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The Contribution of Higher Education to Innovation Development: Long-Term and Short-Term Analysis

Katarzyna Szczepanska-Woszczyna¹, Oleksii Lyulyov^{2*}, Tetyana Pimonenko³, Alfonso Infante-Moro⁴, Andrew Zimbhoff⁵, Serhii Solodovnikov⁶

¹ Institute for Sustainable Development and International Relations, WSB University, Dabrowa Gornicza, Poland
ORCID: 0000-0003-0731-8049
e-mail: kszczepanska@wsb.edu.pl

² Sumy State University, Sumy Ukraine;
Institute for Sustainable Development and International Relations, WSB University, Dabrowa Gornicza, Poland
ORCID: 0000-0002-4865-7306
e-mail: o.lyulyov@biem.sumdu.edu.ua

³ Sumy State University, Sumy Ukraine;
Institute for Sustainable Development and International Relations, WSB University, Dabrowa Gornicza, Poland
ORCID: 0000-0001-6442-3684
e-mail: t.pimonenko@biem.sumdu.edu.ua

⁴ University of Huelva, Huelva, Spain
ORCID: 0000-0002-0718-7053
e-mail: alfonso.infante@decd.uhu.es

⁵ College of Education and Human Sciences, University of Nebraska-Lincoln, Lincoln, USA
ORCID: 0000-0002-4535-879X
e-mail: zimbhoff@unl.edu

⁶ Sumy State University, Sumy, Ukraine
ORCID: 0009-0007-0822-098X
e-mail: s.solodovnikov@finance.sumdu.edu.ua

* Corresponding author: Oleksii Lyulyov, o.lyulyov@biem.sumdu.edu.ua

Abstract

The relationship between higher education and innovation development is pivotal to advancing Sustainable Development Goals (SDGs), particularly in fostering quality education (SDG 4), decent work and economic growth (SDG 8), and industry, innovation, and infrastructure (SDG 9). Understanding how higher education drives innovation can inform policies to develop human capital, accelerate technological progress, and promote sustainable economic and social development. This paper aims to assess the short-term and long-term impacts of higher education indicators on innovation development in Ukraine. Using data from 2014 to 2022, the study employs a vector error correction model to analyse the relationship between innovation development and higher education indicators. Innovation development was evaluated using the Malmquist productivity index, which incorporates time-series data from the Global Innovation Index to analyse short- and long-term dynamics in resource efficiency and innovation output, with a focus on Ukraine and the Visegrad Four countries for cross-country comparison. Methodological steps include stationarity testing with the ADF test, determining optimal lag length, Johansen cointegration analysis, Granger causality testing, and estimating impulse response functions. The results demonstrate a significant long-term equilibrium relationship between innovation development and higher education indicators. STEM graduates and higher education enrolment exhibit substantial positive long-term impacts, while research capacity and intellectual property payments show significant short-term effects. The findings underscore the transformative role of higher education as a driver of sustainable economic growth and

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technological progress. Theoretically, the study advances understanding of how education-driven human capital fosters innovation in transition economies. Practically, it offers evidence-based recommendations for policymakers to prioritise STEM education, support research initiatives, and enhance the use of intellectual property to build a robust and sustainable innovation system.

Key words

human capital, innovation, intellectual property, higher education, STEM, commercialisation, economic growth.



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Introduction

Higher education institutions (HEIs) play a vital role in fostering innovation and driving economic development, with their contributions evident in both short-term and long-term impacts. In the short term, HEIs collaborate with industries through joint research projects, consultancy services, and technology transfer offices, addressing immediate challenges and fostering innovation in processes, products, and services. They also equip graduates with contemporary skills tailored to industry needs, offering training programmes, certifications, and hackathons to address specific workforce gaps. Additionally, universities focus on applied research, developing prototypes and practical solutions in sectors such as healthcare, renewable energy, and digital transformation, while also serving as incubators for startups by providing resources, mentorship, and networking opportunities. Over the long term, HEIs build a knowledge-based workforce, emphasising critical thinking, creativity, and lifelong learning, while advancing foundational research that underpins transformative innovations. They institutionalise a culture of inquiry, influencing societal norms, ethics, and public understanding of science and technology. Moreover, universities act as hubs for regional development by attracting talent, investment, and infrastructure, enhancing regional and national competitiveness, and fostering global collaborations that address pressing challenges such as attaining sustainable development goals (Kwilinski et al., 2023b; 2023c; 2023d; 2024c; Kwilinski, 2024a), climate change (Karpenko et al., 2018), and energy security (Kharazishvili et al., 2021; Ziabina et al., 2023; Mlaabdal et al., 2024; Kwilinski et al., 2024a; 2024f).

However, some scholars argue that the contribution of HEIs to innovation development is not as significant or straightforward as often assumed. Critics point to the misalignment between academic research and market needs, arguing that much of the research conducted within universities lacks practical application and fails to address pressing industrial challenges (Perkmann et al., 2013). Furthermore, concerns about bureaucratic inefficiencies and the slow pace of academic innovation have been raised, with some asserting that HEIs struggle to adapt quickly enough to rapidly changing technological landscapes (Nwogu, 2024). There is also debate over the commercialisation of research, with detractors suggesting that the increasing focus on profit-driven innovation risks undermining the pursuit of fundamental knowledge and the societal mission of universities (Kezar & Bernstein-Sierra, 2024; Andrew et al., 2024). Additionally, critics highlight disparities in innovation contributions across regions, noting that well-funded universities in developed countries often dominate global innovation, while underfunded institutions in developing nations struggle to make comparable impacts (Altbach & Salmi, 2011).

Ayala-Mora et al. (2023) emphasise HEIs' contribution to digital governance by equipping graduates with administrative and technological skills, which improve short-term operational efficiency and support long-term digital transformation. Berg and Spicka (2023) discuss HEIs' role in promoting media literacy to combat misinformation, fostering informed citizens who support democratic innovation in the long term. Boyko et al. (2024) and Dacko-Pikiewicz (2019a, 2019b) underline the importance of educational programmes in strategic and financial management, addressing immediate skills gaps and building sustainable economic frameworks. Some studies (Infante-Moro et al., 2022a; Kharazishvili & Kwilinski, 2022) explore the integration of cybersecurity

and artificial intelligence, respectively, showing HEIs' short-term role in skill development and their long-term impact on embedding digital security and AI-driven policies. Kwilinski (2019, 2023b, 2024b) highlights blockchain and digital technologies' environmental applications, demonstrating how HEIs prepare students for immediate innovation while fostering interdisciplinary sustainable practices. Kwilinski & Vysochyna (2024) focus on healthcare financing, with HEIs addressing short-term administrative innovations and influencing long-term financial sustainability policies. Kwilinski et al. (2022, 2023a, 2024d) extend this to digital governance, emphasising HEIs' role in aligning digital business with public services for short-term innovation and long-term systemic governance improvements.

The synergies between short-term successes, such as spin-offs and applied research, and long-term investments in human capital and basic research reinforce the pivotal role of higher education in innovation ecosystems. However, to maximise their impact and address these criticisms, HEIs must overcome challenges such as funding constraints, misalignment with industry needs, and bureaucratic hurdles by strengthening academia–industry–government collaboration, increasing investment in research, promoting interdisciplinary partnerships, and aligning educational outcomes with innovation goals. By addressing these challenges and balancing short-term practical applications with the pursuit of long-term foundational knowledge, HEIs can continue to make significant contributions to innovation development across both short-term and long-term horizons. The relationship between higher education and innovation development has been extensively analysed in recent studies (Southworth et al., 2023; Michel-Villarreal et al., 2023; Wang et al., 2023; Adeel et al., 2023; Akcigit et al., 2024), underscoring the role of higher education institutions in fostering economic growth, technological advancement, and sustainable development. However, the existing body of research often suffers from two critical limitations. The vast range of studies relies on aggregated indices, such as the Global Innovation Index (GII), which, while useful, obscure the nuanced contributions of specific higher education indicators to innovation development. This aggregation often leads to a lack of clarity in understanding the mechanisms through which higher education impacts innovation. Second, the interplay between the short-term and long-term impacts of higher education on innovation remains underexplored. Studies tend to either focus on immediate effects, such as skill development and technology transfer, or emphasize long-term contributions, such as foundational research and human capital accumulation, without providing an integrated analysis of these dynamics. This research addresses these gaps by developing a methodological framework that integrates specific indicators of higher education into the analysis of innovation development. By applying a vector error correction model (VECM), this study captures both the short-term and long-term dynamics of the relationship, providing a robust analytical tool to understand the equilibrium adjustments in innovation development. The contribution of this research is threefold. First, it advances methodological innovation by quantifying the elasticity of innovation development with respect to individual higher education indicators, providing precise estimates that can guide policy formulation. Second, it offers empirical evidence on the differentiated short-term and long-term impacts of higher education on innovation, highlighting the pathways through which specific indicators contribute to sustainable economic growth. Finally, the study situates Ukraine within the broader context of innovation development in the Visegrad countries, offering insights into best practices and policy interventions that can enhance the country's innovation ecosystem.

The paper has the following structure: literature review—exploring the theoretical background on the role of the university in boosting innovation development; methodology—outlining the data resources, methods and instruments to check the research hypotheses; results—describing the empirical results of the investigation; discussion—comparison analysis of the obtained results with those of previous studies; and conclusion—summarising the core findings, outlining the policy implications, limitations and further directions for investigations.

1. Literature review

HEIs have a dual impact on innovation. Short-term contributions include skill development, research applications, and technological adoption, whereas long-term contributions focus on cultivating human capital, embedding innovation into economic structures, and aligning with global sustainability goals. Dementyev et al. (2021) analyse how innovation and information technologies restructure global political and economic systems. Higher education contributes to the short term by advancing research and technology that improve decision-making. Long-term contributions include shaping global innovation ecosystems and fostering sustainable development. Gigauri et al. (2024) examine the market potential for smart packaging, showcasing how higher education impacts innovation through research on consumer behaviour and technology. Short-term effects include equipping graduates with marketing and technical skills, whereas long-term impacts emerge through sustained industry-academic collaborations.

Infante-Moro et al. (2022b) focus on e-proctoring in Spanish universities, highlighting higher education's role in digital transformation. Short-term contributions include operational efficiency in remote learning, whereas long-term effects normalize digital tools and foster a tech-savvy workforce. Kharazishvili et al. (2020) explore social safety indicators aligned with sustainable development goals. Higher education fosters the human capital that drives society (Titko et al., 2021), with short-term contributions evident in research applications and long-term impacts in shaping strategic sustainability policies. Kwilinski and Kardas (2024a) analyse the Pareto principle in Industry 4.0, emphasizing advanced education and research in adapting to technological shifts. Short-term contributions focus on implementing innovative practices, whereas long-term impacts embed quality management principles in workforce and industry standards. Kwilinski et al. (2024b) examine the connection between a country's global image and immigration flows, highlighting higher education's short-term contributions in addressing cultural diversity and long-term benefits in enhancing global collaboration and competitiveness.

Labudova and Fodranova (2024) discuss socioeconomic factors influencing digital skills in the EU, highlighting higher education's role in addressing skill gaps. Short-term contributions include targeted educational programs, whereas long-term impacts develop a digitally proficient workforce that drives regional innovation. Lyulyov et al. (2024) analyse public perceptions of artificial intelligence, showcasing higher education's role in short-term expertise and research and long-term contributions to ethical frameworks and trust-building in AI technologies. Surya et al. (2024) examine green human resources in hospitality innovation, showing higher education's short-term influence through specialized programs for eco-conscious professionals and long-term impacts through industry-wide adoption of sustainable practices. Zimbroff (2023) explored extension programming postpandemic, emphasizing higher education's role in adapting curricula to meet immediate challenges and ensuring resilience for long-term innovation in education systems.

The relationship between higher education and innovation development has been extensively studied, revealing both direct and indirect impacts on economic and technological progress (Li & Liu, 2021; Zhou & Luo, 2018; Kruss et al., 2015; Cai et al., 2020). HEIs are recognized as crucial drivers of the knowledge economy, contributing to the generation, dissemination, and application of knowledge essential for innovation (Macerinskiene & Vaiksnaite, 2006). However, while investments in higher education yield significant economic benefits, they may also lead to challenges such as diminished quality and diploma devaluation if not carefully managed. Studies (Kwilinski et al., 2024e; Moretti, 2004) highlighted the positive spillover effects of educated workers, demonstrating that higher education enhances not only individual productivity but also the overall performance of peers, even those without higher education.

Kyrylov et al. (2020) analyse international tourism development amidst globalization risks, focusing on Ukraine's integration into the global tourism industry. Higher education institutions

(HEIs) play a vital short-term role by preparing professionals with specialized knowledge in global tourism management. Long-term contributions include fostering research on sustainable tourism practices, enhancing resilience against globalization risks, and integrating academic insights into policymaking. Lyulyov et al. (2020) explored the relationship between economic growth and tourism, emphasizing the impact of COVID-19. HEIs' short-term role includes analysing immediate economic disruptions and preparing students to address tourism sector challenges. In the long term, higher education fosters interdisciplinary research and innovation to align tourism with sustainable development goals, ensuring economic recovery and resilience in the postpandemic era. Payonk et al. (2015) examine the operations of business entities in the context of globalization, highlighting the importance of HEIs in equipping graduates with the skills to navigate globalized markets. In the short term, higher education contributes by providing practical training to adapt to global market dynamics. In the long term, it fosters innovation by integrating globalization studies into curricula and advancing research on global business strategies.

Alqararah (2023) explored the robustness of global innovation rankings such as the GII, revealing discrepancies in methodology that affect middle-ranking countries, thus emphasizing the need for comprehensive and localized approaches.

Critiques of traditional innovation metrics, such as the GII and the European Innovation Scoreboard, highlight their limitations, including aggregation biases and subjective weightings (Grupp & Mogege, 2004). To address these issues, alternative methods such as the VECM offer a more objective analysis of higher education's influence on innovation by integrating human capital and intellectual property dimensions into the assessment.

The formation of human capital through higher education is pivotal for fostering innovative outputs, as shown by studies focusing on regional specificity and stakeholder engagement (Shkarlet et al., 2019). Furthermore, aligning university education with national strategies, such as Saudi Arabia's "Vision 2030," enhances long-term innovation and economic diversification (Thomran & Alshammari, 2023). Mayboroda et al. (2024) proposed a model integrating talent management principles with knowledge economy frameworks, underscoring the importance of cooperation between universities, businesses, and science in creating both short-term innovations and long-term human capital development.

Additional studies emphasize practical aspects of the role of higher education in innovation. Abbas (2019) linked university branding to attracting and retaining talented students and faculty, whereas Migala-Warchol & Pasternak-Malicka (2018) underscored the centrality of HEIs in research and workforce preparation for innovative economies. Dual education systems also strengthen the connection between education and labour market needs, equipping students with practical skills critical for innovation-driven industries (Davlikanova & Hofstetter, 2020).

These papers (Bartha et al., 2019; Danova et al., 2022; Oturakci, 2021) provide valuable insights into how HEIs contribute to innovation development in both short-term and long-term contexts. Bartha et al. (2019) focus on the management of innovations within Hungarian HEIs, particularly through the Erasmus mobility program, highlighting short-term benefits such as knowledge transfer, cultural diversity, and skill development, as well as long-term impacts such as enduring international collaborations and alumni networks that strengthen global innovation ecosystems. Danova et al. (2022) explore the role of innovations in human resource management within HEIs, emphasizing the short-term effects of improved employee performance and organizational efficiency, alongside long-term benefits such as cultivating a highly skilled workforce capable of driving sustained economic and technological advancements. Oturakci (2021) provides a comprehensive analysis of the GII, critiquing its limitations and advocating for region-specific metrics that better capture HEIs' contributions to innovation.

On the basis of the abovementioned results of analysis, this study checks the following research questions:

How do different higher education indicators contribute to the elasticity of innovation development in transition economies?

How do the dynamics between higher education and innovation development evolve over time, and what are the key drivers of these changes in transition economies?

2. Methodology

To investigate the intricate relationship between higher education and innovation development in the country, the following functional form was employed:

$$ID = f(X_i) \quad (1)$$

where ID represents the innovation development of Ukraine and X represents higher education.

To analyse this relationship, the variables were transformed into their natural logarithmic form. This transformation facilitates the interpretation of the coefficients as elasticities, quantifying the percentage change in innovation development resulting from a one-percent variation in higher education indicators. The log-linear model is specified as follows:

$$\ln ID_t = a_0 + a_1 \ln X_{it} + \mu_i \quad (2)$$

where $\ln$ represents the natural logarithm; ID_t denotes the innovation development of the country at time t ; X_{it} is the i -th higher education indicator at time t ; a_0 is the intercept, capturing the baseline level of innovation development; a_1 represents the elasticity of innovation development with respect to the higher education indicator, indicating how sensitive innovation development is to changes in higher education inputs; and μ_i is the error term, accounting for unobserved factors that may influence innovation development.

To evaluate innovation development, the Malmquist productivity index was applied. Compared with existing approaches (Peters, et al., 2017; Schwab, 2018; Hollanders, et al., 2019; Dutta, et al., 2022), this methodology allows for the simultaneous assessment of changes in resource utilization efficiency and innovation output over time. Unlike static methods, the Malmquist productivity index incorporates the time factor, enabling the analysis of both short-term and long-term dynamics (Bansal et al., 2022; Lou et al., 2024). Additionally, the approach allows for the comparison of innovation development levels between countries with varying degrees of economic development, economic structures, and resource capacities. By incorporating time series data, this method enables tracking the dynamics of innovation development over the analysed period, identifying trends and critical influencing factors. The analytical basis for calculating innovation development relies on Global Innovation Index reports prepared by experts from the World Intellectual Property Organization (Dutta et al., 2022). The study focused on data from Ukraine and the Visegrad Four countries (Hungary, Poland, Slovakia, and the Czech Republic). The selection of these countries was justified by shared economic and historical conditions, enabling a valid comparison of their innovation strategies, the similarity of challenges in innovation policy development and investment attraction, and the availability of a comparable statistical database.

To measure the level of higher education development in this study, the following indicators were used: X1 – percentage of graduates from science, technology, engineering and mathematics programmes in tertiary education, both sexes (%); X2 – School enrolment, tertiary (% gross); X3 – Total researchers by higher education sector – full-time equivalent; X4 – Charges for the use of intellectual property payments (BoP, current US\$). These specific indicators are not included in the Global Innovation Index (GII), whose components were used to compute the ID – Innovation Development of Ukraine. The GII is a widely used tool to measure innovation development across countries, but it does not fully capture the specific contributions of higher education systems or

detailed aspects of intellectual property engagement in its composite structure. First, X1 and X2 represent the human capital pipelines—STEM graduates and tertiary school enrolment—which are foundational to a country's innovation capacity (Lenhart et al., 2022; Ng & Park, 2021). A well-educated workforce, particularly in the science and technology fields, is essential for developing cutting-edge technologies and innovations. These variables provide a clearer picture of the supply of skilled professionals who can contribute to research, entrepreneurship, and technological advancements in Ukraine. Second, X3 reflects the research and development capacity of the country, which is critical for generating new knowledge and fostering innovation (Kwiek, 2021; Benito & Romera, 2020). While the GII considers broader research and development expenditures, the number of researchers directly demonstrates the capacity to perform innovative research and thus deserves attention in measuring innovation development. Finally, X4 reflects the country's engagement with the global intellectual property system, indicating how well the country is commercializing and protecting innovations (Llewelyn, 2024; Ploman & Hamilton, 2024). This aspect is essential for understanding how innovations are transferred, protected, and monetized, which is a key driver of sustainable innovation but is not explicitly included as a separate component in the GII. The data on X1, X2, X3, and X4 were collected from the World Data Bank (2024) and Eurostat (2024).

In the first step, the augmented Dickey-Fuller (ADF) test was employed to check for stationarity in the time series data (Singh et al., 2024). Stationarity is a crucial condition for time series analysis, as nonstationary data can lead to misleading results. The null hypothesis of the ADF test posits that the series contains a unit root (nonstationary). If the null hypothesis is rejected, the series is considered stationary. This test was applied to each variable to ensure that it was stationary either in levels or after differencing. After establishing stationarity, the optimal number of lags for the variables was determined. Various criteria, such as the Akaike information criterion (AIC), Hannan-Quinn information criterion (HQIC), and Schwarz Bayesian information criterion (SBIC), were used to select the lag length (Utouh & Tile, 2023). The correct lag selection ensures that the model captures the dynamic relationships between the variables without overfitting. The Johansen cointegration test was applied to examine the presence of long-term equilibrium relationships between the variables (Ivascu et al., 2021). This test determines whether nonstationary variables are cointegrated, indicating that despite short-term deviations, the variables move together in the long run. The trace and maximum eigenvalue statistics were used to assess the number of cointegrating relationships. To identify the direction of causality between the variables, the Granger causality test was performed (Shojaie & Fox, 2022). This test examines whether past values of one variable can predict the current values of another. The test results help to establish whether the independent variables have predictive power over innovation development in Ukraine. On the basis of the results of the cointegration test, either a vector autoregression (VAR) or a vector error correction model (VECM) was estimated. The VAR model is used for noncointegrated series, capturing the interdependencies and dynamic relationships between variables. In the case of cointegrated variables, the VECM model was employed to account for both short-term deviations and long-term equilibrium relationships between the variables (Morshed & Hossain, 2022):

$$\Delta \ln ID_t = b_0 + \lambda_1 ec_{t-1} + b_1 \Delta \ln ID_{t-1} + b_2 \Delta \ln X_{i,t-1} + \varepsilon_t \quad (3)$$

where $\Delta \ln ID_t$ represents the first difference of the natural logarithm of innovation development at time t ; b_0 represents the intercept term, which captures any constant factors affecting innovation development in the short term; λ_1 represents the speed of the adjustment coefficient; ec_{t-1} represents the error correction term from the previous period; b_1 represents how the past period's changes in innovation development affect the current period's changes; $\Delta \ln ID_{t-1}$ represents the short-term lagged effects of changes in innovation development on itself; b_2 represents how past changes in higher education inputs influence current innovation development in the short term; $\Delta \ln X_{i,t-1}$

represents the short-term effects of changes in the higher education indicators; and ε_t represents the error term accounting for random shocks or factors that are not explained by the model at time t .

The error correction term reflects the deviation from the long-run equilibrium. If the system is out of equilibrium, this term helps adjust the variables back toward their long-run relationship. A significant and negative λ_1 suggests that if innovation development deviates from its long-run path, the system will correct itself over time, with the magnitude of λ_1 indicating the speed of this adjustment. The IRF was used to trace the response of one variable to a shock in another over time. This provides insight into the dynamic interactions and how the variables influence each other following an exogenous shock. The Jarque-Bera test was applied to assess whether the residuals of the model followed a normal distribution. This is important for ensuring the validity of the model's inference. The stability of the VECM model was evaluated via the eigenvalue stability condition. A model is considered stable if all the eigenvalues lie within the unit circle, indicating that the system is dynamically stable.

3. Research results

The ADF test results indicate that the variable ID is stationary in level (Table 1). This suggests that the ID is integrated of order 0, or $I(0)$, meaning that it does not contain a unit root and is stable over time.

Table 1. ADF test results.

Variable	Test statistic	MacKinnon approximate p value	Conclusion
ID	-3.903	0.002	Stable
D.ID	-4.141	0.001	Stable
X1	-1.025	0.744	Unstable
D.X1	-3.952	0.002	Stable
X2	-2.653	0.256	Unstable
D.X2	-3.511	0.038	Stable
X3	-1.069	0.727	Unstable
D.X3	-3.723	0.004	Stable
X4	-2.208	0.203	Unstable
D.X4	-3.671	0.004	Stable

Source: created by the authors.

The variables X1, X2, X3, and X4 are nonstationary in their original form (levels). The ADF test statistics for these variables are greater than the critical values at the 1%, 5%, and 10% significance levels, and their p values are not significant. This implies the presence of a unit root, meaning that the variables are integrated of order 1, or $I(1)$. However, after applying first differencing, these variables become stationary, as their test statistics surpass the critical values, and the p values become statistically significant.

The results in Table 2 present the optimal number of lags for the variables in the analysis, which are determined via multiple criteria such as the likelihood ratio (LR), the Akaike information criterion (AIC), the Hannan-Quinn information criterion (HQIC), and the Schwarz Bayesian information criterion (SBIC).

Table 2. Optimal number of lags.

Lag	LL	LR	FPE	AIC	HQIC	SBIC
X1						
0	13.539		0.000*	-4.615	-5.035	-4.772
1	16.896	6.713	0.000	-4.358	-5.616	-4.827
2	327.505	621.22*	.	-127.002*	-129.099*	-127.783*
X2						

Lag	LL	LR	FPE	AIC	HQIC	SBIC
0	9.457		0.000*	-2.982	-3.402	-3.139
1	13.433	7.953	0.093	0.000	-2.973	-4.231
3	323.822			-125.529*	-127.625*	-126.31*
X3						
0	10.065		0.000	-3.226	-3.645	-3.382
1	21.434	22.736*	0.000*	-6.173*	-7.431*	-6.642
X4						
0	2.433		0.002	-0.17336	-0.592	-.3295
1	10.675	16.485*	0.001*	-1.870	-3.128	-2.339
3	328.301			-127.321*	-129.417*	-128.102*

Source: created by the authors.

