The 2022 International Organisation for Migration (IOM) report “Flow Monitoring Surveys’ Report Kosovo” shows that the largest numbers of these migrants are found in Italy (24.4%), Germany (20.3%), and France (15.6%). This distribution reflects a consistent migration pattern to these countries over the last decade. The IOM's 2022 survey reinforces the fact that Italy, Germany, and France remain the top destinations for migrants. This ongoing trend may be influenced by the strong community ties that previous migrants have established in these countries (IOM, 2022).

In fiscal dynamics, the financial contributions from the diaspora, mainly through remittances, have become a crucial support for Kosovo's macroeconomic structure. The World Bank's 2022 report indicates that Kosovo received over USD 1.5 billion in personal remittances during that fiscal year, accounting for more than 18% of the country's gross domestic product (GDP). This significant share positions Kosovo as a leading recipient of remittances in its region. A comparative analysis with data from a decade earlier shows a substantial annual growth rate exceeding 50%, providing a decade-long financial overview. A large portion of these remittances comes from Kosovan expatriates living in Germany and Switzerland, which together represent about 58.1% of total remittance inflows, with individual contributions of 39.2% and 18.9%, respectively (Central Bank of Kosovo, 2021; World Bank, 2022a; World Bank, 2022b). Between 2012 and 2021, Kosovo's labour force participation rate averaged around 39.7%. Surprisingly, only about one-fourth of the working-age population was involved in paid employment. Interestingly, after 2012—a period marked by increased government spending—the labour market has shown remarkable stability. According to 2021 data, key labour market indicators, including participation, employment, and unemployment rates, have remained stable (Kosovo Agency of Statistics (KAS), 2021). Several reasons might explain the low participation rates, with the notably low engagement of women being a major factor. Additionally, the data may be underestimated due to the large informal economy or an increase in the minimum acceptable wage, influenced by the rise in remittance inflows (OECD, 2022).

Leading global financial organisations, including the International Monetary Fund (2022), the OECD (2022), and the World Bank (2023), suggest that in order to significantly reduce current unemployment rates in the next decade, the Republic of Kosovo will need to achieve an economic growth rate of over 5% annually. Additionally, there should be an increase of more than 1.5% per year in the labour force participation rate, along with an improvement in the ratio of economic growth to productive employment (known as the elasticity index) to 1.2%. Since the end of the conflict, job opportunities in the private sector have seen a noticeable increase, especially in the processing, hospitality, gastronomy, and construction industries. This increase is supported by data showing that the number of construction companies has grown by more than 30% between 2013 and 2022, mainly due to the government's ambitious construction projects and financial support (Kosovo Agency of Statistics, 2022). The low involvement of young people in the labour force can be linked to a complex mix of

socio-economic factors. Key among these is the cultural belief of prioritising domestic and family responsibilities, especially for women. The notable lack of affordable and accessible childcare options worsens this situation. Additionally, there is a noticeable reluctance among private sector employers to invest in employee training, viewing it as a financial burden. These challenges are further intensified by the strict barriers to obtaining financing and engaging in financial ventures (Rahman et al., 2017; Behar & Mok, 2019).

The study enhances the theoretical framework by employing the bivariate probit model to dissect the complex interplay between labour force participation, remittances, and migration in Kosovo, addressing crucial endogeneity concerns and expanding labour economics discourse by integrating migration and remittance impacts (Lu & Zuo, 2017; Jena, 2018). The practical implications extend to formulating targeted policies for economic development, suggesting strategies for the productive use of remittances, facilitating return migrant reintegration, and proposing gender-sensitive approaches to improve labour market conditions (Stanley, 2015; Hossain & Sunmoni, 2022). This research not only bridges a critical gap by providing nuanced insights into the remittance–labour nexus in transitional economies but also informs policymakers and practitioners on optimising remittances for sustainable economic growth and labour market enhancement (Tapsoba, 2022).

The paper is organised as follows: Section 1 introduces the study, sets the context, and outlines our research objectives. Section 2 reviews the existing literature, highlighting the gap our research intends to fill. Section 3 describes the methodology, including data sources, the bivariate probit model, and the analytical strategy employed. In Section 4 we present the results of our analysis, detailing the impacts of remittances and migration on labour market dynamics in Kosovo. We also discuss the implications of our theoretical and practical findings and situate them within the broader context of existing research. Section 5 concludes the paper, summarising key findings, limitations, and avenues for future research. Additionally, we include appendices that provide detailed information on data, variables, and additional statistical analyses to support our findings and ensure the transparency and reproducibility of our research.

1. Literature review

Given the complex nature of analysing the impact of remittances and migration flows on labour supply, it is not surprising to encounter a lack of clear empirical evidence. The growing collection of diverse research findings reflects the inherent variety in academic studies, which include different economic models, methodological approaches, and the distinct socio-economic and cultural contexts of the policies being examined. Recognising this diversity, our review is carefully organised according to economic theories, providing a solid basis for our empirical investigation. Our meta-analytical review categorises the research into three distinct groups: those focusing solely on remittances, those primarily concerned with migration, and those integrating both remittances and migration within their analysis. We meticulously examine the empirical methods used in each study area and compare their findings. This academic endeavour highlights the economic importance of the youth demographic and aims to clarify the effects of remittances and migration patterns on labour supply.

The impact of the income effect suggests that remittances can adjust the reservation wage, affecting the opportunity cost linked with leisure and home-based productivity. This leads to a reduced tendency for active participation in the labour market, known as the "disincentive effect." On the other hand, if the opposite occurs, remittances could encourage greater involvement in labour activities. It

is essential to recognise that remittances are typically less risky than income earned locally and are statistically distinct from it (Taylor, 1992).

In the context of the topic under thorough review, Stuart (2010) employs the “Probability with Replacement” (PWR) model as a sophisticated analytical tool to understand the complex issue of voluntary migration. This method allows for a side-by-side comparison based on observable characteristics, avoiding the complex relationship between remittances and labour supply. Foundational research supports the idea that remittances deter labour market participation across different population groups. Using this approach, some scholarly studies have shown that remittances reduce active labour involvement among men and women while simultaneously increasing self-employment rates (Gray, 2009). Additionally, recent academic studies have identified a significant increase in self-employment opportunities in Tajikistan, a trend closely associated with the growing influx of remittances (Bennett et al., 2013). According to the research compiled by Baškot (2020), there is a clear positive relationship between the amount of remittances received and the likelihood of engaging in self-employment. Conversely, the study highlights a strong tendency for remittances to be linked to increased participation in domestic responsibilities.

In their diverse empirical study, researchers Ullah, Akhtar and Zaefarian (2018) tackle the endogeneity issue by applying a fixed-effects model to panel data. The findings of these studies highlight that women in households receiving remittances show a significant tendency to participate more in agricultural activities. In contrast, while men also change their behaviour, these changes are not statistically significant. Conversely, the studies note that remittances negatively affect only male self-employment opportunities. However, it is crucial to point out that these studies acknowledge the inherent limitations of panel data analysis. While this method effectively deals with unobserved heterogeneity that changes over time within households, it may not fully account for the dynamic, unobserved factors that could significantly influence labour supply. Many economists have adopted a more detailed approach to understanding the effects of remittances and welfare responses, moving beyond the traditional problems of endogeneity that previous studies faced. This represents a methodological advancement from earlier research. The findings suggest that remittances lead to a preference among individuals for part-time work. When examining the data by gender, it becomes apparent that the probability of active labour market participation decreases for both men and women as they receive remittances. However, this effect is significantly noticeable only among women from economically disadvantaged households (Adams, 2011; Posso, 2012).

Several economists, including Andruske and O'Connor (2020) and Du, Park and Wang (2005), have contributed to the study subject by suggesting that migration patterns can lead to changes in role definitions and decision-making power within family structures. These changes may transform labour market behaviour, increasing economic independence for emerging family members. Consequently, in situations marked by male migration, women may experience a shift in how they divide their time between professional activities and caring for dependents. This shift could enhance their control over household finances and result in tangible benefits. In this context, women may gain a more remarkable ability to devise strategies to improve the outcomes of their labour efforts. This effect is particularly evident in cases where decision-making becomes less collaborative due to reduced input from migrating family members, especially in societies that adhere to traditional values (Adhikari et al., 2011).

Studies using the propensity score matching method, such as those by Agasty and Patra (2014), have shown varied results. In their research focusing on women from Odisha, India, there was a noticeable increase in the likelihood of finding paid employment in urban and rural areas associated with male migration. The researchers also highlighted that women from households affected by migration, especially those in rural settings, show a greater tendency to engage in unpaid and subsistence labour. Surprisingly, this inclination towards subsistence activities decreases in more rural areas.

The findings remain complex, even in studies utilising the instrumental variable approach. According to this research, living in migrant households in rural areas does not significantly affect the likelihood of men and women participating in non-farming activities (Andruske & O'Connor, 2020). Furthermore, these studies have shown an increase in women's involvement in farming, alongside a rise in men's participation in household duties, influenced by migration factors. In contrast, the research method of Agasty and Patra (2014), which focused on women in Odisha and effectively used both parametric and non-parametric instrumental variable techniques, yielded different results. Their analysis suggested a positive link between migration and the pursuit of subsistence labour in urban settings while revealing a positive relationship with unpaid labour in rural areas. Recent scholarly efforts continue to elucidate the multifaceted nexus between remittances and migration, mainly focusing on their socio-economic impacts across various global contexts (Pudryk et al., 2023). Studies conducted in the latter half of the 2020s, such as those by Jushi et al. (2021), explore how remittances have evolved as a significant economic buffer in Southeast Asian economies, particularly during times of global economic uncertainty. These findings underscore the resilience-building capacity of remittances, contrasting previous views on their consumption-oriented use. Furthermore, research by Ghimire and Kapri (2020) provides fresh insights into the migration–development nexus, suggesting that migration policies need re-evaluation to optimise the developmental impacts of remittances. Their analysis highlights the potential for remittances to contribute to sustainable development when coupled with sound economic policies and investment opportunities. Additionally, the burgeoning field of digital remittance platforms and their impact on traditional banking systems has been explored by Berger (2022), indicating a paradigm shift in how remittance flows are managed and utilised. This shift suggests a broader economic implication, affecting labour force dynamics as these platforms enhance financial inclusion and access to capital. In the European context, some comparative studies on Eastern European migrants reveal how remittance behaviours have adapted in response to fluctuating economic conditions and migration policies, providing a nuanced understanding of remittance flows post-EU enlargement (Miao & Qamruzzaman, 2021; Kahanec et al., 2021; Boese & Moran, 2021). Given the pervasive phenomena of migratory undertakings and concomitant remittance influxes that characterise the familial tapestry of Kosovo, juxtaposed with the concomitant evolutions in labour market contours, the conspicuous absence of a discernible escalation in labour force engagement amongst the youthful populace over the antecedent two decades manifests as an incongruity. This apparent enigma positions Kosovo as a tantalising locus for academic studies. Consequently, it galvanises the formulation of the following hypotheses:

- Hypothesis 1 (H1): Remittances negatively affect labour force participation in Kosovo, decreasing labour supply due to increased household income levels, thereby increasing the reservation wage among recipients (Posso, 2012).
- Hypothesis 2 (H2): The impact of remittances on labour force participation varies significantly between different demographic groups, with more pronounced effects among specific segments,

such as the youth and women, reflecting varying economic motivations and societal roles (Nwokoye et al., 2020).

- Hypothesis 3 (H3): Migration experiences of household members influence the labour market behaviour of non-migrants in Kosovo, potentially leading to changes in employment patterns and income-generating activities due to alterations in household dynamics and economic strategies (Asiedu & Chimbar, 2020).
- Hypothesis 4 (H4): The combined effect of remittances and migration experiences on labour market participation is nuanced, exhibiting direct and indirect influences mediated by educational attainment, age, and gender (Mamun et al., 2015).

These hypotheses are formulated to explore the multifaceted relationships between remittances, migration, and labour market participation in Kosovo. They are designed to guide the empirical investigation, allowing for a detailed analysis of the interplay between international financial flows and local labour dynamics.

2. Methodology

The methodology of this study is designed to systematically explore the impacts of remittances and migration on the labour market dynamics in Kosovo. We employ a quantitative research approach, utilising data from the 2017 Labour Force and Time Use Survey (LFTUS), which provides comprehensive household-level data on income, employment, remittance inflows, and demographic characteristics.

2.1 Core Stages of the Investigation

Our primary data source is the 2017 LFTUS, conducted by the Kosovo Agency of Statistics. This survey covers a representative sample of households across different regions, allowing for an in-depth analysis of labour market participation and the influence of remittances and migration. We preprocess the data by cleaning, handling missing values, and preparing the variables relevant to our study objectives, such as labour force status, remittance receipts, migration history, and socio-demographic factors (Acosta, 2006). We employ the bivariate probit model to analyse the data. This model allows us to examine the simultaneous effects of remittances and migration on labour force participation while accounting for potential endogeneity between these factors (Seidu et al., 2022).

2.2 Justification of Methods

The bivariate probit model is chosen due to its ability to handle binary outcomes and to model the joint determination of two dependent variables. This is particularly relevant for our study as we aim to explore how remittances and migration jointly influence the likelihood of labour market participation (Lokshin & Glinskaya, 2009). Additionally, this method helps address potential endogeneity issues, such as reverse causality and omitted variable bias, which are common in studies examining the effects of remittances and migration (Theodore et al., 2015).

2.3 Data Analysis

The analysis estimates the probabilities of labour market participation concerning remittance receipts and migration experiences, controlling for other socio-economic variables. We conduct separate analyses for different demographic groups to identify variations in the impacts of remittances and migration (Galí, 2010). By employing this methodological framework, we aim to provide robust empirical evidence on the nexus between remittances, migration, and labour market outcomes in Kosovo.

The findings are expected to contribute valuable insights into the economic and social effects of remittances and migration, informing policymakers and stakeholders about the implications for labour market strategies and economic development policies (Ravn & Simonelli, 2007). The framework of this analysis is built on two fundamental indicators: the rate of labour force participation and the classification of occupational status. The first indicator is a binary variable, with 51.89% of the survey participants actively employed. Simultaneously, the second indicator transitions from a categorical format to a binary one, reflecting the specified occupational categories. The study explores remittances and migration patterns through two key dimensions: the occurrence of remittance receipts in the previous year and the future migration intentions among respondents. The collected data reveal that out of 5,520 participants, around 22.28% have received remittances, while about 14.60% exhibit potential plans for migration (Table 1).

Table 1. Descriptive statistics

Variables	Observation	Mean	Standard Deviation	Min	Max	Source
sdls_n	29195	0.519	0.5	0	1	LFTUS
rc_rem_tot	5520	0.223	0.416	0	1	LFTUS
rem_abr_f	5520	0.146	0.353	0	1	LFTUS
rc_ps_age	29195	40.098	18.481	15	86	LFTUS
ps_sex	26127	0.502	0.5	0	1	LFTUS
ea_ur	29195	0.6	0.49	0	1	LFTUS
ps_student	29195	0.172	0.378	0	1	LFTUS
rc_income_hh	5520	5547.642	5984.904	0	52503	LFTUS
rc_ed_highest_nfps	29195	0.051	0.22	0	1	LFTUS
rc_ed_highest_pe	29195	0.072	0.258	0	1	LFTUS
rc_ed_highest_lse	29195	0.338	0.473	0	1	LFTUS
rc_ed_highest_usg	29195	0.152	0.359	0	1	LFTUS
rc_ed_highest_usv	29195	0.257	0.437	0	1	LFTUS
rc_ed_highest_psv	29195	0.028	0.164	0	1	LFTUS
rc_ed_highest_ter	29195	0.086	0.281	0	1	LFTUS
rc_ed_highest_pgd	29195	0.016	0.127	0	1	LFTUS

Source: Millennium Century Corporation, Kosovo Labour Force and Time Use Study research report

The analysis highlights the significant impact of societal norms on labour force participation. Our data in Table 1 indicate that about 44.07% of the surveyed individuals working are men, compared to a significantly lower rate of 13.15% for women. This discrepancy reflects the deep-rooted patriarchal values that still shape Kosovo's social and cultural landscape despite notable progress in the past two decades. The examination shows that the median age for both male and female participants is around 40 years. Although women are proportionately represented in the sample, a significant majority—about 60.01%—of respondents live in rural areas. In assessing educational achievements, this study utilises four binary variables to represent the completion of upper secondary general education, upper secondary vocational education, post-secondary vocational education, and higher education at the tertiary or doctoral levels. Women display a slightly lower educational progression than men, with only a tiny fraction, 7.7%, holding tertiary-level qualifications, in contrast to approximately 9.2% of men who have reached this level of education. However, these educational disparities tend to diminish among younger participants, specifically those under 30.

Table 1 provides a thorough examination of the variables under investigation. Each variable is clearly labelled and defined to ensure comprehensive understanding and uniform interpretation across the study. Additionally, descriptive statistics are carefully calculated to summarise the data and support further analysis. Furthermore, Table 2 lists all the dependent variables: 'sdls_n' denotes labour

force status, initially with seven categories based on the MCC survey data, which we simplified into a binary format, with '1' indicating participation in the labour force and '0' indicating non-participation. The second dependent variable, 'rc_rem_tot', represents the total remittances received in the last 12 months. Originally a continuous measure, it has been converted into a binary one, where '0' denotes no remittances received and '1' indicates receipt of remittances. The third dependent variable, 'rem_abr_f', assesses an individual's plans to migrate in the next 12 months, retaining its original binary coding: '0' for no intention to migrate and '1' for an intention to migrate (Table 2).

Table 2. Describing the Dependent Variables

Variables	Description	Values	Transformed Values
sdls_n	During the last week, in which of the following categories would (the surveyee) classify him/herself?	Employed, including self-employment, unpaid work for a family business or farm, or an apprenticeship or paid training, etc.	Individual participating in the labour market
		Unemployed	(This category includes the following: Employed, including self-employment, unpaid work for a family business or farm, or an apprenticeship or paid training, etc. Unemployed)
		Pupil, student, further training, unpaid work experience	Individual NOT participating in the labour market
		In retirement or early retirement	(This category includes the following: Pupil, student, further training, unpaid work experience
		Permanently disabled	In retirement or early retirement
		Fulfilling domestic tasks	Permanently disabled
		Other (specify)	Fulfilling domestic tasks
			Other (specify))
rc_rem_tot	Over the past 12 months, what is the total amount of foreign remittances that you have received (€)?	Continuous variable	No Remittances (0 € Remittances) Receives remittances (from 1€ and as much as they can get)
rem_abr_f	In the next 12 months, do you plan to work outside of Kosovo?	No Yes	No Yes

Source: Millennium Century Corporation, Kosovo Labour Force and Time Use Study research report

We examine the Social Norm independent variables detailed in Table 3. The variable 'rc_ps_age' denotes the respondent's age, which is used as a continuous variable without any modification in the model. For 'ps_sex' representing gender, our model's original categories '1 – Male' and '2 – Female' have been converted to '0 – Male' and '1 – Female'. The variable 'ea_ur' indicates the living area of the respondent, with '1 – Urban' and '2 – Rural' initially, which we have changed to '0 – Urban' and '1 – Rural' for our analysis. Additionally, we include 'ps_student' to indicate the student status of the individual, with '0' meaning the individual is not a student and '1' indicating they are a student; these values remain unchanged in our model. Finally, 'rc_income_hh' is used as a continuous variable to represent the total annual household income received by an individual, and this variable has been left untransformed in our model (Table 3).

Table 3. Describing the Social Behaviour Variables

Variables	Description	Values	Transformed Values
rc_ps_age	How old is (the surveyee) ?	Continuous variable	Continuous variable
ps_sex	What is the sex of (the surveyee)?	Male Female	Male Female

Variables	Description	Values	Transformed Values
ea_ur	Whether the Enumeration Area (EA) is urban or rural	Urban Rural	Urban Rural
ps_student	Is (the surveyee) a full-time student?	No Yes	No Yes
rc_income_hh	What is the total ANNUAL income in Euros (€) of all the members of your household (including remittances), including your income, as one combined figure?	Continuous variable	Continuous variable

Source: Millennium Century Corporation, Kosovo Labour Force and Time Use Study Research Report

Additionally, in Table 4, the Education variable 'rc_ed_highest' from the MCC survey is used in the model. This variable encompasses eight levels of education, ranging from no primary schooling to post-doctoral qualifications. In our analysis, we have created dummy variables for each category but have excluded the final category, 'rc_ed_highest_pgd', which represents individuals with a graduate or doctoral degree.

Table 4. Describing the Transformed Variable

Variables	Description	Values	Transformed Values
rc_ed_highest	What is the highest level of education completed by (the surveyee)?	Did not finish primary school (Omitted category) Primary education Lower secondary education Upper secondary - general Upper secondary – vocational Post-secondary - vocational Tertiary Postgraduate or Doctorate	For each category, a dummy variable has been created: rc_ed_highest_nfps (Omitted Category) rc_ed_highest_pe rc_ed_highest_lse rc_ed_highest_usg rc_ed_highest_usv rc_ed_highest_psv rc_ed_highest_ter rc_ed_highest_pgd
rc_ed_high-est_nfps	Created from the original variable rc_ed_highest	Dummy Variable	The individual did not finish primary school Otherwise
rc_ed_highest_pe	Created from the original variable rc_ed_highest	Dummy Variable	The individual has completed primary education Otherwise
rc_ed_highest_lse	Created from the original variable rc_ed_highest	Dummy Variable	The individual has completed lower secondary education Otherwise
rc_ed_highest_usg	Created from the original variable rc_ed_highest	Dummy Variable	The individual has completed upper secondary – general Otherwise
rc_ed_highest_usv	Created from the original variable rc_ed_highest	Dummy Variable	The individual has completed upper secondary – vocational education Otherwise
rc_ed_highest_psv	Created from the original variable rc_ed_highest	Dummy Variable	The individual has completed post-secondary – vocational education Otherwise
rc_ed_highest_ter	Created from the original variable rc_ed_highest	Dummy Variable	The individual has completed tertiary education Otherwise
rc_ed_highest_pgd	Created from the original variable rc_ed_highest	Dummy Variable	The individual has a postgraduate or doctorate degree Otherwise

Source: Millennium Century Corporation, Kosovo Labour Force and Time Use Study Research Report

The bivariate probit (biprobit) analysis requires the estimation of two separate models, each consisting of a pair of equations. Model 1 explores an individual's likelihood of participating in the labour

market alongside their tendency to receive remittances. Conversely, Model 2 examines individuals' likelihood of engaging in the labour market while considering their migration intentions. Each model contains two equations, with dichotomous dependent variables measuring the probability of labour market participation on one side and the likelihood of receiving remittances (Model 1) or having migration intentions (Model 2) on the other. The use of the biprobit approach in this study is justified by the binary nature of the dependent variables, which helps to address issues related to unobserved heterogeneity and endogeneity, thereby enhancing the relevance and effectiveness of the analysis. The foundational articulation of the bivariate probit paradigm is encapsulated in a condensed-form equation:

$$Y^* = X'\beta_Y + D\alpha + \varepsilon_1, \quad Y = \mathbb{I}(Y^* > 0); \quad (1)$$

$$D^* = X'\beta_D + Z'\gamma + \varepsilon_2, \quad D = \mathbb{I}(D^* > 0); \quad (2)$$

where $\mathbb{I}(\cdot)$ symbolises the indicator function. In the equations above, X encapsulates the standard covariates, while Z is the instrumental variable repository. The intrinsic continuous latent variables, represented as Y^* and D^* , metamorphose into the palpable outcome Y and the observable (potentially endogenous) regressor D via threshold transversal stipulations. Subsequently, the conjoined distribution of Y and D , conditioned upon X and Z and denoted as $P(Y=y, D=d \mid X=x, Z=z)$ — which, for the expediency of notational brevity, is truncated to P_{yd} — bifurcates into four distinct constituents:

$$P^{11} = P(\varepsilon_1 > -x'\beta_Y - \alpha, \varepsilon_2 > -x'\beta_D - z'\gamma), \quad (3)$$

$$P^{10} = P(\varepsilon_1 > -x'\beta_Y - \alpha, \varepsilon_2 < -x'\beta_D - z'\gamma), \quad (4)$$

$$P^{01} = P(\varepsilon_1 < -x'\beta_Y - \alpha, \varepsilon_2 > -x'\beta_D - z'\gamma), \quad (5)$$

$$P^{00} = P(\varepsilon_1 < -x'\beta_Y - \alpha, \varepsilon_2 < -x'\beta_D - z'\gamma), \quad (6)$$

The probabilities expounded within the formulations above attain definitive clarity after the demarcation of a joint distribution for ε_1 and ε_2 . The logarithmic likelihood function can be meticulously derived with a dataset encapsulating N observations, represented as (y_i, d_i, x_i', z_i') for $i=1, \dots, N$.

$$L(\theta) = \sum_{i=1}^N \log P^{y_i d_i}(\theta) \quad (7)$$

where $P_{yidi}(\theta)$ symbolises the probabilities assessed at the specific coordinates (y_i, d_i, x_i', z_i') . This underscores the contingent nature of the probabilities on the parameter θ , which subsumes the coefficients β_D, β_Y, γ , and α in conjunction with additional latent parameters of the joint distribution of ε_1 and ε_2 that demand derivation from the extant dataset.

The bivariate probit model was chosen for several important reasons, aligning with the specific objectives and challenges of our investigation into the impacts of remittances and migration on labour force participation in Kosovo:

Simultaneous equation modelling: The bivariate probit model allows for the simultaneous analysis of two binary outcomes. In our case, these outcomes are labour force participation and the receipt of remittances. This approach is particularly suited to our study as it captures the potential reciprocal

relationship between labour market behaviour and remittance flows, addressing the issue of endogeneity, which is critical in migration studies.

Endogeneity and sample selection bias: Labour market outcomes often endogenously determine migration and remittance decisions. Traditional single-equation models could provide biased estimates due to omitted variable bias and reverse causality. The bivariate probit model helps mitigate these issues by modelling the joint probability of labour force participation and receiving remittances, allowing us to control for unobserved heterogeneity that may influence both processes (Acerenza et al., 2023).

Advantages over alternative methods: Compared to other econometric models such as the ordinary least squares (OLS) or single-equation probit models, the bivariate probit offers a more nuanced understanding of the interdependencies between migration, remittances, and labour participation. While OLS could be inappropriate due to the binary nature of our dependent variables, and single-equation probit models cannot account for the endogeneity between these variables, the bivariate probit model stands out for its ability to address these methodological challenges.

Applicability to the research context: The choice of this model is also informed by the context of Kosovo, where labour market dynamics are significantly influenced by migration and remittances. The bivariate probit model allows for a detailed examination of these factors in a post-conflict, transitional economy, providing contextually relevant and methodologically robust insights.

Bases for method selection: The selection of the bivariate probit model is grounded in a comprehensive review of the literature, which indicates that issues of endogeneity and sample selection are paramount in studies of migration and labour markets (Monfardini & Radice, 2011). Moreover, the Labour Force and Time Use Survey (LFTUS) data structure supports this model's use, as it contains detailed information on household remittances, migration history, and labour force status, enabling a rich, multifaceted analysis. The methodology delineated above operationalises the biprobit stratagem, concurrently navigating the endogeneity intrinsic to remittances and migration within the confines of a holistic and integrated model, as expounded by Li et al. (2019). A synthesis of these equations is subsequently formulated, wherein the individual renders cogent, simultaneous determinations about labour market engagement, the assimilation of remittances, and the proclivity to emigrate. This academic study weaves in a triad of interlinked binary response variables tailored to gauge the likelihood of an individual's immersion in the labour domain, the procurement of remittances, and the inclination towards migratory pursuits.

3. Research results

3.1 The bivariate probit model

The theoretical propositions relevant to the internal dynamics of migration patterns and remittances within labour market outcomes are examined through reference to Table 5, which presents the findings from the bivariate probit estimations. Model 1 corresponds to the analysis where labour force participation is considered alongside the receipt of remittances. Model 2, however, reflects the situation where engagement in the labour force is closely linked with the development of migration intentions. The results indicate that cognitive frameworks and prevalent social norms shape Kosovo's labour supply decisions. The data support the notion that remittances can disincentivise labour supply, although the effects of migration intentions remain unclear. For conciseness, the discussions from

Model 1 and Model 2 will be combined when significant differences arise. Additionally, the text will periodically refer to the gender-specific bivariate probit analysis conducted in the study.

Table 5: Bivariate Probit Model Regression Results for Labour Force Participation

Variables	Model 1		Model 2	
	Labour Force Participation and Remittances		Labour Force Participation and Migration Plans	
Variables	sdls_n	rc_rem_tot	sdls_n	rem_abr_f
rc_ps_age	-0.042*** (0.002)	0.003** (0.001)	-0.043*** (0.002)	-0.032*** (0.002)
ps_sex	-1.468*** (0.045)	-0.044 (0.04)	-1.472*** (0.045)	-0.466*** (0.045)
ea_ur	-0.118*** (0.04)	0.149*** (0.038)	-0.125*** (0.04)	-0.013 (0.044)
ps_student	-1.365*** (0.439)	0.071 (0.473)	-1.391*** (0.436)	0.554 (0.435)
rc_income_hh	0.000005*** (0.000003)	0.000001*** (0.000002)	0.000006* (0.000003)	-0.000007* (0.000003)
rc_ed_highest_nfps	-1.787*** (0.258)	0.0401** (0.0189)	-1.782*** (0.259)	-0.025 (0.228)
rc_ed_highest_pe	-1.505*** (0.238)	0.176 (0.174)	-1.48*** (0.24)	0.009 (0.2)
rc_ed_highest_lse	-1.372*** (0.227)	0.213 (0.161)	-1.344*** (0.23)	0.129 (0.178)
rc_ed_highest_usg	-1.041*** (0.232)	0.122 (0.167)	-1.042*** (0.235)	0.068 (0.183)
rc_ed_highest_usv	-0.806*** (0.228)	0.118 (0.161)	-0.783*** (0.231)	0.109 (0.177)
rc_ed_highest_psv	0.83*** (0.243)	-0.039 (0.186)	-0.824*** (0.245)	-0.185 (0.22)
rc_ed_highest_ter	-0.315 (0.237)	-0.084 (0.171)	-0.302 (0.24)	-0.141 (0.189)
Constant	5.69*** (0.267)	-1.288*** (0.193)	5.704*** (0.27)	1.018*** (0.214)
rho		-0.056 (0.026)		0.188 (0.031)
Likelihood-ratio test of rho=0; chi2 (1)=		4.612**		34.551***
Observations	6131	6131	6118	6118

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

The response of labour supply to remittance inflows remains ambiguous. The empirical data support the theory that remittances lead to a disincentive effect, in line with many studies. This suggests that receiving remittances increases the reservation wage among Kosovars, thereby reducing the likelihood of them participating in the labour market. However, it is essential to note that the statistical significance of the remittance coefficient is only apparent in Model 1. Analysis based on gender reveals that remittances might have different effects: potentially discouraging women from working while encouraging men to do so. However, it is crucial to highlight that these findings are not statistically robust. Model 1 provides empirical support for the theory that remittances deter labour participation for both genders, though the statistical evidence is more pronounced for men.

According to Model 2, Kosovars with migration intentions are more willing to engage in the labour market. This suggests they aim to enhance their skills through employment, potentially improving their chances of finding jobs abroad. However, the related coefficient does not demonstrate statistically solid reliability, despite these findings. The analysis focused on migration intentions reveals a clear

division in outcomes between genders. The results indicate a beneficial effect on women's labour market participation, contrasting with a negative impact on men, with statistical significance observed in both cases. Model 2's conclusions diverge from those of Model 1, which indicated adverse effects for both genders, though in this model statistical significance is notably confined to the female demographic (Table 5).

The conclusions drawn from both model specifications suggest differences in labour force participation. The regression coefficient related to the gender variable shows a negative relationship with significant statistical weight. This suggests that women have a lower tendency to participate actively in the labour market compared to men. Consistent with initial assumptions, findings from this academic investigation reveal a significant influence of personal cognitive factors on labour supply decisions within the Kosovar context. Individuals with higher educational qualifications are more likely to participate in the labour market, though they show less interest in migration. Male participants demonstrate greater engagement in the labour market, are more likely to send remittances, and have stronger migration intentions than females. Academic engagement reduces the likelihood of participating in the labour market while increasing the tendency to consider migrating. Age progression decreases the inclination to migrate; however, for those residing abroad, the data indicate that the likelihood of sending remittances increases with age. Finally, higher income levels deter migration intentions, with increased income negatively associated with the likelihood of migrating.

Contrary to initial assumptions, the main research hypothesis, which concerns simultaneous decision-making in labour involvement and either remittance receipt or migration planning, lacks empirical support. The correlation coefficient (ρ) representing the relationship between the errors of the two equations shows no significant interdependence; this is apparent in both Model 1 ($\rho = -0.056$, not statistically significant) and Model 2 ($\rho = 0.188$, not statistically significant), suggesting that decisions regarding labour engagement and either remittance assimilation or migration initiation are independent of each other (Table 5). Therefore, we might consider these decisions separate entities suitable for individual probit analysis (Xu & Craig, 2010). However, caution is advised in interpreting these findings, as the bivariate probit approach used in this study may not fully address the endogeneity typical of migration patterns. Consequently, there is a risk that the relationship between labour force participation and remittance receipt might be misrepresented.

3.2 Empirical Findings and Hypothesis Examination

Using the bivariate probit model, our empirical analysis provides nuanced insights into the interplay between remittances, migration, and labour force participation in Kosovo. The data, derived from the 2017 Labour Force and Time Use Survey, allowed for a comprehensive examination of these dynamics.

Hypothesis 1 (H1): Our findings support the hypothesis that remittances negatively affect labour force participation in Kosovo. Specifically, we found that the receipt of remittances is associated with a decreased likelihood of labour force participation, suggesting an increase in the reservation wage among recipients. This aligns with the disincentive effect theory, indicating that higher household income from remittances reduces the necessity for employment among household members.

Hypothesis 2 (H2): The impact of remittances on labour force participation varies across different demographic groups. Our results indicate a more pronounced negative effect among women and younger individuals, reflecting these segments' diverse economic motivations and societal roles. This

suggests that policy interventions should consider these disparities to address labour market participation issues effectively.

Hypothesis 3 (H3): Contrary to our initial assumption, migration experiences of household members have a mixed impact on the labour market behaviour of non-migrants in Kosovo. While some family members' migration experiences encourage labour force participation among those left behind, possibly due to the need to compensate for the absent labour, other instances show a reduction in participation, potentially due to increased household income from remittances.

Hypothesis 4 (H4): The combined effect of remittances and migration experiences on labour market participation is nuanced. Our analysis reveals that while remittances alone have an apparent disincentive effect on labour force participation, the interaction with migration experiences does not uniformly intensify this effect. Instead, it varies by demographic characteristics such as age, gender, and educational attainment, suggesting that the relationship between migration, remittances, and labour force participation is complex and mediated by various factors.

3.3 Economic Implications

The negative relationship between remittances and labour force participation suggests that while remittances contribute to household income, they may also discourage labour market engagement, potentially affecting the overall labour supply in Kosovo. This has significant implications for economic policy, particularly in designing strategies that leverage remittances for economic development while encouraging active labour force participation. The variation in the impact of remittances and migration on different demographic groups highlights the need for targeted policy measures. For example, programmes encouraging female labour force participation and youth employment could mitigate the adverse effects identified in our analysis. Our study provides empirical evidence supporting the complex dynamics between Kosovo remittances, migration, and labour force participation. The findings underscore the need for nuanced policies that address the multifaceted impacts of migration and remittances on the labour market. Future research should explore the long-term effects of these dynamics and the role of other socio-economic factors in shaping labour market outcomes.

4. Discussion

The findings of our study on the effects of migration and remittances on labour market dynamics in Kosovo have significant implications for economic development and labour market behaviour in post-conflict, transitional economies. Our analysis reveals the complex interplay between remittances and labour market participation, indicating that while remittances provide crucial financial support to households, they may also discourage labour force engagement under certain conditions. This underscores the necessity for nuanced policies to harness the economic benefits of remittances while promoting active labour market participation. Moreover, our study highlights gendered and age-related disparities in labour force engagement, emphasising the importance of targeted interventions to address different demographic groups' specific needs and barriers. Policies encouraging female labour market participation and supporting youth employment could be particularly beneficial in addressing these disparities (W. Xu et al., 2006). Using bivariate probit analysis in our study has enabled us to disentangle the simultaneous effects of various factors on labour market outcomes, providing a more nuanced understanding than more straightforward analytical techniques. However, we acknowledge the limitations of our methodology and the need for further research to confirm these findings and explore additional variables that may influence labour market behaviour (Brainerd, 2000). By situating

our study within the broader context of migration, remittances, and labour market studies, we contribute to a deeper understanding of these phenomena and their implications for policy and practice. This Discussion section aims to bridge the gap between our empirical findings and their broader implications, offering a platform for reflection, critique, and future research directions (Hanson & Pratt, 1991).

Conclusions

The effects of remittance inflows and migration patterns on labour force participation have been thoroughly examined. Strict methodologies have been employed, departing from those used in past empirical studies, to emphasise the significant impact of socio-behavioural factors. To address the endogeneity inherent in the complex relationship between remittances, migration, and labour force participation, the bivariate probit (biprobit) statistical model has been utilised as an innovative approach to overcoming these fundamental challenges. The findings indicated that remittance inflows may discourage participation in the labour force. However, it is important to note that this effect is statistically significant only within the entire sample when analysed using the bivariate probit Model 2. As demonstrated by the bivariate probit analysis, this statistical significance is confined to the male demographic. The hypothesis regarding the impact of migration tendencies on investments in education and training yields varied outcomes. The data reveal a gender- and age-based distinction in labour force participation among Kosovar migrants. Specifically, women with migration aspirations are more likely to integrate into the labour force, as indicated by bivariate probit Model 1. Conversely, men with migration plans tend to exhibit a reduced tendency to actively engage in the labour market. In comparison, the results corroborate studies such as that by Posso (2012), which found that remittances can decrease labour force participation, reflecting a common trend across economies with significant remittance inflows. However, this study contributes to the literature by highlighting the differentiated impact across demographic groups in Kosovo, a context less explored in existing research. Significantly, the analysis supports the findings of Nwokoye et al. (2020) regarding the variable impacts of remittances on labour force participation among different demographic segments, but extends this by detailing the specific socio-economic conditions prevailing in Kosovo.

The investigation further elucidates the gendered and age-related disparities in labour force engagement identified in the work of Mamun et al. (2015), underscoring the significant influence of socio-cultural factors. Unlike general trends observed in other regions, this study pinpoints how these disparities manifest within Kosovo's unique post-conflict and transitional economy context. In light of the findings, targeted policy interventions are proposed to harness the potential of remittances for economic development while mitigating their adverse effects on labour market participation. This includes creating programmes to channel remittances into productive investments, such as entrepreneurship and vocational training, particularly tailored for young and female populations most affected by the disincentive-to-work effect. Moreover, considering the mixed effects of migration experiences on labour force participation, policies should also focus on integrating returning migrants into the local economy through re-skilling and job-matching programmes. This approach can leverage the skills and experiences gained abroad for local economic development.

In conclusion, the study underscores the importance of a nuanced understanding of the impacts of remittances and migration on labour markets. It suggests that policies should be multifaceted, addressing different demographic groups' varied needs and challenges to foster inclusive economic

growth in Kosovo. The research suggests avenues for further investigation, particularly in exploring the long-term effects of remittances and migration patterns on labour force participation and examining more deeply the role of educational and skill levels in shaping these dynamics. The study, while comprehensive, encounters several limitations that should be acknowledged. Firstly, the reliance on cross-sectional data limits the ability to definitively establish causal relationships. Longitudinal data would clarify remittances, migration, and labour force participation dynamics. Secondly, while the bivariate probit model helps address some endogeneity concerns, residual endogeneity may still exist due to unobserved factors affecting migration decisions and labour force participation. Thirdly, the generalisability of the findings may be limited to Kosovo's specific post-conflict and transitional economic context; thus, caution should be exercised when applying these results to different settings. Furthermore, while the study provides insights into gender and age disparities, it does not fully explore other potentially influential factors such as education level, sector of employment, and urban versus rural settings. These aspects could significantly affect the relationships examined and warrant further investigation. Building on the findings and limitations of this study, future research should aim to:

- Utilise longitudinal data to explore the temporal dynamics of remittances, migration, and labour force participation, enabling a more nuanced understanding of causality and change over time.
- Expand the analysis to different countries or regions to assess the generalisability of the findings and understand the impact of different economic, cultural, and political contexts.
- Investigate the role of education, sector of employment, and urban–rural divides in shaping the impact of remittances and migration on labour force participation, providing a more detailed picture of the labour market dynamics.
- Explore policy interventions to mitigate the negative impacts of remittances on labour force participation and leverage the positive aspects for economic development, including gender-specific and age-specific strategies.
- Examine the psychological and social impacts of migration and remittances on families left behind, mainly focusing on children and elderly family members, to understand the broader socio-economic effects.

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Reference

1. Acosta, P. (2006). Labor supply, school attendance, and remittances from international migration: the case of El Salvador. In World Bank Policy Research Working Paper 3903.
2. A Adams Jr, R. H. (2011). Evaluating the economic impact of international remittances on developing countries using household surveys: A literature review. *Journal of Development Studies*, 47(6), 809-828.

3. Adhikari, R., Jampaklay, A., & Chamrathirong, A. (2011). Impact of children's migration on health and health care-seeking behavior of elderly left behind. *BMC public health*, 11, 1-8. <https://doi.org/10.1186/1471-2458-11-143>
4. Agasty, M. P., & Patra, R. N. (2014). Migration of labour and left-behind women: A case study of rural Odisha. *American International Journal of Research in Humanities, Arts and Social Sciences*, 7(1), 28-33.
5. Altonji, J. G., Elder, T. E., & Taber, C. R. (2005). An evaluation of instrumental variable strategies for estimating the effects of catholic schooling. *Journal of Human resources*, 40(4), 791-821. <https://doi.org/10.3368/jhr.xl.4.791>
6. A Andruske, C. L., & O'Connor, D. (2020). Family care across diverse cultures: Re-envisioning using a transnational lens. *Journal of Aging Studies*, 55, 100892. <https://doi.org/10.1016/j.jaging.2020.100892>
7. Ashford, J. ., & R.R, S. (1970). Multi-Variate Probit Analysis. *Biometrics*, 26(3), 535-546.
8. Asiedu, E., & Chimbar, N. (2020). Impact of remittances on male and female labor force participation patterns in Africa: Quasi-experimental evidence from Ghana. *Review of Development Economics*, 24(3), 1009-1026. <https://doi.org/10.1111/rode.12668>
9. Bajra, U. Q. (2021). The interactive effects of remittances on economic growth and inequality in Western Balkan countries. *Journal of Business Economics and Management*, 22(3), 757-775.. <https://doi.org/10.3846/jbem.2021.14587>
10. Baškot, B. (2020). Capital flows impact on labor market: how do FDIs and remittances effect youth employment in Bosnia and Herzegovina?. *Economic research-Ekonomska istraživanja*, 33(1), 2633-2647. <https://doi.org/10.1080/1331677X.2020.1761418>
11. Behar, A., & Mok, J. (2019). Does public-sector employment fully crowd out private-sector employment?. *Review of Development Economics*, 23(4), 1891-1925. <https://doi.org/10.1111/rode.12613>
12. Bennett, R., Clifford, D., & Falkingham, J. (2013). Household members' migration and the education of children 'left behind': Empirical findings from Tajikistan and reflections for research practice. *Population, Space and Place*, 19(1), 1-14. <https://doi.org/10.1002/psp.1698>
13. B Berger, A. (2022). Development as non-migration? Examining normative and policy coherence in EU external action on migration and development. *Development Policy Review*, 40, e12589. <https://doi.org/10.1111/dpr.12589>
14. Boese, M., & Moran, A. (2021). The regional migration-development nexus in Australia: what migration? Whose development?. *Frontiers in Socio*logy, 6, 602487. <https://doi.org/10.3389/fsoc.2021.602487>
15. Brainerd, E. (2000). Women in transition: Changes in gender wage differentials in Eastern Europe and the former Soviet Union. *ILR Review*, 54(1), 138-162. <https://doi.org/10.1177/001979390005400108>
16. Central Bank of Kosovo. (2021). Annual Report 2021. In AIMS Microbiology. https://bqk-kos.org/wp-content/uploads/2022/07/CBK_AR_2021.pdf
17. Chami, R., Ernst, E., Fullenkamp, C., & Oeking, A. (2018). *Are Remittances Good for Labor Markets in LICs, MICs and Fragile States?*. International Monetary Fund, No. 2018/102. <https://doi.org/10.2139/ssrn.3221121>

18. Du, Y., Park, A., & Wang, S. (2005). Migration and rural poverty in China. *Journal of comparative economics*, 33(4), 688-709. <https://doi.org/10.1016/j.jce.2005.09.001>
19. Eurostat. (2019). Statistics on migration, residence permits, citizenship and asylum for the enlargement countries 2020 edition The enlargement process in the EU. https://ec.europa.eu/info/policies/eu-enlargement_en.
20. Galí, J. (2010). Monetary policy and unemployment. National bureau of economic research, 9(1), 76–99. https://www.nber.org/system/files/working_papers/w15871/w15871.pdf
21. Gapen, M. T., Chami, R., Montiel, P., Barajas, A., & Fullenkamp, C. (2009). Do Workers' Remittances Promote Economic Growth? IMF Working Papers. <https://doi.org/10.5089/9781451873009.001>
22. Ghimire, S., & Kapri, K. P. (2020). Does the source of remittance matter? Differentiated effects of earned and unearned remittances on agricultural productivity. *Economies*, 8(1), 8. <https://doi.org/10.3390/economies8010008>
23. Gray, C. L. (2009). Rural out-migration and smallholder agriculture in the southern Ecuadorian Andes. *Population and Environment*, 30, 193-217. <https://doi.org/10.1007/s11111-009-0081-5>
24. Hanson, S., & Pratt, G. (1991). Job search and the occupational segregation of women. *Annals of the Association of American geographers*, 81(2), 229-253. <https://doi.org/10.1111/j.1467-8306.1991.tb01688.x>
25. Hollenbach, F. M., Montgomery, J. M., & Crespo-Tenorio, A. (2019). Bayesian versus maximum likelihood estimation of treatment effects in bivariate probit instrumental variable models. *Political Science Research and Methods*, 7(3), 651-659. <https://doi.org/10.1017/psrm.2018.15>
26. Hossain, M. S., & Sunmoni, A. (2022). Remittances and Household Investment Decisions: Evidence from sub-Saharan Africa. *IZA Journal of Development and Migration*, 13(1). <https://doi.org/10.2478/izajodm-2022-0004>
27. International Monetary Fund. (2022). Republic of Kosovo 2021 Article IV consultation—press release and staff report. In IMF Staff Country Reports: Vol. No.22/5. <https://doi.org/10.5089/9798400231001.002>
28. IOM. (2022). Flow monitoring surveys' report Kosovo, Vol. 1244. https://dtm.iom.int/sites/g/files/tmzbd11461/files/reports/DTM_Kosovo_FMS_report_2022.pdf
29. Jena, F. (2018). Migrant remittances and physical investment purchases: Evidence from Kenyan households. *The Journal of Development Studies*, 54(2), 312-326. <https://doi.org/10.1080/00220388.2017.1288219>
30. Jushi, E., Hysa, E., Cela, A., Panait, M., & Voica, M. C. (2021). Financing growth through remittances and foreign direct investment: Evidences from Balkan Countries. *Journal of Risk and Financial Management*, 14(3), 117. <https://doi.org/10.3390/jrfm14030117>
31. Kahanec, M., Zaiceva, A., & Zimmermann, K. F. (2009). Lessons from migration after EU enlargement. In *EU labor markets after post-enlargement migration* (pp. 3-45). Berlin, Heidelberg: Springer Berlin Heidelberg. <https://doi.org/10.2139/ssrn.1423346>
32. Kan, S., & Aytimur, R. E. (2019). Labor force participation of women left behind in Tajikistan. *Oxford Development Studies*, 47(1), 1-28. <https://doi.org/10.1080/13600818.2018.1484899>
33. Kastrati, A., Navakazi, V., Abdyli, A., Sojeva, A., Uka, S., Tahiri, E., & Berisha, V. (2022). Population of Kosovo in 2021. <https://ask.rks-gov.net/media/6873/vlersimi-i-popullesise-ne-kosove-2021-final.pdf>

34. Kosovo Agency of Statistics. (2022). Statistical Repertoire of Enterprises (Issue January). ask.rks-gov.net/media/7398/statistical-repertoire-of-economic-enterprises-in-kosovo-q4-2022.pdf
35. Kosovo Agency of Statistics (KAS). (2021). Labour Force Survey (LFS) in Kosovo in 2021. <https://ask.rks-gov.net/en/kosovo-agency-of-statistics/add-news/labour-force-survey-lfs-in-kosovo-2021>
36. Li, C., Poskitt, D. S., & Zhao, X. (2019). The bivariate probit model, maximum likelihood estimation, pseudo true parameters and partial identification. *Journal of Econometrics*, 209(1), 94–113. <https://doi.org/10.1016/j.jeconom.2018.07.009>
37. Lokshin, M., & Glinskaya, E. (2009). The effect of male migration on employment patterns of women in Nepal. *World Bank Economic Review*. <https://doi.org/10.1093/wber/lhp011>
38. Loxha, A. (2019). Do Remittances reduce poverty in Kosovo?-A counterfactual analysis. *South East European Journal of Economics and Business*, 14(2), 117-132. <https://doi.org/10.2478/jeb-2019-0018>
39. Lu, Z. H., & Zuo, A. (2017). Child disability, welfare payments, marital status and mothers' labor supply: Evidence from Australia. *Cogent Economics & Finance*, 5(1), 1339769. <https://doi.org/10.1080/23322039.2017.1339769>
40. Al Mamun, M., Sohag, K., Uddin, G. S., & Shahbaz, M. (2015). Remittance and domestic labor productivity: Evidence from remittance recipient countries. *Economic Modelling*, 47, 207-218. <https://doi.org/10.1016/j.econmod.2015.02.024>
41. Miao, M., & Qamruzzaman, M. (2021). Dose remittances matter for openness and financial stability: Evidence from least developed economies. *Frontiers in psychology*, 12, 696600. <https://doi.org/10.3389/fpsyg.2021.696600>
42. Monfardini, C., & Radice, R. (2008). Testing exogeneity in the bivariate probit model: A Monte Carlo study. *oxford Bulletin of Economics and Statistics*, 70(2), 271-282. <https://doi.org/10.2139/ssrn.886506>
43. Nwokoye, E. S., Igbanugo, C. I., & Dimnwobi, S. K. (2020). International migrant remittances and labour force participation in Nigeria. *African Development Review*, 32(2), 125-137. <https://doi.org/10.1111/1467-8268.12421>
44. OECD. (2022). SME Policy Index: Western Balkans and Turkey 2016: Assessing the Implementation of the Small Business Act for Europe. <http://dx.doi.org/10.1787/9789264254473-en>
45. Posso, A. (2012). Remittances and aggregate labor supply: evidence from sixty-six developing nations. *The Developing Economies*, 50(1), 25-39. <https://doi.org/10.1111/j.1746-1049.2011.00153.x>
46. Pudryk, D., Kwilinski, A., Lyulyov, O., & Pimonenko, T. (2023, March). Towards Achieving Sustainable Development: Interactions between Migration and Education. In *Forum Scientiae Oeconomica*, Vol. 11, No. 1, 113-132. https://doi.org/10.23762/FSO_VOL11_NO1_6
47. Rahman, M. M., Ashraf, B. N., Zheng, C., & Begum, M. (2017). Impact of cost efficiency on bank capital and the cost of financial intermediation: Evidence from BRICS countries. *International Journal of Financial Studies* <https://doi.org/10.3390/ijfs5040032>
48. Ravn, M. O., & Simonelli, S. (2007). Labor market dynamics and the business cycle: Structural evidence for the United States. *The Scandinavian Journal of Economics*, 109(4), 743-777. <https://doi.org/10.1111/j.1467-9442.2007.00520.x>
49. Rozhkov, D., Koczan, Z., & Pinat, M. (2021). The Impact of International Migration on Inclusive Growth: A Review. *IMF Working Papers*. <https://doi.org/10.5089/9781513571966.001>