The Johansen cointegration test results indicate the presence of long-term equilibrium relationships. For X1, the trace statistic at rank 0 is 28.768, exceeding the critical value of 15.41, and the max statistic of 27.0280 is also greater than its critical value of 14.07. This suggests that the null hypothesis of no cointegration is rejected at rank 0, indicating the existence of at least one cointegrating relationship. However, at rank 1, the trace statistic (1.740) is smaller than the critical value (3.76), leading to the conclusion that X1 has one cointegrating relationship.

Table 3. The Johansen cointegration test.

Maximum rank	Eigenvalue	Trace statistic	Critical value	Max-Statistic	Eigen critical value
For X1					
0		28.768	15.41	27.028	14.07
1	0.978	1.740*	3.76	1.740	3.76
2	0.220				
For X2					
0		41.565	15.41	35.835	14.07
1	0.994	5.730	3.76	5.730	3.76
2	0.558				
For X3					
0		22.073	18.17	18.255	16.87
1	0.897	3.818	3.74	3.818	3.74
2	0.379				
For X4					
0		16.336*	18.17	11.751	16.87
1	0.769	4.584	3.74	4.584	3.74
2	0.436				

Source: created by the authors.

In the case of X2, which represents school enrolment in tertiary education, both the trace statistic (41.565) and the max statistic (35.835) are significantly larger than their respective critical values at rank 0, and even at rank 1, the statistic (5.730) remains above the critical value, suggesting strong evidence of multiple cointegration relationships. For X3, the trace statistic at rank 0 is 22.073, exceeding the critical value of 18.17, and the max statistic (18.255) surpasses the critical value (16.87). This indicates the rejection of the null hypothesis at rank 0, suggesting that X3 has one cointegrating relationship. Finally, for X4, the trace statistic at rank 0 (16.336) falls below the critical value, suggesting no cointegration at this rank, whereas the statistic at rank 1 (4.584) exceeds the critical value, indicating a cointegration relationship. Overall, the Johansen test shows that X1 and X3 each have one cointegrating relationship, X2 has two cointegrating relationships, and X4 does not exhibit clear cointegration in the initial rank but shows weak cointegration at rank 1.

Table 4 presents the results of the Wald tests for Granger causality, which determine whether one variable can predict (Granger-cause) another in a time series context. The null hypothesis for the Granger causality test states that the excluded variable does not Granger-cause the dependent

variable. A significant chi-square statistic (p value < 0.05) indicates the rejection of the null hypothesis, suggesting the presence of Granger causality.

Table 4. Granger causality Wald tests (Dependent variable: ID).

Equation	Excluded	chi2	Prob > chi2
ID	X1	43.876	0.000
X1	ID	2.0717	0.355
ID	X2	22.369	0.000
X2	ID	3.1434	0.208
ID	X3	8.8194	0.012
X3	ID	29.295	0.000
ID	X4	7.9676	0.019
X4	ID	8.428	0.015

Source: created by the authors.

The test shows that X1 Granger-causes ID with a chi-square value of 43.876 and a p value of 0.000, meaning that changes in X1 significantly predict changes in ID. Conversely, ID does not Granger-cause X1, as the chi-square value (2.071) and p value (0.355) indicate that the null hypothesis cannot be rejected. Similarly, X2 Granger-causes ID, but there is no reverse causality from ID to X2. In contrast, there is a significant bidirectional Granger causality between ID and X3. The chi-square value for X3 Granger-causes ID is 8.8194 (p value = 0.012), and for ID Granger-causes X3, the chi-square value is 29.295 (p value = 0.000). This finding indicates that both variables can predict each other. X4 has a bidirectional relationship with ID. The test shows that X4 Granger-causes ID, with a chi-square value of 7.967 and a p value of 0.019, indicating a predictive relationship from X4 to ID. Similarly, ID Granger causes X4, as reflected by a chi-square value of 8.428 and a p value of 0.015, confirming the presence of bidirectional causality between ID and X4.

Table 5 presents the results of the cointegration equation, which outlines the long-term relationship between the dependent variable ID and the explanatory variables X1, X3, and X4, all lagged by one period.

Table 5. Results of the cointegration equation.

Cointegrating equation	Coefficient			
ID(-1)	1	1	1	1
X1(-1)	0.995 [0.000] (0.144)			
X2(-1)		2.093 [0.000] (0.037)		
X3(-1)			0.024 [0.000] (0.005)	
X4(-1)				0.4686 [0.000] (0.067)
const	3.253	-9.161	-0.186	-9.382

Note: Standard errors in () and P values in [].

Source: Developed by the authors.

X1 has a coefficient of 0.9949919, with a p value of 0.000 and a standard error of 0.144, suggesting that an increase in X1 leads to greater innovation development. Similarly, X2 shows a strong positive relationship with a coefficient of 2.093, with a p value of 0.000, implying that greater school enrollment in tertiary education increases innovation development. X3 also has a positive effect on ID, with a coefficient of 0.024, a p value of 0.000, and a standard error of 0.005. Finally, X4 has a positive long-term relationship with ID, with a coefficient of 0.468 and a p value of 0.000.

The VECM estimates are presented in Table 6. It demonstrates the short-term dynamics and the speed of adjustment toward long-term equilibrium among the variables. The significant error

correction terms indicate that innovation development tends to revert to its long-term equilibrium when deviations occur, showing that the innovation system is stable and adjusts over time to changes in key economic variables. This suggests that any shocks or disruptions in innovation are temporary and that the system self-corrects, reinforcing the resilience of innovation efforts in Ukraine.

Table 6. VECM (1) Estimates.

Error correction	ID			
COINT	-2.782 [0.000] (0.438)	-6.38 [0.004] (2.212)	-2.946 [0.000] (0.562)	-1.109 [0.213] (0.8907)
Δ ID	1.272 [0.000] (0.359)	2.155 [0.064] (1.164)	1.123 [0.004] (0.394)	-0.0694 [0.910] (0.6145)
Δ X1	4.250 [0.000] (0.969)			
Δ X2		4.521 [0.070] (2.499)		
Δ X3			0.069 [0.077] (0.039)	
Δ X4				0.463 [0.070] (0.25)
C	-0.0004 [0.990] (0.030)	0.0003 [0.995] (0.049)	0.184 [0.000] (0.039)	-0.019 [0.790] (-0.019)
R-squared	0.9594	0.868	0.945	0.718
AIC	-6.020	-7.063	-0.081	-1.003
HQIC	-6.879	-7.923	-0.941	-1.862
SBIC	-6.089	-7.133	-0.151	-1.072
Log likelihood	30.070	33.722	9.286	12.510

Note: Standard errors in () and P value in [], where Δ is the first difference.

Source: Developed by the authors.

The coefficient for the short-term impact of X1 on ID is 4.250, with a p value of 0.000, indicating a strong and significant positive short-term effect. The highly significant positive impact of X1 (the percentage of STEM graduates) on innovation development underscores the critical role of human capital in fostering innovation. A larger pool of STEM-educated individuals contributes to a more skilled workforce capable of driving technological advancements and innovation. This suggests that policies aimed at increasing STEM education can have a strong, direct effect on enhancing innovation capacity in Ukraine. The coefficient for X2 is 4.52, with a p value of 0.070, indicating a marginally significant positive short-term effect on ID. The short-term effect of X3 is 0.069, with a p value of 0.077, which suggests a weakly significant positive relationship between the first difference of X3 and ID. The coefficient for X4 is 0.463, with a p value of 0.070, indicating a marginally significant positive impact of the first difference of X4 on ID in the short run. The positive, though weaker, impact of X2 (school enrolment in tertiary education), X3 (total researchers), and X4 (intellectual property payments) highlights several important economic implications. An increase in X2 reflects the expanding base of educated individuals who will contribute to the country's innovation capacity in the long term. Higher education plays a key role in equipping students with the skills and knowledge necessary for participating in innovation-driven sectors, laying the groundwork for a more innovative and competitive economy. Thus, even a modest short-term effect of X2 is significant because it reflects investments in human capital, which are crucial for sustained innovation. Similarly, X3 (total researchers) represents the country's research and development capacity. While the short-term effect of X3 is only marginally significant, its role in generating new knowledge and fostering technological advancements is vital. Researchers are at the heart of innovation, driving scientific discoveries and technological innovations that fuel economic growth. Over time, an increase in the number of researchers enhances a country's ability to produce breakthrough innovations, contributing to

sustained improvements in productivity and competitiveness. Finally, X4 (intellectual property payments) reflects the country's ability to engage with global markets and protect its innovations. A positive impact of X4 suggests that the country is increasingly involved in the commercialization of its innovations, as well as the acquisition and licensing of intellectual property from abroad. This integration into the global innovation system not only helps protect domestic innovations but also facilitates knowledge transfer and collaboration, which are essential for building a robust innovation ecosystem. By ensuring that intellectual property is properly managed and commercialized, the country can support the development of new products, services, and technologies, further strengthening its innovation capacity and economic growth trajectory.

Figure 1 shows the dynamic relationships between innovation development and the explanatory variables.

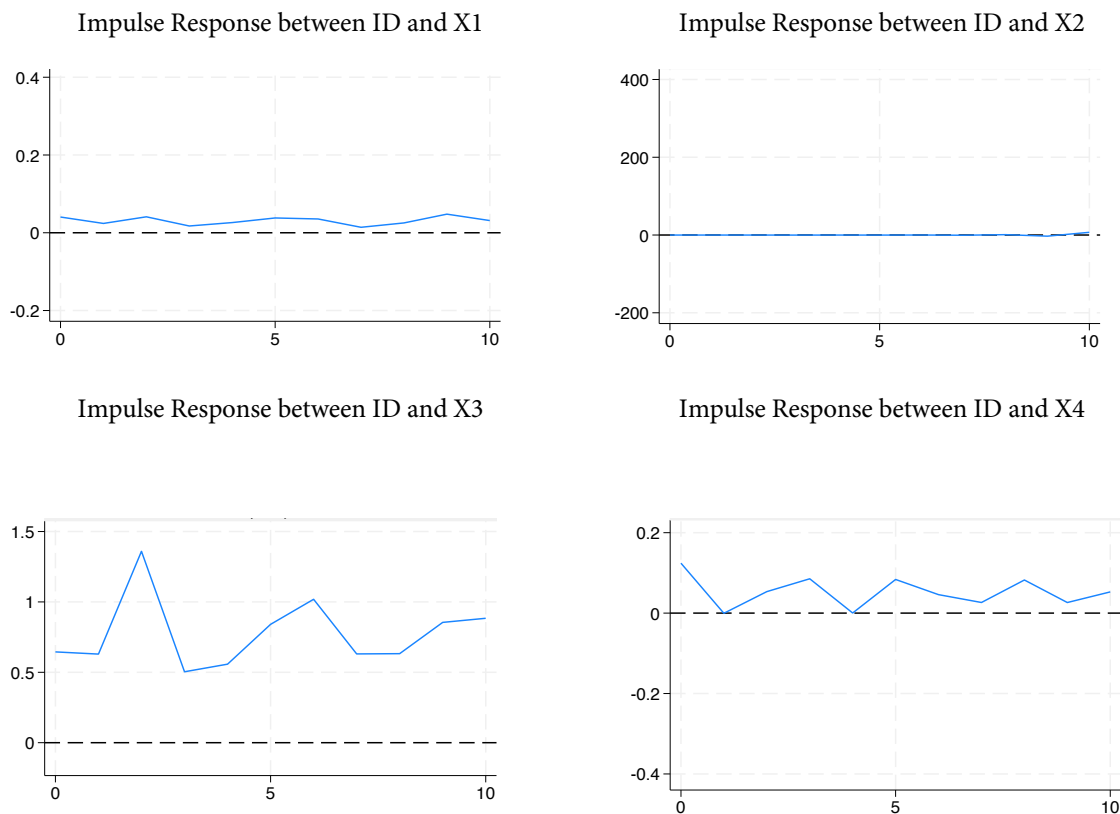


Figure 1. The impulse response graphs between the ID and the variables X1, X2, X3, and X4.

Source: Developed by the authors.

The upper-left graph shows the impulse response function (IRF) of a shock in X1 on ID. This finding indicates that a positive shock to X1 causes an initial increase in ID, suggesting that an increase in the number of STEM graduates leads to greater innovation development. This positive effect diminishes over time but does not entirely die out, indicating a sustained impact on innovation development from improvements in STEM education. The upper-right graph displays the IRF of a shock in X2 on ID. A positive shock to X2 results in a gradual increase in ID, highlighting that higher tertiary school enrollment contributes positively to innovation development. The effect starts strong but begins to diminish after a few periods, eventually stabilizing, although it does not completely die out, indicating a long-term contribution of higher education to innovation. The bottom-left graph illustrates the IRF of a shock in X3 on ID. A positive shock to X3 leads to an immediate increase in ID, suggesting that an increase in the number of researchers enhances innovation development. The effect peaks shortly after the shock and gradually fades over time, showing that research capacity has

a significant, albeit diminishing, effect on innovation. The bottom-right graph shows the IRF of a shock in X4 on ID. A positive shock to X4 results in a delayed but sustained increase in ID, implying that increased intellectual property engagement boosts innovation development over time. The effect tapers off slowly but remains positive, reflecting the long-lasting impact of intellectual property on innovation.

4. Discussion

The findings of this study highlight the significant contributions of HEIs to innovation development in Ukraine, with a focus on both short-term and long-term impacts. These results are consistent with those of previous studies that emphasized the pivotal role of higher education institutions (HEIs) in fostering human capital and technological advancement. For example, the strong positive effect of STEM graduates and tertiary enrolment aligns with findings by Li & Liu (2021), who showed that higher education inputs directly enhance technological innovation and economic growth. Similarly, this study's evidence of higher education's impact on long-term equilibrium relationships corroborates Kruss et al. (2015), who emphasized that HEIs build technological capabilities that drive sustainable innovation ecosystems. The short-term impacts observed in this study, such as the influence of research capacity and intellectual property payments on innovation, are supported by prior research emphasizing HEIs' immediate contributions to technological adoption and applied research. Thus, Dementyev et al. (2021) reported that HEIs advance research and technology to address current economic and political challenges, fostering short-term decision-making capabilities. Similarly, Infante-Moro et al. (2022) highlighted the role of higher education in facilitating digital transformation through operational efficiency, which parallels this study's findings on intellectual property engagement.

This study also identifies challenges related to the short-term effects of tertiary education enrolment and research capacity, which are statistically significant but less impactful than STEM education is. Grupp & Mogege (2004) criticized traditional metrics of GII for underestimating the contributions of human capital development. Furthermore, the results align with those of Zhou and Luo (2018), who demonstrated that investment in higher education yields substantial long-term benefits, even if short-term gains appear modest. Comparative analysis with studies from other regions reveals additional insights. For example, Kyrylov et al. (2020) emphasized HEIs' role in preparing professionals for globalized industries, similar to this study's findings on the role of HEIs in fostering innovation capacity through international collaboration and intellectual property integration. Similarly, Payonk et al. (2015) highlighted the importance of HEIs in adapting business practices to globalization, aligning with the study's focus on long-term innovation capacity.

While this study validates the transformative potential of higher education, it also underscores the importance of targeted policies to increase its impact. Previous studies by Macerinskiene & Vaiksnaite (2006) advocate aligning educational outputs with industry demands to maximize innovation outcomes. This study's findings strengthen the argument for prioritizing STEM education, supporting research initiatives, and leveraging intellectual property frameworks to address immediate and future innovation challenges.

This study contributes to the understanding of the dual role of HEIs in fostering innovation by bridging short-term applied research and long-term human capital development. The results reinforce the theoretical frameworks proposed by earlier studies while offering evidence-based recommendations for policymakers to increase higher education's role in sustainable economic growth and technological progress.

Conclusions

The VECM results highlight that changes in STEM graduates have both immediate and lasting effects on innovation development. The coefficient for X1 is 0.994, with a p value of 0.000, which indicates a strong positive long-term relationship between STEM graduates and innovation

development. Thus, a 1% increase in the number of STEM graduates is associated with an approximately 0.99% increase in innovation development. Policymakers can use this elasticity to set realistic targets. For example, if the goal is to increase innovation by 20%, efforts should focus on increasing the STEM graduate rate by a similar magnitude, considering the near one-to-one relationship. The VECM estimates show the short-term effect of changes in the number of STEM graduates on innovation development, with a coefficient of 4.250 and a p value of 0.000. This finding indicates that in the short run, changes in the number of STEM graduates have a substantial immediate effect on innovation. A 1% increase in the number of STEM graduates results in a 4.25% increase in innovation in the short term. Short-term policy measures, such as scholarships, curriculum updates, and incentives for STEM enrolment, could produce immediate boosts in innovation capacity. The sustained impact seen in the IRF suggests that investments in STEM education yield long-lasting benefits.

The coefficient for X2 is 2.093, with a p value of 0.000, indicating a strong positive long-term relationship between tertiary education enrolment and innovation development. This suggests that a 1% increase in tertiary enrolment is associated with an approximately 2.09% increase in innovation development. Policymakers can use this elasticity to set realistic targets. For example, if the goal is to increase innovation by 10%, efforts should focus on increasing the tertiary school enrollment rate by a proportional amount, considering the greater-than-proportional relationship. The VECM estimates also show the short-term effect of changes in tertiary enrolment on innovation development, with a coefficient of 4.521 and a p value of 0.070. This finding indicates that in the short run, changes in tertiary enrolment have a substantial immediate effect on innovation. A 1% increase in tertiary enrolment results in a 4.52% increase in innovation in the short term. Short-term policy measures, such as expanding access to tertiary education, reducing barriers to enrolment, and improving the quality of higher education, could produce immediate increases in innovation capacity. The sustained impact seen in the IRF suggests that investments in expanding tertiary education enrollment yield long-lasting benefits.

The analysis reveals that an increase in the number of researchers in Ukraine's higher education sector (X3) is crucial for innovation development. The long-term coefficient of 0.024 (p value = 0.000) implies that while the direct impact may seem modest, each 1% increase in research personnel is associated with a 0.024% increase in innovation. This suggests that building research capacity is an essential, albeit gradual, process for boosting innovation. In the short term, the coefficient of 0.069 (p value = 0.077) suggests that an increase in researchers has an immediate, albeit weaker, positive effect on innovation development.

The influence of intellectual property engagement (X4) on innovation in Ukraine is evident from the long-term coefficient of 0.468 (p value = 0.000). This strong relationship indicates that a 1% increase in intellectual property payments corresponds to a nearly 0.47% increase in innovation development. These findings underscore the importance of intellectual property as a driver of innovation, suggesting that policies should encourage both the use and commercialization of intellectual property assets. In the short term, the coefficient of 0.463 (p value = 0.070) highlights a meaningful and almost immediate positive impact of intellectual property payments on innovation.

On the basis of the major findings of this study, several policy recommendations are proposed to align with Ukraine's strategic goals of building a more innovation-driven economy:

1. To support the country's "National Economic Strategy until 2030," policymakers should target a 20–30% increase in STEM graduation rates. This increase is critical for driving innovation development, as evidenced by the positive impact of STEM education on innovation. To achieve this target, investments in scholarships, grants, and other incentives for STEM education in Ukrainian universities and technical institutions are essential. Moreover, collaboration with educational institutions to enhance STEM curricula and facilities will further strengthen Ukraine's transition to a knowledge-based, technologically advanced

economy. The experiences of countries such as Estonia and Poland demonstrate the importance of STEM-focused reforms. Estonia, for example, achieved significant progress in its innovation ecosystem by prioritizing STEM education in its university system, resulting in a pool of skilled professionals capable of driving technological advancements. Similarly, Poland's efforts to expand STEM programs through government-funded initiatives have led to a marked increase in the number of graduates entering high-tech industries. Additionally, integrating practical experience with industry partnerships, as seen in successful programs in South Korea, can provide students with the skills necessary to meet market demands.

2. In line with the strategy for higher education in Ukraine from 2021--2031, a focus on improving access to quality higher education is paramount. Policymakers should aim for a 25–30% increase in tertiary enrolment over the next decade. This strategy not only builds a solid foundation for a knowledge-based economy but also helps develop a skilled workforce that drives innovation. To achieve this goal, strengthening the capacity of Ukrainian universities, enhancing the quality of education, and aligning educational programs with labor market demands are necessary steps. Germany's dual education system provides a relevant model, offering academic knowledge alongside practical, workplace-focused training. Furthermore, Poland's educational reforms over the past decade have successfully increased tertiary enrolment through measures such as expanding student financial aid programmes and enhancing the quality of university infrastructure. By implementing reforms to improve the quality of university programs and aligning education with labor market needs, Lithuania significantly increased its number of tertiary-educated professionals. Similarly, Latvia implemented programs to make higher education more accessible and affordable, which in turn improved its innovation ecosystem.
3. The study's results highlight the importance of research ecosystems within universities. In alignment with the Global Innovation Vision of Ukraine 2030, Ukraine should aim for a 15–20% increase in the research workforce in higher education by 2030. This target can be achieved through enhanced funding for research grants, support for early-career researchers, and initiatives fostering industry–academia partnerships. Investing in research facilities and encouraging the hiring of researchers will strengthen short-term innovation capacity and lay a solid foundation for long-term growth. The government of Estonia invested heavily in building research infrastructure within universities and offered funding opportunities for early-career researchers. These initiatives not only increased Estonia's research output but also fostered stronger industry-academia collaboration, a key driver of technological innovation. Likewise, Czechia has strengthened its research sector through strategic investment in R&D and encouraging partnerships between universities and the private sector.
4. The National Intellectual Property Development Strategy emphasizes the importance of intellectual property rights and the commercialization of innovations. To leverage this effect, policymakers should target a 20–25% increase in intellectual property payments by 2030. Achieving this goal requires establishing a robust intellectual property infrastructure, including legal frameworks and support systems for innovators. Immediate actions include simplifying patenting procedures, providing support to universities and research institutions for intellectual property management, and creating incentives for businesses to protect and commercialize their innovations. Countries such as Poland and Hungary have taken steps to strengthen their intellectual property frameworks to promote innovation. For example, Poland simplified its patenting process and established support systems for universities and research institutions to manage intellectual property effectively. Hungary implemented policies to incentivize businesses to protect and commercialize their innovations, creating an environment conducive to technology transfer and the commercialization of research.

The use of the vector error correction model (VECM) enables the identification of long-term relationships and short-term dynamics between higher education indicators and innovation. However, it does not establish definitive causal relationships. Other unobserved variables or external shocks (e.g., economic crises, policy changes) could also influence innovation development, making it challenging to attribute changes in innovation solely to changes in higher education. The study uses time series data from 2014–2022. This relatively short period might limit the ability to capture longer-term trends and structural changes in Ukraine's innovation ecosystem. The study period also coincides with significant political and economic events in Ukraine, which could have affected the higher education sector and innovation development, potentially confounding the results. Further research could involve in-depth comparative analyses between Ukraine and other countries with similar transitional economies (e.g., Georgia, Moldova, Romania). This comparison helps identify best practices and lessons learned that are most relevant to Ukraine's context. Analysing the success factors and challenges of different innovation strategies across countries can guide more targeted policy development.

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Reference

1. Abbas, S. A. (2019). Brand loyalty of Higher Education Institutions. *Marketing and Management of Innovations*, 1, 46–56. <https://doi.org/10.21272/mmi.2019.1-04>.
2. Adeel, S., Daniel, A. D., & Botelho, A. (2023). The effect of entrepreneurship education on the determinants of entrepreneurial behaviour among higher education students: A multigroup analysis. *Journal of Innovation & Knowledge*, 8(1), Article 100324.
3. Akcigit, U., Pearce, J., & Prato, M. (2024). Tapping into talent: Coupling education and innovation policies for economic growth. *Review of Economic Studies*, Article rdae047.
4. Alqararah, K. (2023). Assessing the robustness of composite indicators: the case of the Global Innovation Index. *Journal of Innovation and Entrepreneurship*, 12, Article 61(2023). <https://doi.org/10.1186/s13731-023-00332-w>.
5. Altbach, P. G., & Salmi, J. (Eds.). (2011). *The Road to Academic Excellence: The Making of World-Class Research Universities*. World Bank Publications. <https://documents1.worldbank.org/curated/en/688061468337210820/pdf/The-road-to-academic-excellence-the-making-of-world-class-research-universities.pdf>
6. Andrew, J., Baker, M., Cooper, C., & Gendron, Y. (2024). Knowledge equity as social justice in academic publishing and why it matters for accounting research. *Meditari Accountancy Research*, 32(6), 2396–2420.
7. Ayala-Mora, J., Infante-Moro, A., & Infante-Moro, J. C. (2023). Electronic administration in the Council of the Judiciary of Ecuador [La administración electrónica en el Consejo de la Judicatura de Ecuador]. *RISTI - Revista Ibérica de Sistemas e Tecnologias de Informação*, 2023(E60), 511–523.