50. Seidu, A., Onel, G., & Moss, C. B. (2022). Do international remittances accelerate out-farm labor migration in developing countries? A dynamic panel time-series analysis. *Journal of Agribusiness in Developing and Emerging Economies* <https://doi.org/10.1108/JADEE-05-2020-0097>
51. Siddiqui, H., Gashi, A., Higgins, J., Dasgupta, B., & Pucilowski, M. (2018). Kosovo Labor Force and Time Use Study Research Report MCC Kosovo Labor Force and Time Use Study (Issue February). <https://millenniumkosovo.org/wp-content/uploads/2018/11/MCC-Kosovo-Labor-Force-and-Time-Use-Study-Final-Research-Report-1.pdf>
52. Stanley, D. (2015). Can international transfers be problematic? Honduran remittances and labor supply decisions. *Contemporary Economic Policy*, 33(3), 550-570. <https://doi.org/10.1111/coep.12092>
53. Stuart, E. A. (2010). Matching methods for causal inference: A review and a look forward. *Statistical science: a review journal of the Institute of Mathematical Statistics*, 25(1), 1. <https://doi.org/10.1214/09-STS313>
54. Tapsoba, T. A. (2022). Remittances and households' livelihood in the context of Covid-19: Evidence from Burkina Faso. *Journal of International Development*, 34(4), 737-753. <https://doi.org/10.1002/jid.3597>
55. Taylor, J. E. (1992). Remittances and inequality reconsidered: Direct, indirect, and intertemporal effects. *Journal of Policy modeling*, 14(2), 187-208. [https://doi.org/10.1016/0161-8938\(92\)90008-Z](https://doi.org/10.1016/0161-8938(92)90008-Z)
56. Theodore, N., Blaauw, D., Schenck, C., Valenzuela Jr, A., Schoeman, C., & Meléndez, E. (2015). Day labor, informality and vulnerability in South Africa and the United States. *International Journal of Manpower*, 36(6), 807-823. <https://doi.org/10.1108/IJM-01-2014-0036>
57. Ullah, S., Akhtar, P., & Zaefarian, G. (2018). Dealing with endogeneity bias: The generalized method of moments (GMM) for panel data. *Industrial Marketing Management*, 71, 69-78. <https://doi.org/10.1016/j.indmarman.2017.11.010>
58. World Bank. (2022a). Personal remittances, received (% of GDP) - Kosovo | Data. <https://data.worldbank.org/indicator/BX.TRF.PWKR.DT.GD.ZS?locations=XK>
59. World Bank. (2022b). Personal remittances, received (current US\$) - Kosovo | Data. <https://data.worldbank.org/indicator/BX.TRF.PWKR.CD.DT?locations=XK>
60. World Bank. (2023). Kosovo Overview: Development news, research, data | World Bank. <https://www.worldbank.org/en/country/kosovo/overview#1>
61. Xu, H., & Craig, B. A. (2010). Likelihood analysis of multivariate probit models using a parameter expanded MCEM algorithm. *Technometrics*, 52(3), 340-348. <https://doi.org/10.1198/TECH.2010.09055>
62. Xu, W., Tan, K. C., & Wang, G. (2006). Segmented local labor markets in postreform China: gender earnings inequality in the case of two towns in Zhejiang province. *Environment and Planning A*, 38(1), 85-109. <https://doi.org/10.1068/a37295>
63. Zaky, H. H., Armanious, D. M., & Hussein, M. A. (2014). Testing for the Endogenous Nature between Women's Empowerment and Antenatal Health Care Utilization: Evidence from a Cross-Sectional Study in Egypt. *Work*, 3073, 973. <https://doi.org/10.1155/2014/403402>

Cognitive Automation of Real Property Management Processes

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Abstract

The article discusses the possibility of using Automated Valuation Models (AVM), enhanced with technologies such as machine learning algorithms and artificial neural networks, for cognitive processing in the field of Facility Management. Experiments verifying the behaviour of a cognitive inference machine in the processes of operational real property management were described. The focus was to assess the functioning of decision service algorithms induced by automated inference engines which operated in the context of general information about real property. The research results confirm that the cognitive perspective, combined with advanced technologies, brings significant benefits. AVMs supplemented with cognitive technologies are able to dynamically react to varying market conditions and real property characteristics. The key aspect of the cognitive approach is that it eliminates the constraints related to different input states and lack of information, which increases the flexibility and efficiency of the processes of operational real property management. This means that real property managers can make more informed decisions while also saving time and resources. The conclusions drawn from the research confirm the importance of using modern technologies in Facility Management and open up new perspectives for the automation of management processes.

Key words

automated valuation models, facility management, real estate, machine learning, neural networks, cognitive systems, cognitive computing, decision-making process.

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Introduction

Normatively, the processes of real property management are built upon the foundation of the concept of Facility Management (FM) as a comprehensive, customer-oriented service, the subject of which are comprehensive decision-making principles for optimal planning, use, and adaptation of buildings, their equipment, and services. Many authors describe the IT tools used for operational real property management. However, there exist few studies describing systems based on algorithmic inference methods used in this field. The fact that algorithmic information processing and automation operating in the data, communication, and application layers increase the productivity of the processes is an axiom. Such an approach can also be applied to real property management processes (Cheng et al., 2016; Kofi et al., 2017; Xu et al., 2019). One of the aspects of real property management is its valuation. Traditional valuation methods are increasingly often being replaced by methods employing IT systems to automate valuation processes. Automated Valuation Models (AVM) are a service allowing for real property valuation with the use of mathematical modelling (Kara et al., 2018; Bilgilioglu & Yilmaz, 2021; Carranza et al., 2022). The subject of the experiments described in the article was the verification of the possibility of applying AVM in FM processes. They verified whether cognitive inference engines

correctly perform AVM procedures in the scope of processes related to planning and budgeting the costs of forecasted future repair works.

1. Literature review

1.1 *Real property management and administration*

The International Organisation for Standardisation (ISO) defines Facility Management as an organizational function which integrates people, place and processes within an environment built with the purpose of improving the quality of life of people and the productivity of the core business (ISO 41011:2017, 2017). The idea behind this standard is not only mechanisms for controlling and reducing the costs of real property management. The standard introduces a new approach to the ways of organising and managing the numerous and diverse operations which constitute the domain of FM. Controlling the costs is no longer sufficient. People now seek the potential and opportunities for processes that emphasise the value added (Pala & Melzi, 2009; Jensen, 2010; Xu et al., 2019). Emphasis is placed on taking a long-term approach by adopting maintenance and utilisation standards, which take into account benefits beyond those whose value for business decisions is purely economic (Opoku & Lee, 2022).

In accordance with the guidelines of the International Facility Management Association (IFMA), the concept of FM focuses on the processes of adding value as well as improving and maintaining the real property in the areas of its actual condition throughout the entire period of its exploitation. These processes put emphasis on examining the actual state of the real property in terms of: (i) efficient management, defined as the assessment of the rationality and effectiveness of the decisions being taken; and (ii) purposefulness, which consists in eliminating activities which are adverse and unnecessary in terms of the organisation's interests (Thomas, 2014; Cheng et al., 2016). The expenses are deemed to include both the costs related to the current operation of the real property; as well as the costs of renovation and modernisation work, including the investment costs of the planned work, resulting from the wear and tear of the real property. In this context, it is important to optimize the technological operation of the facility and its components throughout its entire life cycle as well as the renovation and investment policy. When perceived in this way, FM becomes a management function that focuses on how to develop, maintain and improve the physical resources needed to support and add value to an organisation's business processes (Pruszkowski, 2012; Xu et al., 2019).

Real property management can be analysed in financial (level of income from the real property), technical (technical condition, infrastructure and equipment), legal (leasing conditions, legal status) or utility terms (day-to-day operation and exploitation, provision of ancillary services). The value of the real property can therefore be shaped by operations from various fields of management. This also applies to the operational management related to the day-to-day operation and maintenance of the real property. These fields can be supported by ICT technologies based on the identification of individual factors of a specific real property et al., 2010).

The processes of information exchange between Building Information Modelling (BIM) systems and FM systems are not trivial processes. Various sources of data containing information on the components and equipment of the facility, sources of data on management, maintenance, repair processes or jobs related to occupational health and safety do not ensure interoperability (Matarneha et al., 2019). Ongoing attempts to standardise ontologies describing real property as well as services and operational management standards provided in the FM domain can be observed. Their aim is to

improve the quality, cohesion and interoperability of facility management services (Office of Government Property, 2021, 2022b, 2022a).

1.2 Automated valuation models

Automated Valuation Models (AVM) are perceived as a fast and convenient service of computer real property valuation. In order to analyse the relationship between the value of the real property and its utility features, they employ the statistical approach (Mayer et al., 2019; Renigier-Biłozor et al., 2021; Steurer et al., 2021; Lorenz et al., 2022). Two formal definitions of AVM have been established in literature: (i) the definition contained in European Valuation Standards EVIP 6: "Automated Valuation Models can be defined as statistics-based computer programmes, which use real property information (e.g. comparable sales and real property characteristics etc.) to generate real property-related values or suggested values" (TEGoVA, 2017); (ii) the definition contained in the specification of the standard on AVMs developed by the International Association of Assessing Officers, IAAO: "A mathematically based computer software program that market analysts use to produce an estimate of market value based on market analysis of location, market conditions, and real property characteristics from information that was previously and separately collected" (I.A.A.O., 2018).

It can be concluded that AVM are a computer program used to estimate the market value of a real property based on the analysis of its location, characteristics, and market conditions. AVM is based on three components of the valuation process: (i) an information database containing data on real property characteristics and transaction prices, (ii) analysis of the collected information, (iii) valuation values. The operation of valuation is carried out by software, operating in a deterministic manner and in accordance with built-in workflow mechanisms, searching for the market features of the real property and the conditions for concluding the transaction which have been pre-defined in the query (O.M.G.WfMC Specification, 2000). Real property features, as rules of conduct, are defined by legislation and professional standards on the principles of real property valuation (Gallin et al., 2018; Vallier, 2020).

The widespread emergence of advanced technologies based on artificial intelligence (AI) and the increase in the availability of data, both in terms of frequency and level of observation, allow the development of AVM for the real property sector. AVM software can be converted into stand-alone software bots. A bot is an automated program designed to perform a specific task. By expanding it with artificial neural networks using multiple layers of algorithms, it is possible to allow bots to learn and adapt to new scenarios. As a result, they allow for increasing the flexibility and ability of the software to solve complex tasks. Including tasks going beyond deterministically defined scenario steps (Es Soufi et al., 2016; Tetzlaff & Szepannek, 2022). If an AVM uses information about real property transaction prices, whether it takes into account the change in these prices over time and information entered by users - concerning the building or the number of rooms, for example - it is now technically possible to extend the scope of the information analysed at will (Kok et al., 2017; Bergadano et al., 2019; Manko, 2022; Vathana et al., 2022). The potential costs of future and expected repair works can be analysed as a result of predictive analyses of similar real property and assessing the technical condition of a specific real property (Dimopoulos & Bakas, 2019; Rousopoulou et al., 2022). The determination of the value is based on the basis of a cost estimate, which determines the estimated value of the works based on the market prices of the same or similar component or using the available price indices for construction and assembly production. On this basis, renovation budgets can be planned.

The use of cognitive technology and the application of artificial Neural Networks, (NN) and Machine Learning, (ML) algorithms creates the conditions for exploring the possibility of making decisions only in an automated way without human intervention, using technical solutions, in the real property sector. Whereby the automated manner denotes operation: (i) without waiting for human instructions, (ii) learning through feedback, and (iii) autonomously using data mining mechanisms.

1.3 Cognitive inference

Cognitive Computing (CC) systems based on Artificial Intelligence (AI), and using Machine Learning (ML), for Machine Reasoning (MR), play an increasingly important role in the functioning of organizations. They are widely used in various sectors of the economy, being responsible for data analysis and improving business decision-making processes. Importantly, the essence of CC is to teach computers to solve problems on their own without receiving specific instructions on how to do it. They are supposed to be able to solve problems without requiring human assistance (Gathani et al., 2021; Geng & Varshney, 2023; Malibari et al., 2023).

Machine Learning is an artificial intelligence technique using mathematical algorithms to create predictive models. ML is based on the analysis of data in terms of the of the patterns occurring in it. ML algorithms are capable of processing large amounts of data and "find" hidden patterns used to build predictive models for the proposed result. Predictive models are used to make informed predictions or decisions about new data. Validation of the correctness of models is conducted based on known data. Performance indicators for specific business scenarios are measured. The process of validation and modification is called "learning". Models are modified and improved, as necessary. However, ML algorithms, being based on statistical and deterministic methods, do not provide a method for explaining the causes of the outcome. The argumentation explaining the decision selection criteria, the validity of the criteria, or the ranking of preferences in relation to different choice options is unknown (Nene, 2017; Adamskiy et al., 2019). MR technology is used to identify the causes. Machine reasoning is a technology that extends the results obtained by ML with a synthesis based not only on information sources but also on contexts and conclusions. MR systems use various inference algorithms to manipulate available knowledge in order to solve problems. They process not only logically successive facts but also data characterized by ambiguity and uncertainty. They independently create semantic models which provide the best mapping of logical reasoning. MR generates not only answers to numerical problems but also creates hypotheses and recommendations, eliminating subjectivity and increasing accuracy. This highly organised way of processing information, involving the instantaneous manipulation of representations relating to the external world, can be termed an intelligent one (Nowak-Nova, 2018; Garcez et al., 2019; Ray et al., 2023). The technologically mapped cognitive mechanisms driving MR, rather than repeatedly performing a specific task with little or no change, provide the models with intelligence owing to which they can adapt to the changing environment to achieve the desired goal. They can be used for decision-making processes such as: (i) perceiving information, (ii) understanding the results of observations using existing knowledge, and (iii) making a reasonable change in the environment. Systems implementing such processes are called Cognitive Systems, (CS), because the calculations they perform can simulate human thought processes in a computer model (Sathish & Venkataram, 2009; Lemaignan et al., 2017; Engel et al., 2022). CS have sufficient potential for holistic data interpretation in a dynamic business environment. Research showing gaps in traditional decision-making systems indicates that CS systems, through access to unlimited information, enable organizations to increase efficiency (Kaur et al., 2019; Welck et al., 2020).

1.4. Summary of sources and indication of the scope of research

The results of the literature review demonstrated that advanced technologies have the potential to improve operational efficiency and enable organizations to implement comprehensive and autonomous decision-making processes. Particularly with regard to the specificity of real estate management. However, there is a lack of coherent and comprehensive studies combining Facility Management (FM), Automated Valuation Models (AVM) and Cognitive Computing (CC). The study of the application of CC technology, using statistical AVM models, for the FM area will be interesting for decision-makers, practitioners and researchers who want to have a better understanding of the processes taking place in the real estate sector.

Three potential areas of issues that may be merged and compiled during the study emerge from the literature review.

Real estate management denotes activities whose main objective is the effective coordination of many processes related to real estate management. Analysing the financial aspect, it can be seen how important it is to minimize operating costs while efficiently generating income from real estate. By delving into the technical area, it can be noticed how crucial it is to maintain the infrastructure and adapt to modern technological solutions. In legal aspects, real estate provisions and the rental agreements formed on their basis are crucial. In the operational area, the importance of efficient service, maintenance and sustainable use of real estate is emphasized.

Constantly developing technologies, especially in the field of real estate valuation, are bringing about a revolution owing to Automated Valuation Models. These modern computer tools, based on statistical analysis, offer an instant assessment of the value of real estate. They can use advanced technologies such as artificial intelligence, artificial neural networks and machine learning algorithms, which opens up new possibilities for automating decision-making processes in the real estate sector. This reflects an evolution towards technology offering tools for advanced, adaptive systems that will take into account a variety of market data.

Cognitive computing systems based on artificial intelligence and using machine learning play a key role in the evolution of the functioning of an organization. These advanced technologies bring about the capability of solving problems autonomously, removing the necessity for detailed instructions from humans. Using mathematical algorithms and analysing patterns in the data, CC creates predictive models to improve decision-making processes.

The fusion of these three areas of issues allows for formulating a hypothesis that the introduction of modern technologies will revolutionize the manner in which operational processes proceed in organizations. The hypothesis assumes that AI and ML possess the potential to improve operational efficiency and increase the precision of decision-making processes in the area of real estate management. The following research questions were formulated in the text:

RQ1: Are cognitive decision-making algorithms employing neural networks and machine learning suitable as inference engines in AVMs?

RQ2: Does the extension of AVMs with cognitive decision-making services, allow automatic assessment of a building's technical condition, prediction of future malfunctions, planning of repair work or necessary upgrades?

The text is structured as follows. The first part reviews the literature on real estate management and administration, models of automatic valuation and cognitive inference. The second part describes the methodology and experiments carried out related to the cognitive inference machine and the

application of the AVM in the management of operations and building maintenance. The third part presents the results of the research, and finally, the fourth part contains conclusions and directions for further research.

2. Methodology

The experiments simulated AVM applicability to operational aspects of real property management. The subjects of the study were process models constituting an FM component and algorithm-driven decision-making machines. The logical correctness of the performance of cognitive algorithms as inference engines for assessing the technical condition of buildings and predicting future breakdowns or necessary repairs, as well as estimating the costs of such works, was studied. IBM Rational Software Architect version 9.7 was used as the research environment. The TIBCO Business Studio BPM Edition software version 5.4.0 was employed to test the effectiveness of the processes. In the study, the following were modelled: (i) the processes for identifying renovation needs resulting from the assessment of the technical condition of the real property; and (ii) the processes of budgeting based on the current maintenance costs and estimating work costs for renovation works.

Information concerning real property under the administration of an organization responsible for the management of a total of 446 residential buildings, 180 residential and office buildings, and 372 office buildings was adopted as input data for experiments. These buildings contain 14 009 residential units and 1235 office units. The number of 1201 renovated residential units, 545 empty units, and 174 renovated office units were used as data for the renovation work carried out. The number of 48 construction repairs, 20 repairs of infrastructure installations, 3 finishing repairs, 28 design works, 16 technical opinions, expert opinions, and 102 173 repair works performed as a result of breakdowns were assumed as the works carried out over the years 2019-2021. The data was provided in the form of flat files, extracted from systems used for current facility management, semantic PDF and DOCX files, and spreadsheets. For the purposes of research, they were converted into a text form of TXT files.

2.1 Experiment 1: Cognitive inference machine

The RQ1 study verified the logical correctness of execution and the runtime efficiency of cognitive algorithms using neural networks and machine learning as inference engines in AVM. The decision model of a cognitive inference machine consisted of modules responsible for the functions performed. Collectively, these modules formed a feedback process cycle, enabling continuous improvement of the modules forming the cycle. The employed modules were the following: (i) <Planning> as a module responsible for the design of goals and specification of criteria. (ii) <Analysis> as a module using indicators and variables for the assessment of the solution proposed by the decision-making subprocesses. (iii) <Control Policies> supervising compliance with normative constraints and introducing corrections to the process behaviour. (iv) <Decision State> being a module presenting the best decisions resulting from the decision-making process.

The following steps were adopted for the study:

1. <Planning> defines goals and performance criteria, defining the target limits (SLA). The indices (Y) represent efficiency which is customer satisfaction (S) and the quality of the developed plan (Q). The indices (Y) depend on the performance parameters: $Y = (S, Q)$. The parameters (X) are represented by decision state variables and include cost (C), timeliness (T), and completeness (R). The parameters (X) are presented by the formula: $X = (C, T, R)$. At the stage of launching the process, their values are determined based on the parameters contained in the databases forming <Decision-making

Services>. The measures are functions (f) used to map the decision state variable coefficients (X) onto the performance indicators (Y) according to the equation $f: X \rightarrow Y$. The module <Planning> provides information about C_o and R_o (which represent <Planning Cost> and <Completeness of Requirements>).

2. <Analysis> concerns the calculation and evaluation of the indicators for the correctness of the analysed information. This stage maps indicators C , T , and R onto performance indicators S and Q . The task is carried out by a subprocess <Decision-making Service> which selects the appropriate process classification <Cognitive Decision-making Process>. It is also executed by a subprocess which calculates indices for S and Q based on real costs (C_A) and information on the completeness of requirements (R_A) which are sampled over time (T_o). <Sampling> (T_o) is associated with the collection of qualitative and quantitative information about variables (X). Vector X contains C , T and R , which represents the period of collecting new information about X . In the study, T_o is defined as equal to the planning period, therefore information on the actual cost (C_A) and actual completeness of requirements (R_A) is generated at the end of the process. In the study, it was assumed that the real time (T_A) is equal to the sampling time (T_o), therefore it is not included as a variable for computing.

3. <Control Policies> govern the behaviour of the process. They take into account the laws, norms, standards, and internal regulations of the organization implemented in the workflow rules based on <ontology> and controlling the process flow, ensuring that the decision (d) generated by <Cognitive Decision-making Process> using <Supervised Machine Learning> decision (d) will be consistent with the assumed (SLA).

4. <Decision State> an interface presenting a conscious, non-random selection of one of the recognized and considered to be feasible options for action.

The model of the decision-making process by the cognitive inference machine is shown in the figure below.

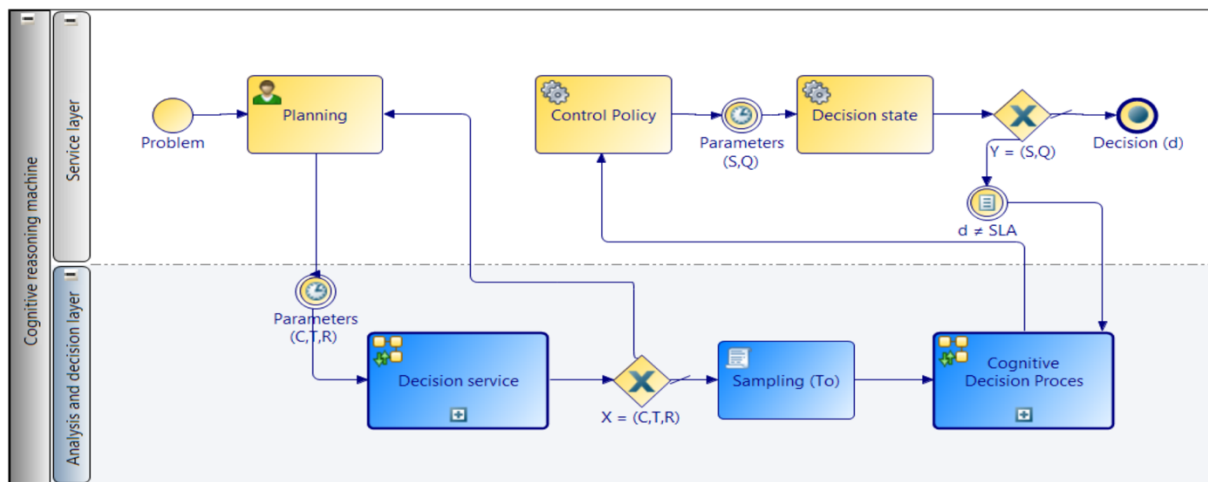


Figure 1. The decision model of a cognitive inference machine in BPMN notation

Source: the author's own compilation based on research.

The <Cognitive Decision-making Service> pattern was designed in accordance with the decision-making model in DMN notation (O.M.G.DMN Guide, 2019). This ensured a uniform decision-making model which guaranteed repeatable applications for each <Decision-making Service> used.

According to it, prior decisions enriched the <Decision Repository> by providing <Business knowledge> which is the basis for activating quality criteria, thus expanding the analysed sets. The <Cognitive decision-making process> consisted of individual <Decision-making Services> for the FM domain areas: <Accommodation Resource Services>, <Record Services>, <Rental Services>, <Operation Services>. It operated in the <Service Bus> environment and was performed by the <Agent Algorithm>. <Accommodation Resource Service>, <Record Service>, <Rental Service>, <Operation Service> as "packages" of tasks were launched by successively narrowing the area of the dependencies discovered between the O classification, their A attributes and R associations. Each <Decision-making Service> could carry out its tasks asynchronously after receiving a specific event, at the most suitable moment. The role of the orchestration was fulfilled by the <Agent Workflow> which supervised the process. The orchestration was responsible for sending commands to initiate events and the correctness of their execution. The categorisation, clustering and creation of associations were performed by ontology, which provided recognisable and understandable <concepts> subject to semantic analysis when searching for criteria for useful decision-making strategies (C) and alternative solutions (W). The Quantitative determination of C and W was supervised by the qualitative assessment (Qc and Qw). The choice of the preferred decision was made on the basis of the most closely matching fulfilment of the conditions of accuracy $d = f(C, W)$. A narrowing scale was adopted as standard deviation for individual services: from 0.4 in the former case to 0.1 in the latter case. The aim of the study was to verify the effectiveness of performed tasks. Varied duration of working times of each service, lack of preliminary tasks and the expected maximum effectiveness of using the working time at the level of 99% were assumed. The occurrence of new tasks was generated through uniform distribution, during which tasks have an equal probability of starting in a given range determined by the minimum and maximum, and in accordance with the task completion time.