8. Bansal, P., Kumar, S., Mehra, A., & Gulati, R. (2022). Developing two dynamic Malmquist-Luenberger productivity indices: An illustrated application for assessing productivity performance of Indian banks. *Omega*, 107, Article 102538.
9. Bartha, Z., Gubik, A., S., & Rethi, G. (2019). Management of innovations in Hungarian HEIs: enhancing the Erasmus mobility programme. *Marketing and Management of Innovations*, 1, 84–95. <https://doi.org/10.21272/mmi.2019.1-07>.
10. Benito, M., Gil, P., & Romera, R. (2020). Evaluating the influence of country characteristics on the Higher Education System Rankings' progress. *Journal of Informetrics*, 14(3), Article 101051.
11. Berg, S., & Spicka, J. (2023). Shaping farm workers' political trust: The moderating role of misinformation exposure. *Central European Business Review*, 12(5), 177–199. <https://doi.org/10.18267/j.cebr.357>.
12. Boyko, A., Zimbhoff, A., Mynenko, S., & Chen, Y. (2024). Anti-money laundering in the digital economy: Institutional, financial, and educational channels. *Virtual Economics*, 7(3), 59–80. [https://doi.org/10.34021/ve.2024.07.03\(4\)](https://doi.org/10.34021/ve.2024.07.03(4)).
13. Byrkovych, T., Humenchuk, A., Kobyzcha, N., Akimova, L., Grinberg, L., & Akimov, O. (2023). Economic Effectiveness of State Policy in Reforming Higher Library and Information Education in Ukraine. *Economic Affairs*, 68(1), 599–616.
14. Cai, Y., Ma, J., & Chen, Q. (2020). Higher Education in Innovation Ecosystems. *Sustainability*, 12(11), Article 4376. <https://doi.org/10.3390/su12114376>.
15. Dacko-Pikiewicz, Z. (2019a). Building a family business brand in the context of the concept of stakeholder-oriented value. *Forum Scientiae Oeconomia*, 7(2), 37–51. https://doi.org/10.23762/FSO_VOL7_NO2_3.
16. Dacko-Pikiewicz, Z. (2019b). 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. *Polish Journal of Management Studies*, 19(1), 130–144. <https://doi.org/10.17512/pjms.2019.19.1.10>.
17. Danova, M., Kravcakova Vozarova, I., & Sira, E. (2022). Innovations in human resources management: impact on economic growth. *Marketing and Management of Innovations*, 3, 53–65. <https://doi.org/10.21272/mmi.2022.3-05>.
18. Davlikanova, O., & Hofstetter, H. (2020). The «duales studium» adaptation as an innovation in ukrainian tertiary education: management aspects and results. *Marketing and Management of Innovations*, 3, 208–221. <https://doi.org/10.21272/mmi.2020.3-15>.
19. 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)).
20. Dutta, S., Lanvin, B., Wunsch-Vincent, S., & León, L. R. (Eds.). (2022). *Global innovation index 2022: What is the future of innovation-driven growth?* (Vol. 2000). WIPO.
21. Eurostat. (2024). Eurostat statistics. <https://ec.europa.eu/eurostat>.
22. Gigauri, I., Palazzo, M., & Siano, A. (2024). Examining the market potential for smart intelligent packaging: A focus on Italian consumers. *Virtual Economics*, 7(2), 89–116. [https://doi.org/10.34021/ve.2024.07.02\(5\)](https://doi.org/10.34021/ve.2024.07.02(5)).
23. Grupp, H., & Moge, M. E. (2004). Indicators for national science and technology policy: how robust are composite indicators?. *Research policy*, 33(9), 1373–1384. [https://doi.org/10.1016/S0048-7333\(04\)00118-0](https://doi.org/10.1016/S0048-7333(04)00118-0).
24. Hollanders, H., Es-Sadki, N., & Luczak, A. (2019). *European Innovation Scoreboard 2019*. Publications Office of the European Union. <https://doi.org/10.55643/fcaptp.1.42.2022.3683>.
25. Infante-Moro, A., Infante-Moro, J. C., & Gallardo-Pérez, J. (2022a). Key factors to raise cybersecurity awareness among employees [Factores claves para concienciar la ciberseguridad en los empleados]. *Revista de Pensamiento Estratégico y Seguridad CISDE*, 7(1), 69–79.

26. Infante-Moro, A., Infante-Moro, J. C., Gallardo-Pérez, J., & Martínez-López, F. J. (2022b). Key factors in the implementation of e-proctoring in the Spanish university system. *Sustainability*, 14(13), 8112. <https://doi.org/10.3390/su14138112>.
27. Ivascu, L., Sarfraz, M., Mohsin, M., Naseem, S., & Ozturk, I. (2021). The causes of occupational accidents and injuries in Romanian firms: an application of the Johansen cointegration and Granger causality test. *International journal of environmental research and public health*, 18(14), Article 7634.
28. Karpenko, L., Serbov, M., Kwilinski, A., Makedon, V., & Drobyazko, S. (2018). Methodological platform of the control mechanism with the energy saving technologies. *Academy of Strategic Management Journal*, 17(5), 1–7.
29. Kezar, A., & Bernstein-Sierra, S. (2024). Commercialization of Higher Education 110. *Second Handbook of Academic Integrity*, Article 1867.
30. 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)).
31. Kharazishvili, Y., Kwilinski, A., Grishnova, O., & Dzwigol, H. (2020). Social Safety of Society for Developing Countries to Meet Sustainable Development Standards: Indicators, Level, Strategic Benchmarks (with Calculations Based on the Case Study of Ukraine). *Sustainability*, 12(21), Article 8953. <https://doi.org/10.3390/su12218953>.
32. Kharazishvili, Y., Kwilinski, A., Sukhodolia, O., Dzwigol, H., Bobro, D., & Kotowicz, J. (2021). The Systemic Approach for Estimating and Strategizing Energy Security: The Case of Ukraine. *Energies*, 14(8), Article 2126. <https://doi.org/10.3390/en14082126>.
33. Kruss, G., McGrath, S., Petersen, I.-h., & Gastrow, M. (2015). Higher education and economic development: The importance of building technological capabilities. *International Journal of Educational Development*, 43, 22–31. <https://doi.org/10.1016/j.ijedudev.2015.04.011>.
34. Kulikov, P., Aziukovskyi, O., Vahonova, O., Bondar, O., Akimova, L., & Akimov, O. (2022). Postwar Economy of Ukraine: Innovation and Investment Development Project. *Economic Affairs*, 67(05), 943–959.
35. Kwiek, M. (2021). The prestige economy of higher education journals: A quantitative approach. *Higher Education*, 81(3), 493–519.
36. Kwilinski, A. (2019). Implementation of blockchain technology in accounting sphere. *Academy of Accounting and Financial Studies Journal*, 23(SI2), 1–6.
37. Kwilinski, A. (2023a). 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)).
38. Kwilinski, A. (2024b). Mapping global research on green energy and green investment: A comprehensive bibliometric study. *Energies*, 17(5), 1119. <https://doi.org/10.3390/en17051119>.
39. Kwilinski, A. (2024c). Understanding the nonlinear effect of digital technology development on CO2 reduction. *Sustainable Development*, 32(5), 5797–5811. <https://doi.org/10.1002/sd.2964>.
40. Kwilinski, A., & Kardas, M. (2024a). The role of the Pareto principle in quality management within Industry 4.0: A comprehensive bibliometric analysis. *Virtual Economics*, 7(3), 7–24. [https://doi.org/10.34021/ve.2024.07.03\(1\)](https://doi.org/10.34021/ve.2024.07.03(1)).
41. Kwilinski, A., & Vysochyna, A. (2024). Efficiency of healthcare financing: Case of European countries. *International Journal of Financial Studies*, 12(3), Article 87. <https://doi.org/10.3390/ijfs12030087>.
42. Kwilinski, A., Dalevska, N., & Dementyev, V. V. (2022). Metatheoretical issues of the evolution of the international political economy. *Journal of Risk and Financial Management*, 15(3), Article 124. <https://doi.org/10.3390/jrfm15030124>.

43. Kwilinski, A., Lyulyov, O., & Pimonenko, T. (2023a). The coupling and coordination degree of digital business and digital governance in the context of sustainable development. *Information*, 14(12), Article 651. <https://doi.org/10.3390/info14120651>.
44. Kwilinski, A., Lyulyov, O., & Pimonenko, T. (2023b). Unlocking Sustainable Value through Digital Transformation: An Examination of ESG Performance. *Information*, 14(8), Article 444. <https://doi.org/10.3390/info14080444>.
45. Kwilinski, A., Lyulyov, O., & Pimonenko, T. (2023c). Greenfield investment as a catalyst of green economic growth. *Energies*, 16(5), Article 2372. <https://doi.org/10.3390/en16052372>.
46. Kwilinski, A., Lyulyov, O., & Pimonenko, T. (2023d). Environmental Sustainability within Attaining Sustainable Development Goals: The Role of Digitalization and the Transport Sector. *Sustainability*, 15(14), Article 11282. <https://doi.org/10.3390/su151411282>.
47. Kwilinski, A., Lyulyov, O., & Pimonenko, T. (2024a). Reducing transport sector CO2 emissions patterns: Environmental technologies and renewable energy. *Journal of Open Innovation: Technology, Market, and Complexity*, 10(1), Article 100217. <https://doi.org/10.1016/j.joitmc.2024.100217>.
48. Kwilinski, A., Lyulyov, O., & Pimonenko, T. (2024b). Green economic development and entrepreneurship transformation. *Entrepreneurial Business and Economics Review*, 12(4), 157–175. <https://doi.org/10.15678/EBER.2024.120409>.
49. Kwilinski, A., Lyulyov, O., Pimonenko, T., & Pudryk, D. (2024c). Global image of countries and immigration flows. *Central European Business Review*, 13(4), 83–101. <https://doi.org/10.18267/j.cebr.359>.
50. Kwilinski, A., Merritt, P., & Wróblewski, Ł. (2024d). Advancing sustainable development goals through digital culture: A global research overview. *Cultural Management: Science and Education*, 8(1), 61–80. <https://doi.org/10.30819/cmse.8-1.04>.
51. Kwilinski, A., Szczepańska-Woszczyna, K., Lyulyov, O., & Pimonenko, T. (2024e). Digital public services: Catalysts for healthcare efficiency. *Journal of Open Innovation: Technology, Market, and Complexity*, 10(3), Article 100319. <https://doi.org/10.1016/j.joitmc.2024.100319>.
52. Kwilinski, A., Szczepańska-Woszczyna, K., Lyulyov, O., & Pimonenko, T. (2024f). Government effectiveness and immigrant outflows: Their role in advancing greenfield investment globally and regionally. *Polish Journal of Management Studies*, 29(2), 365–379. <https://doi.org/10.17512/pjms.2024.29.2.19>.
53. Kyrylov, Y., Hranovska, V., Boiko, V., Kwilinski, A., & Boiko, L. (2020). International tourism development in the context of increasing globalization risks: On the example of Ukraine's integration into the global tourism industry. *Journal of Risk and Financial Management*, 13(12), Article 303. <https://doi.org/10.3390/jrfm13120303>.
54. Labudova, V., & Fodranova, I. (2024). The impact of socioeconomic factors on digital skills in the population of the EU 27 countries. *Virtual Economics*, 7(3), 81–101. [https://doi.org/10.34021/ve.2024.07.03\(5\)](https://doi.org/10.34021/ve.2024.07.03(5)).
55. Lenhart, C., Bouwma-Gearhart, J., Keszler, D. A., Giordan, J., Carter, R., & Dolgos, M. (2022). STEM Graduate Students' Development at the Intersection of Research, Leadership, and Innovation. *Journal of College Science Teaching*, 52(2), 3–5. <https://doi.org/10.1080/0047231x.2022.12290689>.
56. Li, H., & Liu, S. (2021). Higher Education, Technological Innovation, and Regional Sustainable Development: Insights from a VAR Model. *Discrete Dynamics in Nature and Society*, 2021, 1–15. <https://doi.org/10.1155/2021/8434528>.
57. Llewelyn, M. (2024). European plant intellectual property. In *Breeding Research on Aromatic and Medicinal Plants* (pp. 389–397). CRC Press.
58. Lou, Y. Y., Yang, G. L., Guan, Z. C., Chen, X. L., Pan, H., Wang, T., & Zheng, H. J. (2024). A parallel data envelopment analysis and Malmquist productivity index model of virtual frontier

- for evaluating scientific and technological innovation efficiency at universities. *Decision Analytics Journal*, 10, Article 100384.
59. Lyulyov, O., Pimonenko, T., Infante-Moro, A., & Kwilinski, A. (2024). Perception of artificial intelligence: GSR analysis and face detection. *Virtual Economics*, 7(2), 7–30. [https://doi.org/10.34021/ve.2024.07.02\(1\)](https://doi.org/10.34021/ve.2024.07.02(1)).
 60. Lyulyov, O., Us, Y., Pimonenko, T., Kwilinski, A., Vasylieva, T., Dalevska, N., Polcyn, J., & Boiko, V. (2020). The link between economic growth and tourism: COVID-19 impact. In *Proceedings of the 36th International Business Information Management Association (IBIMA)* (pp. 8070–8086). International Business Information Management Association.
 61. Macerinskiene, I., & Vaiksnaite, B. (2006). The Role of Higher Education to Economic Development. *Vadyba/Management*, 2(11), 82–88.
 62. Mayboroda, T., Karpusha, V., & Balahurovska, I., (2024). Talent Management Model in the Context of Coopetitive Interaction and the Knowledge Economy. *Marketing and Management of Innovations*, 15(3), 141–150. <https://doi.org/10.21272/mmi.2024.3-11>.
 63. Michel-Villarreal, R., Vilalta-Perdomo, E., Salinas-Navarro, D. E., Thierry-Aguilera, R., & Gerardou, F. S. (2023). Challenges and opportunities of generative AI for higher education as explained by ChatGPT. *Education Sciences*, 13(9), Article 856.
 64. Migala-Warchol, A., & Pasternak-Malicka, M. (2018). Living standards of EU countries' residents: impact of education and innovation. *Marketing and Management of Innovations*, 4, 307–315. <https://doi.org/10.21272/mmi.2018.4-26>.
 65. Mlaabdal, S. M. A., Kulish, A., Kwilinski, A., & Chygryn, O. (2024). Sustainable energy policy and environmental responsibility: Clustering of key development patterns. *Journal of Sustainability Science and Management*, 19(8), 132–148. <https://doi.org/10.46754/jssm.2024.08.010>.
 66. Moretti, E. (2004). Workers' Education, Spillovers, and Productivity: Evidence from Plant-Level Production Functions. *American Economic Review*, 94(3), 656–690. <https://doi.org/10.1257/0002828041464623>.
 67. Morshed, N., & Hossain, M. R. (2022). Causality analysis of the determinants of FDI in Bangladesh: fresh evidence from VAR, VECM and Granger causality approach. *SN business & economics*, 2(7), Article 64.
 68. Ng, O. L., & Park, M. (2021). Using an enhanced video-engagement innovation to support STEM teachers' professional development in technology-based instruction. *Educational Technology & Society*, 24(4), 193–204.
 69. Nwogu, O. W. (2024). The Role of Personnel Management in Enhancing Organizational Efficiency: A Comparative Study of Public and Private Institutions in Rivers State, Nigeria. *Journals for Social Sciences*, 1(10), 164–175.
 70. Oturakci, M. (2021). Comprehensive analysis of the global innovation index: statistical and strategic approach. *Technology Analysis & Strategic Management*, 35(6), 676–688. <https://doi.org/10.1080/09537325.2021.1980209>.
 71. Payonk, K., Lyashenko, V., & Kvilinskyi, O. (2015). Operation of a business entity in the context of globalization. *Economic Herald of the Donbas*, 4(42), 18–23.
 72. Perkmann, M., Tartari, V., McKelvey, M., Autio, E., Broström, A., D'Este, P., Fini, R., Geuna, A., Grimaldi, R., Hughes, A., Krabel, S., Kitson, M., Llerena, P., Lissoni, F., Salter, A., & Sobrero, M. (2013). Academic engagement and commercialization: A review of the literature on university–industry relations. *Research Policy*, 42(2), 423–442. <https://doi.org/10.1016/j.respol.2012.09.007>.
 73. Peters, B., Roberts, M. J., Vuong, V. A., & Fryges, H. (2017). Estimating dynamic R&D choice: an analysis of costs and long-run benefits. *The RAND Journal of Economics*, 48(2), 409–437. <https://doi.org/10.1111/1756-2171.12181>.

74. Ploman, E. W., & Hamilton, L. C. (2024). *Copyright: Intellectual property in the information age*. Taylor & Francis.
75. Power, D., & Malmberg, A. (2008). The contribution of universities to innovation and economic development: in what sense a regional problem? *Cambridge Journal of Regions, Economy and Society*, 1(2), 233–245. <https://doi.org/10.1093/cjres/rsn006>.
76. Saura, J. R. (Ed.). (2022). *Teaching Innovation in University Education: Case Studies and Main Practices: Case Studies and Main Practices*. IGI Global.
77. Saura, J. R., Reyes-Menendez, A., & Bennett, D. R. (2019). How to extract meaningful insights from UGC: a knowledge-based method applied to education. *Applied Sciences*, 9(21), Article 4603.
78. Schwab, K. (2018, October). The global competitiveness report 2018. World Economic Forum.
79. Shkarlet, S., Kholiavko, N., Dubyna, M. (2019). Information economy: management of educational, innovation, and research determinants. *Marketing and Management of Innovations*, 3, 126–141. <https://doi.org/10.21272/mmi.2019.3-10>.
80. Shojaie, A., & Fox, E. B. (2022). Granger causality: A review and recent advances. *Annual Review of Statistics and Its Application*, 9(1), 289–319.
81. Singh, V. P., Singh, R., Paul, P. K., Bisht, D. S., & Gaur, S. (2024). Time series analysis. In *Hydrological Processes Modelling and Data Analysis: A Primer* (pp. 35–71). Singapore: Springer Nature Singapore.
82. Southworth, J., Migliaccio, K., Glover, J., Reed, D., McCarty, C., Brendemuhl, J., & Thomas, A. (2023). Developing a model for AI Across the curriculum: Transforming the higher education landscape via innovation in AI literacy. *Computers and Education: Artificial Intelligence*, 4, Article 100127.
83. Surya, B. K., Kot, S., Astawa, I. P., Rihayana, I. G., & Arsha, I. M. R. M. (2024). Unlocking sustainability through innovation: A green HR approach for the hospitality industry. *Virtual Economics*, 7(2), 50–62. [https://doi.org/10.34021/ve.2024.07.02\(3\)](https://doi.org/10.34021/ve.2024.07.02(3)).
84. Titko, J., Lapina, I., & Lentjušenkova, O. (2021). Measuring of intellectual capital investments in higher education: case of Latvia. *International Journal of Quality and Service Sciences*, 13(4), 601–617.
85. Titko, J., Steinbergs, K., Achieng, M., & Uzule, K. (2023). Artificial Intelligence for Education and Research: Pilot Study on Perception of Academic Staff. *Virtual Economics*, 6(3), 7–19.
86. Utouh, H., & Tile, A. (2023). The Nexus between Foreign Direct Investment and Nominal Exchange Rate, Real GDP, and Capital Stock In Tanzania. *Acta Scientiarum Polonorum. Oeconomia*, 22(1), 73–87.
87. Verina, N., Titko, J., & Shina, I. (2021). Digital transformation outcomes in higher education: Pilot study in Latvia. *International Journal of Learning and Change*, 13(4-5), 459–473.
88. Wang, K., Li, B., Tian, T., Zakuan, N., & Rani, P. (2023). Evaluate the drivers for digital transformation in higher education institutions in the era of industry 4.0 based on decision-making method. *Journal of Innovation & Knowledge*, 8(3), Article 100364.
89. World Bank. (2024). *World Data Bank*. <https://databank.worldbank.org>.
90. Zhou, G., & Luo, S. (2018). Higher Education Input, Technological Innovation, and Economic Growth in China. *Sustainability*, 10(8), Article 2615. <https://doi.org/10.3390/su10082615>.
91. 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), Article 998. <https://doi.org/10.3390/en16020998>.
92. Zimbrow, A. (2023). The future of extension programming postpandemic: The need for diverse approaches. *The Journal of Extension*, 61(2), Article 6. <https://doi.org/10.34068/joe.61.02.06>.

Systematic Literature Review on the Methodological Approaches of the Efficiency of Green Investment in Renewable Energy-Based Development

Egle Norgren ^{1*}, Jelena Stankeviciene ²

¹ Institute of Economics and Rural Development, Lithuanian Centre for Social Sciences, Vilnius, Lithuania
ORCID: 0000-0003-4512-2362
e-mail: egle.norgren@ekvi.lt

² Department of Finance, Faculty of Economics and Business Administration, Vilnius University, Lithuania
ORCID: 0000-0002-5600-5842
e-mail: jelena.stankeviciene@evaf.vu.lt

* Corresponding author: Egle Norgren, egle.norgren@ekvi.lt

Abstract

Analysing the efficiency of investments in renewable energy-based development plays a pivotal role in maximising the benefits of transitioning to a more sustainable energy future. Examining the efficiency of these investments ensures the optimal allocation of resources to preserve the environment and promote economic growth and social well-being. Reviewing the methodologies utilised in past research enables researchers and policymakers to discern the strengths and weaknesses of various approaches. Different researchers focus on distinct aspects of renewable energy-based development by applying a solid variety of different empirical methods. The purpose of the systematic literature review of the methodological approaches is to assess the efficiency of green investment in renewable energy-based development, advance knowledge, improve the quality of the research, and guide future investigations. A bibliometric review was conducted in the field of research based on Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA 2020) guidelines. Descriptive and performance analyses, along with a bibliometric review, cover the timeline from 2018 to the present. Utilising data from Web of Science (WoS) and Scopus databases, the VOSviewer software graphically presents the results. The examination of 105 WoS and 97 Scopus articles selected based on keyword combinations identifies the main research streams, focusing on green investment and investment efficiency in renewable energy-based development. The findings enable the identification of the most productive countries, journals, authors, and their collaborative efforts, all of which significantly contribute to shaping the theoretical framework of investment efficiency and green finance. The study also traces the evolution of research on the linkages between these two areas. Moreover, the results highlight the methodologies commonly employed within this field. Analysis of the WoS and Scopus databases revealed four emerging clusters, closely interconnected in research on investment efficiency in renewable energy development. The first cluster centres on green finance; the second on environmental economics and performance; the third on efficiency; and the fourth specifically on investment efficiency. As a result of the research, it was revealed that data envelopment analysis (DEA) is one of the most reliable methods used to assess the efficiency of green investment in renewable energy-based development under conditions of risk and uncertainty. The meta-analysis further uncovers new research avenues, shedding light on potential areas for future exploration regarding the relationship between investment efficiency and green investment, and methodological approaches. The findings of the systematic literature review contribute to the academic community by summarising existing research, providing a comprehensive overview, offering recommendations, and building the foundation for further scholarly work.

Key words

investment efficiency, green investment, green finance, renewable energy, data envelopment analysis.

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Introduction

In the discourse surrounding the efficiency of investments in renewable energy-based development, several conflicting viewpoints emerge. One of the primary debates focuses on how to measure the true efficiency of green investments. Additionally, there is disagreement over whether private or public investment models are more efficient in driving the transition to renewable energy. Some researchers advocate for market-driven investments (Azhgaliyeva et al., 2023), emphasising innovation and competition (Strielkowski, 2024), while others argue that government intervention and public funding (Phan, 2024; Ziabina & Navickas, 2022) are essential to mitigate risk and ensure equitable access to renewable energy.

A better understanding of effective methodologies will aid in assessing the efficiency of green investments in renewable energy-based development for future research. By reviewing the methodologies employed in existing studies, researchers and policymakers can gain insights into the strengths and weaknesses of different approaches. This understanding can contribute to the development of more robust methodologies. Therefore, the purpose of the research is to identify effective models that can be used to assess the efficiency of green investments in renewable energy-based development, and to present the different approaches used by researchers to disseminate scientific thinking in this area. In view of this, the aim is to answer the following research question:

RQ – What models are most effective in terms of assessing the efficiency of green investment in renewable energy-based development under conditions of risk and uncertainty?

The study utilises a bibliometric analysis of scientific articles retrieved from the WoS and Scopus databases, involving the examination of 105 and 97 articles selected based on keywords, respectively. Bibliometric methods have immense potential to introduce a systematic, transparent, and replicable peer-review process and thus improve the quality of literature reviews. They help to map the structure of a research field by categorising elements such as documents, authors, journals, and keywords into diverse groups (Zupic & Čater, 2015). The shift towards renewable energy represents a major transformation in the energy landscape, aligning with global endeavours to combat climate change and establish sustainable energy systems. Moreover, it emphasises the dynamic interaction among environmental, economic, and security factors in energy policy and implementation (Kut & Pietrucha-Urbanik, 2023).