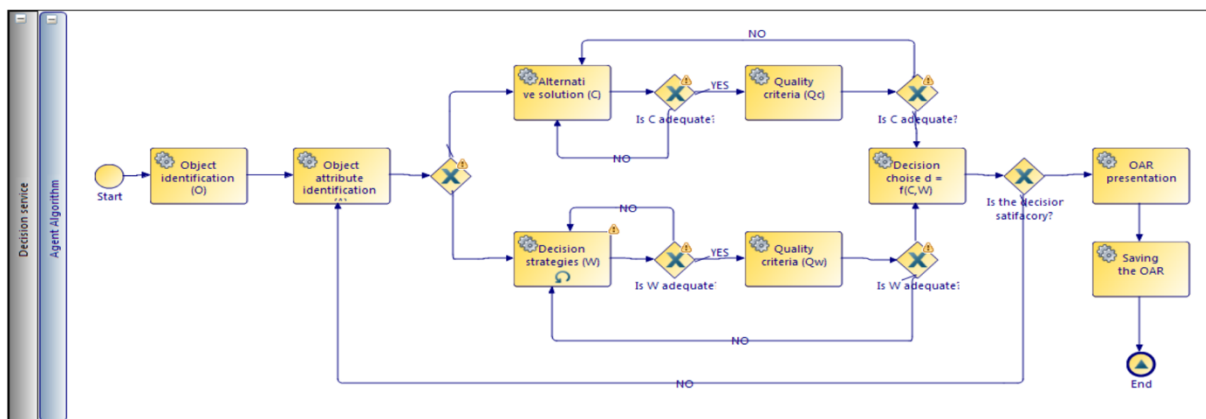


Figure 2. The <Cognitive Decision-making Service> model for a single decision implemented by the <Agent Algorithm> presented in BPMN notation

Source: the author's own compilation based on research.

The <Cognitive Inference Machine> processed the value-oriented processes that served as components of the Facility Management domain as well as decision-making machines controlled by algorithms. Everything was performed under the supervision of machine learning. The subject of the analysis was a case of creating a process capable of identifying and reporting potential renovation needs caused by the condition and wear-and-tear of the real property (damage communication). The

study consisted in the execution of the Supervised Learning task on data sets containing text documents and their <Labels> (metainformation). The time it took to perform computational operations and the completeness of information were subject to analysis. In the study, the data pipeline coming from statistical sources (databases in the form of flat files) was divided into increasingly smaller parts for three different scopes of information regarding the recording, rental and exploitation of real property resources. The efficiency of performing all assumed operations was subject to investigation, with the assumption of their completeness.

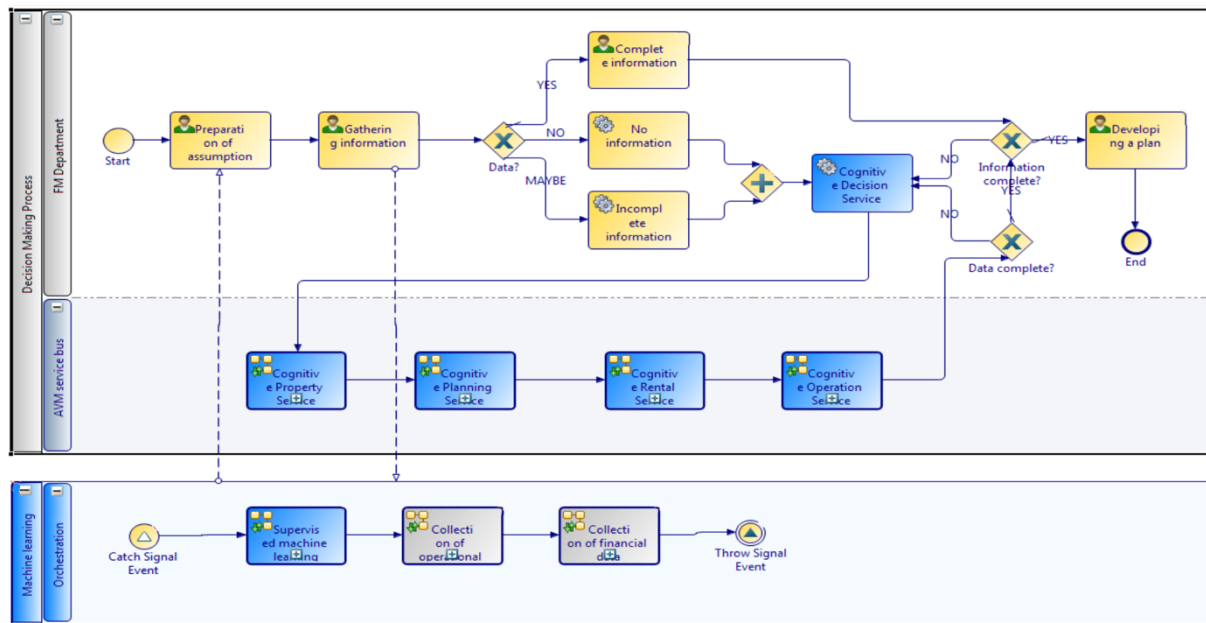


Figure 3. The <Cognitive Inference Machine> model presented in BPMN notation

Source: the author's own compilation based on research.

2.2 Experiment 2: The use of AVM to manage the operations and maintenance of a building

The RQ2 study, with the assumption that AVM are used to estimate the market value of a real property based on the analysis of its location, features and market conditions, verified whether the use of AVM to automatically assess the technical condition of buildings and predict future breakdowns or necessary repairs of the real property resulting from predictive analyses of similar properties benefits the real property manager. For this purpose, an AVM process based on induced automated decision-making services, which used cognitive technology algorithms to determine the values, was created. AVM employ statistical evaluation techniques. In the first step, data is collected and analysed to develop an assessment model that can be applied to equivalent properties in the same or similar area. The data subsequently undergoes stratification in order to organise it into homogeneous groups characterised by similar properties <Vectors> of the layers. In later steps, these layers are subject to adjustments, which assess the population of the properties; and then calibration to determine the coefficient associated with each variable. Calibration using neural network algorithms allows for the calibration of models which consist of data analysed both in both a linear and non-linear manner.

In the study, classification tasks were triggered by independently performed flows of complete tasks. Subtasks were closed as a series of steps created from the following components:

1. <Data Collection>, which is the definition of the problem and leads to the determination of the scope of business data.
2. <Data Transformation> responsible for data cleaning processes and determining function engineering, i.e., values that the model uses during learning and for production purposes.
3. <Input Data> that the supervised learning model uses for learning so that the model is able to learn and predict the required <Problem Class> in order to solve the pre-defined business problem.
4. <Feature Vector> containing information describing the properties of <Input Data>.
5. <Labels>, are categories of <ontological classes> predefined in the <ontology>, taken into consideration by the model.
6. <Algorithm> used in the study.
7. The <Predictive Model> presenting results based on the <Input Data> set and predicting new <Labels>.

The structure of the model together with functional blocks is demonstrated in Figure 4.

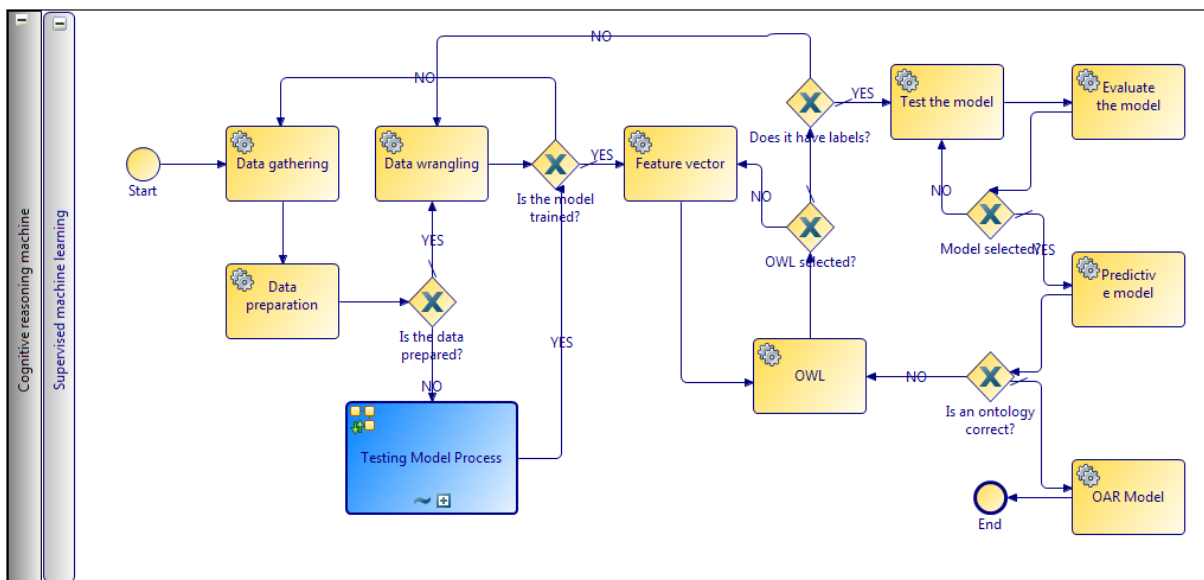


Figure 4. The course of the cognitive inference process using neural networks and machine learning in AVM

Source: the author's own compilation based on research.

Subsequently, in the <Cognitive Inference Machine>, after entering the variable with the assigned weights, the software component defined as the <Agent Algorithm> explored and ordered the <Input Data> by finding its best matches. Matching was performed using a neural network. The matching process used mechanisms contained in a hidden layer in which the weights were corrected (calibrated) in a way that reduced the root square error. Because the neural network learns on an ongoing basis as new information is received and processed to recognise and match unclear or incomplete data patterns, the process was conducted in an iterative manner. The measurement in the <Services> made available in the <Service Bus> met a set of the following criteria:

1. The <Agent Workflow> identifies the type of request and a <Business Model Specification> follows, consistent with the <Cognitive Service> category that forms the <Business Rule>.

2. <Model calibration> uses business process specifications by transforming them into data mining rules, according to a dictionary of <ontology>. The <Agent Algorithm> executing a task may notify of an exception or several exception types. Exceptions are intercepted by the <Workflow Agent> exception handler. The exception is handled by calling the <Feature vector> value which decides whether the <Business Rule> requires retrospective information, contained in <Internal data>, or a request for information or data in <External data>. Once the data has been compiled, the new value is checked and either returned to <Model Calibration> or is passed directly to <Testing>. Exceptions are recorded in the repository in order to handle them correctly in the future.

3. <Testing> is responsible for examining the validity of generalizations in other circumstances. <Agent Workflow> acting within the constraints specified by the established <Quality Criteria>, examines whether the selection corresponds to the level of satisfaction. The process is repeated iteratively until the model's quality assurance tests are successfully completed.

4. <Modification of Specification> occurs when <Model Calibration> requires the application of new or modifications to existing <Business Rules>. In this case, <Agent Workflow> handles the <send info()> command to <Model calibration> starting a renewed assessment. If a new <Business Rule> is created, its <New model> is moved into the repository.

5. After the process is completed correctly, the control sends the command <answer service()> outside the process.

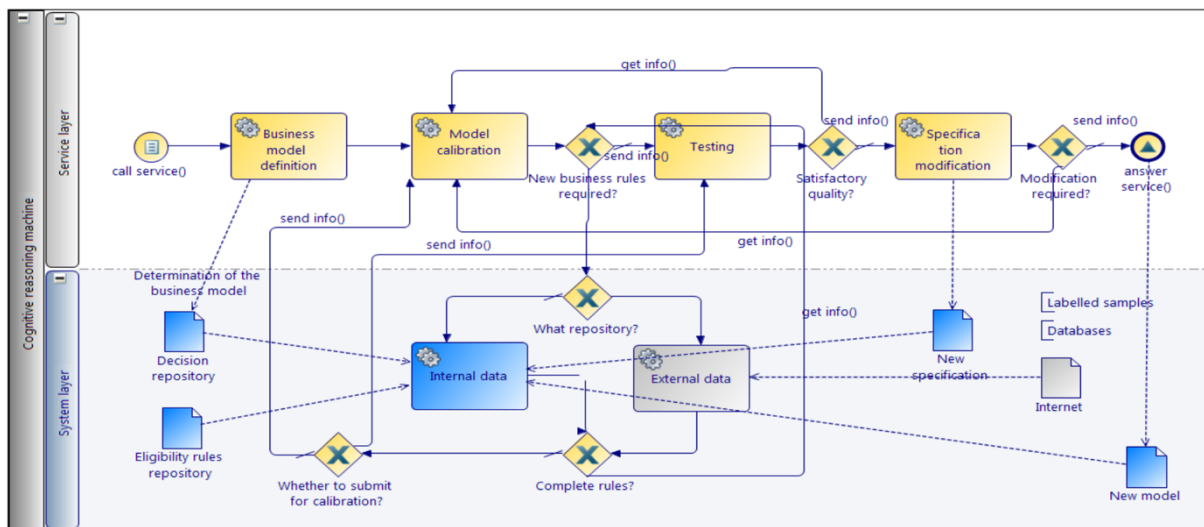


Figure 5. Diagram of the measurement model in the <Cognitive decision-making service> made available by the enterprise service bus in BPMN notation

Source: the author's own compilation based on research.

3. Research results

3.1 RQ1: Are cognitive decision-making algorithms using neural networks and machine learning suitable as inference engines in AVM?

Single decision-making processes associated with individual FM domains were examined, and the aggregate behaviour of all cognitive services operating in the <Enterprise service bus> was also investigated. The visualised effects of each service are illustrated in the Figure 6–9 and Table 1–4.

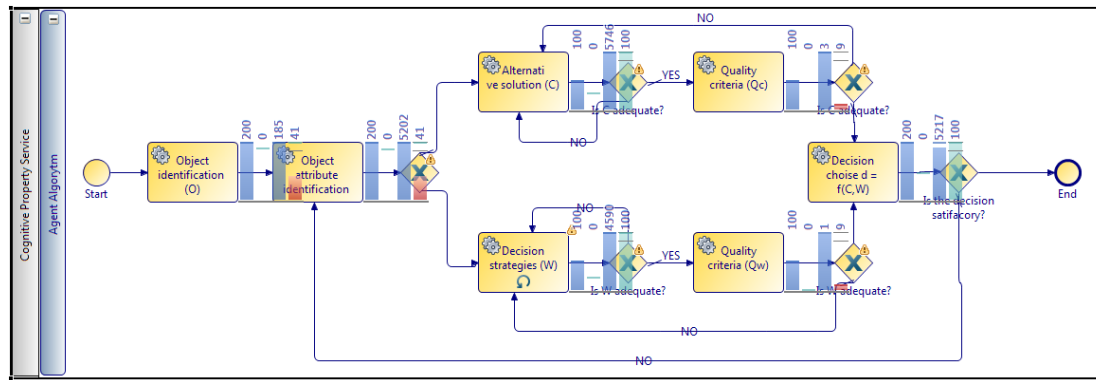


Figure 6. Values of actions for Cognitive Property Service in BPMN notation

Source: the author's own compilation based on research.

Table 1. Effectiveness parameters of the cognitive decision-making process for the Cognitive Property Service

Step name	Number of cases	Cases not implemented	Sum of adjustments	Efficiency of working time
Object identification (O)	200	0	185	41
Identification of an attribute of the object (A)	200	0	5202	41
Alternative solution (C)	100	0	5746	100
Quality criteria (Qc)	100	0	3	9
Decision-making strategies (W)	100	0	4590	100
Quality criteria (Qw)	100	0	1	9
Choice of decision (d)	200	0	5217	100

Source: the author's own compilation based on research.

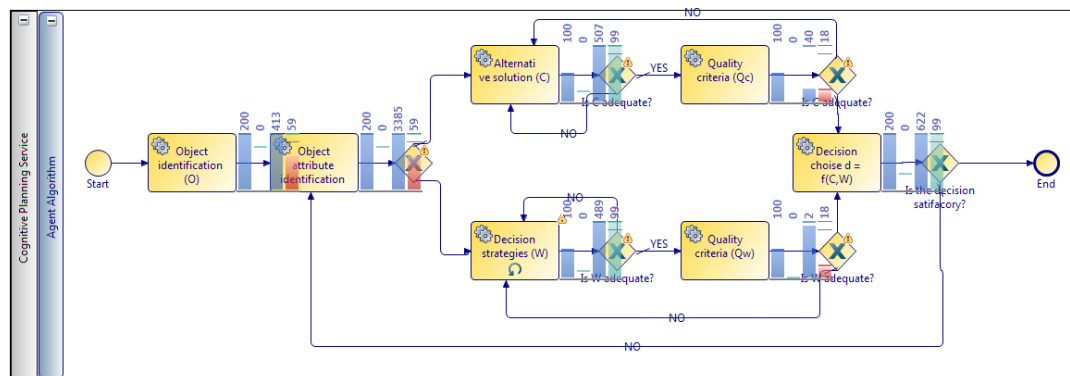


Figure 7. Values of activities for the Cognitive Planning Service in BPMN notation

Source: the author's own compilation based on research.

Table 2. Performance parameters of the cognitive decision-making process for the Cognitive Planning Service

Step name	Number of cases	Cases not implemented	Sum of adjustments	Efficiency of working time
Object identification (O)	200	0	413	59
Identification of an attribute of the object (A)	200	0	3385	59
Alternative solution (C)	100	0	507	99
Quality criteria (Qc)	100	0	40	18
Decision-making strategies (W)	100	0	489	99
Quality criteria (Qw)	100	0	2	18
Choice of decision (d)	200	0	622	99

Source: the author's own compilation based on research.

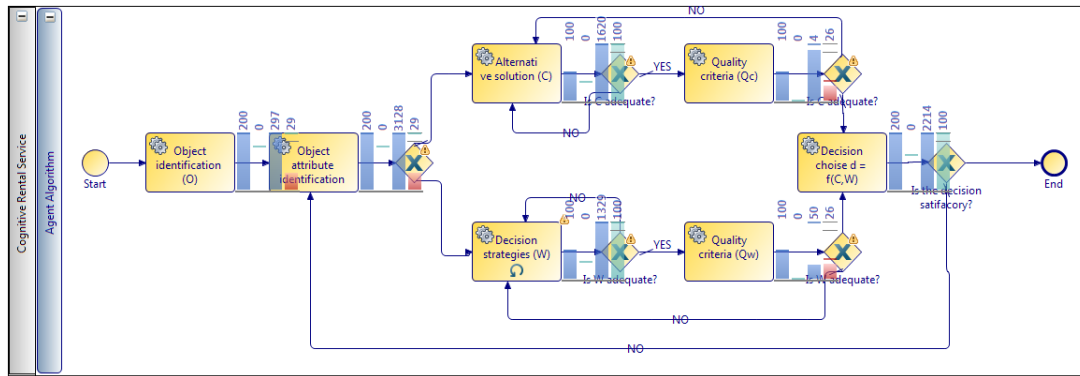


Figure 8. Values of actions for the Cognitive Planning Service in BPMN notation

Source: the author's own compilation based on research.

Table 3. Performance parameters of the cognitive decision-making process for the Cognitive Rental Service

Step name	Number of cases	Cases not implemented	Sum of adjustments	Efficiency of working time
Object identification (O)	200	0	297	29
Identification of an attribute of the object (A)	200	0	3128	29
Alternative solution (C)	100	0	1620	100
Quality criteria (Qc)	100	0	4	26
Decision-making strategies (W)	100	0	1329	100
Quality criteria (Qw)	100	0	50	26
Choice of decision (d)	200	0	2214	100

Source: the author's own compilation based on research.

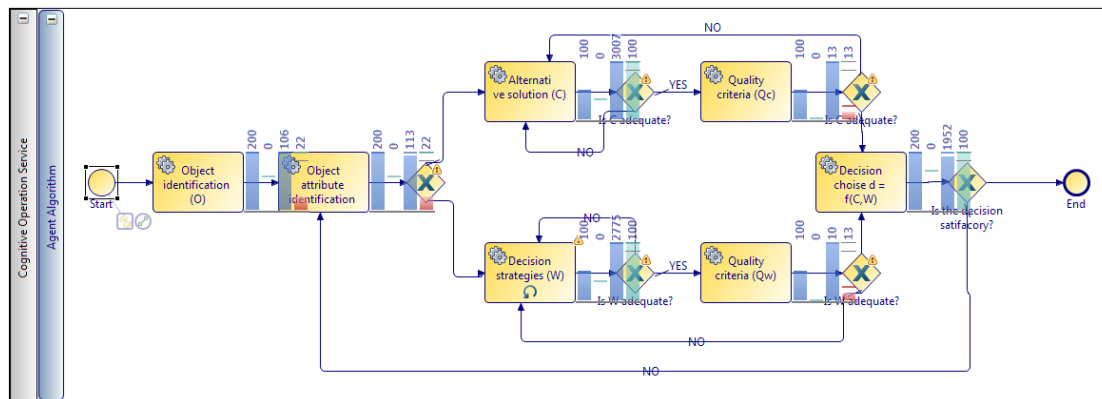


Figure 9. Values of actions for the Cognitive Operation Service in BPMN notation

Source: the author's own compilation based on research.

Table 4. Performance parameters of the cognitive decision-making process for the Cognitive Operation Service

Step name	Number of cases	Cases not implemented	Sum of adjustments	Efficiency of working time
Object identification (O)	200	0	106	22
Identification of an attribute of the object (A)	200	0	113	22
Alternative solution (C)	100	0	3007	100
Quality criteria (Qc)	100	0	13	13
Decision-making strategies (W)	100	0	2775	100
Quality criteria (Qw)	100	0	10	13
Choice of decision (d)	200	0	1952	100

Source: the author's own compilation based on research.

The simulation results for the entire planning process using algorithms and automated decision services which is launched in the <Enterprise service bus> are presented in Figure 9. The summary parameters of cognitive services are based on the values for individual transactions executed by the system during the process simulation. A single transaction is assigned to a one-off action of the participant in the process, and then the program calculates the cost of the action (the duration of the action multiplied by the participant's unit cost). The bars presented in the diagram denote: (i) the number of analysed cases, (ii) the size of the queue of uncompleted cases, (iii) the sum of adjustments in the implementation of actions resulting from delays in previous actions, (iv) effectively used working time.

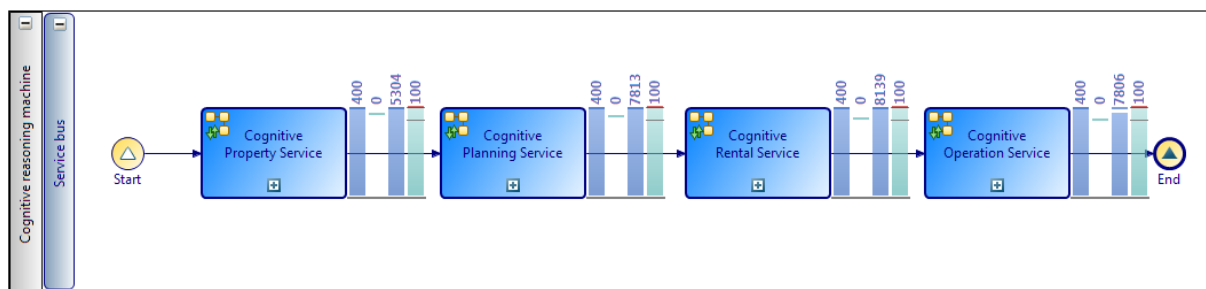


Figure 10. Values of individual <Cognitive services> operating in the <Service bus> in BPMN notation

Source: the author's own compilation based on research.

3.2 RQ2: Does the extension of the AVM to include cognitive decision-making services allow the automated assessment of the technical condition of a building, the prediction of future breakdowns, the planning of repair work, or necessary upgrades?

In the study, based on the pre-defined parameters, the model specification process identified features (variables) that influenced the model structure, and then selected the appropriate (most favourable) <Business process> model for calibration. The calibration of the model consisted in deriving new parameters for previously defined variables. New variables were created through transformations. The basic steps followed the pattern proposed as a standard for using AVM: (i) defining the scope, (ii) data identification, (iii) exploratory data analysis, (iv) stratification, (v) determining data representativeness, (vi) model specification, (vii) model calibration, (viii) quality assurance, (ix) model application and value review. Steps (ii-ix) were carried out by cognitive services running sequentially in the <Service bus>. The model provided an interface where all the required information about the real property was presented. Access to the range of data was individualised according to roles and their assigned authorisation levels.

1. The operator indicates the range of data being of interest to them, including limiting and hypothetical conditions triggering a process of sequentially triggered cognitive decision-making services running implicitly in the <Service bus>.
2. The first service is the <Cognitive Property Service> sending the request <get info()> to the <Cognitive Planning Service>. The request is supervised semantically by the respective <ontological classes>. The request is executed sequentially until the exhaustive scope of the request is reached.
3. In the next step, the <Cognitive Planning Service> responsible for providing information related to the registration data of the real property is launched. In the case of lack of data, the sub-process

of the <Cognitive Inference Machine> responsible for providing the decision (d) in accordance with the assumed (SLA) is started. The request is executed sequentially until the exhaustive scope of the request is reached.

4. Next in line to be launched is the <Cognitive Rental Service> responsible for up-to-date data on rental agreements, their terms, conditions, methods, and manners of calculating the cost of using the real property. Also in this case, before the result of the request is delivered, the data is updated and reworked by the <Cognitive Inference Machine> according to the rules of <ontology>.
5. Last to be launched is the <Cognitive Operation Service> providing the entire set of data on operational issues for the real property. In the case of missing or obsolete data, the <Technical Data Collection> subprocess supervised by the <Cognitive Inference Machine> is launched. The operation of the service is carried out sequentially until the end result is exhaustive in the scope of the request.

A flow diagram of the process is shown in Figure 11. The bars presented in the diagram denote: (i) the number of analysed cases, (ii) the number of cases not completed, (iii) the sum of adjustments in the implementation of actions resulting from delays in prior actions, (iv) effectively used working time.