The originality of this study lies in its identification of a significant rise in the importance of renewable energy-based development and green finance. While scholars have explored various dimensions of these subjects using diverse empirical approaches, this research distinguishes itself by highlighting the prominent application of DEA methods, particularly in addressing the inherent risks and uncertainties associated with green finance and renewable energy investments.

This paper consists of five interconnected chapters and a list of references. The first chapter provides a theoretical framework based on a review of the literature on renewable energy-based development. The second chapter describes the research methodology. Chapter three presents the results of the descriptive and performance analysis, followed by a discussion conducted in the fourth chapter. Conclusions are drawn in the fifth and last chapter of the paper.

1. Literature review

The significance of renewable energy in addressing climate change and guaranteeing a stable energy future has grown significantly (Akpan & Olanrewaju, 2023). The level of research is quite broad but not homogeneous. A systematic literature review and bibliometric analysis offer valuable insights into the field of assessing the efficiency of green investment in renewable energy-based development, facilitating the analysis of current trends and providing guidelines and motivations for future research endeavours (Tripathy et al., 2024; Odilova et al., 2023; Ziabina & Pimonenko, 2020; Muhuri et al., 2019; Fahimnia et al., 2015). This approach essentially outlines the general framework and overall

structure of the research field. Kwilinski (2024) delved into the relationship between green energy and green investment, highlighting the evolution of scholarly investigation into the linkages between these two domains. Muhmad et al. (2024) confirmed the positive relationship between green finance and renewable energy development, while Łukasiewicz et al. (2022) concluded that there is no one unified definition of sustainable energy development.

Green finance has emerged as a focal point of extensive research, reflecting the growing urgency to address environmental challenges (Wang et al., 2022). This field encompasses financial instruments, strategies, and initiatives aimed at promoting environmentally sustainable investments and practices. The studies (Zhang & Zhao, 2024; Li et al., 2024; Zhang et al., 2023; Sharma et al., 2022; Wang & Wang, 2022; Zhao et al., 2022; Iqbal et al., 2021; Lyeonov et al., 2019) actively investigating the dynamics of green finance, exploring its implications for sustainable development, economic resilience, and climate change mitigation by delving into topics such as green bonds (Strielkowski, 2024; Feng et al., 2024; Lin et al., 2023; Phan, 2024; Chygryn, 2018), green investment efficiency (Sun & Waqas, 2024; Chen & Feng, 2019), renewable energy financing alternatives (Azhgaliyeva et al., 2023), green innovations (Wu & Song, 2024; Kolosok et al., 2022;), fiscal policies (Zhao et al., 2023) and the role of governmental regulation to promote the green transformation (Li et al., 2024; Kut & Pietrucha-Urbanik, 2023; Wang et al., 2023; Pan & He, 2022; Ziabina & Navickas, 2022; Liu & Luo, 2019). Fang (2023) concentrates on sustainable investment portfolios, and the integration of environmental factors into financial decision-making. Muhmad et al. (2024) proposes that combining green finance with renewable energy development accelerates the transition to a low-carbon economy and mitigates the impacts of climate change. This makes green financing crucial for facilitating the shift to renewable energy sources (RES). Iqbal et al. (2021) suggest using green finance index as prerequisite to mitigate environmental pollution risk and Jiakui et al. (2023) addresses the gap in existing literature by constructing a thorough index of green finance expansion and examining its impact on green total factor productivity within the context of energy and environmental constraints.

According to Hailiang et al. (2023), Łukasiewicz et al. (2022) and others green finance and technological innovation promote environmentally conscious growth by shifting capital from carbon-intensive industries to those using advanced technologies. A key advantage of green finance is its ability to unite developed and underdeveloped countries in the fight against pollution (Ye et al., 2023). The notion of developing and developed countries appears to be pivotal in the context of renewable energy-based development. This aspect delves into the feasibility and dynamics of transitioning towards renewable energy sources, highlighting disparities and opportunities between nations at different stages of economic and technological advancement (Mohsin et al., 2021, 2023; Kyriacou et al., 2019). Scholars and policymakers are increasingly studying how developing countries can leverage renewable energy resources to leapfrog traditional development pathways and achieve sustainable growth (Lin et al., 2023; Miskiewicz, 2022; Zeng et al., 2018), while also examining how developed nations can support and collaborate with their counterparts to accelerate the global transition towards renewable energy adoption (Gavkalova et al., 2022; Iqbal et al., 2021; D. Zhang et al., 2021). Dzwigol et al. (2023) supports previous findings that green energy, along with responsible consumption and production, can positively impact green economic growth in both developed and developing countries.

It is noteworthy that numerous scientific articles employ various DEA model variations in conjunction with the Tobit model to evaluate regional energy efficiency and analyse the impact of green finance on energy performance (Wang & Wang, 2022), to calculate the regional ecological efficiency and verify the impact of green finance (Wang et al., 2022), to examine the impact, efficiency, and policy effects of green finance on industrial transformation (Gu et al., 2021). A Tobit regression model is also developed to investigate the influence of green finance and environmental regulations on green innovation efficiency (Zhao et al., 2022). Technique for Order Preference by Similarity to an

Ideal Solution method (TOPSIS) is prioritised to assess the level of renewable energy development in Belt and Road Initiative countries (An et al., 2023), to evaluate the level of renewable energy development in different countries (Leng & Zhang, 2023), to calculate the energy dependence index (Wang et al., 2022), as well as to evaluate the sustainable development of road transport in EU (Siksnyte-Butkiene & Streimikiene, 2022). Super-efficiency relaxation DEA model (Super-SNB) gained an attention in assessing energy efficiency (Nyangchak, 2024) and green innovation efficiency estimation (Wu & Song, 2024). Among dynamic panel regression models, the generalized estimation of moments (GMM) model is extensively used in exploring the impact of environmental regulations on green economic growth (Dzwigol et al., 2023), evaluating the importance of regulatory mechanism of green finance. Akpan & Olanrewaju (2023) employed five methodological or evaluation frameworks deemed necessary to achieve 100% renewable energy systems, while acknowledging that the existing literature lacks a comprehensive compilation of methods and evaluation approaches.

Scholars propose a variety of empirical research methods to evaluate the effectiveness and efficiency of investments in renewable energy-driven development, while also acknowledging and addressing the associated risks and uncertainties. In general, scholars seek to advance understanding and provide insights to shape policy measures aimed at fostering a financial system that is both more sustainable and resilient.

2. Methodology

The bibliometric analysis in the research field was conducted in two parts. First, descriptive analysis was performed to identify patterns and relationships that help to describe, illustrate, and usefully summarise data points by using recent and historical data. Secondly, performance analysis was conducted to provide systematic views and observations aiming to provide objective statistical data and visual feedback. The scope for systematic review was identified based on PRISMA 2020 guidelines. The key words used for data collection from Wos and Scopus databases: “data envelopment analysis (DEA)”, “investment efficiency”, “green finance” in the “title, abstract, keywords” category. The search was performed on 14th of September 2024 resulting in 143 records in WoS and 174 in Scopus databases. The records extracted from WoS database contained 114 articles, 27 proceeding papers, 6 early access and 1 editorial material, retracted documentation, and review article, between the period of 1998-2024. Simultaneously the records extracted for Scopus database resulted in 124 articles, 43 conference papers, 4 retracted and 1 book chapters, erratum, and review, between the period of 2005-2024. To ensure the comprehensiveness of systematic literature review the research was limited to document type “Article”, papers written in English language and the year range from 2018 to 2024, ensuring that the information investigated in the research remains both new and pertinent. The studies included in the research, after applying limitations, resulted in 105 articles from the WoS database and 97 articles from the Scopus database (Table 1).

Table 1. Keywords and other search criteria.

Keywords	Fields	Limited to	Period	WoS	Scopus
DEA OR “data envelopment analysis” AND “investment efficiency” OR “green finance”	Title, abstract, keywords	1. Document type: Articles 2. Language: English	2018.01.01 – 2024.09.14	105	97

Source: own elaboration.

The productivity-based analysis in the descriptive examination offers findings highlighting the most active production years, countries, journals within the research field. Performance analysis incorporated citation, co-citation and co-occurrence analyses, which are favoured by many researchers (Kwilinski, 2024; Soliman et al., 2021; Muhuri et al., 2019; Fahimnia et al., 2015; Fetscherin

& Heinrich, 2015; Zupic & Čater, 2015) due to their ability to objectively uncover relationships between articles and content, while also aiding in the identification of thematic clusters and emerging research streams. The number of citations acts as a metric for influence, considering heavily cited articles as noteworthy. This concept is grounded in the belief that authors reference documents they consider crucial for their research (Abdelmageed & Zayed, 2020; Odilova et al., 2023) and it is commonly referred to as a comprehensive synthesis of the literature (Fetscherin & Heinrich, 2015). Co-citation method is the most frequently employed and validated bibliometric approach (Zupic & Čater, 2015). Establishing connections between documents, authors, or journals through co-citation has proven to be dependable. The data from co-citation analysis can be utilised to assess not only the prominence of specific authors but also the influence of their publications (Ziabina & Pimonenko, 2020; Fahimnia et al., 2015). While co-occurrence is essential for mapping the thematic and conceptual landscape of a research field by analysing how often specific keywords appear together in the literature (Kwilinski, 2024; W. Wang et al., 2023). Co-occurrence of keywords encapsulates the knowledge domains within a particular field of research, defining its boundaries, revealing interconnections, and highlighting trends among research areas (Zupic & Čater, 2015).

Data analysis was carried out using the methodological approach outlined by the authors (Fig. 1), employing excel and the VOSviewer software. VOSviewer is widely used to construct and visualise bibliometric networks based on data from extensive databases like Wos or Scopus (Kwilinski, 2024; Seminario-Córdova & Rojas-Ortega, 2023).

Bibliographic Methods	Analysis design	Tools	outcome
Citation	Bibliometric analysis	WoS database	Top articles
			Top journals
Co-citation		Scopus database	Top authors
			Top countries
	Visualisation	Excel	intellectual structure
Co-occurrence			Development over time
		VOSviewer	Impact of collaboration

Figure 1. Research methodology.

Source: own elaboration.

3. Research results

3.1 Descriptive analysis

Bibliometric analysis proves to be a valuable method for assessing and scrutinising the outcomes of academic research. It aids in tracking progress, identifying the most dependable sources of scientific publications, establishing an evaluation framework for academic discoveries, recognising noteworthy contributors to scholarly endeavours, and constructing bibliometric indices for assessing academic productivity (Sharma et al., 2022). The total number of 202 articles from WoS and Scopus databases were analysed to determine the characteristics of the sample. The peak of publications paying attention to and analysing the efficiency of investments into renewable energy-based envelopment started in 2021 and about 80% of all articles were published during the past four years (Table 2). It indicates a global response to escalating environmental challenges, with efforts focused on exploring ways to address the impacts of environmental pollution through a shift towards sustainable solutions.

Table 2. Number of articles per year from 2018-2024.

Publication year	WoS		Scopus	
	Articles	% of total articles	Articles	% of total articles
2024	18	19	18	19
2023	19	18	21	22
2022	28	27	25	26
2021	18	17	12	12
2020	8	7	9	9
2019	8	7	7	7
2018	6	5	5	5

Source: WoS and Scopus databases.

China is responsible for over 90 % of the research activity in the respective subject area. China's leading position in research is linked to its role as the world's largest energy consumer, utilising 20% of global energy. Therefore, it emphasises China's crucial involvement in the global transition to sustainable energy. However, with over 60 % of its total energy supply dependent on imports, concerns have emerged about China's energy security and the environmental impact associated with heavy reliance on fossil fuels (Zeng et al., 2018). The statistics on the most active countries, which encompass the number of documents, citations, and total link strength based on VOSviewer summarised data, with a minimum requirement of 5 documents per country, suggested threshold by VOSviewer to keep visualization meaningful and focusing on highlighting most significant trends and connections, revealed that out of the 37 countries analysed, 9 countries from WoS and 6 countries from Scopus met the criteria (Table3).

Table 3. Most active countries.

Country	WoS			Scopus		
	Articles	Citations	Total link strength	Articles	Citations	Total link strength
China	82	2771	101	75	2716	4
Pakistan	12	843	55	8	685	2
United Kingdom	9	219	11	9	213	5
Malaysia	8	766	57	5	748	2
Taiwan	8	72	5	6	71	1
UAE	6	178	21	-	-	-
Vietnam	6	471	42	-	-	-
Japan	5	790	50	-	-	-
South Korea	5	40	2	5	48	0

Source: WoS and Scopus databases.

The leading journals with the highest number of publications are Environmental Science and Pollution Research with 16 publications in total, followed by Sustainability and Economic Change and Restructuring with 17 and 8 publications accordingly. The first free journals cover almost 52% of all publications. The results obtained by setting 3 as the minimum number of documents of a source to get a more comprehensive picture of journals with the highest number of citations (VOSviewer suggesting to use 4 as a minimum number). From the WoS database of the 62 sources, 9 met the thresholds and from the Scopus database of the 65 sources, 8 met the thresholds (Table 4). Notably, it is striking that the most cited journal is Energy Policy with 1533 citations, despite only 6 articles being published in the research area.

3.2 Performance analysis

The performance analysis involved an examination of various networks and the assessment of bibliometric data. Three bibliometric methods (Soliman et al., 2021; Fahimnia et al., 2015) – citation

analysis, co-citation analysis, and co-occurrence analysis – were employed, and each one plays a unique role in bibliometric analysis.

Table 4. Journals with highest number of publications.

Journal	WoS			Scopus		
	Articles	Citations	Total link strength	Articles	Citations	Total link strength
Environmental Science and Pollution Research	10	260	3	6	139	2
Sustainability	10	93	1	7	94	0
Energy Economics	4	171	2	4	190	1
Economic Change and Restructuring	4	142	1	4	169	0
International Journal of Environmental Research and Public Health	3	16	0	4	25	0
Energy Policy	3	728	11	3	805	0
Journal of Cleaner Production	3	320	1	3	447	0
Renewable Energy	4	207	3	4	226	3
Resources Policy	3	138	3	-	-	-

Source: WoS and Scopus databases.

The first two methods utilise citation data to establish measures of influence and similarity which helps to select the most relevant research works (Odilova et al., 2023; Łukasiewicz et al., 2022; Muhuri et al., 2019; Fetscherin & Heinrich, 2015). The third is the method of content analysis that leverages the words found in documents to establish connections and build a conceptual framework within the field (Muhmad et al., 2024; Wang et al., 2023). Kwilinski (2024) and Zupic & Čater (2015) explain that fundamental concept behind this method is that the frequent co-occurrence of words in documents signifies a close relationship between the underlying structures within scientific literature and identifying both emerging research areas and those that are already well-established.

The most cited article by Zhang et al. (2021), with a total of 992 citations in both WoS and Scopus databases, surpasses the citation count of Jiakui et al. (2023) by almost two times. Jiakui et al. (2023) work has been cited 555 times. The third most cited paper is Song et al. (2021) with 463 citations in total. Zhang et al. (2021) examines panel data from 2008 to 2018 for countries involved in the Belt and Road Initiative (BRI) by applying the Generalised Method of Moments (GMM) and Data Envelopment Analysis (DEA) with the goal to evaluate the correlation between R&D public spending, and the aspects of green economic growth and energy efficiency. The research uncovers the simultaneous presence of both composition and technology effects in achieving the goals of green growth. Furthermore, Zhang et al. (2021) underlines that public investment in both green energy technology research and education speeds up the development of the green economy. Jiakui et al. (2023) uses DEA and directional distance function (DEA-DEF) model to address the gap in the existing literature by creating a thorough index for the expansion of green finance and analysing the Total Factor Productivity Growth (GTFP) within the constraints of energy and the environment. Song et al. (2021) applies super-efficiency DEA and a spatial econometric model to assess energy use efficiency in the context of environmental constraints in the east, middle, and west region of China. Wang et al. (2022) study seeks to explore how green financing impacts renewable energy dependence and the transition to renewable energy in E7 countries by employing the combination of Entropy method (EM), grey relational analysis (GRA), and technique for order preference by similarity to an ideal solution (TOPSIS), DEA methods. Other most cited scholars are Zeng et al. (2018), Zhao et al. (2023), Gu et al. (2021), Feng et al. (2022), Wang et al. (2022), Wang & Wang (2022) and all of them employed different variations of DEA in combination with other supportive methodologies (Table 5).

Table 5. Most cited articles.

Document	Title	Cited WoS	Cited Scopus	Total	Methods used
Zhang et al. (2021)	Public spending and green economic growth in BRI region: Mediating role of green finance	472	520	992	Generalised method of moments (GMM), DEA
Jiakui et al. (2023)	Green technological innovation, green finance, and financial development and their role in green total factor productivity: Empirical insights from China	264	291	555	DEA, directional distance function (DEF)
Song et al. (2021)	Impact of green credit on high-efficiency utilisation of energy in China considering environmental constraints	220	243	463	super-efficiency DEA, spatial econometric model
Wang et al. (2022)	Green financing role on renewable energy dependence and energy transition in E7 economies	145	160	305	Entropy method (EM), grey relational analysis (GRA), and technique for order preference by similarity to an ideal solution (TOPSIS), DEA
Zeng et al. (2018)	Investment efficiency of the new energy industry in China	120	134	254	Four stage DEA
Zhao et al. (2023)	Testing green fiscal policies for green investment, innovation and green productivity amid the COVID-19 era	104	126	230	Baker, Chanes, and Cooper's (BSS) DEA
Gu et al. (2021)	The policy effect of green finance in promoting industrial transformation and upgrading efficiency in China: analysis from the perspective of government regulation and public environmental demands	86	91	177	VAR model, super-efficiency DEA, Tobit
Feng et al. (2022)	Nexus between Government spending's and Green Economic performance: Role of green finance and structure effect	62	73	143	DEA, Generalised method of moments (GMM)
Wang et al. (2022)	Research on the impact of green finance and abundance of natural resources on China's regional eco-efficiency	67	74	141	Super-efficiency DEA, Tobit
Wang & Wang (2022)	Research on the impact of green finance on energy efficiency in different regions of China based on the DEA-Tobit model	64	67	131	DEA, Tobit

Source: WoS and Scopus databases.

Co-citation analysis was conducted by employing reference co-citation analysis to determine the links between published articles in selected research areas. The term "co-citation" refers to the frequency with which two units are referenced together, and the more frequently items are cited together, the more likely they are related (Sharma et al., 2022). Representation of co-citation analysis by using full counting method and setting 5 as the minimum number of citations of cited references from WoS resulted in 54 references which met the threshold criteria out of 5284 cited references (Fig. 2). While setting the same parameters for the data from Scopus resulted in only 4 references meeting the threshold of 5260 cited references.

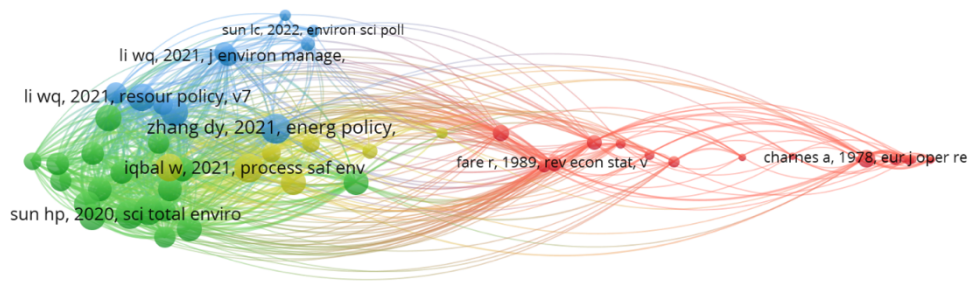


Figure 2. Co-citations of cited references from WoS database.

Source: visualisation by using VOSviewer.

Co-citation analysis disclosed the fact that much more similarity scores between articles, authors, and journals related to renewable energy-based development are among WoS references compared to Scopus. WoS reference total strength link co-citation map (Fig. 2) illustration depicts 4 clusters, each representing a unique thematic focus within the area of investment efficiency into renewable energy-based development. The initial three clusters – cluster 2 (green) comprising 18 items, cluster 3 (blue) containing 10 items and cluster 4 (yellow) containing 7 items – exhibit a notable co-citation strength, suggesting a strong semantic relationship between the items. Sun et al. (2020), Alemzero et al. (2021) and Agyekum et al. (2021) display the highest total link strength, resulting in scores of 164, 157 and 134 respectively, within cluster 2 (green). D. Zhang et al. (2021), Alemzero, Iqbal, et al. (2021) and W. Li et al. (2021) from cluster 3 (blue) display total link strengths of 175, 143, and 142 respectively, and Baloch et al. (2020), Iqbal et al. (2021) and Mohsin et al. (2021) from cluster 4 (yellow) display total link strengths of 158, 154, and 127. Cluster 1 (red) with 19 items which include a significant amount of historical research, dating as far back as 1957 and has much weaker connection to the other clusters, suggests that this is due to potentially outdated and not relevant research information.

Another beneficial aspect in comprehending the research patterns of a specific topic is the identification of co-occurring keywords. When conducting the analysis of co-occurrence of all keywords to determine the relatedness of items based on the number of documents in which they occur together, number 5 was set as the minimum number of occurrences of keywords, which resulted in 31 of 624 keywords meeting a threshold requirement in WoS. Irrelevant words “China” and “impact” were eliminated from keyword co-occurrence network map analysis and visualization (Fig. 3).

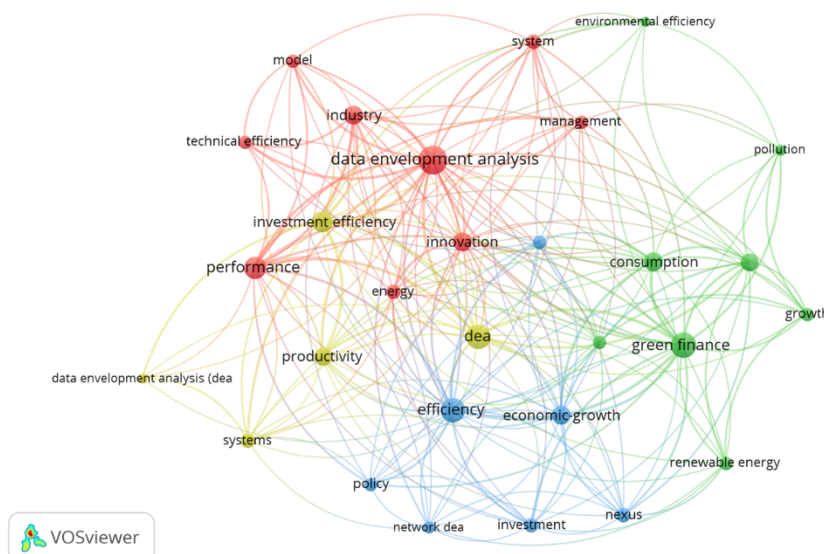


Figure 3. All keyword co-occurrence from WoS.

Source: visualisation by using VOSviewer.

From Scopus database 33 keywords of 850 met a threshold requirement before eliminating irrelevant words “China”, “panel data”, “article”, “human” from keyword co-occurrence network map analysis and visualization (Fig. 4).

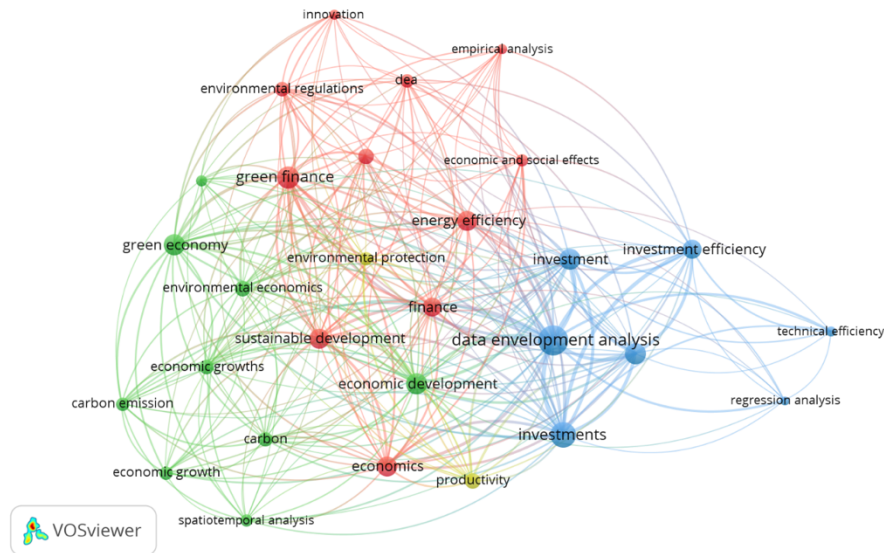


Figure 4. All keyword co-occurrence from Scopus.

Source: visualisation by using VOSviewer.