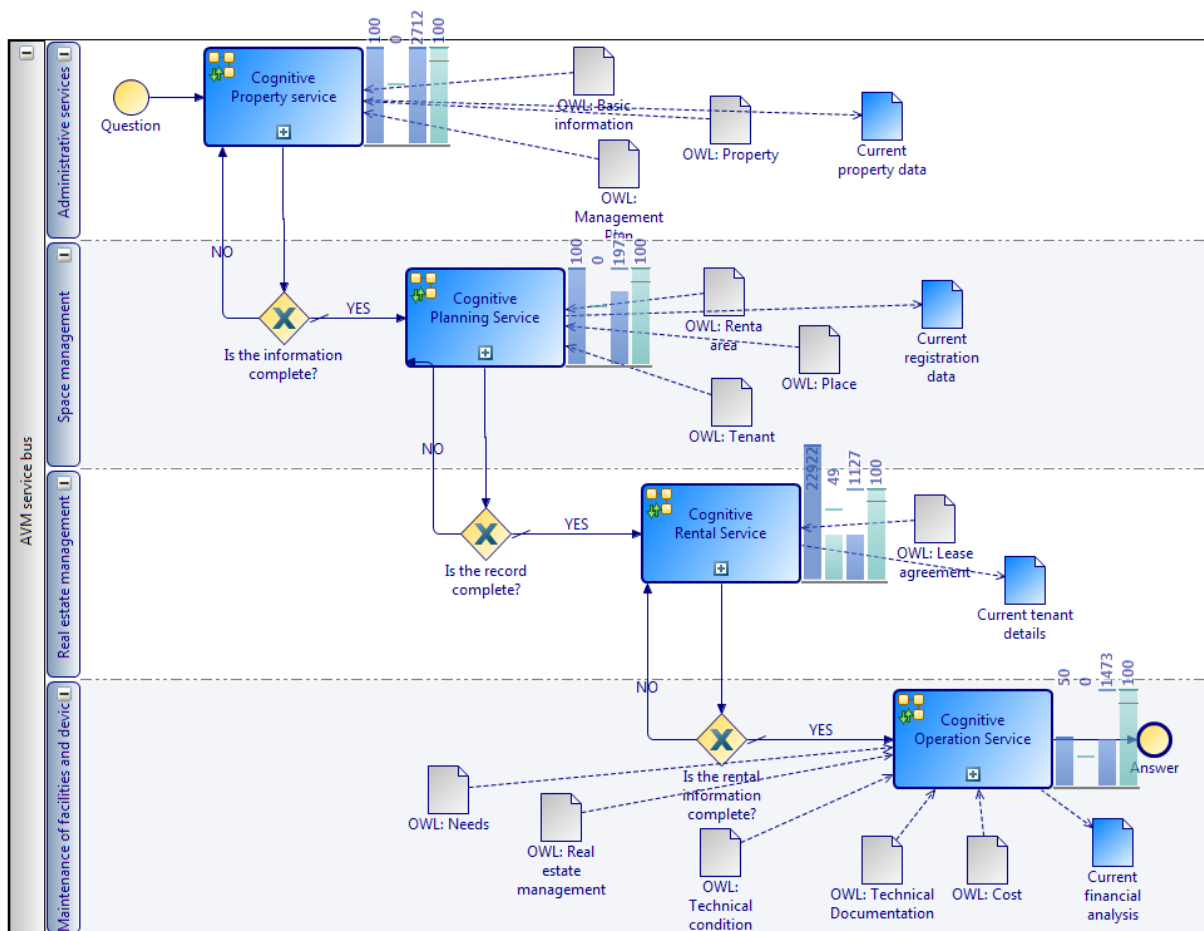


Figure 11. Process of sequentially triggered cognitive AVM services in <Service Bus> in BPMN notation

Source: the author's own compilation based on research.

Table 5. Values of individual <Cognitive Services> in the planning process using algorithms and automated decision-making services

Step name	Number of cases	Cases not implemented	Sum of adjustments	Efficiency of working time
Cognitive Property Service	100	0	1076	100
Cognitive Planning Service	100	0	2629	100
Cognitive Rental Service	3676	49	1173	100
Cognitive Operation Service	50	0	1466	100

Source: the author's own compilation based on research.

4. Discussion

4.1 RQ1 study conclusions

The study analysed whether cognitive decision-making algorithms using neural networks and machine learning are suitable as inference engines in AVM. The <Cognitive Inference Machine> applied in the study used decision-making machines controlled by algorithms and processed processes which are part of the Facility Management domain. The entire process took place under the supervision of machine learning. Each cognitive service was tested autonomously, then the entire sequential process running in the <Service Bus> was evaluated. For each service, the effectiveness of decision making was calculated at the level of 100%. The input state related to the number of analysed attributes or alternative solutions did not affect the effectiveness. Similarly, the initial <Lack of Information> and <Partial Information> status did not have any significance for the flow and time of the information completion process. This means that in the case of using algorithms and automated decision-making services as inference engines in AVM, the input state is irrelevant or of minimal importance for the effect of the entire process. The processes execute themselves correctly and at the same time display high efficiency.

4.2 RQ2 study conclusions

The study analysed whether the use of AVM for automated real property valuation brings benefits to the real property manager. The conducted simulation showed that the <Value Measurement Models> running independently for each of the cognitive services work properly and perform calculations without disturbing the entire sequential process carried out by the <Service Bus>. For each cognitive service, the efficiency of its performance was 100%. <Cognitive Rental Service> (3676) was responsible for the most repeated iterations, looking for appropriate associations in the provided data sequences. This is due to the large, natural dynamics associated with the formation of rental agreements. This affected the <Cognitive Planning Service>, in which an increased number of re-analyses on vacant units were observed (2669). Importantly, this did not disturb the <Cognitive Operation Service>, which was responsible for providing the most appropriate decision presenting the value sought. For the 50 analysed reference cases, 1466 probable and expected minor repair works resulting from breakdowns were observed. The process was carried out entirely by software. It involved <Agent Algorithm>, <Agent Workflow>, <Agent Software> and <Agent System>. The study confirmed that AVM can be used to assess the characteristics of the real property in an automated manner, thus creating an advantage (in the form of cost and time devoted to the implementation of tasks) for the real property manager.

4.3 Future research direction

Cognitive automation of real estate management processes is a novel approach using machine learning algorithms to analyse real estate data, combining artificial intelligence technology with

automation. It makes possible autonomous decision-making by software bots (AI agents) without the need for human intervention. Operating on the principle of cognitive data processing, such systems are able to not only interpret information items occurring in logical succession one after another but also deal with ambiguous data, which makes them intelligent. The research described in the article concerned the cognitive automation of real estate management processes in the field of optimizing renovation budgets and forecasting changes in real estate value. It seems that this technology may improve not only the operational processes related to the maintenance of facilities but also, thanks to holistic data analysis, it may contribute to more effective and flexible management of other processes in the real estate sector. Research into Automated Valuation Models in the context of Facility Management opens up the prospect of improving the efficiency and precision of processes involved in the widely understood management of real estate. One key area of research could be the integration of cognitive technologies, such as machine learning and machine reasoning, in order to improve models of other FM processes. Research should focus on understanding how these technologies could improve the ability of models to analyse data from different sources and generate more precise valuations.

Exploring the potential for the development of autonomous software bots (AI agents) within Automated Valuation Models is another fascinating area of research. The use of artificial neural networks for learning and adaptation may increase the flexibility and ability of models to solve more complex problems in the context of real estate valuation.

As autonomous software bots can take greater responsibility for end-to-end processes, minimizing or even completely eliminating the required human intervention, this can affect the efficiency of other "manual" processes currently functioning in organizations. If all information and data are delivered through digital channels, bots can work faster, throughout the whole process from start to finish. Viewed in this way, "smart" digital automation will provide a greater return on investment and the final comprehensive solutions will be more efficient than the sum of digitized individual processes. An important area of research is data standardisation in the context of Facility Management and Automated Valuation Models. Exploring opportunities to standardize real estate information may improve data exchange between different facility management systems and AVMs. This can also be achieved by running a single cognitive adapter working with any older system and as a result, digitize new areas of business processes. Research into analysing the impact of external factors, such as market changes, economic trends or regulation, on real estate values may lead to improvements in AVM models, enabling them to improve prediction of changes in value. In addition, research into the optimization of decision-making processes within Facility Management may lead to more effective planning of investment, renovation or budget. The analysis of the impact of cognitive technologies on valuation processes and assessing how these modern approaches can change traditional real estate appraisal methods are further areas of research that may contribute to the further development of advanced and flexible AVM models. Cognitive computing systems and machine reasoning technology have the potential to change traditional decision-making methods, enabling organizations to solve problems faster through more comprehensive data analysis. The combination of digital technology with cognitive robotics may lead to improved operational efficiency, increased precision of data analysis and the creation of more autonomous decision-making processes in various sectors of the economy.

Conclusions

The article focuses on the perspectives of using Automated Valuation Models, which have been enriched with advanced technologies of machine learning algorithms and artificial neural networks, in the area of Facility Management. A series of experiments simulating AVM activities in the context of operational management of the real property was carried out. The study focused on assessing the effectiveness of decision-making service algorithms, activated by automated inference engines, in terms of general information about real property and the process of planning with the use of algorithms. The conclusions of the study indicate that adopting a cognitive perspective in relation to AVM, as well as the use of advanced algorithm technologies and artificial neural networks in operational real property management, may significantly increase the productivity of processes. This in turn results in benefits for real property managers. In addition, the experiments demonstrated that AVM combined with advanced cognitive technologies excels at adapting to changing market conditions and the specifics of various real properties. Machine learning algorithms allow for the rapid analysis of huge quantities of data, which allows continuous monitoring and assessment of the technical condition of buildings. Meanwhile, artificial neural networks enable advanced inference and forecasting of future breakdowns or maintenance costs.

Noteworthy is the fact that the cognitive approach to AVM eliminates barriers related to various input states and lack of information, which translates into greater flexibility and efficiency in operational real property management. As a result, real property managers are able to make decisions with better justification while saving time and resources. The conclusions indicate a great potential for the use of modern technologies in Facility Management and open up new perspectives for the automation of management processes.

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Reference

1. Adamskiy, D., Bellotti, A., Dzhamtyrova, R., & Kalnishkan, Y. (2019). Aggregating algorithm for prediction of packs. *Machine Learning*, 108, 1231–1260. <https://doi.org/10.1007/s10994-018-5769-2>.
2. Bergadano, F., Bertilone, R., Paolotti, D., & Ruffo, G. (2019). Learning real estate automated valuation models from heterogeneous data sources. *arXiv preprint arXiv:1909.00704*
3. Bilgilioğlu, S. S., & Yilmaz, H. M. (2023). Comparison of different machine learning models for mass appraisal of real estate. *Survey review*, 55(388), 32–43. <https://doi.org/10.1080/00396265.2021.1996799>.
4. vom Brocke, J., Recker, J. & Mendling, J. (2010). Value-oriented process modeling: Integrating financial perspectives into business process re-design. *Business Process Management Journal*, 16(2), 333–356.
5. Carranza, J. P., Piumetto, M. A., Lucca, C. M., & Da Silva, E. (2022). Mass appraisal as affordable public policy: Open data and machine learning for mapping urban land values. *Land use policy*, 119, 106211. <https://doi.org/10.1016/j.landusepol.2022.106211>

6. Cheng, J. C., Chen, W., Tan, Y., & Wang, M. (2016, July). A BIM-based decision support system framework for predictive maintenance management of building facilities. In *Proceedings of the 16th International Conference on Computing in Civil and Building Engineering (ICCCBE2016)* (pp. 711–718)
7. Dimopoulos, T., & Bakas, N. (2019). Sensitivity analysis of machine learning models for the mass appraisal of real estate. Case study of residential units in Nicosia, Cyprus. *Remote sensing*, 11(24), 3047 <https://doi.org/10.3390/rs11243047>
8. Engel, C., Ebel, P. & Leimeister, J. M. (2022). Cognitive automation. *Electronic Markets*. Springer Science and Business Media Deutschland GmbH, 32(1), 339–350. <https://doi.org/10.1007/s12525-021-00519-7>
9. Es-Soufi, W., Yahia, E., & Roucoules, L. (2016). On the use of Process Mining and Machine Learning to support decision making in systems design. In *Product Lifecycle Management for Digital Transformation of Industries: 13th IFIP WG 5.1 International Conference, PLM 2016, Columbia, SC, USA, July 11-13, 2016, Revised Selected Papers 13* (pp. 56–66). Springer International Publishing. https://doi.org/10.1007/978-3-319-54660-5_6
10. Gallin, J., Molloy, R., Nielsen, E. R., Smith, P. A., & Sommer, K. (2018). Measuring aggregate housing wealth: New insights from an automated valuation model. *Measuring Aggregate Housing Wealth: New Insights from an Automated Valuation Model* (September, 2018). FEDS Working Paperm 2018-64, 1–43. <https://doi.org/10.17016/FEDS.2018.064>
11. Garcez, A. D. A., Gori, M., Lamb, L. C., Serafini, L., Spranger, M., & Tran, S. N. (2019). Neural-symbolic computing: An effective methodology for principled integration of machine learning and reasoning. *arXiv preprint arXiv:1905.06088*
12. Gathani, S., Hulsebos, M., Gale, J., Haas, P. J., & Demiralp, Ç. (2021). Augmenting decision making via interactive what-if analysis. *arXiv preprint arXiv:2109.06160*.
13. Geng, B. & Varshney, P. K. (2023). Human-Machine Collaboration for Smart Decision Making: Current Trends and Future Opportunities, *arXiv preprint*. <http://arxiv.org/abs/2301.07766>.
14. I.A.A.O. (2018) *Standard on Automated Valuation Models (AVMs) – 2018*. Kansas City, MO.: International Association of Assessing Officers.
15. ISO 41011:2017 (2017) *ISO 41011:2017 - Facility management — Vocabulary*.
16. Jensen, P. A. (2010). The facilities management value map: A conceptual framework. *Facilities*, 28(3–4), 175–188. <https://doi.org/10.1108/02632771011023131>.
17. Kara, A., Çağdaş, V., Işıkdağ, Ü., & Turan, B. O. (2018). Towards harmonizing property measurement standards. *Journal of Spatial Information Science*, 17, 87–119.
18. Kaur, S., Gupta, S., Singh, S. K., & Perano, M. (2019). Organizational ambidexterity through global strategic partnerships: A cognitive computing perspective. *Technological Forecasting and Social Change*, 145, 43–54. <https://doi.org/10.1016/j.techfore.2019.04.027>
19. Tudzi, E. P., Gavu, E. K., Ayitey, J. Z., & Boakye-Agyeman, N. A. (2015). Corporate real estate management: a survey of literature. In *Proceedings of 4th International Conference on Infrastructure Development in Africa (ICIDA)* (pp. 720–740).
20. Kok, N., Koponen, E.-L. & Martínez-Barbosa, C. A. (2017). Big Data in Real Estate? From Manual Appraisal to Automated Valuation. *The Journal of Portfolio Management*, 43(6), 202–211. <https://doi.org/10.3905/jpm.2017.43.6.202>
21. Lemaignan, S., Warnier, M., Sisbot, E. A., Clodic, A., & Alami, R. (2017). Artificial cognition for

- social human–robot interaction: An implementation. *Artificial Intelligence*, 247, 45–69.
22. Lorenz, F., Willwersch, J., Cajias, M., & Fuerst, F. (2023). Interpretable machine learning for real estate market analysis. *Real estate economics*, 51(5), 1178–1208. <https://doi.org/10.1111/1540-6229.12397>
 23. Malibari, N., Katib, I. & Mehmood, R. (2023). Systematic Review on Reinforcement Learning in the field of Fintech, *arXiv preprint arXiv:2305.07466*.
 24. Manko, B. A. (2022). Data Analytics in Real Estate How Zillow.com uses social media information. *International Journal of Teaching and Education*, X(1), 27–33.
 25. Matarneh, S. T., Danso-Amoako, M., Al-Bizri, S., Gaterell, M., & Matarneh, R. (2019). Building information modeling for facilities management: A literature review and future research directions. *Journal of Building Engineering*, 24, 100755.
 26. Mayer, M., Bourassa, S. C., Hoesli, M., & Scognamiglio, D. (2019). Estimation and updating methods for hedonic valuation. *Journal of European Real Estate Research*, 12(1), 134–150.
 27. Nene, S. (2017). Deep Learning for Natural Language Processing. *International Research Journal of Engineering and Technology*, 04(11). www.irjet.net.
 28. Nowak-Nova, D. (2018). Potencjał kognitywnej robotyzacji zaawansowanych procesów biznesowych. Mit czy rzeczywistość?. *Przedsiębiorczość i Zarządzanie*, 19(5, cz. 2), 163–176.
 29. O.M.G.DMN Guide (2019) *Decision Model And Notation: Version 1.2, OMG Document*.
 30. O.M.G.WfMC Specification (2000) *Workflow Management Facility Specification, V1.2, OMG Document*.
 31. Office of Government Property (2021) *Government Functional Standard – GovS 004: Property*. <http://www.nationalarchives.gov.uk/doc/open-government-licence/>.
 32. Office of Government Property (2022a) *Facilities Management Standard FMS 001: Management and Services*. <http://www.nationalarchives.gov.uk/doc/open-government-licence/>.
 33. Office of Government Property (2022b) *Facilities Management Standard FMS 002: Asset Data*. <http://www.nationalarchives.gov.uk/doc/open-government-licence/>.
 34. Opoku, A. and Lee, J. Y. (2022). The Future of Facilities Management: Managing Facilities for Sustainable Development. *Sustainability (Switzerland)*, 14(3), 1705. <https://doi.org/10.3390/su14031705>
 35. Pala, F. and Melzi, E. (2009). Facility Management organizational models. in *Open facility management*. Milano: IFMA, 85–104.
 36. Pruszkowski, L. (2012). Facility Management jako innowacyjna koncepcja zarządzania procesami pomocniczymi. *Innowacje w zarządzaniu i inżynierii produkcji*, 214–225.
 37. Ray, A., Padmanabhan, B. & Bouayad, L. (2023). Systemic Fairness. *arXiv preprint*. <http://arxiv.org/abs/2304.06901>.
 38. Renigier-Biłozor, M., Chmielewska, A., Walacik, M., Janowski, A., & Lepkova, N. (2021). Genetic algorithm application for real estate market analysis in the uncertainty conditions. *Journal of Housing and the Built Environment*, 36(4), 1629–1670. <https://doi.org/10.1007/s10901-020-09815-8>
 39. Rousopoulou, V., Vafeiadis, T., Nizamis, A., Iakovidis, I., Samaras, L., Kirtsoglou, A., Georgiadis, K., Ioannidis, D. & Tzovaras, D. (2022). Cognitive analytics platform with AI solutions for anomaly detection. *Computers in Industry*, 134, 103555. <https://doi.org/10.1016/j.compind.2021.103555>.
 40. Sathish, B. & Venkataram, P. (2009). A dynamic authentication scheme for mobile transactions.

International Journal of Network Security, 8(1), 59–74.

41. Steurer, M., Hill, R. J. & Pfeifer, N. (2021). Metrics for evaluating the performance of machine learning based automated valuation models. *Journal of Property Research*, 38(2), 99–129. <https://doi.org/10.1080/09599916.2020.1858937>
42. Śliwiński, A., & Śliwiński, B. (2006). *Facility management*. CH Beck.
43. TEGoVA (2017). *EVS 6 Automated Valuation Models (AVMs)*.
44. Tetzlaff, L. M. & Szepannek, G. (2022). mlr3shiny—State-of-the-art machine learning made easy. *SoftwareX*, 20, 101246. <https://doi.org/10.1016/j.softx.2022.101246>
45. Thomas, M. (2014) *Zarządzanie utrzymaniem technicznym i konserwacją budynków*. Oficyna Wydawnicza Politechniki Warszawskiej.
46. Valier, A. (2020). Who performs better? AVMs vs hedonic models. *Journal of Property Investment and Finance*, 38(3), 213–225. <https://doi.org/10.1108/JPIF-12-2019-0157>
47. Vathana, D., Patel, R., & Bargoti, M. (2022). Real Estate Price Prediction Using Machine Learning Algorithm. in *Advances in Intelligent Computing and Communication: Proceedings of ICAC 2021*. Springer Science and Business Media Deutschland GmbH, 431–440. https://doi.org/10.1007/978-981-19-0825-5_47
48. Welck, M., Derdak, I. J., & Veit, D. (2020). “Understanding Individuals” Perceptions Regarding Cognitive Computing Systems. in *International Conference on Information Systems (ICIS) 2020*, 1–9.
49. Xu, J., Lu, W., Xue, F., & Chen, K. (2019). ‘Cognitive facility management’: Definition, system architecture, and example scenario. *Automation in Construction*, 107, 102922.
50. Xu, J., Lu, W., & Li, L.-H. (2019). Cognitive Facilities Management: Definition And Architecture. in *International Conference on Smart Infrastructure and Construction 2019 (ICSIC)*. ICE Publishing, 115–122. <https://doi.org/10.1680/icsic.64669.115>

Digital Transformation: A Study of how SACCO Members in Kenya Experience Financial Inclusion through Digital Financial Services

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Abstract

Financial inclusion has gained prominence as a critical element for sustainable development and inclusive growth. Saving and Credit Cooperative Societies (SACCOs) in Kenya play a vital role in providing financial services to their members, particularly those who are underserved by traditional banking institutions. However, limited access to financial services remains a significant challenge. This conference paper investigates how the adoption of digital financial services influences financial inclusion among members of saving and credit cooperative societies in Kenya. Survey data were collected from 334 randomly selected SACCO members. This study employed probit regression analysis to assess the hypotheses developed. The findings of the research support the hypothesis that the adoption of digital financial services positively influences financial inclusion among SACCO members. The analysis revealed that the implementation of digital financial services (DFSs) has significantly expanded financial access for previously underserved populations. Members now have convenient and efficient channels to save, borrow, and manage their finances, leading to increased economic empowerment and reduced inequalities. Moreover, the adoption of digital financial services has streamlined SACCO operations, improving efficiency, transparency, and accountability. This has aided SACCOs in serving their members' financial needs more effectively.

Key words

digital financial services, financial inclusion, SACCOs, credit unions.

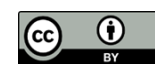
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Introduction

The World Bank reports of 2018, 2022, define financial inclusion as the accessibility and availability of financial services to all individuals, especially those who have been historically excluded or underserved. It encompasses access to a range of digital financial services, including mobile money services,

payment cards, and other financial technology (or fintech) applications (Demirgüç-Kunt et al., 2018; Demirgüç-Kunt et al., 2022). Financial inclusion is considered crucial for economic development, a spotlight for economic policy making (Nguyen, 2021), and thus plays a significant role in promoting inclusive growth and reducing poverty (Ezzahid & Elouaourti, 2022). According to the World Bank's 2020 report, 65% of adults in the world's poorest economies lack access to even the most basic transaction account, which would allow them to send and receive payments more safely and efficiently. Only 20% of adults in developing economies save through formal financial institutions. The remaining savers use less formal and more costly methods (Pazarbasioglu et al., 2020). Access to financial institutions is often difficult for underserved populations, particularly those living in remote or rural areas. These financial institutions frequently overlook or underestimate the unique financial needs of underserved populations, such as microenterprises and smallholder farmers, limiting their ability to access suitable financial services (Gupta, 2022). Traditional financial institutions frequently charge high transaction fees, have minimum balance requirements, and have complicated account opening processes, which discourages underserved people from using their services. Financial services can be unaffordable, especially for people with low incomes or irregular cash flows (Misati et al., 2022). Underserved populations, especially women, may face barriers to accessing financial services due to sociocultural norms, traditions, and gender inequalities. Discrimination limits decision-making power, and restricted mobility can impede women's ability to open bank accounts or access loans (Were et al., 2021). Research on savings and credit cooperative societies (SACCOs) in Kenya has predominantly concentrated on examining the connection between digital financial services and financial inclusion, with a particular emphasis on its impact on overall financial performance. Moki et al. (2019) found that financial innovation significantly increased the financial performance of SACCOs. Hemed (2022) focused on how financial inclusion strategies affect how deposit-taking SACCOs in Kenya perform financially. Ogindo and Njoka (2023) aimed to examine how digital transformation affects the financial performance of Nairobi-based SACCOs. The FinAccess (2021) survey conducted in Kenya highlighted challenges faced by members of Saving and Credit Cooperative Societies (SACCOs) in accessing digital financial services (DFS), consequently affecting their access to SACCO products. The current study aims to investigate how the adoption of digital financial services influences financial inclusion among members of saving and credit cooperative societies in Kenya. Specifically, the hypothesis posits that the adoption of digital financial services will enhance financial inclusion within SACCOs, leading to improved access to financial services, economic empowerment, and overall well-being for members.

The rest of the article is divided into the following sections. Section 1 reviews the literature. The approach used is explained in Section 2. The results are presented in Section 3, and the main subject is discussed in Section 4. The paper's conclusions are included in Section 5, and references are given in Section 6.

1. Literature review

1.1 *Saving and Credit Cooperative Societies (SACCOs)*

Savings and credit cooperatives are also referred to as financial cooperatives or credit unions (McKillop & Wilson, 2011). SACCOs serve as localized, member-owned financial cooperatives that play a significant role in expanding access to financial services, particularly in areas where traditional banking infrastructure may be limited (McKillop et al., 2020). Kenya experienced a series of bank

collapses in the 1990s, which led to the SACCO sector becoming the fastest-growing subsector of co-operatives in Kenya, making it a regional leader in Africa (Mathuva & Kiweu, 2016; Ototo, 2017). SACCOs are a subcategory of cooperatives in Kenya with the purpose of advancing credit or other lending facilities to SACCO members and mobilizing savings from members (SASRA, 2021). SACCO members are frequently motivated to promote socioeconomic benefits through their organization's lending activities, both for their fellow savers and borrowers and for the larger community (Feather and Meme, 2019). SACCOs are categorized into two types: deposit-taking SACCOs (DT-SACCOs) and non-deposit-taking SACCOs (non-DT-SACCOs). In their 2020 Sacco Supervision Annual Report 2020, the Sacco Societies Regulatory Authority (SASRA) declared that SACCOs must fully embrace the usage of ICT and other technologically enabled mobile devices in their operations and service provision (SASRA, 2021). The Sacco Societies Regulatory Authority (SASRA) is the authority that regulates and supervises the activities of qualifying SACCOs. The World Bank (2020) reported how developing economies benefit from digital financial services, increasing access to these services and making them critical for poverty reduction and economic growth (Pazarbasioglu et al., 2020). The FinAccess Survey (FSD Kenya, 2021) also revealed that the disparity between rural and urban consumers of financial services was narrowed as a result of the adoption of mobile money and subsequent digitalization of financial services and products leading to financial inclusion.