Employing VOSviewer software for keyword co-occurrence analysis and visualisation facilitated the recognition of groups and domains delineated by distinct colour clusters within bibliometric networks. Upon analysing both databases, a total number of 4 emerging clusters closely interrelated in research on investment efficiency into renewable energy-based development (Table 6). The predominant keyword correlations revolved around DEA and investments, interment efficiency, green finance and energy efficiency. This outcome offers insights into the primary subjects of each cluster and describes meaningful characteristics.

Table 6. Main keywords and primary subject of each Cluster.

Cluster	Colour	WoS		Scopus	
		Main keywords	Primary subject	Main keywords	Primary subject
1	Red	DEA, industry, innovation, model, performance, technical efficiency	DEA, Performance	Green finance, energy efficiency, sustainable development, finance, environmental regulations, economics	Green finance, sustainable development
2	Green	Consumption, pollution, environmental efficiency, growth, renewable energy, green finance	Green finance	Green economy, economic development, environmental economics, carbon emissions	Green economy, economic development
3	Blue	Efficiency, economic growth, investment, sustainability, policy	Efficiency	DEA, investments, investment efficiency,	DEA, investments
4	Yellow	DEA, investment efficiency, productivity, systems	Investment efficiency, DEA	Environmental protection, productivity	Environmental protection

Source: WoS and Scopus databases.

4. Discussion

Ultimately, the study highlights the important role of bibliometric analysis as an invaluable tool for understanding the evolving landscape of academic research. By enabling comprehensive insights, informed decision-making, and the progression of knowledge, it becomes instrumental in propelling endeavours towards a sustainable energy future.

Descriptive analysis underscored the significance of bibliometric methods in assessing and scrutinising academic research outcomes. It's evident that scholarly attention to investment efficiency in renewable energy-based development has escalated, especially since 2021. This surge in publications reflects a global response to environmental challenges, with a focus on sustainable solutions. Environmental Science and Pollution Research emerges as the leading journal focusing on research areas, followed by Sustainability and Economic Change and Restructuring. Notably, Energy Policy stands out as the most cited journal despite having a smaller number of articles.

Performance analysis delves deeper into the research landscape, highlighting key articles and methodologies. Notably, D. Zhang et al. (2021) emerges as the most cited article, offering insights into green economic growth and energy efficiency. In most cited references various methods were employed by different scholars, including Data Envelopment Analysis (DEA), Generalised Method of Moments (GMM), super-efficiency DEA, spatial econometric model, directional distance function (DEF), four-stage DEA, Baker, Chanes, and Cooper's (BSS) DEA, entropy method (EM), grey relational analysis (GRA), technique for order preference by similarity to an ideal solution (TOPSIS), Vector Autoregression (VAR) model, Tobit model, and Common Weight DEA. Co-citation analysis revealed 4 thematic clusters within the literature, with notable associations between publications within 3 clusters with noteworthy items (Alemzero et al., 2021a; Alemzero et al., 2021b; Baloch et al., 2020; Iqbal et al., 2021; Sun et al., 2020; Zhang et al., 2021). Keyword co-occurrence analysis further enriches the understanding, identifying clusters of related keywords such as DEA, green finance, and investment efficiency. These findings provide a nuanced view of the primary subjects and characteristics within the research landscape.

The results have addressed the primary research question: What are the effective models to assess the efficiency of green investment into renewable energy-based development under risk and uncertainty? Bibliometric analysis has revealed that a predominant portion of the research relies on the Data Envelopment Analysis (DEA) method and its variants, often complemented by methodologies such as Tobit, TOPSIS, spatial econometric models, among others. This analysis not only outlines initial research directions but also maps the interconnections and links between published research, demonstrating the diverse combinations of methodological approaches. This comprehensive overview serves to facilitate and guide future research endeavours in the field.

Conclusions

In conclusion, the significance of renewable energy in combating climate change and ensuring a stable energy future has surged, with researchers exploring various dimensions of renewable energy-based development. Green finance has emerged as a crucial area of focus, addressing environmental challenges through financial instruments and strategies. Scholars explore and utilise a diverse range empirical approach, mainly facilitated by DEA method, to assess investments and cooperative efforts aimed at fostering a sustainable future.

The research findings revealed valuable insights through descriptive and performance analyses applied in many similar studies (Kut & Pietrucha-Urbanik, 2023; Seminario-Córdova & Rojas-Ortega, 2023; Sharma et al., 2022), shedding light on the dynamics of academic research in the domain of renewable energy-based development. Abdelmageed & Zayed (2020) propose a similar three-step research process which includes bibliometric research, quantitative and qualitative analysis for critical analysis and future directions.

The study's findings offer valuable insights for shaping future research, policy decisions, and practical applications. By highlighting active countries, key scholars, and leading journals, it underscores the growing global focus on renewable energy investment efficiency, especially since 2021. The prominence of methodologies like Data Envelopment Analysis (DEA) in green finance and energy efficiency research suggests a need for continued exploration and refinement in these areas. For policymakers, the identification of emerging trends and thematic clusters can help prioritise investment strategies and create regulations that support sustainable energy transitions. For practitioners, the study provides guidance on optimising investments and enhancing efficiency, making it a critical resource for advancing green finance and technological innovation.

Bibliometric analysis proves invaluable in uncovering the interconnectedness and thematic trends within the literature on renewable energy-based development and applied empirical methodologies from solid databases. By providing insights into research directions and facilitating future inquiry, these analyses pave the way for continued scholarly advancement in the field.

It is important to note that, despite the extensive literature review based on descriptive and performance analyses, this study has certain limitations. While the bibliometric analysis provides a broad overview, it may not capture all the nuances of the dynamic relationships among DEA, green finance, and investment efficiency. Limitations arise from reliance on existing literature, the choice of databases, and the restricted time frame, which could constrain interpretative possibilities. Additionally, the selection of keywords may influence the scope and quality of the analysis, potentially affecting the generalisability of certain findings.

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Reference

1. Abdelmageed, S., & Zayed, T. (2020). A study of literature in modular integrated construction - Critical review and future directions. *Journal of Cleaner Production*, 277, Article 124044. <https://doi.org/10.1016/j.jclepro.2020.124044>.
2. Agyekum, E. B., Amjad, F., Mohsin, M., & Ansah, M. N. S. (2021). A bird's eye view of Ghana's renewable energy sector environment: A Multi-Criteria Decision-Making approach. *Utilities Policy*, 70, Article 101219. <https://doi.org/10.1016/j.jup.2021.101219>.
3. Akpan, J., & Olanrewaju, O. (2023). Towards a Common Methodology and Modelling Tool for 100% Renewable Energy Analysis: A Review. *Energies*, 16(18), Article 6598. <https://doi.org/10.3390/en16186598>.
4. Alemzero, D. A., Iqbal, N., Iqbal, S., Mohsin, M., Chukwuma, N. J., & Shah, B. A. (2021a). Assessing the perceived impact of exploration and production of hydrocarbons on households perspective of environmental regulation in Ghana. *Environmental Science and Pollution Research*, 28(5), 5359–5371. <https://doi.org/10.1007/s11356-020-10880-3>.
5. Alemzero, D. A., Sun, H., Mohsin, M., Iqbal, N., Nadeem, M., & Vo, X. V. (2021b). Assessing energy security in Africa based on multi-dimensional approach of principal composite analysis.

- Environmental Science and Pollution Research*, 28(2), 2158–2171. <https://doi.org/10.1007/s11356-020-10554-0>.
6. An, Y., Tan, X., Gu, B., Zhu, K., Shi, L., & Ding, Z. (2023). An assessment of renewable energy development in Belt and Road Initiative countries: An entropy and TOPSIS approach. *Energy Reports*, 10, 3545–3560. <https://doi.org/10.1016/j.egy.2023.09.085>.
 7. Azhgaliyeva, D., Beirne, J., & Mishra, R. (2023). What matters for private investment in renewable energy? *Climate Policy*, 23(1), 71–87. <https://doi.org/10.1080/14693062.2022.2069664>.
 8. Baloch, Z. A., Tan, Q., Iqbal, N., Mohsin, M., Abbas, Q., Iqbal, W., & Chaudhry, I. S. (2020). Trilemma assessment of energy intensity, efficiency, and environmental index: evidence from BRICS countries. *Environmental Science and Pollution Research*, 27(27), 34337–34347. <https://doi.org/10.1007/s11356-020-09578-3>.
 9. Chen, Y., & Feng, J. (2019). Do corporate green investments improve environmental performance? Evidence from the perspective of efficiency. *China Journal of Accounting Studies*, 7(1), 62–92. <https://doi.org/10.1080/21697213.2019.1625578>.
 10. Chygryn, O., Pimonenko, T., Lulyov, O., & Goncharova, A. (2019). Green bonds like the incentive instrument for cleaner production at the government and corporate levels: Experience from EU to Ukraine. *Journal of Environmental Management and Tourism*, 9(7), 1443–1456.
 11. Dzwigol, H., Kwilinski, A., Lyulyov, O., & Pimonenko, T. (2023). The Role of Environmental Regulations, Renewable Energy, and Energy Efficiency in Finding the Path to Green Economic Growth. *Energies*, 16(7), Article 3090. <https://doi.org/10.3390/en16073090>.
 12. 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>.
 13. Fang, L. (2023). Dynamics of renewable energy index in G20 countries: influence of green financing. *Environmental Science and Pollution Research*, 30(23), 63811–63824. <https://doi.org/10.1007/s11356-023-26804-w>.
 14. Feng, C., Zhong, S., & Wang, M. (2024). How can green finance promote the transformation of China's economic growth momentum? A perspective from internal structures of green total-factor productivity. *Research in International Business and Finance*, 70, Article 102356. <https://doi.org/10.1016/j.ribaf.2024.102356>.
 15. Feng, H., Liu, Z., Wu, J., Iqbal, W., Ahmad, W., & Marie, M. (2022). Nexus between Government spending's and Green Economic performance: Role of green finance and structure effect. *Environmental Technology & Innovation*, 27, Article 102461. <https://doi.org/10.1016/j.eti.2022.102461>.
 16. 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>.
 17. Gavkalova, N., Lola, Y., Prokopovych, S., Akimov, O., Smalskys, V., & Akimova, L. (2022). Innovative Development of Renewable Energy During The Crisis Period and Its Impact on the Environment. *Virtual Economics*, 5(1), 65–77. [https://doi.org/10.34021/ve.2022.05.01\(4\)](https://doi.org/10.34021/ve.2022.05.01(4)).
 18. Gu, B., Chen, F., & Zhang, K. (2021). The policy effect of green finance in promoting industrial transformation and upgrading efficiency in China: analysis from the perspective of government

- regulation and public environmental demands. *Environmental Science and Pollution Research*, 28(34), 47474–47491. <https://doi.org/10.1007/s11356-021-13944-0>.
19. Hailiang, Z., Iqbal, W., Chau, K. Y., Raza Shah, S. A., Ahmad, W., & Hua, H. (2023). Green finance, renewable energy investment, and environmental protection: empirical evidence from B.R.I.C.S. countries. *Economic Research-Ekonomska Istraživanja*, 36(2), 2125032–2125032. <https://doi.org/10.1080/1331677X.2022.2125032>.
 20. Iqbal, S., Taghizadeh-Hesary, F., Mohsin, M., & Iqbal, W. (2021). Assessing the Role of the Green Finance Index in Environmental Pollution Reduction. *Studies of Applied Economics*, 39(3), Article 18. <https://doi.org/10.25115/eea.v39i3.4140>.
 21. Jiakui, C., Abbas, J., Najam, H., Liu, J., & Abbas, J. (2023). Green technological innovation, green finance, and financial development and their role in green total factor productivity: Empirical insights from China. *Journal of Cleaner Production*, 382, Article 135131. <https://doi.org/10.1016/j.jclepro.2022.135131>.
 22. Kolosok, S., Saher, L., Kovalenko, Y., & Delibasic, M. (2022). Renewable Energy and Energy Innovations: Examining Relationships Using Markov Switching Regression Model. *Marketing and Management of Innovations*, 2(1), 151–160. <https://doi.org/10.21272/mmi.2022.2-14>.
 23. Kut, P., & Pietrucha-Urbanik, K. (2023). Bibliometric Analysis of Renewable Energy Research on the Example of the Two European Countries: Insights, Challenges, and Future Prospects. *Energies*, 17(1), Article 176. <https://doi.org/10.3390/en17010176>.
 24. Kwilinski, A. (2024). Mapping Global Research on Green Energy and Green Investment: A Comprehensive Bibliometric Study. *Energies*, 17(5), Article 1119. <https://doi.org/10.3390/en17051119>.
 25. Kyriacou, A. P., Muinelo-Gallo, L., & Roca-Sagalés, O. (2019). The efficiency of transport infrastructure investment and the role of government quality: An empirical analysis. *Transport Policy*, 74, 93–102. <https://doi.org/10.1016/j.tranpol.2018.11.017>.
 26. Leng, Y.-J., & Zhang, H. (2023). Comprehensive evaluation of renewable energy development level based on game theory and TOPSIS. *Computers & Industrial Engineering*, 175, Article 108873. <https://doi.org/10.1016/j.cie.2022.108873>.
 27. Li, T., Wang, H., & Lin, Y. (2024). Selection of renewable energy development path for sustainable development using a fuzzy MCDM based on cumulative prospect theory: the case of Malaysia. *Scientific Reports*, 14(1), Article 15082. <https://doi.org/10.1038/s41598-024-65982-6>.
 28. Li, W., Chien, F., Hsu, C.-C., Zhang, Y., Nawaz, M. A., Iqbal, S., & Mohsin, M. (2021). Nexus between energy poverty and energy efficiency: Estimating the long-run dynamics. *Resources Policy*, 72, Article 102063. <https://doi.org/10.1016/j.resourpol.2021.102063>.
 29. Lin, M., Zeng, H., Zeng, X., Mohsin, M., & Raza, S. M. (2023). Assessing green financing with emission reduction and green economic recovery in emerging economies. *Environmental Science and Pollution Research*, 30(14), 39803–39814. <https://doi.org/10.1007/s11356-022-24566-5>.
 30. Liu, Q., & Luo, C. (2019). The Impact of Government Integrity on Investment Efficiency in Regional Transportation Infrastructure in China. *Sustainability*, 11(23), Article 6747. <https://doi.org/10.3390/su11236747>.
 31. Łukasiewicz, K., Pietrzak, P., Kraciuk, J., Kacperska, E., & Cieciora, M. (2022). Sustainable Energy Development—A Systematic Literature Review. *Energies*, 15(21), Article 8284. <https://doi.org/10.3390/en15218284>.

32. Lyeonov, S., Pimonenko, T., Bilan, Y., Štreimikiene, D., & Mentel, G. (2019). Assessment of green investments' impact on sustainable development: Linking gross domestic product per capita, greenhouse gas emissions and renewable energy. *Energies*, 12(20), Article 3891. <https://doi.org/10.3390/en12203891>.
33. Miskiewicz, R. (2022). Clean and Affordable Energy within Sustainable Development Goals: The Role of Governance Digitalization. *Energies*, 15(24), Article 9571. <https://doi.org/10.3390/en15249571>.
34. Mohsin, M., Dilanchiev, A., & Umair, M. (2023). The Impact of Green Climate Fund Portfolio Structure on Green Finance: Empirical Evidence from EU Countries. *Ekonomika*, 102(2), 130–144. <https://doi.org/10.15388/Ekon.2023.102.2.7>.
35. Mohsin, M., Hanif, I., Taghizadeh-Hesary, F., Abbas, Q., & Iqbal, W. (2021). Nexus between energy efficiency and electricity reforms: A DEA-Based way forward for clean power development. *Energy Policy*, 149, Article 112052. <https://doi.org/10.1016/j.enpol.2020.112052>.
36. Muhmad, S. N., Cheema, S., Mohamad Ariff, A., Nik Him, N. F., & Muhmad, S. N. (2024). Systematic literature review and bibliometric analysis of green finance and renewable energy development. *Sustainable Development*, 32(6), 7342–7355. <https://doi.org/10.1002/sd.3093>.
37. 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>.
38. Nyangchak, N. (2024). Assessing renewable energy efficiency and policies: A combined analysis of LMDI, super-SBM, and fieldwork in Qinghai, China. *Energy for Sustainable Development*, 80, Article 101420. <https://doi.org/10.1016/j.esd.2024.101420>.
39. Odilova, S., Sharipova, Z., & Azam, S. (2023). Investing in the Future: A Systematic Literature Review on Renewable Energy and its Impact on Financial Returns. *International Journal of Energy Economics and Policy*, 13(4), 329–337. <https://doi.org/10.32479/ijeep.14375>.
40. Pan, K., & He, F. (2022). Does Public Environmental Attention Improve Green Investment Efficiency?—Based on the Perspective of Environmental Regulation and Environmental Responsibility. *Sustainability*, 14(19), Article 12861. <https://doi.org/10.3390/su141912861>.
41. Phan, T. C. (2024). Impact of green investments, green economic growth and renewable energy consumption on environmental, social, and governance practices to achieve the sustainable development goals: A sectoral analysis in the ASEAN economies. *International Journal of Engineering Business Management*, 16, Article 18479790241231725. <https://doi.org/10.1177/18479790241231725>.
42. Seminario-Córdova, R., & Rojas-Ortega, R. (2023). Renewable Energy Sources and Energy Production: A Bibliometric Analysis of the Last Five Years. *Sustainability*, 15(13), Article 10499. <https://doi.org/10.3390/su151310499>.
43. Sharma, G. D., Verma, M., Shahbaz, M., Gupta, M., & Chopra, R. (2022). Transitioning green finance from theory to practice for renewable energy development. *Renewable Energy*, 195, 554–565. <https://doi.org/10.1016/j.renene.2022.06.041>.
44. Siksnyte-Butkiene, I., & Streimikiene, D. (2022). Sustainable Development of Road Transport in the EU: Multi-Criteria Analysis of Countries' Achievements. *Energies*, 15(21), Article 8291. <https://doi.org/10.3390/en15218291>.

45. 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, Article 2801. <https://doi.org/10.54055/ejtr.v28i.2069>.
46. Song, M., Xie, Q., & Shen, Z. (2021). Impact of green credit on high-efficiency utilization of energy in China considering environmental constraints. *Energy Policy*, 153, Article 112267. <https://doi.org/10.1016/j.enpol.2021.112267>.
47. Strielkowski, W. (2024). Innovations in the Energy Sector as a Powerful Catalyst for Financial Transformations. *Marketing and Management of Innovations*, 15(1), 131–142. <https://doi.org/10.21272/mmi.2024.1-11>.
48. Sun, H., Pofoura, A. K., Adjei Mensah, I., Li, L., & Mohsin, M. (2020). The role of environmental entrepreneurship for sustainable development: Evidence from 35 countries in Sub-Saharan Africa. *Science of The Total Environment*, 741, Article 140132. <https://doi.org/10.1016/j.scitotenv.2020.140132>.
49. Sun, X., & Waqas, M. (2024). Assessing the influence of tourism development, via renewable energy and green finance in achieving high-quality economic development. *Heliyon*, 10(14), Article e33970. <https://doi.org/10.1016/j.heliyon.2024.e33970>.
50. Tripathy, P., Jena, P. K., & Mishra, B. R. (2024). Systematic literature review and bibliometric analysis of energy efficiency. *Renewable and Sustainable Energy Reviews*, 200, Article 114583. <https://doi.org/10.1016/j.rser.2024.114583>.
51. Wang, R., Zhao, X., & Zhang, L. (2022). Research on the impact of green finance and abundance of natural resources on China's regional eco-efficiency. *Resources Policy*, 76, Article 102579. <https://doi.org/10.1016/j.resourpol.2022.102579>.
52. Wang, S., Sun, L., & Iqbal, S. (2022). Green financing role on renewable energy dependence and energy transition in E7 economies. *Renewable Energy*, 200, 1561–1572. <https://doi.org/10.1016/j.renene.2022.10.067>.
53. Wang, W., Melnyk, L., Kubatko, O., Kovalov, B., & Hens, L. (2023). Economic and Technological Efficiency of Renewable Energy Technologies Implementation. *Sustainability*, 15(11), Article 8802. <https://doi.org/10.3390/su15118802>.
54. Wang, Y., Liu, J., Yang, X., Shi, M., & Ran, R. (2023). The mechanism of green finance's impact on enterprises' sustainable green innovation. *Green Finance*, 5(3), 452–478. <https://doi.org/10.3934/GF.2023018>.
55. Wang, Z., & Wang, X. (2022). Research on the impact of green finance on energy efficiency in different regions of China based on the DEA-Tobit model. *Resources Policy*, 77, Article 102695. <https://doi.org/10.1016/j.resourpol.2022.102695>.
56. Wu, Y., & Song, J. (2024). Impact of New Energy Industry Agglomeration on Green Innovation Efficiency–Based on the Regulative Effect of Green Finance. *Sustainability*, 16(8), Article 3311. <https://doi.org/10.3390/su16083311>.
57. Ye, N., Yuan, L., & Xu, Y. (2023). Non-parametric research methods to measure energy efficiency and renewable energy nexus: evidence from emerging economies. *Economic Research-Ekonomska Istraživanja*, 36(1), 2421–2442. <https://doi.org/10.1080/1331677X.2022.2097448>.
58. Zeng, S., Jiang, C., Ma, C., & Su, B. (2018). Investment efficiency of the new energy industry in China. *Energy Economics*, 70, 536–544. <https://doi.org/10.1016/j.eneco.2017.12.023>.

59. Zhang, D., Mohsin, M., Rasheed, A. K., Chang, Y., & Taghizadeh-Hesary, F. (2021). Public spending and green economic growth in BRI region: Mediating role of green finance. *Energy Policy*, 153, Article 112256. <https://doi.org/10.1016/j.enpol.2021.112256>.
60. Zhang, G., Guo, B., & Lin, J. (2023). The impact of green finance on enterprise investment and financing. *Finance Research Letters*, 58, Article 104578. <https://doi.org/10.1016/j.frl.2023.104578>.
61. Zhang, T., & Zhao, F. (2024). A study on the relationships among green finance, environmental pollution and economic development. *Energy Strategy Reviews*, 51, Article 101290. <https://doi.org/10.1016/j.esr.2023.101290>.
62. Zhao, L., Zhang, Y., Sadiq, M., Hieu, V. M., & Ngo, T. Q. (2023). Testing green fiscal policies for green investment, innovation and green productivity amid the COVID-19 era. *Economic Change and Restructuring*, 56(5), 2943–2964. <https://doi.org/10.1007/s10644-021-09367-z>.
63. Zhao, T., Zhou, H., Jiang, J., & Yan, W. (2022). Impact of Green Finance and Environmental Regulations on the Green Innovation Efficiency in China. *Sustainability*, 14(6), Article 3206. <https://doi.org/10.3390/su14063206>.
64. Ziabina, Y., & Navickas, V. (2022). Innovations in Energy Efficiency Management: Role of Public Governance. *Marketing and Management of Innovations*, 13(4), 218–227. <https://doi.org/10.21272/mmi.2022.4-20>.
65. Ziabina, Y., & Pimonenko, T. (2020). The Green Deal Policy for Renewable Energy: A Bibliometric Analysis. *Virtual Economics*, 3(4), 147–168. [https://doi.org/10.34021/ve.2020.03.04\(8\)](https://doi.org/10.34021/ve.2020.03.04(8)).
66. Zupic, I., & Čater, T. (2015). Bibliometric Methods in Management and Organization. *Organizational Research Methods*, 18(3), 429–472. <https://doi.org/10.1177/1094428114562629>.

The Business Model of a Retailer Based on the Consumer-Centric Approach in Building the Value of a Loyalty Programme on the Food Market

Pavol Kita ¹, Marian Cvirik ², Grzegorz Maciejewski ^{3,*}

¹ Comenius University in Bratislava, Slovakia
ORCID: 0000-0001-5870-9328
e-mail: pavol.kita@uniba.sk

² University of Economics in Bratislava, Slovakia
ORCID: 0000-0003-4701-1543
e-mail: marian.cvirik@euba.sk

³ University of Economics in Katowice, Poland
ORCID: 0000-0002-1318-0747
e-mail: grzegorz.maciejewski@ue.katowice.pl

* Corresponding author: Grzegorz Maciejewski, grzegorz.maciejewski@ue.katowice.pl

Abstract

Digitalisation brings great opportunities for marketing communication with customers through loyalty programmes, particularly in times of economic crisis. The objective of the article is to present the importance of a Loyalty Programme (LP) in regard to its role in cultivating a retailer–supplier relationship with the aim of creating exceptional value for a retailer’s business model on the food market, which it then brings to the end customer in its offer. The study presents a survey of 251 food store managers that assessed how they perceive their customer LP. The factors identified in the managers’ thinking about the LP provide the knowledge that managers are insufficiently aware of the importance of creating value for the customer, which is associated with building their relationship with the customer. This has a negative impact on the daily traffic and sales of the store.

Key words

retail, digitalisation, loyalty programmes, multichannel, value proposition, consumers.

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Introduction

The success of a retail business depends on how it is accepted by customers. From the marketing concepts point of view, in order to achieve this goal, some retailers have invested in customer loyalty programmes (LPs) (Gu et al., 2022). This strategic approach aims to better address the challenges posed by competitors, adapt to the realities of a multichannel market, and navigate the economic difficulties affecting the food industry. At the same time, by doing so they seem to have found a business model component that would be able to maintain a relationship with their customers and achieve success on the market (Moskalenko et al., 2021). The creation of value has a central place in the considerations of contemporary management in the post-COVID-19 period (Krowicki & Maciejewski, 2024). Through loyalty programmes, it takes different forms in terms of time (immediate, cumulated), type of partnership (value for suppliers, for customers), or scientific discipline (marketing, management, strategy, etc.). The value in itself hides a contradiction in supplier–retailer and retailer–consumer relationships: the value in the form of the advantage offered to customers when shopping requires the retailer’s value chain to be constructed such that it still makes a profit with a sufficient margin and the manufacturer does not suffer a loss (Li & Song, 2022). From this, it follows that retailers should create a market-driven approach (Carpenter, 2023) that will enable them to understand buyer needs, share what they learn within the company, and respond to customers. In terms of the dyad of relations with suppliers, the retailer runs into key problems with customer relationship management, such as a company’s frustration at its inability to embed itself within stakeholders’ networks (Albadvi & Hosseini, 2011). The dyad of the retailer–customer relationship is dependent on the consumer’s purchasing behaviour, reflecting his willingness to pay, which is linked to a comparison of the retailer’s offer with another competitive offer. This is all reflected in the retailer’s selected business model; how it is capable, on the one hand, of expanding the role of LP not only as a traditional element of the retailer’s communication mix, but also, like Odekerken-Schröder et al. (2003) state, of using loyalty as a tactic for the orientation of the retailer towards customer retention. Loyalty programmes have become even more crucial in the retail sector following the COVID-19 pandemic, as businesses adapt to shifts in consumer behaviour and expectations. For instance, Deloitte highlights that loyalty programmes, which were already growing in complexity and importance before the pandemic, have taken centre stage as brands aim to drive specific consumer behaviours and provide curated, personalised experiences (Murali, 2024). These programmes have evolved to meet post-pandemic demands for digital engagement, inclusivity, and sustainability, reflecting a broader transformation in customer–brand relationships.

Furthermore, research by Latif and Bashir (2024) emphasises that loyalty is not driven by singular factors but by a blend of elements such as customer satisfaction, trust, and perceived social responsibility. Post-pandemic, these factors have gained new relevance as customers seek businesses that align with their values and prioritise safety and connection. This nuanced approach to loyalty-building suggests that retailers who leverage these insights can achieve sustained consumer engagement and brand success. Therefore, it is still necessary to deal with the arrangement of the supply chain so as to create the value needed to satisfy all members of the ecosystem. The current post-SARS-CoV-2 pandemic period has shown that many traditional retailers now need to completely reconfigure their business model as rapidly as possible (Kucharska et al., 2024). A solution based on a loyalty programme will not be the same for everyone, but those who do not realise a principle change in the management of relationships with their customers may have a hard time surviving.

The contribution of the article is to show from a managerial point of view how retailers could integrate a loyalty programme into their new concepts of customer value as a starting point for marketing activities on the food market, since Tommasetti et al. (2017) characterise the food market as a contemporary hypercompetitive marketplace. The article follows on from studies related to loyalty programmes based on rewards (Eason et al., 2015), relationships (Zakaria et al., 2014), and company performance (Gu et al., 2022).

Based on this, we predict, on the basis of an empirical survey, that LPs integrate the basic elements of the business model (Doganova & Eyquen-Renault, 2009; Bocken et al., 2014) so that the company generates profit. For this reason, the objective of the article is to examine loyalty programmes as a value for the customer, since they can predict changes in consumer demand based on geographical areas (Kita et al. 2023, 2024), while also affecting the inter-organisational performance of the entire supply-chain retailer. In summary, the authors propose to answer four research questions in this study:

RQ1: How can activities in the area of creating customer value be assessed in the surveyed retail food units?

RQ2: What factors shape activities focused on the creation of customer value?

RQ3: How can the effect of the size of retail food units on the identified factors of customer value creation be characterised?

RQ4: How can the connection between the identified factors of creating customer value and selected business success indicators be characterised?

At the beginning, we explain the context of LP in the business models of retailers for creating value for consumers. We then conduct a systematic review of the theoretical foundations of the study. We next present the methodological basis and specify the sample with the research method used to achieve the results, and we conclude with a discussion of the implications of our findings for further research directions.

1. Literature review

Broadly defined, marketing is a function and a set of processes (Jenson et al., 2020; Theoharakis et al., 2024) that enable an organisation to create, communicate and deliver value to its customers. Because it enables organisations to deliver more value propositions, it also represents an organisational resource (Hunt, 2000; Hunt et al., 2006). Additionally, when fully developed, it becomes a competence (Bozic, 2018). Organisations that develop marketing competence are able to maintain a coordinated deployment of assets in a way that helps them achieve their goals (Sanchez et al., 1996).

Retail today is perceived by consumers through a positive shopping experience that allows them to buy anything at any time through a ubiquitous offer visualised by digital applications (Kotler et al. 2017). This fact, according to Chen et al., (2021) has created new opportunities for the management of LPs. Basically, loyalty programs have been addressing loyal customers in retail for centuries. They offer more affordable purchases, savings, gifts, rewards and other benefits that many customers sometimes don't even remember. The launch of an LP helps to induce perceived value, which leads consumers to enrol in and stay with an LP and reinforces their purchasing behaviour and relationship with the company. According to Frow et al. (2015) a business must be able to create exceptional value to be competitive. This can be done through the creation and maintenance of relationships with each stakeholder, i.e., for example, a supplier and the end customer. A business model represents a certain systematisation of the essence of an enterprise's operation, the creation of a market offer, access to the market and to customers and the creation of profit. Given that the study of Myllyskagas et al. (2010) states that the importance of individual stakeholders varies over time, relationships with individual interest groups thus change, too. Crosno et al. (2021) draw attention to the fact that performance refers to the economic outcomes realised in a relationship. Their study on contracts in marketing channels states that in a relational exchange, specificity coordinates activities and provides guidance, leading to heightened satisfaction and performance. Loyalty is generally a multidimensional construct (Belli et al. 2021). Evanschitzky et al. (2012) state that loyalty explains a complex psychological and behavioural trait that can be affected by many things, such as commitment, trust, shared identity, values, rewards and incentives (Evanschitzky et al. 2012). According to Nettet et al. (2023), loyalty is defined as an attitudinal concept. In this context, the advantage, or the perceived value of the offer to consumers represents a marketing task for the retailer,

which it must secure through its business model. With respect to the dual marketing concept (Carpenter, 2023), loyalty programs, as a classic element of the business model, paradoxically have the potential to increase customer value (Hwang & Choi, 2020; Faramarzi & Bhattacharya, 2021; Vieira et al., 2022).

Some authors expect the effect sizes of specificity and utilisation with exchange outcomes to be stronger when more specific assets have been invested (Crosno et al., 2021). We consider an LP that has a dual character in contemporary marketing, because this element fulfils various tasks in the given whole (Kim et al. 2022), i.e. business models.

The value of the customer for a retailer is becoming an ever more current topic within loyalty programs, since the online offers of competitors are presented to an ever-larger number of connected customers and also contribute to the expansion of the possibility of managing social relations with the customer in their marketing concept (Krowicki & Maciejewski, 2024). Retailers have likewise always been inundated with data (Grewal et al., 2017). This means that managers have the opportunity to better handle their supply chains and, simultaneously, relationships with customers.

2. Methodology

Historically, the first retail chain to introduce a loyalty programme on the Slovak grocery market was Billa in 2002, operating since 1993 (Billa, 2024). Subsequently, LP Coop Jednota, since 2003 (Jednota 2024), Tesco, established in 2010 (Tesco, 2024.). Overall, these first LP programs that were on focused on data collection to learn about consumer behaviour. They offered only a limited reward function because the consumer market was not yet sufficiently developed in terms of the current market concentration criteria of digitalization or the economic maturity of the country. Although the chains Lidl, established since 2014, and Kaufland, established since 2000, operating for more than 10 years, only launched their LP programmes with the advent of digital apps in 2020 (Lidl) and 2021 (Kaufland) respectively (Now, 2021). Thus, it is possible to divide LP programmes into LP before digitalisation and LP programmes after the onset of digitalisation, from 2020 onwards. After the largest retail chains, the chains Kraj, Terno and the like followed from 2020. Therefore, it is possible to characterise the Slovak retail industry might be characterised as being the opposite case to the “Norwegian case” (Nesset, 2023), where the market is dominated primarily by foreign retail chains, such as Tesco, Kaufland and Lidl. A similar situation exists, among others, in Poland (Maciejewski, 2018). Nevertheless, the similarity with this study is that we analyse the value that customers attribute to a loyalty program. What’s more, however, we identify LPs on the basis of elements of the retailers’ business models from a managerial perspective.

2.1 Sample and Data collection

The article is supported by primary research, and the population was defined as retail food units in Bratislava, the capital of Slovakia. It may be asked why in this paper a Bratislava retail network in selected aspects of LPs was treated only. The authors examine the city of Bratislava in their longitudinal papers (Kita et al. 2014, Kita et al. 2020, Kita et al. 2024, etc.) because its population is more than 500,000 and it cannot compare its retail network and the shopping behaviour of its residents with other Slovak cities that have less than 100,000 inhabitants. Bratislava's retail network cannot be considered as a general model applied to the whole of Slovakia. Other aspects such as the transport network, motorways and geographical location, e.g. close to Vienna, Brno and Budapest, are not comparable to other cities. Also, the phenomenon of cross-border shopping has to be considered in the managers' deliberations in the market scenario of the small-chain stores, because they are confronted with a situation where generating profit is no longer enough. Cross-border shopping has not only an economic dimension but also a social dimension. Retail chains in Austria, which are located close to the border with Slovakia, try to get closer to Slovak customers by employing Slovak-speaking staff (Kita et al. 2020) and by being attractive to those consumers who want to gain a new consumer experience. Therefore, when interpreting the results of similar research, according

to Krizan and Bikova (2013), one should take into account the possibilities of using the database in relation to other determinants and also in relation to the applied scale of output.

From the above it follows that the retail unit had to meet the following criteria: (1) it must be a retail unit; (2) it must mainly offer food products and (3) it must be in the Bratislava region. Data collection ran in September to October 2023. The primary survey involved 251 retail food units, and the sample had the character of a random sample. Upon cleaning the data, the sample was reduced to 240 retail units due to the failure of some to provide some answers to the research statements or the failure to provide some of the characteristics of the defined population. The statistical determination of the error size indicates that, given the size of the population and the size of the sample, the maximum statistical error (with a 95% confidence probability) is around 5%. Out of the 240 retail units, only 38 offered exclusively food products; the other 202 (84.17%) also offered non-food products. A total of 67 (27.9%) of the retail food units did not offer service, and 173 (72.1%) did have service available. In the context of the size categories of retail food units, we used the categorisation according to the Institut national de la statistique et des études économiques (INSEE, 2020), i.e. into the five categories depicted, namely the category up to 40 m² (n = 10.83%), up to 100 m² (n=25.42%), up to 400 m² (n=27.5%), up to 700 m² (n=8.75%), and over 700m² (n= 27.5%). This study is a continuation of retail research in Bratislava, where retailing has undergone significant changes over the past decades (Križan et al., 2014; Kita et al., 2022, 2024; Korec & Ondoš, 2021). According to Šveda & Sládeková Madajová (2023), Bratislava is now a multifunctional city with supra-regional retail and service facilities that are spatially differentiated, which brings new opportunities for new competitors with their business models to meet the needs of citizens in this local food market (Grewal et al., 2017).

Retailers can rely on survey-based measures, such as purchase intentions or positive evaluations, to generate greater engagement, loyalty and profits. Therefore, we decided to continue in our research from 2022 applied to the managers of retail stores in different retail chains.

Based on a questionnaire survey of the managers of 251 grocery retail chains, we were now interested in LP in the context of value creation by a retailer's business model. The sample was divided according to the size categories of the sales area, as in the research conducted in 2022 (Kita, et al. 2023). Table 1 shows the division by size categories into five segments with an emphasis on their location (district) and the use of loyalty programs (yes – uses a loyalty program, no – does not use a loyalty program).

Table 1. Sample characteristics

Retail size category	District 1		District 2		District 3		District 4		District 5	
	yes	no	yes	no	yes	no	yes	no	yes	no
40 m ²	3	6	0	2	0	3	0	6	0	6
to 100 m ²	3	9	7	13	3	8	2	7	4	6
to 400 m ²	6	3	18	4	13	2	6	4	8	2
to 700 m ²	1	1	7	0	1	0	7	0	4	0
over 700 m ²	3	1	15	0	11	1	19	0	16	0
Total	16	20	47	19	28	14	34	17	32	14

Source: Own processing.

In Table 1, the existence of a certain relationship can be observed, where there is an increasing trend of loyalty program usage at retail sales units of larger sizes; therefore, we used the chi-square calculation (p-value = 1.248×10^{-22} ; alpha = 0.05) and Cramér's V (Cramér's V = 0.674). The results indicate that within a random sample as well as in a population, an association can be expected between group size and loyalty programs, and this relationship will be very strong. Based on partial geomarketing data, we identified the location of stores with regard to the use of LPs. Table 1 also shows that the most frequent providers of LP are supermarkets and hypermarkets belonging most often to international chains, and they are most often located outside the city centre (District 1).

Almost no small stores up to 40 m² provide an LP at all, and from the viewpoint of localisation, this type of store format appears to be on the decline. The table also shows that consumers prefer large-sized stores, and it can be assumed, also based on the knowledge of the research carried out from 2022, that large-scale formats will be successful, because with the increasing sales area, retailers provide LPs, which indicates that the stores belong under the brand of the given business chain.

2.2 Research concept

Within the primary survey, we focused on the basic characteristics of retail sales units and the core of the research, which consisted of nine questions focused on value, the loyalty program as an element of customer knowledge and digitalisation, with the statements reflecting the professional literature (Table 2).

Table 2. Concept of the primary research.

Statement	Basis for making the statement
We do our best for customer satisfaction.	Gilbert and Veloutsou (2006); Simon and DeVaro (2006); Otto et al. (2020)
We do everything to make the customer happy.	Schmitt et al. (2015); Zhong and Moon (2020); Lucas (2023)
Loyalty programs work better than promotional materials.	Lee et al. (2014); Bowen and Chen McCain (2015); Kang et al. (2015); Chun and Ovchinniko (2019); Hwang et al. (2019)
The loyalty program is a significant long-term value for our customers.	Breugelmans et al. (2015); Stathopoulou and Balabanis (2016); Steinhoff and Palmatier (2016); Alshurideh et al. (2020);
Loyalty programs have the potential to improve relations between the unit and the customer.	Beck et al. (2015); Zakaria et al. (2014); Melnyk and Bijmolt (2015) Breugelmans et al. (2015)
Thanks to our loyalty program, every customer can save money.	Kreis and Mafael (2014); Eason et al. (2015); Stourm et al. (2015); Alshurideh et al. (2020);
Members of our loyalty programme have privileges over non-members.	Colliander et al. (2016); Viswanathan et al. (2017); Ma et al. (2018)
Digitalisation of the store is a key success factor.	Hagberg et al. (2016); Hänninen et al. (2018); Akram et al. (2021)
Digitalisation of the loyalty programme brings significant value to customers.	Bijmolt and Verhoef (2017); Cobelli and Chiarini (2020); Chen et al. (2021)

Source: Own processing.

The statements (Table 2) reflect both the professional literature and the cognitive and conative aspect of implementing business models, i.e. activities and a knowledge base focused on the direction and creation of the business model.

We use several methods and methodological procedures in the article. Within the primary research, we used the method of questioning with the use of a questionnaire. In this context, it is suitable to detail the methods of processing the obtained data with an emphasis on the statistical methods. The use of descriptive statistical methods, the aim of which is to demonstrate the situation in the examined sample with an orientation on measures of location and variability, is a given. In the work, we use exploratory factor analysis (EFA) to investigate latent factors, while following the latest recommendations (Watkins, 2018). In this sense, the suitability of the data for this type of analysis was examined (with an emphasis on the Kaiser-Meyer-Olkin (KMO) Test and Bartlett's Test). Within the KMO, the basic assumption is that the test value should be above 0.5, and values around 0.8 to 0.9 can be considered meritorious (Goni et al., 2020); within Bartlett's Test we expect significance (a value

lower than alpha, usually 0.05) (Nunes et al., 2020; Shrestha, 2021). Determining an appropriate number of factors is important, and we use the newest method – parallel analysis – which seems to be the best in simulations (Guo & Choi, 2023). Parallel analysis is a robust method for determining the number of factors as it compares empirical eigenvalues with randomly generated ones, reducing the risk of including noise or irrelevant factors and ensuring more accurate results than traditional criteria like the Kaiser rule (Iacobucci et al., 2022; Čvirik, 2024). We subsequently examine the suitability of the EFA implementation method as well as the rotation options. Within factor loadings, it is recommended to indicate only values higher than 0.4 (Hair, 2010). Several authors have pointed out the suitability of graphical visualisation of EFA; this, however, is not a standard output (Piter Nizu Kekry et al., 2021; Tripathi & Chaturvedi, 2024). We also use the ANOVA test with calculation of effects to examine the differences; on the one hand, we examine the assumptions of its use and, of course, on the other post hoc tests. Anova is suitable for comparing several groups if the conditions for the application of this method are met (Nađová Krošláková et al., 2024). The use of correlation coefficients is a given, of course, and they are verified in terms of their generalisability to the population (Wu et al., 2022), even though in the case of correlation coefficients it is more appropriate to use confirmation intervals (Prel et al., 2009).

3. Research results

Due to the complexity of the objective, in the next section we will proceed according to the formulated research questions.

RQ1: How can activities in the area of creating customer value be assessed in the surveyed retail food units?

In the first step, the description of the acquired data is key. For this purpose, we use the basic elements of descriptive statistics. We recorded the results in Table 3.

Table 3. Descriptive statistics of the examined statements

Statement	Code	Valid	Median	Mean ¹	Std. dev.	Min	Max
We do our best for customer satisfaction.	Q1	240	7	6.86	0.45	3	7
We do everything to make the customer happy.	Q2	240	7	6.76	0.59	4	7
Loyalty programmes work better than promotional materials.	Q3	240	5	5.05	1.35	1	7
The loyalty programme is a significant long-term value for our customers.	Q4	240	6	5.68	1.42	1	7
Loyalty programmes have the potential to improve relations between the unit and the customer.	Q5	240	6	5.68	1.38	1	7
Thanks to our loyalty programme, every customer can save money.	Q6	240	6	5.65	1.49	1	7
Members of our loyalty programme have privileges over non-members.	Q7	240	4	4.64	1.67	1	7
Digitalisation of the store is a key success factor.	Q8	240	6	5.80	1.47	1	7
Digitalisation of the loyalty programme brings significant value to customers.	Q9	240	6	5.45	1.47	1	7

Note: Due to the fact that the variables are measured on the ordinal scale, only the median can be interpreted. The arithmetic average value and standard deviation value are given for illustrative purposes only.

Source: Own processing in R.

As follows from the results in Table 3, 240 retail food units commented on individual statements. We measured the highest median rating (and at the same time the average rating) for statements Q1 and Q2, which are directly oriented on customer satisfaction and happiness. It is worth noting that for the statement Q1, none of the investigated subjects gave a rating lower than 3, and for Q2 even a rating lower than 4, and this unity of answers is also indicated by a very low level of standard error. In relation to the other statements, we identified full use of the offered seven-level scale. We measured the lowest score with the highest degree of diversity of answers from the average within the statement Q7 (Members of our loyalty programme have privileges over non-members), which represents a certain paradox, since the aim of the loyalty programme is to provide a benefit. It seems that a loyalty programme is seen as a marketing tool rather than a differentiation/discrimination tool.

RQ2: What factors shape activities focused on the creation of customer value?

Following the latest recommendations we used exploratory factor analysis (EFA) to investigate the latent factors (Watkins, 2018). We first verified the suitability of the data for this type of analysis using the Kaiser-Meyer-Olkin (KMO) Test and Bartlett's Test. The KMO test shows an acceptable value (0.815), and the Bartlett's Test was also significant ($p\text{-value} = 1.853 \times 10^{-249}$), which indicates the appropriateness of using the data for EFA.

It is necessary to correctly determine the factoring method, and with respect to the nature of the data as well as the goal of the analysis, we chose Principal axis factoring. The determination of the number of factors is equally crucial. Scientific analytical work offers several options for determining the number of factors (manually, based on the Kaiser-Guttman rule); however, parallel analysis currently appears to be the best option. We recorded the parallel analysis simulation in the scree plot, presented as Figure 1.

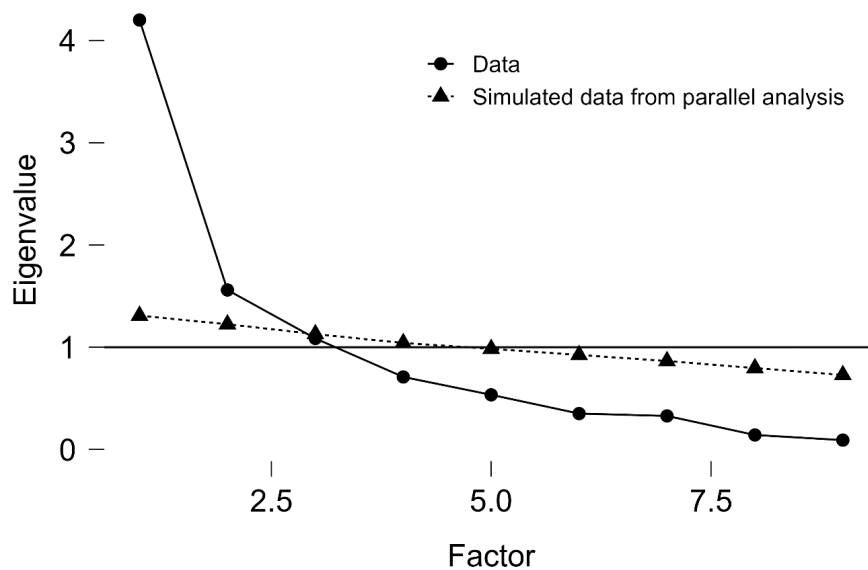


Figure 1. Scree plot with parallel analysis.

Source: Own processing in R.

The results from Figure 1 indicate that in this case both parallel analysis and the Kaiser-Guttman rule point to the existence of three factors. Therefore, we will work with three factors in the article. The initial solution (without rotation), however, did not provide a satisfactory solution, since many statements were not clearly assigned to factor groups. For this reason, we decided on the use of rotation. Given the expectation of correlation between latent factors and taking into consideration the nature of the data as well as the correctness of the methodological procedures, we selected oblique rotation, specifically promax. We recorded the results of exploratory factor analysis for the mentioned procedures in Table 4.

Table 4. Result of exploratory factor analysis

Factor Loadings	Factor 1	Factor 2	Factor 3
Q4	0.996		
Q5	0.984		
Q6	0.919		
Q3	0.581		
Q9	0.537		
Q1		0.803	
Q2		0.796	
Q8			0.821
Q7			0.428
Eigenvalues	4.2	1.559	1.086
Proportion var.	0.386	0.146	0.113
Cumulative	0.386	0.531	0.645

Note: Only factor loadings greater than 0.4 are shown.

Source: Own processing in R.

The results of the exploratory factor analysis (Table 4) point to the fact that the model explains roughly 65% of the variability in the data, which can be considered a high-quality model. At the same time, we can observe the assigning of individual statements to latent factors. The first factor represents a grouping of five statements, namely Q4, Q5, Q6, Q3 and Q9. The second factor contained two statements, namely Q1 and Q2. The third factor also consisted of two statements, namely Q8 and Q7. With respect to the semantics of the statements, as well as their strength in terms of belonging to the factor, factor 1 can be called “Loyalty Impact”; factor 2 “Customer-centric Approach” and factor 3 “Digital Transformation”. We recorded the correlations of the identified factors in Table 5.

Table 5. Factor correlations matrix.

Factor Correlations	Factor 1	Factor 2	Factor 3
Factor 1	1		
Factor 2	0.17	1	
Factor 3	0.567	0.1	1

Source: Own processing in R.

As we hypothesised, positive correlations do exist between the identified factors (Table 5). We can observe that the strongest correlation is between Loyalty Impact (factor 1) and Digital Transformation (factor 3), which only points to the synergy of these effects. The model achieves good values within the framework of additional fit indices, and the specific RMSEA is at the level of 0.008; SRMR is at the level of 0.02; TLI is at 0.951 and CFI is at 0.984. The newly created factors achieve an acceptable level of reliability, with Cronbach’s alpha for factor one at 0.912 and for factor 2 at 0.760. We graphically visualised the model in the form of a path diagram in Figure 2.

It points to a connection within individual latent factors and individual statements. Thicker lines present a stronger relationship between the elements.

RQ3: How can the effect of the size of retail food units on the identified factors of customer value creation be characterised?