1.2 Digital financial services

Digital financial services (DFSs) include mobile banking, online lending, digital payment platforms, and other technological advancements that allow people to perform financial transactions and gain access to a variety of financial goods from a distance (Ong et al., 2023). According to Demirgüç-Kunt et al. (2018), access to mobile money services provided significant benefits, particularly to women in Kenya. It enabled women-headed households to increase their savings by more than a fifth, allowed 185,000 women to leave farming to pursue business or retail opportunities, and contributed to a 22% reduction in extreme poverty among women-headed households.

DFSs have become much more well known in recent years and have the potential to broaden financial inclusion. By providing accessible, specialized, and community-driven digital financial services that empower people and support regional economic development, SACCOs in Kenya play a crucial role in fostering financial inclusion (Maina et al., 2020). According to the 2019 FinAccess survey, SACCOs in Kenya are more accessible and affordable than are those in other financial institutions (FSD Kenya, 2019). SACCOs design their financial products and services to cater to the specific needs of their members. This might include savings accounts, loans, insurance, and investment opportunities tailored to local economic conditions and member preferences (Frank et al., 2015). SACCOs also empower their members by offering financial education and training. This knowledge equips members with the skills to manage their finances effectively, make informed decisions, and plan for the future (Wanyonyi & Ngaba, 2021). The theoretical framework for this study was based on Davis's (1989) technology acceptance model (TAM). TAM proposes that a person's acceptance of a technology is determined by his or her voluntary intention to use it. Intention, in turn, is determined by the person's attitude toward using that technology and his or her perception of its usefulness (Davis, 1989). This study aimed to contribute to the literature by investigating the extent to which the adoption of digital financial services within SACCOs fostered the financial inclusion of their members.

1.3 Financial Inclusion

Financial inclusion refers to the accessibility and availability of financial services to all individuals, especially those who have been historically excluded or underserved (Demirgüç-Kunt et al., 2022). Government restrictions due to the COVID-19 pandemic led to a change in the way business was performed, especially in financial services. In Kenya, the government-imposed restrictions on physical contact, which led to the SACCO regulator SASRA to encourage SACCOs to adopt cashless transactions via digital payment channels such as ATMs, POS terminals, online, mobile or smartphones, and card networks (SASRA, 2021). These orders resulted in an exponential increase in DFS, which has since been maintained in the postpandemic period. (Mhlanga & Dzingirai, 2023). According to the World Bank (2021), the adoption of DFS by SACCOs and other financial institutions experienced rapid growth in digital financial inclusion after the 2020 period. Technological advances such as FinTech, the digitalization of products and services and online provision continue to shape the business model of co-operative financial institutions (McKillop et al. 2020). The emergence of DFS has led to a shift in focus from the products and services delivered to those that deliver products and services (Arner et al., 2017a; 2017b). DFSs are primarily used by SACCOs to provide credit, deposits, and access to other cooperative services (e.g., credit cards, queries, and special savings) (Westermeyer, 2018). However, the FinAccess (2021) survey in Kenya revealed difficulties for SACCO members in accessing DFS and, as a result, SACCO products. These challenges lead to the following hypothesis:

H1: The adoption of digital financial services will positively influence the financial inclusion of SACCO members.

2. Methodology

This study employed a quantitative approach to investigate how the adoption of digital financial services influences financial inclusion among SACCOs members in Kenya. The SACCO members were from both DT-SACCOs and Non-WDT-SACCOs, licenced and authorized SACCOs in Kenya. Because there are over 10,000 SACCO members in Kenya, a sample of 384 SACCO members was randomly chosen with a 95% confidence level (Mugenda and Mugenda, 2003). Primary data were collected through online surveys and self-administered questionnaires. Secondary data were collected from publications from the Central Bank of Kenya and from FinAccess household surveys. Self-administered questionnaires were randomly distributed and distributed in two ways: SACCO members who were employees of the SACCOs preferred drops and picks in the SACCO offices, and for members visiting the SACCO for services, this was conducted face to face. Stockemer et al. (2019) indicated that the researcher is able to observe nonverbal behaviour, draw conclusions and respond to respondents who will not understand the content of questions and explain them in more detail. Some of the questionnaires had to be translated from English to Swahili (the local language) upon request from the SACCO members who were not conversant with some financial terms. Online surveys were conducted by sharing the online link with SACCO officials who were requested to complete the survey and share the link to their SACCO members. There were 27 online surveys completed, and 307 self-administered questionnaires were collected. This translated to a total of 334 surveys for the study, which represented an 87% response rate from the targeted sample. The response rate was considered adequate, as supported by Cele (2022), who considered a 39% response rate adequate. The data are therefore representative of SACCO members in Kenya. Sixty-six percent of the respondents were from DT-SACCOs, while 34% were from Non-WDT-SACCOs, which shows that both categories of SACCOs in Kenya were well represented. As noted by Mathuva (2016), DT-SACCOs control 82% of total

membership in the sector; thus, their representation is adequate in the sample. The survey assessed members' access to digital financial services, frequency of tracking transactions, perceived impact on their financial activities and control variables, which included demographics. Financial inclusion was measured using users' indicators proposed by the World Bank (Demirgüç-Kunt et al., 2022). The study required binary responses, where individuals were categorized as either being financially included or not, and a probit regression model was therefore suitable for analysis (Wooldridge, 2018). The probit model was estimated using STATA statistical software. The probit model is specified as follows:

$$Pr(Y_i = 1) = \Phi(\beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \dots + \beta_k X_{ki} + \varepsilon_i) \quad (1)$$

where: Y_i represents the binary dependent variable indicating financial inclusion for SACCO member; Φ – the cumulative distribution function of the standard normal distribution; $X_{1i} \dots X_{ki}$ – the independent variables related to digital financial service adoption, demographic characteristics, and other relevant factors for SACCO members; $\beta_0 \dots \beta_k$ – the coefficients to be estimated; ε_i – the error term.

3. Research results

Table 1 represents the variable definitions based on the model.

Table 1. Variable definitions

Variable	Variable type	Description	Measurement
Dependent variable			
Financial_inclusion	Binary		= 1: “financially_included”, 0: “not_financially_included”
Test variables			
DFS_Access	Binary	Access to digital financial services	= 1: increased access, 0: limited or no access
DFS_Benefits	Categorical	Benefits of DFS in terms of increasing security, convenience, transparency	= DFS increases security, convenience, transparency; Likert scale 1: “not at all” to 5: “to a great extent”
Control variables			
Age	Continuous	Age of the SACCO member	= Number of years from birthdate
Gender	Binary	Gender of the respondent	= 1: female, 0: male
Marital_Status	Categorical	Marital status of the respondent	= 1: divorced, 2: married, 3: separated, 4: single, 5: widowed
Education	Categorical	Education level of the member	= 1: high school, 2: diploma, 3: bachelors degree, 4: masters degree, 5: doctorate
Income	Categorical	Income level of the respondent	= 1: below Kshs. 10,000, 2: 10,001-20,000, 3: 20,001-30,000, 4: 30,001-40,000, 5: 40,001-50,000, 6: 50,001 and above
Tracking_savings_regularly	Categorical	The type of employment the member is in	= 1: part time, 2: full time, 3: self, 4: student, 5: unemployed
Fin_Literacy	Binary	A measure of the extent of a member's financial literacy	= A score derived using a nine-question test administered to respondents: 1: denotes a high score (100%), 0: denotes any score below 100%
House_Location	Categorical	The location of the respondent's household	= 1: rural, 2: semiurban, 3: urban
SACCO_Category	Binary	The classification of the SACCO as per SASRA's categories	= 1: deposit-taking SACCO; 0: nonwithdrawable deposit taking SACCO
Member_Code (pi)	N/a	Heterogeneity in the various members responding to the survey	= a unique code to capture the different respondents
SACCO_Code (phi)	N/a	Heterogeneity in the 74 SACCOs in the sample	= a unique code to capture the different SACCOs.

Source: developed by the authors.

Table 2 presents descriptive statistics on the variables in the study. According to the results, 87.43% of the respondents were financially included due to DFS. Overall, 92.22% of the respondents indicated having access to DFS. A majority of the respondents agreed that DFS had various benefits in terms of speed (68.86%), security (59.28%) and transparency (74.85%).

Table 2. Descriptive statistics

Variable	Category 1: Freq.	Category 2: Freq.	Category 3: Freq.	Category 4: Freq.	Category 5: Freq.	Mean	St. Dev.	Min.	Max.
Dependent variables	1: "Financially included"	0: "Not financially included"							
Financial_inclusion	87.43%	12.57%				0.87	0.33		
Test variables	1: Increased access	0: Limited or no access							
DFS_Access	92.22%	7.78%				0.92	0.27		
	1: Not at all	2: To a small extent	3: To some extent	4: To a moderate extent	5: To a great extent				
DFS_Benefits_Speed	10.18%	7.19%	13.77%	23.65%	45.21%	3.87	1.33		
DFS_Benefits_Security	11.68%	4.49%	24.85%	29.64%	29.34%	3.60	1.27		
DFS_Benefits_Transparency	8.08%	6.89%	10.18%	28.44%	46.41%	3.98	1.25		
Control variables									
All binary control variables	1: Female	0: Male							
Gender	50.90%	49.10%				0.51	0.50		
	1: A 100% score	0: Score below 100%							
Fin_Literacy	19.46%	80.54%				0.19	0.40		
	1: DT SACCO	0: Non-WDT SACCO							
SACCO_Category	65.87%	34.13%				1.34	0.47		
All categorical control variables	1: Divorced	2: Married	3: Separated	4: Single	5: Widowed				
Marital_Status	0.30%	47.60%	4.49%	47.31%	0.30%	3.00	0.99		
	1: High school	2: Diploma	3: Bachelors degree	4: Masters degree	5: Doctorate				
Education	13.17%	23.65%	51.50%	8.38%	3.29%	2.65	0.93		
	1: Below Kshs. 10,000	2: 10,001-20,000	3: 20,001-30,000	4: 30,001-40,000	5: 40,001-50,000				
Income	4.49%	10.78%	16.77%	16.47%	9.88%	4.41	1.61		
	1: Part time	2: Full time	3: Self	4: Student	5: Unemployed				
Employment Type	8.38%	73.05%	14.37%	3.59%	0.60%	2.15	0.64		
	1: Rural	2: Semiurban	3: Urban						
House_Location	5.69%	36.53%	57.78%			2.52	0.60		
All continuous control variables									
Age (years)						34.94	8.60	19.0	62.0

Source: developed by the authors.

In terms of gender, the response rate was fairly balanced, with female respondents having a response rate slightly greater than that of their male counterparts (50.90%). This finding confirms the notion that SACCOs can be effectively utilized as vehicles for financial inclusion for all members of society in an inclusive and meaningful way (ILO, 2015). This was not the case for financial literacy levels, for which 80.54% of respondents scored below 100%, meaning that they did not answer at least one of the nine financial literacy questions correctly. The SACCO members need to be trained on the financial services offered by the SACCO to enable them to use them efficiently.

Table 3 below shows the probit regression analysis results of the relationship between the dependent variable (financial inclusion of SACCO members) and the independent variables (access to DFS by SACCO members) and the significant control variables. Some variables were excluded due to collinearity. It also shows the predictive margins representing the estimated probabilities of the outcome variables.

Table 3. Probit regression analysis results

Variables	Financial Inclusion		
	Coefficient	Marginal Effect	Standard error
Access to digital financial services	1.736***	0.916***	0.392
Financial literacy	0.015	0.878***	0.306
DFS benefits	1.522***	0.924***	0.310
Tracking savings regularly	0.807**	0.892***	0.296
Location	0.050	0.882***	0.522
SACCO category	-0.135	0.871***	0.260
Age	-0.003	0.00	0.014
Gender	0.089	0.882***	0.243
Constant	-2.047**		0.718
* p<0.05, **p<0.01, *** p<0.001			

Source: developed by the authors.

Table 4 presents the goodness-of-fit tests and assesses whether the observed data match the expected frequencies predicted by the probit model (Pituch and Stevens, 2015). The rate of correct classification was tested by comparing the predicted category with the actual dependent variable (Cele, 2022). The performance metrics indicate that the probit model has reasonably good predictive performance, with high sensitivity and specificity. The tests showed that the model fit the data adequately for predicting the dependent variable. Some variables were excluded due to collinearity.

Table 4. Goodness-of-fit test and rate of classification

Goodness-of-fit test after probit model	Financial Inclusion
Pearson chi2 test	Pearson chi2(202) = 181.04; Prob > chi2 = 0.8526
McFadden's R2	0.455
Cragg & Uhler's R2:	0.546
Rate of classification	
Sensitivity	98.62%.
Specify	55.00%.
Overall classification rate	93.33%

Source: developed by the authors.

4. Discussion

The probit regression model was used to test the following hypotheses: The adoption of digital financial services will positively influence the financial inclusion of SACCO members. Table 3 reports the results of the estimation examining the influence of DFS on a SACCO member's financial inclusion. According to the results, access to digital financial services is positive and highly significant at the 1 percent level. This finding confirms our hypothesis (H1) that adoption of DFS positively influences financial inclusion among SACCOs. This finding implies that the adoption of DFS by SACCOs will increase access to financial services for their members compared to those who do not. This finding supports the TAM and the arguments of Jumena (2022), Edigbonya et al. (2023) and Moki et al. (2019) that DFS is a necessary tool for improved financial inclusion. According to the model, SACCO members with high access to DFS are predicted to have a probability of accessing financial services of approximately 91.6%. Our findings align with the work of Ndwiga et al. (2018), who demonstrated that DFS adoption positively impacts the frequency and consistency of members' contributions. Similarly, our research resonates with that of Varlamova et al. (2020), revealing the positive impact of DFS on saving behaviours. Pazarbasioglu et al. (2020) emphasize the importance of DFS in increasing efficiency in financial service delivery while also improving the speed, transparency, security, and availability of tailored financial services that serve all consumer categories.

SACCO members in rural areas are predicted to have a probability of accessing financial services of approximately 88.2%. The predicted probability of DFS increasing security, convenience and transparency is approximately 92.4%. of accessing financial services. In their study on digital savings in emerging economies, Awosika et al. (2023) found that digital savings for unbankable people can improve their economic well-being. Ouma et al. (2017) showed that individuals who perceived an increase in the security of digital financial services were more likely to have savings. A study by Demirgüç-Kunt et al. (2022) suggested that access to digital financial services positively influences savings behaviour by providing convenience, reducing transaction costs, and increasing financial security. SACCOs also seem to remove barriers to accessing financial services for underserved populations, particularly women (Jagtiani and Lemieux, 2018). Approximately 88.2% of women in SACCOs were predicted to access financial services. This finding is consistent with the study by Bwana and Mwakujonga (2013), who reported that SACCOs generally have an equal gender and that females are well represented. According to the 2021 FinAccess Household Survey, gender disparities in access to digital financial services have narrowed over time, allowing females to participate more meaningfully in formal economic activities (FSD Kenya, 2021).

Conclusions

In conclusion, the study reveals a significant positive correlation between the adoption of digital financial services and increased financial inclusion among SACCO members. Members who engage with digital platforms showcase improved access to formal financial activities, including savings, credit, and payments. By offering digital services, SACCOs can expand their reach beyond their immediate geographical area. Members who may live far from a physical branch can access services digitally, broadening the SACCO's member base. Digital financial services also contributed to the operational sustainability of SACCOs. By reducing manual processes and increasing efficiency, SACCOs can allocate resources more effectively and manage costs, ensuring their long-term viability. However, the SACCO needs to train its members on the DFS and their uses and benefits.

In the era where technology is the conduit for reshaping societal landscapes, our findings reinforce the assertion that digital transformation is not only a pathway but also a catalyst for financial inclusion. By breaking down the barriers of geography, gender, and limited access, digital financial services empower individuals to harness economic opportunities previously beyond their reach. Policy makers should create a regulatory framework that supports digital financial innovation while ensuring consumer protection, data security, and privacy. This framework should encourage innovation while maintaining a level playing field.

Future research and collaboration are essential for advancing the field of digital financial inclusion and sustainable development. Researchers could explore the application of behavioural economics principles in designing digital financial services that encourage positive financial behaviours. Investigations on the long-term impact of digital financial inclusion on various socioeconomic indicators, such as poverty reduction, income distribution, and job creation, could also be considered.

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Reference

1. Arner, D. W., Barberis, J., & Buckley, R. P. (2017a). FinTech, RegTech, and the reconceptualization of financial regulation. *Northwestern Journal of International Business and Law*, 37, 371–413.
2. Arner, D. W., Zetsche, D. A., Buckley, R. P., & Barberis, J. N. (2017b). FinTech and RegTech: Enabling innovation while preserving financial stability. *Georgetown Journal of International Affairs*, 47–58. <https://www.jstor.org/stable/26395923>
3. Awosika, O. A. (2023). Chasing the digital savings dream for Sub-Saharan Africa: Navigating policy, behaviour and financial inclusion literature in emerging economies. Lancaster University (United Kingdom).
4. Bwana, K. M., & Mwakujonga, J. (2013). Issues in SACCOS development in Kenya and Tanzania: The historical and development perspectives. *Developing Country Studies*, 3(5), 114–121.
5. Cele, L. (2022). Youth perceptions of, and willingness to join Irish dairy cooperatives and their governance. *Journal of Co-operative Organization and Management*, 10(2), 100180. <https://doi.org/10.1016/j.jcom.2022.100180>
6. Central Bank of Kenya. (2021). FinAccess Household Survey December 2021. Nairobi, Kenya.
7. Consumers International. (2017). Banking on the future: An exploration of Fintech and the consumer interest, monograph, consumers international: Coming together for change – July 2017. <https://www.consumersinternational.org/media/154710/banking-on-the-future-full-report.pdf>
8. Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*, 319–340.

9. Demirgüç-Kunt, A., Klapper, L., Singer, D., & Ansar, S. (2022). Financial inclusion, digital payments, and resilience in the age of COVID-19. <https://openknowledge.worldbank.org/handle/10986/37578>.
10. Demirgüç-Kunt, A., Klapper, L., Singer, D., Ansar, S., & Hess, J. (2018). Global Findex database 2017, The Global Findex Database 2017: Measuring Financial Inclusion and the Fintech Revolution. <https://doi.org/10.1596/978-1-4648-1259-0>
11. DigiPay. (2023). What is a SACCO and why should it be digitized? <https://www.digipay.guru/blog/digital-evolution-of-saccos-after-covid-19/>
12. Ediabonya, V., & Tioluwani, C. (2023). The role of fintech in driving financial inclusion in developing and emerging markets: issues, challenges and prospects. *Technological Sustainability*, 2(1), 100–119. <https://doi.org/10.1108/techs-10-2021-0017>
13. Ezzahid, E., & Elouaourti, Z. (2022). Financial inclusion, financial frictions, and economic growth: Evidence from Africa. *Journal of African Business*, 23(3), 731–756. DOI: [10.1080/15228916.2021.1926856](https://doi.org/10.1080/15228916.2021.1926856)
14. Feather, C., Meme, C. K. (2019), Strengthening housing finance in emerging markets: the savings and credit cooperative organization (SACCO) model in Kenya, *Housing Studies*, 34(9), 1485–1520. <https://doi.org/10.1080/02673037.2019.1584663>
15. Frank, T., Mbabazize, M., & Shukla, J. (2015). Savings and credit cooperatives (Sacco's) services' terms and members' economic development in Rwanda: A case study of Zigama Sacco Ltd. *International Journal of Community and Cooperative Studies*, 3(2), 1–56.
16. FSD Kenya (2019). The 2019 FinAccess household survey – Financial sector deepening Kenya. Nairobi, Kenya. <https://fsdkenya.org/publication/finaccess2019/>
17. Gupta, N. (2022). How SACCOS' digitization can improve loan distribution - Wakandi Group. <https://blog.wakandi.com/blog/how-saccos-digitization-can-improve-loan-distribution>
18. Government of Kenya. (2010). SACCO Societies Act: The Sacco societies (Deposit-Taking Business) Regulations, 2010. SARA, Nairobi, Kenya. <https://www.sasra.go.ke/download/sacco-society-regulations/>
19. Government of Kenya. (2020), SACCO Societies Act: The Sacco societies (Non-Deposit-Taking Business) Regulations, 2020. SASRA, Nairobi, Kenya. <https://www.sasra.go.ke/download/sacco-societies-non-deposit-taking-business-regulations-2020/> (
20. Hemed, H. R. (2022). *The Effects of Financial Inclusion Strategies on Financial Performance of Deposit Taking Savings and Credit Co-operatives Societies (Saccos) in Kenya* (Doctoral dissertation, University of Nairobi).
21. International Labour Organization (ILO). (2015). Advancing gender equality: The co-operative way. Geneva, Switzerland. https://www.ilo.org/wcmsp5/groups/public/---ed_emp/---emp_ent/---coop/documents/publication/wcms_379095.pdf
22. Jagtiani, J., & Lemieux, C. (2018). Do FinTech lenders penetrate areas that are underserved by traditional banks?. *Journal of Economics & Business*, 100, 43–54.
23. Jumena, B. B., Siaila, S., & Widokarti, J. R. (2022). Saving behaviour: Factors that affect saving decisions (Systematic Literature Review Approach). *Journal Economic Resource*, 5(2), 217–235. <https://doi.org/10.56750/jer.v5i2.365>
24. Kenya National Bureau of Statistics (KNBS). (2022). Economic survey 2022. Nairobi, Kenya. <https://www.knbs.or.ke/wp-content/uploads/2022/05/2022-Economic-Survey1.pdf>

25. Maina, J. N., Kiai, R. M., & Ngina, T. (2020). Financial innovation practice, sacco size and financial sustainability of deposit taking saving and credit co-operatives in Kenya. *Financial Studies*, 24(3), 51–65.
26. Mathuva, D. (2016). Revenue diversification and financial performance of savings and credit co-operatives in Kenya. *Journal of Co-operative Organization and Management*, 4(1), 1–12. <https://doi.org/10.1016/j.jcom.2015.11.001>
27. Mathuva, D. M. (2016). Drivers of financial and social disclosure by savings and credit cooperatives in Kenya: A managerial perspective. *Journal of Co-operative Organization and Management*, 4(2), 85–96. <https://doi.org/10.1016/j.jcom.2016.08.001>
28. Mathuva, D., & Kiweu, J. (2016). Cooperative social and environmental disclosure and financial performance of savings and credit cooperatives in Kenya. *Advances in Accounting*, 35, 197–206. <https://doi.org/10.1016/J.ADIAC.2016.09.002>
29. McKillop, D., & Wilson, J. O. S. (2011). Credit unions: A theoretical and empirical overview, Financial Markets. *Institutions and Instruments*, 20(3), 79–123. <https://doi.org/10.1111/j.1468-0416.2011.00166.x>
30. McKillop, D., French, D., Quinn, B., Sobiech, A. L., & Wilson, J. O. S. (2020). Cooperative financial institutions: A review of the literature. *International Review of Financial Analysis*, 71. <https://doi.org/10.1016/j.irfa.2020.101520>
31. Mhlanga, D., & Dzingirai, M. (2023). Postindependence development and financial inclusion in Africa: Case studies and the way Forward to support further financial inclusion, In Mhlanga, D., Ndhlovu, E. (eds) *Economic Inclusion in Post-Independence Africa*. *Advances in African Economic, Social and Political Development*. Springer, Cham. https://doi.org/10.1007/978-3-031-31431-5_8
32. Misati, R., Osoro, J., Odongo, M., & Abdul, F. (2022). Does digital financial innovation enhance financial deepening and growth in Kenya? *International Journal of Emerging Markets*, 19(3), 679–705. <https://doi.org/10.1108/IJOEM-09-2021-1389>
33. Moki, N. M., Kanini, & Kinyua, S. G. M. (2019). Financial innovation strategy and financial performance of deposit taking Sacco's in Nairobi City County. *International Academic Journal of Economics and Finance*, 3(3), 398–417.
34. Ndwiga, P. M., & Maina, J. N. (2018). Financial innovation as an alternative delivery channel and financial performance of listed commercial banks in Kenya. *European Journal of Business and Management*, 10(17), 65–69.
35. Nguyen, T. (2021). Measuring financial inclusion: a composite FI index for the developing countries. *Journal of Economics and Development*, 23(1), 77–99. <https://doi.org/10.1108/JED-03-2020-0027>
36. Ogindo, E. A., & Njoka, C. . (2023). Digital Transformation and Financial Performance of Deposit-Taking Savings and Credit Co-Operatives in Nairobi City County, Kenya. *Journal of Finance and Accounting*, 3(2), 45–56. <https://edinburgjournals.org/journals/index.php/journal-of-finance-and-accountin/article/view/172>
37. Ong, H.-B., Wasiuzzaman, S., Chong, L.-L., & Choon, S.-W. (2023). Digitalization and financial inclusion of lower middle-income ASEAN. *Heliyon*, e13347. <https://doi.org/10.1016/j.heliyon.2023.e13347>

38. Ouma, S. A., Odongo, T. M., & Were, M. (2017). Mobile financial services and financial inclusion: Is it a boon for savings mobilization?. *Review of Development Finance*, 7(1), 29–35. <https://doi.org/10.1016/J.RDF.2017.01.001>
39. Ototo, G. (2017). The SACCO movement in Kenya up to 2017, 88–93.
40. Ozili, P. K. (2018). Impact of digital finance on financial inclusion and stability. *Borsa Istanbul Review*, 18(4), 329–340. <https://doi.org/10.1016/j.bir.2017.12.003>
41. Pazarbasioglu, C., Mora, A. G., Uttamchandani, M., Natarajan, H., Feyen, E., & Saal, M. (2020). Digital financial services, World Bank Group. <https://pub-docs.worldbank.org/en/230281588169110691/Digital-Financial-Services.pdf>
42. SASRA. (2021). The Sacco supervision annual report 2020, In Sacco Societies Regulatory Authority (SASRA). <https://www.sasra.go.ke/download/sacco-supervision-annual-report-2020/>
43. Slovin, E. (1960). Slovin's formula for sampling technique. <https://prudencexd.weebly.com/>
44. Stockemer, D., Stockemer, G., & Glaeser, J. (2019). Quantitative methods for the social sciences, 50, (pp. 185). Cham, Switzerland: Springer International Publishing.
45. The World Bank. (2021). World development indicators. DataBank, Data Bank. <https://data-bank.worldbank.org/source/world-development-indicators>
46. Varlamova, J., Larionova, N., & Zulfakarova, L. (2020). *Digital technologies and saving behavior*. In International Scientific Conference" Far East Con"(ISCFEC 2020), 1661–1667.
47. Wanyonyi, K. S., & Ngaba, D. (2021). Digital financial services and financial performance of savings and credit cooperative societies in Kakamega County, Kenya. *International Journal of Current Aspects in Finance, Banking and Accounting*, 3(1), 9–20. <https://doi.org/10.35942/ijcfa.v3i1.177>
48. Westermeier, C. (2018). The bank of international settlements as a think tank for financial policy-making. *Policy and Society*, 37(2), 170–187.
49. Were, M., Odongo, M., & Israel, C. (2021). Gender disparities in financial inclusion in Tanzania, WIDER Working Paper, 2021/97, The United Nations University World Institute for Development Economics Research (UNU-WIDER), Helsinki. <https://doi.org/10.35188/UNU-WIDER/2021/037-5>
50. Wooldridge, J. M. (2018), Introductory econometrics: A modern approach (upper level economics titles). Southwestern College Publishing, Nashville, T ATN, 41, 673–690.