Store size appears to be a significant factor in the business model of retail units (Amato & Amato, 2012; Cheah et al., 2018; Haas, 2019). Therefore, it is appropriate to verify the meaning also in the framework of a business model focused on customer value.

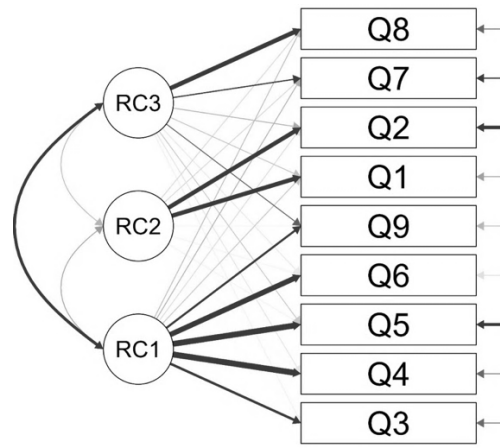


Figure 2. Path diagram.

Source: Own processing in R.

We first examined the descriptive parameters in terms of individual size groups and recorded the results in Table 6.

Table 6. Descriptive of identified factors

Size_cat	RC1		RC2		RC3	
	Mean	St. dev.	Mean	St. dev.	Mean	St. dev.
1	21.96	3.67	13.69	0.88	9.00	1.98
2	22.69	5.13	13.49	1.15	9.34	2.33
3	28.68	5.69	13.53	1.03	10.62	2.78
4	32.05	2.66	13.86	0.48	10.81	2.79
5	31.55	3.85	13.71	0.78	11.73	2.08

Source: Own processing in R.

The results from Table 6 indicate certain tendencies; however, statistical testing needs to be done. For this purpose we chose to use the ANOVA test due to the nature of the data.

In the first factor, a significant difference was shown between at least two groups in individual size groups ($\alpha = 0.05$; $p\text{-value} = 2.008 \times 10^{-27}$), and these differences have a significant effect ($\eta^2 = 0.427$). For a deeper examination of the issue, we used post hoc testing, the results of which we recorded in Table 7.

Table 7. Post hoc test for factor 1

Size_group_1	Size_group_2	Mean difference	p-value
1	2	-0.727	0.964
	3	-6.72	2.302×10^{-8}
	4	-10.086	3.030×10^{-11}
	5	-9.584	5.196×10^{-14}
2	3	-5.993	6.878×10^{-11}
	4	-9.359	9.827×10^{-13}
	5	-8.857	4.230×10^{-14}
3	4	-3.366	0.035
	5	-2.864	0.005
4	5	0.502	0.993

Source: Own processing in R.

The results from Table 7 point to a difference between all groups in pairs, aside from groups 1 and 2 and groups 4 and 5, where statistically significant differences could not be demonstrated. Therefore, it is possible to assume that the levels in the use of the factor Loyalty Impact in business models differ according to the size of the retail food units, and in groups 1 and 2 a low rate of use of this factor can be identified without a significant difference; subsequently, a significantly higher rate can be identified within the size category 3, and the highest level of use of Loyalty Impact can be identified within size groups 4 and 5 without a significant difference.

In the factor labelled “Customer-centric Approach” we do not observe significant differences regarding the description (Table 6). Of course, we verified this assumption statistically using the ANOVA test. As we assumed, it was not possible to demonstrate significant differences even between the two size groups ($p\text{-value}=0.437$). Given the above-presented, a certain universality of the mentioned factor in the context of size groups can be expected.

We also investigated the possible impact of the size categories of retail food units on the third factor, “Digital Transformation”, using the ANOVA test. The result of the one-way ANOVA test ($p\text{-value} = 8.894 \times 10^{-8}$) indicates that significant differences do exist between at least two size categories. For the purpose of a deeper examination, we used post-hoc tests, the results of which we recorded in Table 8.

Table 8. Post hoc test for factor 3.

Size_group_1	Size_group_2	Mean difference	p-value
1	2	-0.344	0.985
	3	-1.621	0.08
	4	-1.81	0.165
	5	-2.727	1.347×10^{-4}
2	3	-1.277	0.067
	4	-1.465	0.22
	5	-2.383	6.914×10^{-6}
3	4	-0.188	0.999
	5	-1.106	0.142
4	5	-0.918	0.679

Source: Own processing in R.

The results from Table 8 indicate a significant difference between size categories 1 and 5 and between size categories 2 and 5. Therefore, it can be expected that categories 1 and 2 will use the transformation to digitalisation to a lesser extent than the other size categories.

RQ4: How can the connection between the identified factors of creating customer value and selected business success indicators be characterised?

We chose two factors as key indicators of a company’s success, namely 1) sales (per month) and 2) number of customers (per day) (Panay et al., 2021).

Sales represented the monthly sales of a retail unit, and only 139 retail units reporting their sales (101 missing values). For this reason, we will continue with a sample of 139 retail food units from Bratislava. For a description of the obtained sales data, it can be stated that the minimum sales were €5,000 and the maximum sales were €3 million. The relationship between sales and identified factors were examined using correlation. The results indicate the existence of a strong positive relationship between RC1 and sales ($r_s=0.502$; $CI_{95\%}=<0.366 - 0.617>$), a trivial positive correlation between RC2 and sales ($r_s=0.018$; $CI_{95\%}=<-0.149 - 0.184>$), and a moderately strong positive correlation between RC3 and sales ($r_s = 0.446$; $CI_{95\%}=<0.302 - 0.57>$).

The second investigated factor was the number of customers. Again, a total of 23 retail food units did not respond to the question; therefore, the basis for the solution was 217 retail food units. The lowest listed number of customers was 20 and the highest was 8400, while the average value was 985

customers in one day. We again used correlation in the investigation of connections. The results indicate a strong positive association between the number of customers per day and RC1 ($r_s = 0.537$; $CI_{95\%} = <-0.435 - 0.625>$); a weak positive association between the number of customers per day and RC2 ($r_s = 0.109$; $CI_{95\%} = <-0.025 - 0.239>$), and a moderately strong positive association between the number of customers per day and RC3 ($r_s = 0.420$; $CI_{95\%} = <-0.303 - 0.524>$).

4. Discussion

In a marketing context, every retail transaction relates to an exchange between a retailer and a customer, who exchanges money for some kind of product. Retailers are aware of the trend that simply selling products and services is not enough, but that they have to build a natural relationship connecting the product and the customer. The idea of a connection in the form of offered product benefits (advantages) brings an increase in the level of customer service, i.e., the development of a loyal and long-term relationship with the customer, or in the development of the customer experience (Grewal et al., 2009). This means that not only the economic and financial situation of the retailer depends on the level of retail sales and the acceptance of the offer of retail units by final consumers, but also of the producers and all economic entities taking part in the value chain of creating value for the customer. A general characteristic feature of studies related to the concept of market orientation of a business is that it consists of several components (e.g. store operations, competitors, private label merchandise and positive customer shopping experiences etc.), which the authors statistically analysed and offered their perspectives on when managing marketing activities and creation of marketing strategies on the food market. The connection of market orientation and business models consists in the fact that market orientation itself offers important guidance to modern businesses in their response to customers and competition (Shoji, 2011).

Our results pay attention to the relational benefits that come from retailers creating value delivered to consumers in the context of the definition of contemporary marketing proposed by the American Marketing Association, which defines contemporary marketing as “the activity, set of institutions, and processes for creating, communicating, delivering, and exchanging offerings that have value for customers, clients, partners, and society at large.” This means that a retailer’s loyalty programme is perceived by managers as being very sensitive to contextual and industry factors (Sirdeshmukh et al. 2002). Likewise, the study of Corsaro & Snehota (2010) on customer perceptions of how the value of the inter-organisational relationship affect relational aspects (Corsaro & Snehota, 2010, Coleta et al. 2021) presents a similar opinion. The value of LP, which consists in the mentioned three factors, points to the fact that digital innovations are likely to help customers make good decisions, feel less time pressure or even increase their confidence and satisfaction with their decisions (Grewal et al., 2017).

Conclusions

The presented issue of LPs, together with the growing focused on business models in literature and practice, shows that this is a useful framework for business innovation in terms of exchange relations. In the digital era, most innovations in retailing will be driven by technology, with the aim of becoming customer orientated, and to manage communication and information technology, which will lead the retailer to become flexible and improve effective management (Kwilinski et al., 2022). These, together with an LP, consist of data about customers. This indicates that building an LP will provide the retailer with the capability of creating value by anticipating customer needs and responding to them with a customised offering.

The study shows how to identify elements that will have a major impact on resolving customer satisfaction and subsequently how the main business processes, supply chain management, integration of digital and physical channels, communication, performance management, sustainable development economics, employee evaluation and the like could be influenced in the future. This indicates a need to change the way of thinking and behaviour of retailers, which will require not only

new personnel and their skills, but also new specific retail processes, as evidenced by the current LP applications.

The study has several limitations, which we can divide into empirical and scientific. The empirical problem of the study is that it is increasingly difficult to conduct a survey in stores smaller than 40 m². This trend of the gradual disappearance of stores of this size format is also documented in a previous survey (Kita et al. 2023), where stores with an area of 100 m² or more predominate. A similar problem is also visible in other European countries (Kucharska et al., 2015). Further, it can be observed that foreign chains in particular use multi formats and offer online shopping, which represents a long-term European trend of ongoing concentration and integration in food retail.

Several problems can be identified from a theoretical point of view in the future research. First of all, the question of costs for maintaining relationships is very unclear, since value would require a balanced study of the costs and benefits of relationships (Sirdeshmukh et al. 2002). The authors of the studies only document the value of LP by showing that retailers who provide a loyalty programme make a profit overall. Secondly, the study primarily processes endogenous data provided by managers, which creates a risk of bias and manipulation.

Thirdly, this is a pilot study related to identifying the elements of loyalty programmes of retail chains from a managerial point of view, which can be considered as a foundation for future research on the impact of LP on the management of relationships with stakeholders within the ecosystem of a retailer's business model in exchange relations and within the framework of a sustainable smart city (Kwilinski et al., 2023). From this it follows that the duality of research in distribution is inevitably necessary for inter-organisational research of relationships and relationships with the end customer, since a retailer must organise its supply chain so that the consumer can partially or fully benefit, due to joint actions with suppliers (stakeholders). Our results in this context measured the duality indirectly, as scholars adopt various model specifications to examine its performance impact (Lyulyov et al., 2021, Kim et al. 2022). Furthermore, from the perspective of retail marketing development, future research should address issues such as exploring the long-term impact of LPs on sustainability, their influence on stakeholder relationships, and their role in promoting green retailing practices. It would also be interesting to conduct in-depth studies on the relationship between customer value factors and business success indicators.

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References

1. Akram, U., Fülöp, M. T., Tiron-Tudor, A., Topor, D. I., & Căpuşneanu, S. (2021). Impact of Digitalization on Customers' Well-Being in the Pandemic Period: Challenges and Opportunities

- for the Retail Industry. *International Journal of Environmental Research and Public Health*, 18(14), 7533. <https://doi.org/10.3390/ijerph18147533>.
2. Albadvi, A., & Hosseini, M. (2011). Mapping B2B value exchange in marketing relationships: A systematic approach. *The Journal of Business & Industrial Marketing*, 26(7), 503–513. doi:<https://doi.org/10.1108/08858621111162307>.
 3. Alshurideh, M., Gasaymeh, A., Ahmed, G., Alzoubi, H., & Kurd, B. A. (2020). Loyalty program effectiveness: Theoretical reviews and practical proofs. *Uncertain Supply Chain Management*, 8(2020), 599–612. <https://doi.org/10.5267/j.uscm.2020.2.003>.
 4. Amato, L. H., & Amato, C. H. (2012). Retail Philanthropy: Firm Size, Industry, and Business Cycle. *Journal of Business Ethics*, 107(4), 435–448. <https://doi.org/10.1007/s10551-011-1048-x>.
 5. Beck, J. T., Chapman, K., & Palmatier, R. W. (2015). Understanding Relationship Marketing and Loyalty Program Effectiveness in Global Markets. *Journal of International Marketing*, 23(3), 1–21. <https://doi.org/10.1509/jim.15.0010>.
 6. Belli, A., O'Rourke Anne-Maree, Carrillat, F. A., Ljubomir, P., Valentyna, M., & Ekaterina, N. (2022). 40 years of loyalty programs: How effective are they? generalizations from a meta-analysis. *Journal of the Academy of Marketing Science*, 50(1), 147–173. <https://doi.org/10.1007/s11747-021-00804-z>.
 7. Bijmolt, T. H. A., & Verhoef, P. C. (2017). Loyalty Programs: Current Insights, Research Challenges, and Emerging Trends. V B. Wierenga & R. Van Der Lans (Ed.), *Handbook of Marketing Decision Models*, 254, 143–165. Springer International Publishing. https://doi.org/10.1007/978-3-319-56941-3_5.
 8. Bilková, K., & Križan, F. (2013). Koncentrácia podnikateľských subjektov v maloobchode v slovenských mestách. *Geographia Cassoviensis*, 7(1), 31–44.
 9. Billa, 2024. <https://www.billa.sk/o-spolocnosti/kto-sme/zakladne-informacie>.
 10. Bocken, N. M. P. Rana, P., & Short, S. W. (2014). Value mapping for sustainable business thinking. *Journal of Industrial and Production Engineering*, 32(1), 67 – 81.
 11. Bowen, J. T., & Chen McCain, S.-L. (2015). Transitioning loyalty programs: A commentary on “the relationship between customer loyalty and customer satisfaction”. *International Journal of Contemporary Hospitality Management*, 27(3), 415–430. <https://doi.org/10.1108/IJCHM-07-2014-0368>.
 12. Bozic Yams, N. (2018). The impact of contemporary dance methods on innovative competence development. *Journal of Business Research*, 85, 494–503. <https://doi.org/10.1016/j.jbusres.2017.10.028>.
 13. Breugelmans, E., Bijmolt, T. H. A., Zhang, J., Basso, L. J., Dorotic, M., Kopalle, P., Minnema, A., Mijnlief, W. J., & Wunderlich, N. V. (2015). Advancing research on loyalty programs: A future research agenda. *Marketing Letters*, 26(2), 127–139. <https://doi.org/10.1007/s11002-014-9311-4>.
 14. Carpenter, G. S. 2023. Market driving, market driven, or both? toward a concept of dual market orientation. *Industrial marketing management*, 113, 357–359.
 15. Cheah, S., Ho, Y.-P., & Li, S. (2018). Business Model Innovation for Sustainable Performance in Retail and Hospitality Industries. *Sustainability*, 10(11), 3952. <https://doi.org/10.3390/su10113952>.
 16. Chen, Y., Mandler, T., & Meyer-Waarden, L. (2021). Three decades of research on loyalty programs: A literature review and future research agenda. *Journal of Business Research*, 124, 179–197. <https://doi.org/10.1016/j.jbusres.2020.11.057>.
 17. Chun, S. Y., & Ovchinnikov, A. (2019). Strategic Consumers, Revenue Management, and the Design of Loyalty Programs. *Management Science*, 65(9), 3969–3987. <https://doi.org/10.1287/mnsc.2018.3139>.
 18. Cobelli, N., & Chiarini, A. (2020). Improving customer satisfaction and loyalty through mHealth service digitalization: New challenges for Italian pharmacists. *The TQM Journal*, 32(6), 1541–1560. <https://doi.org/10.1108/TQM-10-2019-0252>.

19. Coletta, L., Vainieri, M., Noto, G., & Murante, A. M. (2021). Assessing inter-organizational performance through customer value: a literature review. *Journal of Business & Industrial Marketing*, 36(13), 15–27. <https://doi.org/10.1108/JBIM-07-2020-0353>.
20. Colliander, J., Söderlund, M., & Szugalski, S. (2016). Multi-level loyalty program rewards and their effects on top-tier customers and second-tier customers. *Journal of Consumer Marketing*, 33(3), 162–171. <https://doi.org/10.1108/JCM-03-2015-1349>.
21. Coop Jednota 2024. <https://coopklub.sk/>.
22. Corsaro, D., & Snehota, I. (2010). Searching for Relationship Value in Business Markets: Are We Missing Something? *Industrial Marketing Management*, 39, 986–995. <https://doi.org/10.1016/j.indmarman.2010.06.018>.
23. Crosno, J., Dahlstrom, R., Yuerong Liu, Y., & Tong, P. Y. (2021). Effectiveness of contracts in marketing exchange relationships: A meta-analytic review. *Industrial Marketing Management*, 92, 122–139. <https://doi.org/10.1016/j.indmarman.2020.11.007>.
24. Čvirik, M. (2024). The importance of music as a mood regulator: Adaptation of Music in Mood Regulation Scale in the conditions of Slovakia. *Ceskoslovenska Psychologie*, 68(3), 255–272. <https://doi.org/10.51561/cspsych.68.3.255>.
25. Doganova, L., & Eyquem-Renault, M. (2009). What do business models do? Innovation devices in technology entrepreneurship. *Research Policy*, 38(10), 1559–1570.
26. Eason, C. C., Bing, M. N., & Smothers, J. (2015). Reward me, charity, or both? The impact of fees and benefits in loyalty programs. *Journal of Retailing and Consumer Services*, 25, 71–80. <https://doi.org/10.1016/j.jretconser.2015.04.001>.
27. Evanschitzky, H., Ramaseshan, B., Woisetschlager, D. M., Richelsen, V., Blut, M., & Backhaus, C. (2012). Consequences of customer loyalty to the loyalty program and to the company. *Journal of the academy of marketing science*, 40, 625–638. <https://doi.org/10.1007/s11747-011-0272-3>.
28. Faramarzi, A., & Bhattacharya, A. (2021). The economic worth of loyalty programs: An event study analysis. *Journal of Business Research*, 123, 313–323. <https://doi.org/10.1016/j.jbusres.2020.09.044>.
29. Frow, P., Nenonen, S., Payne, A., & Storbacka, K. (2015). Managing co-creation design: A strategic approach to innovation. *British journal of management*, 26(3), 463–483. <https://doi.org/10.1111/1467-8551.12087>.
30. Gilbert, G. R., & Veloutsou, C. (2006). A cross-industry comparison of customer satisfaction. *Journal of Services Marketing*, 20(5), 298–308. <https://doi.org/10.1108/08876040610679918>.
31. Grewal, D., Levy, M., & Kumar, V. (2009). Customer Experience Management in Retailing: An Organizing Framework. *Journal of Retailing*, 85, 1–14. <https://doi.org/10.1016/j.jretai.2009.01.001>.
32. Grewal, D., Roggeveen, A. L., Jens Nordfält, J. (2017). *The Future of Retailing*. *Journal of Retailing*, 93(1), 1–6. <https://doi.org/10.1016/j.jretai.2016.12.008>.
33. Grossmanová, M., Kita, P., & Žambochová, M. (2016). Segmentation of Consumers in the Context of their Space Behaviour: Case Study of Bratislava. *Prague Economic Papers*, 25(2), 189–202. <https://doi.org/10.18267/j.pep.554>.
34. Gu, W. Luan, X., Song, Y., & Shang, J. (2022). Impact of loyalty program investment on firm performance: Seasonal products with strategic customers. *European Journal of Operational Research*, 299, 621–630.
35. Guo, W., & Choi, Y.-J. (2023). Assessing Dimensionality of IRT Models Using Traditional and Revised Parallel Analyses. *Educational and Psychological Measurement*, 83(3), 609–629. <https://doi.org/10.1177/00131644221111838>.
36. Haas, Y. (2019). Developing a generic retail business model – a qualitative comparative study. *International Journal of Retail & Distribution Management*, 47(10), 1029–1056. <https://doi.org/10.1108/IJRDM-10-2018-0234>.

37. Hagberg, J., Sundstrom, M., & Egels-Zandén, N. (2016). The digitalization of retailing: An exploratory framework. *International Journal of Retail & Distribution Management*, 44(7), 694–712. <https://doi.org/10.1108/IJRDM-09-2015-0140>.
38. Hair, J. F. (Ed.). (2010). *Multivariate data analysis* (7th ed). Prentice Hall.
39. Hänninen, M., Smedlund, A., & Mitronen, L. (2018). Digitalization in retailing: Multi-sided platforms as drivers of industry transformation. *Baltic Journal of Management*, 13(2), 152–168. <https://doi.org/10.1108/BJM-04-2017-0109>.
40. Hunt, S. D. (2000). *A General Theory of Competition: Resources, Competences, Productivity, Economic Growth*. Thousand Oaks, California: SAGE Publications, Inc.
41. Hunt, S. D., Arnett, D. B., & Madhavaram, S. (2006). The explanatory foundations of relationship marketing theory. *Journal of business & industrial marketing*, 21(2), 72–87. <https://doi.org/10.1108/10610420610651296>.
42. Hwang, E., Baloglu, S., & Tanford, S. (2019). Building loyalty through reward programs: The influence of perceptions of fairness and brand attachment. *International Journal of Hospitality Management*, 76, 19–28. <https://doi.org/10.1016/j.ijhm.2018.03.009>.
43. Hwang, J., & Choi, L. (2020). Having fun while receiving rewards?: Exploration of gamification in loyalty programs for consumer loyalty. *Journal of Business Research*, 106, 365–376. <https://doi.org/10.1016/j.jbusres.2019.01.031>.
44. Iacobucci, D., Ruvio, A., Román, S., Moon, S., & Herr, P. M. (2022). How many factors in factor analysis? New insights about parallel analysis with confidence intervals. *Journal of Business Research*, 139, 1026–1043. <https://doi.org/10.1016/j.jbusres.2021.09.015>.
45. INSEE. (2020). 300 000 points de vente dans le commerce de détail. <https://www.insee.fr/fr/statistiques/4474959#documentation>
46. Jenson, I., Doyle, R., & Miles, M. P. (2020). An entrepreneurial marketing process perspective of the role of intermediaries in producing innovation outcomes. *Journal of Business Research*, 112, 291–299. <https://doi.org/10.1016/j.jbusres.2019.09.054>.
47. Kang, J., Alejandro, T. B., & Groza, M. D. (2015). Customer–company identification and the effectiveness of loyalty programs. *Journal of Business Research*, 68(2), 464–471. <https://doi.org/10.1016/j.jbusres.2014.06.002>.
48. Kim, Y. M., Busenbark, J. R., Jeong, S., & Lam, S. K. (2022). The performance impact of marketing dualities: A response surface approach to resolving empirical challenges. *Journal of the Academy of Marketing Science*, 50(5), 915–940. <https://doi.org/10.1007/s11747-022-00848-9>.
49. Kita P., Čvirik M., Maciejewski G., Žambochová M., & Kitová Mazalánová V. (2023). Activities of retail units as an element of business model creation. *Polish Journal of Management Studies*, 27(1), 133–147. <https://doi.org/10.17512/pjms.2023.27.1.08>.
50. Kita, P., & Grossmanová, M. (2014). Reflection of Bratislava retail network in selected aspects of consumer behaviour. *Business: Theory and Practice*, 15(3), 279–284. <https://doi.org/10.3846/btp.2014.28>.
51. Kita, P., Križan, F., Bilková, K., Zeman, M., & Siviček, T. (2020). Comparison of Grocery Shopping Behaviour of Slovak Residents on the Slovak-Austrian Border: an Empirical Study – Hainburg an der Donau. *E&M Economics and Management*, 23(1), 215–230. <https://doi.org/10.15240/tul/001/2020-1-015>.
52. Kita, P., Maciejewski, G., Čvirik, M., & Mazalánová, V.K. (2022). New factors of consumer behaviour in the context of business models used in retailing during the COVID-19 era. *Forum Scientiae Oeconomia*, 10(3), 75–92. https://doi.org/10.23762/FSO_VOL10_NO3_4.
53. Kita, P., Maciejewski, G., Žambochová, M. & Križan, F. (2024). Geomarketing as an important element of a food retailer's business model: A managerial view. *International Journal of Management and Economics*, 60(1), 46–58. <https://doi.org/10.2478/ijme-2024-0005>.