Public Health Efficiency and Country Competitiveness: Empirical Study in Pre-Pandemic and Pandemic Periods

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Abstract

Dramatical fall in economic growth both in terms of COVID-19 pandemic and military threats actualizes the need to identify the drivers and inhibitors of ensuring the country competitiveness. Instead, in the conditions of intense load on the public health system caused by both the challenges of the COVID-19 pandemic and military threats, the definition of these drivers and inhibitors among public health factors is of critical importance. The purpose of this study is to identify the impact of public health factors on the level of the country's competitiveness, as well as the change of these causal patterns in the context of the unfolding of the coronavirus disease (COVID-19). For the empirical implementation of the research goal, several hypotheses have been formed: hypothesis 1 – improving the efficiency of the public health system has a positive effect on the country's competitiveness (both in pre-pandemic and pandemic periods); hypothesis 2 – in the context of the spread of the COVID-19 pandemic, there was an increase in the significance of the influence of public health factors on the level of the country's competitiveness. The study involves the implementation of several stages: 1) formation of an integral index of the country's competitiveness; 2) modelling the impact of public health factors on the level of the country's competitiveness in the pre-pandemic and pandemic periods. Modelling of the influence of public health factors on the level of the country's competitiveness was carried out using panel data regression modelling and the Hausman test in the Stata/SE 14.2 software. The implementation of the theoretical part of the study proved the existence of five contextual clusters of scientific research on ensuring the country's competitiveness in the context of the spread of the coronavirus pandemic. The results of the practical approbation of the developed approach made it possible to partially confirm hypothesis 1 (among the factors characterizing the effectiveness of the public health system, only the birth rate, mortality rate, life expectancy, and number of hospital beds had a statistically significant impact on the country's competitiveness, while neither current nor capital expenditures on health care did not have a significant impact) and to confirm hypothesis 2 (in the context of the unfolding of the pandemic, the influence of relevant public health factors on the country's competitiveness increased).

Key words

competitiveness of the country, coronavirus disease, COVID-19, public health, health care expenditures.

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Introduction

In the conditions of the intensification of globalization and integration processes, the need to ensure the stability of the national economy is becoming more urgent due to the significant intensity and scale of cross-border interaction, the probability and speed of transmission of destructive processes. These processes were quite acutely manifested during the global financial crisis of 2007-2009, when the collapse of several systemically important financial institutions provoked a crisis in the financial and economic sector of a number of countries around the world (Dubina et al, 2020; Titko & Shina, 2017). The experience of the global financial crisis has shown that crisis phenomena are becoming more intense, and their consequences are becoming more large-scale. The negative synergy of the interstate transmission of destructive processes was also intensified during the outbreak of the COVID-19 pandemic, when, against the background of restrictive state interventions aimed at countering the spread of the coronavirus infection, there was a sharp decrease in the level of business activity, which resulted in a catastrophic decrease in the rate of economic growth (Letunovska et al., 2021; Titko et al., 2015; Komańda, 2022). Thus, according to forecasts of experts of the International Monetary Fund (International Monetary Fund, 2022) in 2023, the dynamics of economic growth among the countries of the world will decrease to the level that is the lowest result since 1970. It is also worth noting that in conditions where the intensity of crisis processes and the scale of transmission of destructive shocks is rapidly increasing, it is important to identify the determinants of ensuring the state's competitiveness. At the same time, in the conditions of intense load on the public health system caused by both the challenges of the COVID-19 pandemic and military threats, the identification of drivers and inhibitors of ensuring the state's competitiveness among public health factors is gaining relevance. In addition, an important task is to identify changes in the patterns of ensuring the state's competitiveness, caused precisely by the challenges of the COVID-19 pandemic. All this determines the relevance, purpose and tasks of this research.

1. Literature review

In order to formalize the theoretical basis for ensuring the competitiveness of the state and the determinants that affected it in the conditions of the COVID-19 pandemic, relevant scientific Scopus publications were analysed (Scopus, 2024). In particular, 292 scientific publications were selected for the sample, the title, abstract or keywords of which contain such concepts as "competitiveness" AND "country" AND "COVID-19". So, by processing keywords in publications on a certain issue using the VOSviewer software (VOSviewer, 2024), a visualization map was built, which is presented in Figure 1.

Thus, according to the results of the bibliometric analysis, it is possible to note the existence of several meaningful directions of scientific research in the context of ensuring countries' competitiveness in the conditions of the COVID-19 pandemic, namely:

- red cluster – represents a scientific direction within which researchers are focused on identifying the impact of population employment, trade and the development of various industries on the country's competitiveness;
- green cluster – covers scientific research on the identification of the role of digital technologies, artificial intelligence, economic determinants and economic crises in ensuring the country's competitiveness;

- blue cluster – covers scientific publications on identifying the impact of governance, education, human potential development, labour productivity, as well as the impact of the COVID-19 pandemic and public health on the country's competitiveness;
- yellow cluster – integrates scientific results in the sphere of the impact of the development of commerce, entrepreneurship and management of supply chains in ensuring the country's competitiveness;
- purple cluster – covers scientific papers regarding the role of globalization and tourism in ensuring the country's competitiveness.

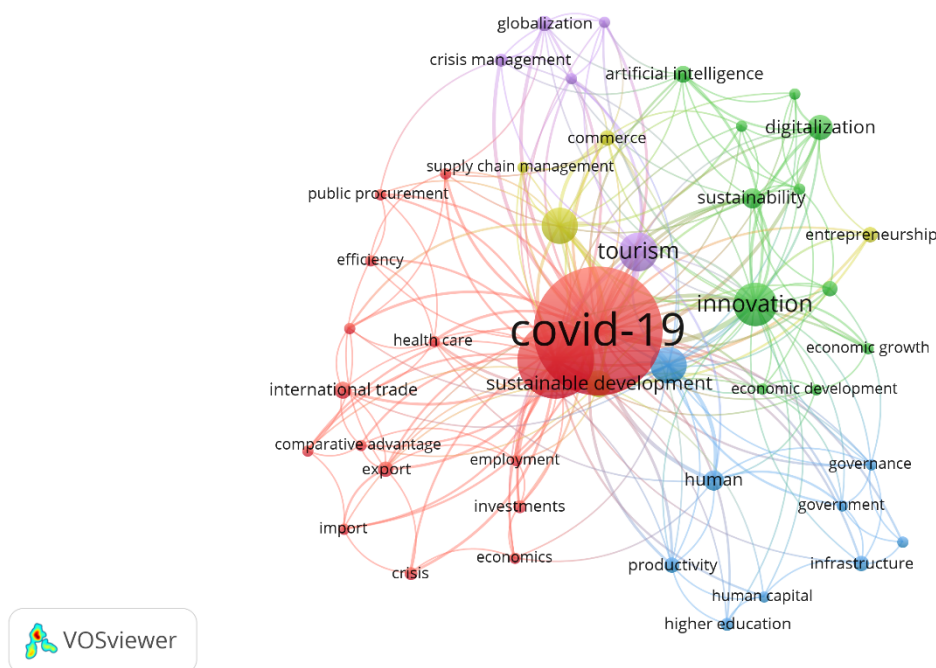


Figure 1. Co-occurrence map of key words in Scopus publication on country competitiveness in terms of COVID-19

Source: created with VOSviewer (VOSviewer, 2024) based on information from Scopus (Scopus, 2024).

According to the results of the bibliometric analysis of Scopus publications, it can be noted that ensuring the country's competitiveness depends on a number of various factors, including both socio-economic and digital determinants. An in-depth analysis of existing publications on relevant issues made it possible to underline more specific scientific results, the general trends of which were revealed during the bibliometric analysis. Thus, a rather popular scientific direction is the study of the impact of education (Çidik et al., 2023), the development of human potential and labour productivity in the context of ensuring the country's competitiveness (Lyulyov et al., 2018; Chygryn et al., 2023; Szczepanska-Woszczyna, Bogaczyk, 2023). The generalization of scientific research proved that investing in the development of human capital, improving qualifications and developing professional competences allows to increase labour productivity, which, in turn, allows to obtain additional competitive advantages in the domestic and foreign markets.

One of the important focuses of scientific research in terms of clarifying social determinants of country's competitiveness is the study of the peculiarities of migration processes. Thus, the analysis of the trends of internal migration of the population allows to balance the urban development of the

territories, to contribute to the reduction of the socio-economic gap between the urban and rural territories due to the use of appropriate regulatory interventions. Instead, the determination of trends in external migration of the population allows taking into account all the risks and opportunities of such a labour flow in the context of ensuring the competitiveness of the national economy (Kwilinski et al., 2022). eAt the same time, the strengthening of globalization and integration processes, taking into account cross-cultural factors and the expansion of export-import operations contribute to the active involvement of the country in foreign economic activity and the opportunities to develop new markets, modernize production technologies and obtain additional competitive advantages (Dacko-Pikiewicz, 2019; Szczepańska-Woszczyna et al., 2022; Dzwigol, 2021).

No less important than socio-demographic parameters are natural resource factors. Thus, countries with a higher level of competitiveness have larger reserves of land resources characterized by good fertility, as well as a larger reserve of natural resources that can be developed for the development of industry (Hussain et al., 2021). However, the presence of rich natural resource potential or, on the contrary, its absence is not an exclusive prerequisite for the presence or absence of a country's competitiveness. Thus, in countries rich in natural resources, in the absence of proper infrastructure and other related prerequisites, there may be a rather mediocre level of competitiveness. Instead, countries that are not rich in natural resources have the opportunity to gain additional competitive advantages due to the effective use of existing potential and its multiplication with the use of innovative technologies. The positive role of innovation in ensuring the country's competitiveness is also confirmed by Hakhverdyan & Shahinyan (2022), Szczepańska-Woszczyna (2018), Szczepańska-Woszczyna et al. (2021), Baltgailis & Simakhova (2022).

At the current stage of the development of global economic relations, the competitiveness of the national economy is significantly determined by environmental factors (Panchenko et al., 2021), because only countries that constantly introduce eco-innovations and use a wide range of environmental protection technologies have prospects for sustainable development, and therefore for the growth of the country's competitiveness (Chen et al., 2023; Dzwigol et al., 2023; Kwilinski et al., 2023; Titko et al., 2013; Veckalne & Tambovceva, 2023; Spicka, 2018; Spicka et al., 2019). Reducing the level of energy dependence is also one of the main prerequisites for ensuring the national security of the state and the competitiveness of the national economy. In particular, reducing the level of energy dependence can be achieved through the active development of renewable energy (Ziabina, & Pimonenko, 2020; Ziabina, Y., Pimonenko et al., 2021; Ortina, et al., 2023).

The development of the institutional environment is also defined by scientists as an important prerequisite for ensuring the country's competitiveness, since even under good initial conditions, the lack of good governance (corruption, instability of legislation, etc.) can lead to irrational use and waste of existing potential (Dzwigol, 2019; Dzwigol, 2023; Szczepańska-Woszczyna, Kurowska-Pysz, 2016). Among the micro-level determinants of ensuring business and economic competitiveness, the use of digital technologies (Ortina et al., 2023) and artificial intelligence to optimize business processes and production technologies is gaining importance (Chygryn et al., 2022; Tambovceva et al., 2020; Wang et al., 2022; Us et al., 2021; Melnychenko, 2019; Miśkiewicz, 2019; Trushkina et al., 2020; Trzeciak et al., 2022; Zhanibek et al., 2022; Grebosz-Krawczyk & Siuda, 2022; Seržantė & Pakalka, 2022; Di Sabato & Kozáková, 2023). It is worth noting that the implementation of digital technologies is impossible without significant investments (Kostiukevych et al., 2020), which is also determined in numerous studies (Moskalenko et al., 2022a; Lyulyov & Moskalenko, 2020; Szczepańska-Woszczyna, Gatnar,

2022). At the same time, there is a lack of scientific research aimed at determining the role of public health factors in ensuring the country's competitiveness both in the conditions of the COVID-19 pandemic and in the pre-pandemic period (Letunovska et al., 2022), which determines the need for further research in this direction.

2. Methodology

The purpose of this study is to determine the impact of public health factors on the level of the country's competitiveness, as well as the change of these causal patterns in the context of the spread of the coronavirus pandemic. Thus, for the empirical implementation of the research goal, several hypotheses were formed:

Hypothesis 1: improvement of the efficiency of the public health system has a positive effect on the country's competitiveness (both in pre-pandemic and pandemic periods);

Hypothesis 2: in the conditions of the spread of the COVID-19 pandemic, there was an increase in the significance of the influence of public health factors on the level of the country's competitiveness.

In order to test the proposed hypotheses, an array of statistical data was formed for a geographical sample of 15 European countries with common trends in socio-economic development (Albania, Bulgaria, Croatia, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Moldova, Poland, Romania, Serbia, Slovakia, Slovenia and Ukraine). The time period of the study covers both pre-pandemic and pandemic periods (2000–2022).

2.1 Formation of the country's competitiveness index

Taking into account the fact that there are no comparable international ratings or indices that allow to assess the state of the country's competitiveness on a single scale both in the pre-pandemic and pandemic periods (the latest report, in which it is presented the results of the Global Competitiveness Index from World Economic Forum, have been published in 2020 (Schwab, Zahidi, 2020), while the results of the World Competitiveness Ranking from the International Institute for Management Development (IMD, 2024) cover only 2019-2023), the it was developed own country competitiveness index, taking into account the basic methodological aspects of both indicated indices.

In particular, 18 indicators were initially selected to assess the level of the country's competitiveness: Agricultural land (% of land area) (Agr_L); Control of Corruption: Estimate (CC); Government Effectiveness: Estimate (GE); Regulatory Quality: Estimate (RQ); Political Stability and Absence of Violence/Terrorism: Estimate (PS); Current account balance (% of GDP) (CAB); Employment to population ratio, 15+, total (%) (Empl); Foreign direct investment, net inflows (% of GDP) (FDI); GDP growth (annual %) (GDPg); General government final consumption expenditure (% of GDP) (GGFCE); Gini index (Gini); Gross fixed capital formation (% of GDP) (GFCF); Inflation, consumer prices (annual %) (CPI); New business density (new registrations per 1,000 people ages 15-64) (Bus); Portfolio investment, net (BoP, current US\$) (Portfolio); Tax revenue (% of GDP) (Tax_rev); Trade (% of GDP) (Trade); Total reserves in months of imports (Res). The statistical array of the above indicators for 15 European countries for 2000-2022 was formed from the collections of the World Bank Group (World Bank DataBank, 2024).

The formation of the integrated index of the country's competitiveness involves the implementation of several consecutive procedures. First, all indicators must be brought to a comparable measurement, because they have different units of measurement. Considering the existence of negative values for some indicators, it is first necessary to transform all data into non-negative values by adding to all

current values of the indicators the largest absolute negative value of the indicator. After bringing all indicators for non-negative values, they must be brought to a comparable form, taking into account the nature of their influence on the future integral indicator. Considering the existence of zero values among the values of the individual indicators, the application of the simplest approaches to normalization is impossible, and therefore the normalization will be carried out using combination of the natural normalization and Savage normalization. Thus, among the entire set of individual indicators for assessing the country's competitiveness, only two – the Gini index and Inflation, consumer prices (annual %) – are inhibitors, that is, their increase leads to a deterioration of the country's competitiveness. Normalization of inhibitor indicators will be carried out using Savage normalization according to the formula:

$$cci_n = \frac{cci_{max} - cci_i}{cci_{max} - cci_{min}} \quad (1)$$

where cci_n is the value of the individual indicator for assessing the country's competitiveness after the normalization procedure; cci_i – the value of the individual indicator of the country's competitiveness, which is normalized; cci_{min} – the minimum value of the individual indicator of the country's competitiveness; cci_{max} – the maximum value of the individual indicator of the country's competitiveness.

The remaining individual indicators of the country's competitiveness have a positive effect on the integrated indicator, so their normalization will be carried out using natural normalization according to the formula:

$$cci_n = \frac{cci_{max} - cci_{min}}{cci_i - cci_{min}} \quad (2)$$

where cci_n is the value of the individual indicator for assessing the country's competitiveness after the normalization procedure; cci_i – the value of the individual indicator of the country's competitiveness, which is normalized; cci_{min} – the minimum value of the individual indicator of the country's competitiveness; cci_{max} – the maximum value of the individual indicator of the country's competitiveness.

After bringing the indicators to a comparable form, all the values of the individual indicators of the country's competitiveness will be in the range from 0 to 1, where a higher value of the indicator is characterized by a better influence on the integrated indicator. Since the preliminary selection of indicators for assessing the country's competitiveness was carried out using an expert-monographic approach, it is advisable to check the indicators for the existence of internal consistency. Cronbach's alpha test in Stata/SE 14.2 software was used for this purpose. As it is mentioned in Stata manual (Stata, 2023) "Cronbach's alpha assesses the reliability of a summative rating scale composed of the variables (called items) specified". If the results of the test determine an individual indicator that worsens the internal consistency of the indicators, then they will be eliminated. At the next stage, it is necessary to determine the weighting coefficients of the contribution of each of the individual indicators of the country's competitiveness to the integrated indicator. To perform the task, the principal

component analysis in the Stata/SE 14.2 software will be applied. This process involves the implementation of several sequential procedures, namely:

- selection of the minimum number of principal components, the eigenvalues of which will be used to identify the importance of the contribution of individual indicators to the integral. When choosing the number of principal components, both graphic and analytical approaches will be used. Thus, according to the graphical approach, a graph of the scree plot will be constructed using the Stata software, based on which the number of principal components is selected, at which the intensity of the decrease of the eigenvalues of the principal components slows down. In addition, the correctness of this choice will be checked using an analytical approach, since, as a rule, the number of principal components characterizing more than 70% of the total variation of variables is chosen;
- determining the ranks of individual indicators of the country competitiveness according to the Fishburne approach. On the basis of averaging the absolute eigenvalues of individual indicators from the principal components selected at the previous stage, the indicators are assigned ranks. If the difference between the levels of averaged absolute eigenvalues of individual indicators is not significant, then the indicators are assigned the same rank;
- determination of the weight coefficients of individual indicators for assessing the level of country competitiveness by the ratio of the rank of the individual indicator to the total sum of ranks.

At the final step of this stage, the country's competitiveness index is determined by adding the multiplications of the actual normalized values of individual indicators to their weighting coefficients.

2.2 Modelling the influence of public health factors on the level of the country's competitiveness in the pre-pandemic and pandemic periods

To test hypothesis 1 regarding the positive impact of improving the public health system efficiency on the country's competitiveness in the pre-pandemic and pandemic periods, panel data regression models in the Stata/SE 14.2 software will be built, and the model specification (fixed or random effects) will be determined using the Hausman test. To determine causality in the pre-pandemic period, a model will be built only for the period 2000-2019. Instead, the following indicators will be chosen as factor variables: Birth rate, crude (per 1,000 people) (Birth); Capital health expenditure (% of GDP) (CHE); Current health expenditure (% of GDP) (CurHE); Death rate, crude (per 1,000 people) (Death); Hospital beds (per 1,000 people) (Beds); Life expectancy at birth, total (years) (Life). In turn, to determine the impact of public health factors on country's competitiveness during the pandemic period, two additional variables will be added – total COVID-19 cases, per million cumulative and total COVID-19 death, per million cumulative. The modelling period is 2020-2022. In order to test hypothesis 2 about the impact of public health factors on the level of the country's competitiveness increase during the COVID-19 pandemic period, the strength and direction of the relationship between the relevant independent and dependent variables in the model for the pre-pandemic and pandemic periods will be compared.

3. Research results

3.1 Formation of the integrated index of the country's competitiveness

After normalization of 18 selected individual indicators of country's competitiveness measurement using the Savage formula (formula 1) and natural normalization (formula 2), all indicators are in the range from 0 to 1. In order to check the internal consistency of the indicators, the Cronbach's alpha test was applied, the results of the first iteration of which are presented in Table 1.

Table 1. Cronbach's alpha test results (1st iteration)

Item	Item-test correlation	Item-rest correlation	Average interitem correlation	Alpha
Agr_L	0.5365	0.4462	0.1815	0.7904
CC	0.8518	0.8147	0.1615	0.7660
GE	0.8602	0.8251	0.1610	0.7653
RQ	0.8151	0.7701	0.1638	0.7691
PS	0.7184	0.6548	0.1700	0.7768
CAB	0.3979	0.2940	0.1903	0.7998
Empl	0.3104	0.2006	0.1959	0.8055
FDI	0.2451	0.1322	0.2000	0.8096
GDPg	0.3099	0.2001	0.1959	0.8055
GGFCE	0.3567	0.2498	0.1929	0.8025
Gini	0.4382	0.3377	0.1878	0.7972
GCF	0.2065	0.0924	0.2025	0.8119
CPI	0.4332	0.3322	0.1881	0.7975
Bus	0.6183	0.5387	0.1763	0.7844
Portfolio	0.1356	0.0200	0.2070	0.8161
Tax_rev	0.1470	0.0315	0.2063	0.8154
Trade	0.7163	0.6524	0.1701	0.7770
Res	0.5425	0.4529	0.1811	0.7899
Test scale			0.1851	0.8035

Source: authors' calculations in Stata/SE 14.2 software.

After the first iteration, the "Portfolio" variable was eliminated, after the second iteration – the "Tax_rev" variable, after the third – the "GCF" variable. This made it possible to increase the internal consistency of indicators from 0.8035 to 0.8478. Further removal of indicators led to worsening of the test results. Thus, for the formation of the country's competitiveness index, it is advisable to choose 15 of the 18 individual indicators that were primarily selected.

At the next stage, the principal component analysis was used, the results of the first stage of which are presented in Table 2 and Figure 2.

Table 2. Results of Principal Component Analysis

Component	Eigenvalue	Difference	Proportion	Cumulative
Comp1	5.3387	3.4305	0.3559	0.3559
Comp2	1.9082	0.4178	0.1272	0.4831
Comp3	1.4904	0.2113	0.0994	0.5825
Comp4	1.2791	0.2168	0.0853	0.6678
Comp5	1.0623	0.2790	0.0708	0.7386
Comp6	0.7833	0.0888	0.0522	0.7908
Comp7	0.6945	0.1589	0.0463	0.8371
Comp8	0.5355	0.0427	0.0357	0.8728
Comp9	0.4929	0.0353	0.0329	0.9057
Comp10	0.4576	0.1207	0.0305	0.9362
Comp11	0.3369	0.0379	0.0225	0.9586
Comp12	0.2990	0.1235	0.0199	0.9786
Comp13	0.1755	0.0803	0.0117	0.9903
Comp14	0.0952	0.0443	0.0063	0.9966
Comp15	0.0509	.	0.0034	1.0000

Source: authors' calculations in Stata/SE 14.2 software.

The combination of graphic (Figure 2) and analytical (Table 2) approaches allowed us to determine that it is optimal to choose 6 principal components, which together explain 79.08% of the total variation of factors.

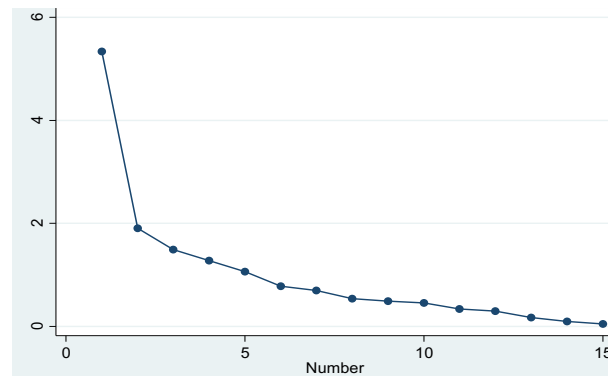


Figure 2. Scree plot of eigenvalues after Principal Component Analysis

Source: authors' calculations in Stata/SE 14.2 software.

According to the data in Table 3, it can be noted that among the indicators for assessing the level of country's competitiveness, the most significant are Foreign direct investment, net inflows (% of GDP) and General government final consumption expenditure (% of GDP). In turn, the least influential are control of corruption, government efficiency and regulatory quality.

Table 3. Results of identification of weighting coefficients

Variable	Comp1	Comp2	Comp3	Comp4	Comp5	Comp6	Av_comp	Rank	Weight
Agr_L	0.2422	0.4156	0.0846	0.0129	0.1961	0.1193	0.1785	3	0.0417
CC	0.3982	0.1489	0.0088	0.074	0.0309	0.0053	0.1110	1	0.0139
GE	0.4047	0.1061	0.0571	0.0312	0.0207	0.0475	0.1112	1	0.0139
RQ	0.3856	0.1345	0.0382	0.0246	0.0076	0.1113	0.1170	1	0.0139
PS	0.3503	0.1609	0.0057	0.2534	0.1556	0.1006	0.1711	2	0.0278
CAB	0.1817	0.3077	0.3934	0.1903	0.1165	0.014	0.2006	5	0.0694
Empl	0.1108	0.4176	0.3885	0.0409	0.2241	0.3895	0.2619	8	0.1111
FDI	0.0030	0.0900	0.1997	0.199	0.8279	0.3483	0.2780	9	0.1250
GDPg	0.0213	0.2216	0.5717	0.2382	0.0225	0.5117	0.2645	8	0.1111
GGFCE	0.1488	0.0765	0.3913	0.4876	0.1693	0.4045	0.2797	9	0.1250
Gini	0.1662	0.5056	0.0228	0.2088	0.1292	0.01	0.1738	3	0.0417
CPI	0.1857	0.0601	0.1425	0.6206	0.1755	0.1463	0.2218	6	0.0833
Bus	0.2604	0.107	0.1758	0.3242	0.2928	0.3389	0.2499	7	0.0972
Trade	0.3061	0.2771	0.1395	0.0674	0.1557	0.2091	0.1925	4	0.0556
Res	0.2368	0.2649	0.3022	0.1352	0.0117	0.2868	0.2063	5	0.0694

Source: authors' calculations in Stata/SE 14.2 software

Taking into account the weighting factors defined in Table 3, the country's competitiveness index was calculated, the dynamics of which are presented at Figure 3. According to the results of the analysis of the dynamics of the countries' competitiveness index for 15 European countries for 2000-2022, it can be noted that the level of this indicator ranges from 0.32 to 0.62 with the maximum value of the indicator – 1. In particular, the Czech Republic and Estonia belong to the countries with the highest level of competitiveness. The group of countries catching up to the leaders is formed by Bulgaria, Croatia, Hungary, Latvia, Lithuania, Moldova, Poland, Romania, Slovakia and Slovenia. The rest of the countries have a below-average level of country competitiveness. In addition, it is worth noting that for most of the countries in the sample, the trend of the change in the level of the indicator is gentle and mostly upward (with a slight drop during the coronavirus pandemic). However, for Hungary and Moldova, the drop in the level of competitiveness after 2020 is more critical. On the other hand, the level of competitiveness of Ukraine during the studied period decreased critically twice – after the

global financial crisis and after the start of military invasion to Ukraine. However, the COVID-19 pandemic did not have such a dramatical effect on Ukraine's competitiveness.

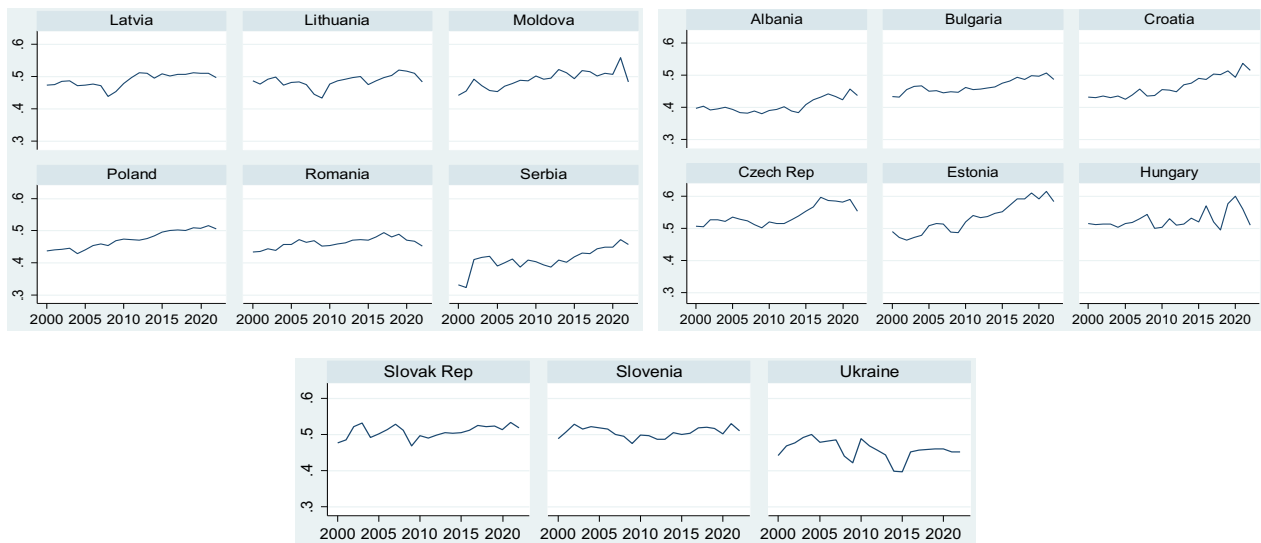


Figure 3. Dynamic of Country Competitiveness Index in 15 European countries in 2000–2022

Source: authors' calculations in Stata/SE 14.2 software.

3.2. Modelling the influence of public health factors on the level of the country's competitiveness in the pre-pandemic and pandemic periods

Before the regression analysis, the descriptive statistics of all variables might be performed (Table 4).

Table 4. Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max	Variable	Obs	Mean	Std. Dev.	Min	Max
Agr_L	345	0.48	0.26	0	1	Portfolio	345	0.65	0.09	0	1
CC	345	0.45	0.22	0	1	Tax_rev	345	0.53	0.20	0	1
GE	345	0.55	0.27	0	1	Trade	345	0.50	0.19	0	1
RQ	345	0.56	0.23	0	1	Res	345	0.36	0.21	0	1
PS	345	0.72	0.18	0	1	CCI	345	0.48	0.05	0.32	0.62
CAB	345	0.60	0.16	0	1	Birth	345	10.19	1.39	6.97	17.08
Empl	345	0.40	0.16	0	1	CHE	345	0.29	0.18	0	0.93
FDI	345	0.30	0.06	0	1	CurHE	345	6.83	1.29	4.21	13.68
GDPg	345	0.75	0.11	0	1	Death	345	12.33	2.39	5.8	20.18
GGFCE	345	0.30	0.10	0	1	Beds	345	6.22	1.36	2.88	9.4
Ginny	345	0.69	0.19	0	1	Life	345	74.52	3.07	66.42	81.53
GCF	345	0.44	0.18	0	1	Covid_cases	45	116524.99	100046.39	20309.83	456046.03
CPI	345	0.94	0.09	0	1	Covid_death	45	1415.93	766.54	176.46	3447.24
Bus	345	0.15	0.15	0	1						

Source: authors' calculations in Stata/SE 14.2 software.

To test hypothesis 1 regarding the positive impact of improving the efficiency of the public health system on the country's competitiveness in the pre-pandemic and pandemic periods, panel data regression models were built. The Hausman test made it possible to confirm that in the context of determining the impact of public health factors on the country's competitiveness in the pre-pandemic period, the model with fixed effects is more effective (Table 5).

Table 5. Regression results on relationships between Country Competitiveness Index and public health determinants for 15 European countries in 2000-2019 (fixed effects model)

CCI	Coef.	St. Err.	t-value	p-value	95% Confidence Interval		Sig
Birth	-0.0026221	0.0015224	-1.72	0.086	-0.01	0	*
CHE	0.0002827	0.0085871	0.03	0.974	-0.02	0.02	
CurHE	0.0009131	0.0017653	0.52	0.605	0	0	
Death	-0.0071334	0.0022374	3.19	0.002	0	0.01	***
Beds	0.0055396	0.0022591	2.45	0.015	0	0.01	**
Life	0.0093725	0.0009197	10.19	0.000	0.01	0.01	***
Constant	-0.3199525	0.073868	-4.33	0.000	-0.47	-0.17	***
F-test		29.206	Prob > F		0.000		
Akaike crit. (AIC)		-1516.013	Bayesian crit. (BIC)		-1490.087		

Note: *** p<.01, ** p<.05, * p<.1

Source: authors' calculations in Stata/SE 14.2 software.

On the other hand, to detect the same cause-and-effect relationship during the pandemic pandemic, both models confirmed their effectiveness, but the model with fixed effects is also more reliable (Table 6).

Table 6. Regression results on relationships between Country Competitiveness Index and public health determinants for 15 European countries in 2020-2022 (fixed effects model)

CCI	Coef.	St.Err.	t-value	p-value	95% Confidence Interval		Sig
Birth	-.0135534	.0166119	-0.82	0.423	-.05	.02	
CHE	.0137972	.0675853	0.20	0.840	-.13	.15	
CurHE	.0080856	.0063033	1.28	0.213	0	.02	
Death	-.0138065	.0069723	1.98	0.060	0	.03	*
Beds	-.0195758	.0089599	-2.18	0.040	-.04	0	**
Life	.0172587	.0086432	2.00	0.058	0	.04	*
Covid_cases	-1.80e-08	4.59e-08	-0.39	0.698	0	0	
Covid_death	5.94e-06	5.42e-06	1.10	0.285	0	0	
Constant	-.81	.64	-1.26	0.222	-2.14	.53	
F-test		1.937	Prob > F		0.064		
Akaike crit. (AIC)		-249.407	Bayesian crit. (BIC)		-233.147		

Note: *** p<.01, ** p<.05, * p<.1

Source: authors' calculations in Stata/SE 14.2 software

Thus, according to the simulation results, it was established that for the studied 15 European countries in the pre-pandemic period (2000-2019), the relevant public health factors for ensuring country competitiveness are: a decrease in the mortality rate (a decrease in the independent variable by 1 unit leads to an increase in the Country Competitiveness Index by 0.007 units), an increase in the number of hospital beds (an increase in the factor indicator by 1 unit causes an increase in the effective indicator by 0.006 units) and life expectancy (an increase in the independent variable by 1 year causes an increase in the effective indicator by 0.009 units). Moreover, the influence of the rest public health factors are insignificant. Specifically, an increase in both current and capital expenditures on health care does not have a statistically significant effect on the performance indicator.

In turn, the modelling of the impact of public health factors on the Country Competitiveness Index during the pandemic proved the relevance of practically the same set of determinants, but the direction of their influence is somewhat different. In particular, it was determined that the country's

competitiveness is inhibited by an increase in the mortality rate (a decrease in the independent variable by 1 unit leads to an increase in the Country Competitiveness Index by 0.014 units) and the number of hospital beds (an increase in the factor indicator by 1 unit leads to a decrease in the effective indicator by 0.019 units), and the driver is an increase in life expectancy (an increase in the independent variable by 1 year causes an increase in the performance indicator by 0.017 units).

Conclusions

Thus, on the basis of the conducted research results, it was partially confirmed hypothesis 1, since the significance of certain public health factors on the country's competitiveness, in particular, such as the birth rate and mortality rate, life expectancy and number of hospital beds was confirmed. However, the significance of the impact in the context of strengthening the country's competitiveness of such factors as the growth of current and capital expenditures on health care was not confirmed. At the same time, on the basis of the second model, hypothesis 2 was also fully confirmed. It is confirmed that during the COVID-19 pandemic, there was an increase in the significance of the influence of those public health factors, the relevance of which influence on the level of the country's competitiveness was confirmed in the pre-pandemic period. Thus, the strength of the negative impact of an increase in the mortality rate on country's competitiveness increased from 0.007 to 0.014 units, the strength of the positive effect of the increase in the life expectancy on the performance indicator increased from 0.009 to 0.017 units. The influence of the increase in the number of hospital beds also increased from 0.006 to 0.019 units. However, in the pre-pandemic period, this effect was positive, while during the pandemic, it turned into a negative one. It is also worth emphasizing two special points. First, it was established that in the pre-pandemic period, the increase in the birth rate had a negative impact on the country's competitiveness, which may be due to the increase in the load on both the social security system and the health care system, which increases state expenditures, diverting financial resources from investments in sustainable economic growth. Secondly, during the COVID-19 pandemic, the direction of the influence of the increase in the number of hospital beds on the level of the country's competitiveness changed from positive to negative. This can also be explained by the excessive load on the system of financial support of the health care system, which also diverts financial resources from more productive areas. These conclusions are also confirmed by the lack of statistical significance of the impact of the growth of current and capital healthcare expenditures on the country's competitiveness.

Thus, it can be concluded that the country's competitiveness both in crisis conditions (the unfolding of the coronavirus pandemic) and in a more stable period (pre-pandemic period) depends on the efficiency of the health care system, which is manifested in a decrease in the mortality rate and an increase in life expectancy. However, the increase in the number of hospital beds as a factor of the infrastructural capacity of the public health system has different effects on the country's competitiveness in crisis and stable conditions. Thus, in stable conditions, this public health factor has a positive effect, and in crisis – when the load on the health care system is excessive – it becomes negative. Taking into account the above, it can be noted that in order to ensure the country's competitiveness, it is advisable to create favourable conditions for ensuring the health of the population in periods of stability, while forming a margin of safety for more volatile periods.

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Reference

1. Baltgailis, J., & Simakhova, A. (2022). The Technological Innovations of Fintech Companies to Ensure the Stability of the Financial System in Pandemic Times. *Marketing and Management of Innovations*, 2, 55-65. <https://doi.org/10.21272/mmi.2022.2-05>
2. Chen, Y., Lyulyov, O., Pimonenko, T., Kwilinski, A. (2023). Green development of the country: Role of macroeconomic stability. *Energy & Environment*, 0(0). <https://doi.org/10.1177/0958305x231151679>
3. Chygryn, O., Kolosok, S., & Hordiienko, V. (2022). Digital Eco-Energy: Patterns of Achieving Economic Leadership, National Security, and Sustainability. In *PRIZK International Conference-Novel Insights in the Leadership in Business and Economics After the COVID-19 Pandemic*, 329-341.
4. Chygryn, O., Ziabina, Y., & Isakov, A. (2023). Communicative Channels of Stakeholder Interaction as an Element of Ensuring Sustainable Development of the Business Sector. In *E3S Web of Conferences*, 456, 02001
5. Çidik, M. S., Schiller, G., Zhang, N., Rizzo, A., Tambovceva, T., Bajare, D., & Hendawy, M. (2023). How Does ‘Locality’ Matter in Enabling a Circular Built Environment?: A Focus on Space, Knowledge, and Cities. In *Creating a Roadmap Towards Circularity in the Built Environment*, 251-261.
6. Dacko-Pikiewicz, Z. (2019). The selected aspects of strategic management in the city divided by the border in the context of the development of the cross-border market of cultural services [Wybrane aspekty zarządzania strategicznego w mieście podzielonym granicą w kontekście rozwoju transgranicznego rynku usług kulturalnych]. *Polish Journal of Management Studies*, 19(1), 130–144.
7. Di Sabato, V., & Kozáková, J. (2023). Investigation of CSR Activities Connected to Covid-19 in Czech and Slovak Businesses. *Economics and Culture*, 20(1), 114-124
8. Dubina, O., Us, Y., Pimonenko, T., & Lyulyov, O. (2020). Customer loyalty to bank services: The bibliometric analysis. *Virtual Economics*, 3(3), 53-66.
9. Dzwigol, H. (2019). Research Methods and Techniques in New Management Trends: Research Results. *Virtual Economics*, 2019, 2(1), 31–48. [https://doi.org/10.34021/ve.2019.02.01\(2\)](https://doi.org/10.34021/ve.2019.02.01(2))

10. Dzwigol, H. (2021). The Uncertainty Factor in the Market Economic System: The Microeconomic Aspect of Sustainable Development. *Virtual Economics*, 4(1), 98–117. [https://doi.org/10.34021/ve.2021.04.01\(5\)](https://doi.org/10.34021/ve.2021.04.01(5))
11. Dzwigol, H. (2023). The Quality Determinants of the Research Process in Management Sciences. *Virtual Economics*, 6(2), 35–54. [https://doi.org/10.34021/ve.2023.06.02\(3\)](https://doi.org/10.34021/ve.2023.06.02(3))
12. Dzwigol, H., Kwilinski, A., Lyulyov, O., Pimonenko, T. (2023). Renewable Energy, Knowledge Spillover and Innovation: Capacity of Environmental Regulation. *Energies*, 16(3), 1117. <https://doi.org/10.3390/en16031117>
13. Grebosz-Krawczyk, M. & Siuda, D. (2022). The COVID-19 Pandemic Impact on the TV Commercials Content in European Countries. *Marketing and Management of Innovations*, 2, 76–85. <http://doi.org/10.21272/mmi.2022.2-07>
14. Hakhverdyan, D., & Shahinyan, M. (2022). Competitiveness, innovation and productivity of the country. *Marketing and Management of Innovations*, 1, 108–123. <https://doi.org/10.21272/mmi.2022.1-08>
15. Hussain, H.I., Haseeb, M., Kamarudin, F., Dacko-Pikiewicz, Z., Szczepańska-Woszczyna, K. (2021). The role of globalization, economic growth and natural resources on the ecological footprint in Thailand: Evidence from nonlinear causal estimations. *Processes*, 9, 1103. <https://doi.org/10.3390/pr9071103>
16. IMD (2024). World Competitiveness Ranking. <https://www.imd.org/centers/wcc/world-competitiveness-center/rankings/world-competitiveness-ranking/>
17. International Monetary Fund (2022). <https://www.imf.org/en/Publications/WEO/Issues/2022/07/26/world-economic-outlook-update-july-2022>
18. Komańda, M. (2022). Was it doomsday? first wave of the COVID-19 pandemic impact on the polish cultural industry. *Economics and Culture*, 19(1), 98–107.
19. Kostiukevych, R., Mishchuk, H., Zhidebekkyzy, A., Nakonieczny, J., & Akimov, O. (2020). The impact of European integration processes on the investment potential and institutional maturity of rural communities. *Economics & Sociology*, 13(3), 46–63.
20. Kwilinski, A., Lyulyov, O., Pimonenko, T. (2023). Environmental Sustainability within Attaining Sustainable Development Goals: The Role of Digitalization and the Transport Sector. *Sustainability*, 15, 11282. <https://doi.org/10.3390/su151411282>
21. Kwilinski, A., Lyulyov, O., Pimonenko, T., Dzwigol, H., Abazov, R., Pudryk, D. (2022). International Migration Drivers: Economic, Environmental, Social, and Political Effects. *Sustainability*, 14(11), 6413. <https://doi.org/10.3390/su14116413>
22. Letunovska, N., Abazov, R., Chen, Y. (2022). Framing a Regional Spatial Development Perspective: The Relation between Health and Regional Performance. *Virtual Economics*, 5, 87–99. [https://doi.org/10.34021/ve.2022.05.04\(5\)](https://doi.org/10.34021/ve.2022.05.04(5))
23. Letunovska, N., Yashkina, O., Saher, L., Alkhashrami, F. A., & Nikitin, Yu. (2021). Analysis of the model of consumer behavior in the healthy products segment as a perspective for the inclusive marketing development. *Marketing and Management of Innovations*, 4, 20–35. <https://doi.org/10.21272/mmi.2021.4-02>
24. Lyulyov, O., & Moskalenko, B. (2020). Institutional quality and shadow economy: An investment potential evaluation model. *Virtual Economics*, 3(4), 131–146.

25. Lyulyov, O., Chygryn, O., and Pimonenko, T. (2018). National brand as a marketing determinant of macroeconomic stability. *Marketing and Management of Innovations*, 3, 142-152. <https://doi.org/10.21272/mmi.2018.3-12>
26. Melnychenko, O. (2019). Application of artificial intelligence in control systems of economic activity. *Virtual Economics*, 2, 30-40. [https://doi.org/10.34021/ve.2019.02.03\(3\)](https://doi.org/10.34021/ve.2019.02.03(3)).
27. Miśkiewicz, R. (2019). Challenges facing management practice in the light of Industry 4.0: The example of Poland. *Virtual Economics*, 2, 37-47. [https://doi.org/10.34021/ve.2019.02.02\(2\)](https://doi.org/10.34021/ve.2019.02.02(2))
28. Moskalenko, B., Lyulyov, O., Pimonenko, T. (2022). The investment attractiveness of countries: coupling between core dimensions. *Forum Scientiae Oeconomia*, 10, 153-172. https://doi.org/10.23762/FSO_VOL10_NO2_8
29. Ortina, G., Zayats, D., Akimova, L., Akimov, O., & Karpa, M. (2023). Economic Efficiency of Public Administration in the Field of Digital Development. *Economic Affairs*, 68(3), 1543-1553.
30. Panchenko, O., Domashenko, M., Lyulyov, O., Dalevska, N., Pimonenko, T., & Letunovska, N. (2021). Objectivation of the Ecological and Economic Losses from Solid Domestic Waste at the Heating Enterprises. *Management Systems in Production Engineering*, 29(3), 235-241
31. Schwab, K., Zahidi, S. (2020). The Global Competitiveness Report. How Countries are Performing on the Road to Recovery. *The World Economic Forum*. https://www3.weforum.org/docs/WEF_TheGlobalCompetitivenessReport2020.pdf
32. Scopus (2024). <https://www.scopus.com/search/form.uri?display=basic&zone=header&origin=searchbasic#basic>
33. Seržantė, M., & Pakalka, A. (2022). Assessment of the Impact of COVID-19 Pandemic on the Service Sector in Lithuania. *Economics and Culture*, 19(2), 57-69.
34. Spicka, J. (2018). How Do Agricultural Biogas Investments Affect Czech Farms? *Central European Business Review*, 7(4), 34-60. <https://doi.org/10.18267/j.cebr.205>
35. Spicka, J., Hlavsa, T., Soukupova, K., Stolbova, M. (2019), Approaches to estimation the farm-level economic viability and sustainability in agriculture: A literature review. *Agricultural Economics*, 65(6), 289-297. <https://doi.org/10.17221/269/2018-AGRICECON>.
36. Stata (2023). Manual for Cronbach's alpha. Retrieved from <https://www.stata.com/manuals/mvalpha.pdf>
37. Szczepańska-Woszczyna, K. (2018). Strategy, Corporate Culture, Structure and Operational Processes as the Context for the Innovativeness of an Organization. *Foundations of Management*, 10(1), 33-44.
38. Szczepańska-Woszczyna, K., & Bogaczyk, R. (2023). Organisational Climate and Employee Engagement – a Case Study of International Corporations. *Forum Scientiae Oeconomia*, 11(3), 9-29.
39. Szczepańska-Woszczyna, K., & Kurowska-Pysz, J. (2016). Sustainable business development through leadership in SMEs. *Engineering Management in Production and Services*, 8(3), 57-69.
40. Szczepańska-Woszczyna, K., Gatnar, S. (2022). Key Competences of Research and Development Project Managers in High Technology Sector. *Forum Scientiae Oeconomia*, 10, 107-130. https://doi.org/10.23762/FSO_VOL10_NO3_6
41. Szczepańska-Woszczyna, K., Gedvilaitė, D., Nazarko, J., Stasiukynas, A., Rubina, A. (2022). Assessment of Economic Convergence among Countries in the European Union. *Technological and Economic Development of Economy*, 28, 1572-1588. <https://doi.org/10.3846/tede.2022.17518>

42. Szczepańska-Woszczyna, K., Muras, W., & Pikiewicz, M. (2021). Shareholders in creating the value of IT sector companies by shaping organisational culture in the context of the digital economy. In I. Stańczyk, & M. M. Stuss (Eds.), *Sustainability, Technology and Innovation 4.0* (pp. 304–316). Routledge.
43. Tambovceva, T., Ivanov, I. H., Lyulyov, O., Pimonenko, T., Stoyanets, N., & Yanishevskaya, K. (2020). Food security and green economy: Impact of institutional drivers. *International Journal of Global Environmental Issues*, 19(1-3), 158-176.
44. Titko, J., & Shina, I. (2017). Non-financial value drivers: case of Latvian banks. *Procedia Engineering*, 178, 192-199.
45. Titko, J., Lace, N., & Kozlovskis, K. (2013). Service quality in banking: developing and testing measurement instrument with Latvian sample data. *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis*, 61(2), 507-515.
46. Titko, J., Lace, N., & Polajeva, T. (2015). Financial issues perceived by youth: preliminary survey for financial literacy evaluation in the Baltics. *Oeconomia Copernicana*, 6(1), 75-98.
47. Trushkina, N., Abazov, R., Rynkevych, N., Bakhautdinova, G. (2020). Digital Transformation of Organizational Culture under Conditions of the Information Economy. *Virtual Economics*, 3, 7-38. [https://doi.org/10.34021/ve.2020.03.01\(1\)](https://doi.org/10.34021/ve.2020.03.01(1)).
48. Trzeciak, M., Kopec, T.P., Kwilinski, A. (2022). Constructs of Project Programme Management Supporting Open Innovation at the Strategic Level of the Organization. *Journal of Open Innovation: Technology, Market, and Complexity*, 8, 58. <https://doi.org/10.3390/joitmc8010058>
49. Us, Y., Pimonenko, T., & Lyulyov, O. (2021). The impact of energy efficiency policy on Ukraine's green brand: a bibliometrics analysis. *Polityka Energetyczna*, 24(4), 5-18.
50. Veckalne, R., & Tambovceva, T. (2023). Sustainability in Regional Planning: A Bibliometric Analysis. *TalTech Journal of European Studies*, 13(1), 133-149.
51. VOSviewer (2024). <https://www.vosviewer.com/>
52. Wang, Q., Chen, Y., Guan, H., Lyulyov, O., & Pimonenko, T. (2022). Technological Innovation Efficiency in China: Dynamic evaluation and driving factors. *Sustainability*, 14(14), 8321.
53. World Bank DataBank. (2024). Retrieved from <https://databank.worldbank.org/home.aspx>
54. Zhanibek, A., Abazov, R., Khazbulatov, A. (2022). Digital Transformation of a Country's Image: The Case of the Astana International Finance Centre in Kazakhstan. *Virtual Economics*, 5, 71-94. [https://doi.org/10.34021/ve.2022.05.02\(4\)](https://doi.org/10.34021/ve.2022.05.02(4))
55. Ziabina, Y., & Pimonenko, T. (2020). The Green Deal Policy for renewable energy: a bibliometric analysis. *Virtual Economics*, 3(4), 147-168.
56. Ziabina, Y., Pimonenko, T., Lyulyov, O., Us, Y., & Proshkin, D. (2021). Evolutionary development of energy efficiency in the context of the national carbon-free economic development. In *E3S Web of Conferences*, 307, 09002.



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