54. Korec, P., & Ondoš, S. (2021). Socio-economic development in Bratislava during post-socialism, in: W. Cudny, J. Kunc, (Eds), *Growth and change in post-socialist cities of central Europe*, Routledge, London, 113–135.
55. Kotler, P., Kartajaya, H., & Setiawan, I. (2017). *Marketing 4.0: moving from traditional to digital*. Wiley and Sons: Hoboken, New Jersey.
56. Kreis, H., & Mafael, A. (2014). The influence of customer loyalty program design on the relationship between customer motives and value perception. *Journal of Retailing and Consumer Services*, 21(4), 590–600. <https://doi.org/10.1016/j.jretconser.2014.04.006>.
57. Križan, F., Bilková, K., & Kita, P. (2014). Urban retail market in bratislava (slovakia): Consumers perception and classification of shopping centres. *Management & Marketing*, 9(4), 483–500.
58. Krowicki, P., & Maciejewski, G. (2024). *Shopping Centre Marketing: Value Creation and Customer Engagement* (1st edition). Routledge. Taylor & Francis Group, London and New York. <https://doi.org/10.4324/9781032690544>.
59. Kucharska, B., Kucia, M., Maciejewski, G., Malinowska, M., & Stolecka-Makowska, A. (2015). *The retail trade in Europe – Diagnosis and future perspectives*, Publishing House of the University of Economics in Katowice, Katowice.
60. Kucharska, B., Maciejewski, G., Malinowska M., & Suchecki K. (2024). *COVID-19 Pandemic as a Catalyst for Change – Consumer's Perspective*. Logos Verlag, Berlin. <https://doi.org/10.30819/5837>.
61. Kwilinski, A., Lyulyov, O., & Pimonenko, T. (2023). The Effects of Urbanisation on Green Growth within Sustainable Development Goals. *Land*, 12, Article 511. <https://doi.org/10.3390/land12020511>.
62. Kwilinski, A., Lyulyov, O., Pimonenko, T., Dzwigol, H., Abazov, R., & Pudryk, D. (2022). International Migration Drivers: Economic, Environmental, Social, and Political Effects. *Sustainability*, 14, Article 6413. <https://doi.org/10.3390/su14116413>.
63. Latif, K.F., & Bashir, S. (2024). Achieving customer loyalty during post-pandemic: an asymmetric approach. *Future Business Journal*, 10(14), Article 1891. <https://doi.org/10.1186/s43093-024-00305-9>.
64. Lee, J. J., Capella, M. L., Taylor, C. R., Luo, M., & Gabler, C. B. (2014). The financial impact of loyalty programs in the hotel industry: A social exchange theory perspective. *Journal of Business Research*, 67(10), 2139–2146. <https://doi.org/10.1016/j.jbusres.2014.04.023>.
65. Li, N., & Song, J.-D. (2022). Impact of mixed bundling type on consumers value. *International Journal of Consumer Studies*, 46, 2167–2182. <https://doi.org/10.1111/ijcs.12776>.
66. Lidl, 2024. <https://spolocnost.lidl.sk/informacie-pre-media/tlacove-spravy/2024/lidl-plus-ceny-minus-uz-styri-roky>.
67. Lucas, R. W. (2023). *Customer service: Skills for success* (Eighth edition). McGraw Hill Education.
68. Lyulyov, O., Vakulenko, I., Pimonenko, T., Kwilinski, A., Dzwigol, H., & Dzwigol-Barosz, M. (2021). Comprehensive Assessment of Smart Grids: Is There a Universal Approach? *Energies*, 14, Article 3497. <https://doi.org/10.3390/en14123497>.
69. Ma, B., Li, X., & Zhang, L. (2018). The effects of loyalty programs in services – a double-edged sword? *Journal of Services Marketing*, 32(3), 300–310. <https://doi.org/10.1108/JSM-06-2016-0227>.
70. Maciejewski, G. (2018). Consumers' attitudes towards modern solutions in the retail trade, *Economics and Business Review*, 4(18), 69–85, <https://doi.org/10.18559/ebv.2018.3.6>.
71. Melnyk, V., & Bijmolt, T. (2015). The effects of introducing and terminating loyalty programs. *European Journal of Marketing*, 49(3/4), 398–419. <https://doi.org/10.1108/EJM-12-2012-0694>.
72. Miskiewicz, R. (2022). Clean and Affordable Energy within Sustainable Development Goals: The Role of Governance Digitalization. *Energies*, 15, Article 9571. <https://doi.org/10.3390/en15249571>.

73. Moskalenko, B., Lyulyov, O., Pimonenko, T., Kwilinski, A., & Dzwigol, H. (2021). Investment attractiveness of the country: Social, ecological, economic dimension. *International Journal of Environment and Pollution*, 69(1-2), 80–98.
74. Murali, R. (2024). COVID-19 broke the orthodoxies of customer loyalty and retention. Reimagining your customer loyalty strategy postpandemic. <https://www2.deloitte.com/us/en/pages/consulting/articles/the-orthodoxies-of-loyalty.html>.
75. Myllykangas, P., Kujala, J., & Lehtimäki, H. (2010). Analyzing the essence of stakeholder relationships: What do we need in addition to power, legitimacy, and urgency?. *Journal of Business Ethics*, 96, 65–72. <https://doi.org/10.1007/s10551-011-0945-3>.
76. Naďová Krošláková, M., Čvirik, M., & Manuel Guaita Martínez, J. (2024). Intervention and adaptation options for measuring brand trust in the context of its dimensionality with an emphasis on the generational context. *ESIC Market*, 55(2), Article e328. <https://doi.org/10.7200/esicm.55.328>.
77. Nettet, E., Bergem, O., Nervik, B., Schiøll Sørle, E., & Helgesen, Ø. (2023). Building chain loyalty in grocery retailing by means of loyalty programs – A study of ‘the Norwegian case’. *Journal of Retailing and Consumer Services*, 60, Article 102450.
78. Nunes, A. F., Monteiro, P. L., Nunes, A. S. (2020). Factor structure of the convergence insufficiency symptom survey questionnaire. *Plos One*, 15(2), Article e0229511. <https://doi.org/10.1371/journal.pone.0229511>.
79. Odekerken-Schrödera, G., De Wulf, K., & Schumacher, P. (2003). Strengthening outcomes of retailer–consumer relationships The dual impact of relationship marketing tactics and consumer personality. *Journal of Business Research*, 56, 177–190.
80. Otto, A. S., Szymanski, D. M., & Varadarajan, R. (2020). Customer satisfaction and firm performance: Insights from over a quarter century of empirical research. *Journal of the Academy of Marketing Science*, 48(3), 543–564. <https://doi.org/10.1007/s11747-019-00657-7>.
81. Panay, B., Baloian, N., Pino, J. A., Peñafiel, S., Frez, J., Fuenzalida, C., Sanson, H., & Zurita, G. (2021). Forecasting Key Retail Performance Indicators Using Interpretable Regression. *Sensors*, 21(5), Article 1874. <https://doi.org/10.3390/s21051874>.
82. Piter Nizu Kekry, B., Shinta Komang, S., Yare, H., & Duwiri, D. (2021). Economic Student Scientific Publication Model Exploration Factor Analysis (EFA) Approach. *Jurnal Sosial Teknologi*, 1(12), 1.580 – 1.587. <https://doi.org/10.59188/jurnalsostech.v1i12.268>.
83. Prel, J.-B. D., Hommel, G., Röhrig, B., & Blettner, M. (2009). Confidence Interval or P-Value? Part 4 of a Series on Evaluation of Scientific Publications. *Deutsches Ärzteblatt international*. <https://doi.org/10.3238/arztebl.2009.0335>.
84. Sanchez, R., Heene, A., & Thomas, H. (1996). *Dynamics of Competence-Based Competition*. Oxford: Elsevier.
85. Schmitt, B., Brakus, J., & Zarantonello, L. (2015). From experiential psychology to consumer experience. *Journal of Consumer Psychology*, 25(1), 166–171. <https://doi.org/10.1016/j.jcps.2014.09.001>.
86. Shoji, M. (2011). Relationship between Market Orientation and Customer Relationship Management in Retailing, *Journal of Japan Management Diagnosis Association*, 11, 151–156, <https://doi.org/10.11287/jmda.11.151>.
87. Shrestha, N. (2021). Factor Analysis as a Tool for Survey Analysis. *American Journal of Applied Mathematics and Statistics*, 9(1), 4–11. <https://doi.org/10.12691/ajams-9-1-2>.
88. Simon, D. H., & DeVaro, J. (2006). Do the best companies to work for provide better customer satisfaction? *Managerial and Decision Economics*, 27(8), 667–683. <https://doi.org/10.1002/mde.1303>.
89. Sirdeshmukh, D., Singh, J., & Sabol, B. (2002). Consumer Trust, Value, and Loyalty in Relational Exchanges, *Journal of Marketing*, 66(1), 15–37. <https://doi.org/10.1509/jmkg.66.1.15.18449>.

90. Stathopoulou, A., & Balabanis, G. (2016). The effects of loyalty programs on customer satisfaction, trust, and loyalty toward high- and low-end fashion retailers. *Journal of Business Research*, 69(12), 5801–5808. <https://doi.org/10.1016/j.jbusres.2016.04.177>.
91. Steinhoff, L., & Palmatier, R., W. (2016). Understanding loyalty program effectiveness: Managing target and bystander effects. *Journal of the Academy of Marketing Science*, 44(1), 88–107. <https://doi.org/10.1007/s11747-014-0405-6>.
92. Stourm, V., Bradlow, E. T., & Fader, P. S. (2015). Stockpiling Points in Linear Loyalty Programs. *Journal of Marketing Research*, 52(2), 253–267. <https://doi.org/10.1509/jmr.12.0354>.
93. Šveda, M., & Sládková Madajová, M. (2023). Estimating distance decay of intra-urban trips using mobile phone data: The case of Bratislava, Slovakia. *Journal of Transport Geography*, 107, Article 103552. <https://doi.org/10.1016/j.jtrangeo.2023.103552>.
94. Teraz, 2021. <https://www.teraz.sk/ekonomika/kaufland-prinasa-zakaznikom-kartu-s/525369-clanok.html>.
95. Tesco. 2024. <https://tesco.sk/25rokov/>.
96. Theoharakis, V., Zheng, Y., & Zhang, L. (2024). Dynamic strategic marketing planning: The paradox of concurrently reconfiguring and implementing strategic marketing planning. *Journal of Business Research*, 174, Article 114525. <https://doi.org/10.1016/j.jbusres.2024.114525>.
97. Tommasetti, A., Troisi, O., Vesci, M. (2017). Measuring Customer Value Co-Creation Behaviour: Developing a Conceptual Model Based on Service-Dominant Logic. *Journal of Service Theory and Practice*, 27, 930–950. <https://doi.org/10.1108/JSTP-10-2015-0215>.
98. Tripathi, S., & Chaturvedi, R. K. (2024). How personal beliefs determine adherence to standards of research ethics: An EFA and path analysis study. *International Journal of Ethics and Systems*, 40(4), 808–828. <https://doi.org/10.1108/IJOES-05-2023-0117>.
99. Vieira, V.A., Agnihotri, R., De Almeida, M. I. S., & Lopes, E. L. (2022). How cashback strategies yield financial benefits for retailers: The mediating role of consumers' program loyalty. *Journal of Business Research*, 141, 200–212. <https://doi.org/10.1016/j.jbusres.2021.11.072>.
100. Viswanathan, V., Sese, F. J., & Krafft, M. (2017). Social influence in the adoption of a B2B loyalty program: The role of elite status members. *International Journal of Research in Marketing*, 34(4), 901–918. <https://doi.org/10.1016/j.ijresmar.2017.08.003>.
101. Watkins, M. W. (2018). Exploratory Factor Analysis: A Guide to Best Practice. *Journal of Black Psychology*, 44(3), 219–246. <https://doi.org/10.1177/0095798418771807>.
102. Wu, J., Li, N., Zhao, Y., & Wang, J. (2022). Usage of correlation analysis and hypothesis test in optimizing the gated recurrent unit network for wind speed forecasting. *Energy*, 242, Article 122960. <https://doi.org/10.1016/j.energy.2021.122960>.
103. Zakaria, I., Rahman, B. Ab., Othman, A. K., Yunus, N. A. M., Dzulkipili, M. R., & Osman., M. A. F. (2014). The Relationship between Loyalty Program, Customer Satisfaction and Customer Loyalty in Retail Industry: A Case Study. *Procedia - Social and Behavioral Sciences*, 129, 23–30. <https://doi.org/10.1016/j.sbspro.2014.03.643>.
104. Zhong, Y., & Moon, H. C. (2020). What Drives Customer Satisfaction, Loyalty, and Happiness in Fast-Food Restaurants in China? Perceived Price, Service Quality, Food Quality, Physical Environment Quality, and the Moderating Role of Gender. *Foods*, 9(4), Article 460. <https://doi.org/10.3390/foods9040460>.

Smart Intelligent Packaging: Understanding the Perspective of Food Producers in Georgia

Iza Gigauri ^{1*}, Maria Palazzo ², Alfonso Siano ³, Maria Antonella Ferri ⁴

¹ The University of Georgia, Tbilisi, Georgia
ORCID: 0000-0001-6394-6416
e-mail: i.gigauri@sangu.edu.ge

² Universitas Mercatorum, Rome, Italy
ORCID: 0000-0002-8710-9054
e-mail: maria.palazzo@unimercatorum.it

³ University of Salerno, Italy
ORCID: 0000-0002-8577-8158
e-mail: sianoalf@unisa.it

⁴ Universitas Mercatorum, Rome, Italy
ORCID: 0000-0003-1769-1664
e-mail: a.ferri@unimercatorum.it

* Corresponding author: Iza Gigauri, i.gigauri@sangu.edu.ge

Abstract

Given the scholarly emphasis on researching intelligent packaging, this study seeks to examine food manufacturers' awareness of intelligent packaging and explore the specific features and characteristics they seek in such packaging. The paper aims to answer the following research questions by means of the qualitative interview method: (i) To what extent do smart packaging features matter to food manufacturers in Georgia? (ii) How familiar are food manufacturers in Georgia with innovative packaging solutions? The aim of this exploratory study is to gain a deeper understanding of the research phenomena and delve into various factors influencing the perspectives of food producers related to smart intelligent packaging in Georgia for the first time. Purposive sampling was applied to recruit food manufacturers. The main results show that although Georgian food producers are less aware of smart intelligent packaging, they are interested in it and determine certain smart intelligent features, traceability and monitoring attributes, and indicators that would increase their products' quality and safety. While the research is confined to a single country, the findings provide valuable insights into the attitudes of food producers towards intelligent packaging, shedding light on the market potential of smart packaging systems in Georgia. Consequently, the study contributes to the discourse on intelligent packaging in the food industry, offering diverse perspectives on its practicality in business. The research outcomes offer dual contributions to both academic knowledge and business practices. This investigation into food manufacturers' perspectives on smart intelligent packaging in Georgia is unprecedented. By examining their opinions on packaging, the study uncovers the market potential of intelligent packaging in developing economies. The insights gained from the research may assist food manufacturers in making informed decisions regarding the adoption of innovative packaging solutions, weighing the costs against the perceived benefits.

Key words

food packaging, intelligent packaging, smart packaging, marketing, sustainability, exploratory study.

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Introduction

Contemporary developments determine leading trends in the food packaging market. The modern age is marked by increasing concern for health and safety, ecology and environmental protection, an ageing society and modern technologies, which leads to changing lifestyles and growing demand for comfort and individualisation (Kita et al., 2021). By the same token, the importance of natural and organic food, produced and packed without artificial food additives, is increasingly required (Nile et al., 2020; Kalpana et al., 2019). These advancements have been reflected in the packaging industry producing environmentally friendly packaging from biodegradable materials, which at the same time are practical, simple, and contain a minimal amount of visual incentives while accentuating food safety (Han et al., 2018; Santeramo et al., 2018; Sharma & Ghoshal, 2018; Gréa et al., 2023). Consequently, the sustainable packaging concept has emerged, intertwined with smart intelligent packaging ideas. Intelligent packaging systems are used for monitoring packaged food, especially during transportation and storage (Shao et al., 2021). Smart, active, and intelligent packaging monitors packaged products and the surrounding environment to communicate product conditions in real time, and in this way help to avoid unsafe food and prevent unnecessary food waste (Yousefi et al., 2019). Thus, smart packaging communicates information about the product and improves its conditions. Smart packaging is comprised of active and intelligent packaging, which was initially introduced in Japan in the 1970s (Dainelli et al., 2008) and expanded to the American, Australian, and European markets in the 1990s, mainly for food and pharmaceutical products (Stoma & Dudziak, 2022). Since then, the packaging industry has shifted from the passive protective function to active protective capability, avoiding not only external damage but also controlling the internal deterioration of a product (Stoma & Dudziak, 2022). In addition, intelligent packaging technologies can reveal those suppliers who violate the storage conditions by, for example, turning off refrigerators at night in order to economise energy expenses (Azerdo & Correa, 2021). At this point, it should be noted that a similar practice is also observed in Georgia.

Selecting Georgia as a location to analyse the topic of intelligent packaging is driven by several factors. First of all, Georgia has a significant presence of industries related to packaging, such as food and beverage manufacturing, pharmaceuticals, or logistics. Among these industries, there are companies that can be considered early adopters and other organisations that have heavily invested in exploring intelligent packaging solutions to improve efficiency, traceability, or customer engagement. Moreover, Georgia's regulatory environment is conducive to innovation in packaging technologies. Hence, understanding the regulatory landscape – considered thanks to the manufacturers' perspective – can shed light on the opportunities and challenges associated with implementing intelligent packaging solutions, such as compliance with food safety standards or labelling requirements. Besides, Georgia, as a post-Soviet, developing country with a population of 3.7 million, aspires to join the European Union and has joined several trade agreements to be integrated into the global market. Therefore, the country represents an engaging environment to perform research in the field of intelligent packaging, due to the lack of studies in this regard. Moreover, the new law on the Protection of Consumer Rights in Georgia demands that manufacturers disclose exhaustive information about their products on the label. In this sense, smart intelligent packaging facilitates the fulfilment of those requirements. Although there are studies examining smart intelligent packaging, they mainly focus on customers or packaging technologies. Studies examining manufacturers, B2B customers, and suppliers are still scarce. Therefore, this research is focused on producers who are potential users of such packaging solutions. Moreover, researchers confirm the need for studies regarding innovative packaging solutions in the food industry (Stoma & Dudziak, 2022). Similarly, food producers' standpoint and acceptance of smart packaging features can be a step forward in the food packaging market. For this reason, the qualitative research fills the gap in the packaging literature by investigating food manufacturers' perspectives on intelligent packaging in Georgia. This study aims to explore the awareness of intelligent packaging among food

manufacturers and to investigate the features and characteristics of the packaging the producers are demanding.

In addition, there is limited research available on food producers' awareness of smart intelligent packaging systems and the importance of the features and attributes of such packaging for the food products they produce. Their knowledge may be related to the degree of selecting innovative packaging (Grubor et al., 2020). Food producers' attitudes toward smart intelligent packaging can influence the demand for innovative packaging solutions on the market (Young et al., 2023). It is noteworthy that certain characteristics of food products and market conditions in emerging countries can shape food producers' behaviour toward smart packaging systems and affect companies' innovation performance. Furthermore, our research focuses on the context of emerging markets, which have received less scholarly attention as most studies related to innovative packaging systems have been conducted in advanced economies, omitting the perspectives of emerging economies.

Accordingly, the research questions are formulated as follows.

RQ1: How important are the smart packaging features for food manufacturers in Georgia?

RQ2: How aware are food manufacturers in Georgia of innovative packaging solutions?

Although the scope of this research is restricted to only one country, the results still create noteworthy knowledge about the attitude of food producers toward intelligent packaging and shed light on the market potential of smart packaging systems in Georgia. Thus, the research contributes to the discussion about intelligent packaging in the food industry and illuminates its applicability to business from a variety of perspectives.

The research results contribute to both the knowledge body and business practice. Food manufacturers' viewpoints toward smart intelligent packaging studied in Georgia is the first one of this type. Since the study investigates their opinion toward packaging, it can reveal the market potential of intelligent packaging in developing economies similar to Georgia. Food manufacturers can refrain from investing in the adoption of innovative packaging solutions unless they realize the real benefits. Therefore, the research results help food manufacturers in making the decision on whether intelligent packaging is worthwhile for their products taking into consideration the costs, and if such technologies can decrease waste or increase sales from their point of view. In addition, the research sheds light on what marketing actions are needed to promote the technologies of intelligent packaging.

1. Literature review

Scholars based on their empirical studies describe various characteristics as important factors for packaging, including environmental, marketing chains, logistics functions (Firouz et al., 2021; Rundh, 2013), marketing communication, and branding functions (Ketelsen et al., 2020; Dopico-Parada et al., 2021). According to Robertson (2013), the main functions of packaging are containment, protection, convenience, and communication. Producers prefer packaging that not only protects goods during transportation, distribution, storage, and retailing from getting into contact with other products or environmental contaminants to avoid any damage to the quality but also to ensure minimal delivery costs and maximum sale revenues (Kalpana et al., 2019).

Stoma and Dudziak (2022) emphasize the motivation of producers to use lighter packaging in order to save transportation costs while maintaining its protective function. Packaging must protect food from external factors (e.g. weather) but also ensure the quality and freshness of food products inside it. For consumers, packaging must be convenient and functional in terms of its size, shape, closure and sealing along with being eco-friendly. Thus, on the one hand, packaging should satisfy producers' logistical and marketing needs while being in compliance with legislative regulations relating to marking, labelling, and food safety, and on the other hand, it should respond to customers' individual packaging requirements (Stoma & Dudziak, 2022; Chen et al., 2010). Packaging is regarded as the most essential part of the product serving as a marketing communication tool (Rundh, 2016).

In this way, information on packaging can increase market awareness, which in turn influences food product purchase decisions (Ahmad & Juhdi, 2010). The survey conducted in Malaysia by Ahmad and Juhdi (2010) demonstrated that “the belief in the safety and health aspect of the product” impacts on purchase decision of food products.

Consumer attitudes undertake a pivotal role in purchase intention. Studies confirm the increasing demand of consumers for packaging design. Specifically, focus group participants in North Ireland declared that form, function and appearance of packaging are important and hence, companies in the food industry use packaging design as a marketing tool (Hollywood et al., 2013). Previous studies emphasize consumers’ demand for convenience (Rundh, 2013), and for essential functional elements including, shape, openings and closing functions (Jinkarn & Suwannaporn, 2015). Moreover, environmental characteristics of packaging were perceived as important for consumers, which influenced their purchase decisions (Baruk & Iwanicka, 2016). In addition, design, fonts, colours, symbols, pictures, and brand communication signals, play a key role in packaging (Underwood, 2015; Spence & Van Doordn, 2022). According to the case study results used the simulation approach, smart packaging has the potential to generate considerably higher profit, especially for grocery retailers, and simultaneously reduce food waste (Kabadurmus et al., 2023).

Intelligent packaging contains indicators, sensors, and data carriers (Kabadurmus et al., 2023; Azeredo & Correa, 2021; Drago et al., 2020). Indicators are specific devices that transmit information about microbial, chemical, or biological activities that influence food quality, which can be visible through color change (Kalpana et al., 2019). External indicators are located outside while internal indicators are inside packaging (Pavelková, 2013). Indicators inform consumers about the quality of the food and measure mainly the temperature and freshness of a product inside the packaging (Azeredo & Correa, 2021). Temperature control throughout the food supply chain is essential for food quality as it indirectly notifies manufacturers about potentially spoiled food. Conversely, freshness indicators directly provide information on microbiological or chemical contamination in the products indicating that food is damaged (Kalpana et al., 2019; Mohammadian et al., 2020). Sensors facilitate the transformation of particular chemical information to electronic signals and help detect any deteriorative changes in the food (Azeredo & Correa, 2021). Data carriers in food packaging are comprised of barcodes and radiofrequency identification tags (RFID) and aim to monitor product transportation and storage through the wireless communication system connected with antennas and chips (Azeredo & Correa, 2021). They gather information on the movement of products along the distribution chain and mostly intend to trace products, prevent theft or counterfeit (Ghaani et al., 2016). However, the listed tools that are included in the intelligent packaging system are not without limitations as they represent a complex system. Therefore, the technologies are under constant improvement process to perform better, be harmless in case of interaction with food, and be useful for various types of foods (Azeredo & Correa, 2021; Drago et al., 2020). Main studies about intelligent packaging technologies are summarized in Table 1.

Table 1. Intelligent Packaging Technologies: indicators, description, source.

Indicators	Description	Source
Temperature indicators	Measure and display temperature changes of the product or its package.	Kalpana et al., 2019; Pavelková, 2013.
Critical temperature indicators	Reveal changes or worsening of foods because of fluctuations in threshold temperatures causing noticeable colour changes of the indicator.	Barska & Wyrwa, 2017; Taoukis & Labuza, 2003.
Critical temperature/time integrators (CTTIs)	Indicate a reaction above a reference critical temperature, which can be interpreted as an equivalent exposure time at that critical temperature.	Barska & Wyrwa, 2017; Taoukis & Labuza, 2003.

Indicators	Description	Source
Time-temperature indicators (TTIs)	The devices that record the temperature history of a packaged food during packaging, storage, transportation, and selling.	Taoukis & Labuza, 2003; Robertson, 2013; Brizio, 2016.
Freshness indicators	Evaluates chemical reactions by focusing on microorganisms that trigger food deterioration. A ripe sensor also indicates the ripeness of certain fruits.	Brizio, 2016; Kalpana et al., 2019.
Leak indicators	Informs if a modification due to leakage takes place inside packaging to improve shelf-life of foods. There are CO ₂ , oxygen, and other leak indicators.	Daş et al., 2006; Brizio, 2016; Saliu & Della Pergola, 2018.
pH and colorimetric indicators	Monitor food freshness in terms of pH variations and convey information by a noticeable colour change in meat products, for example, from red to green, or from green to yellow.	Choi et al., 2017; Yoshida et al., 2014.
Sensors	Description	Source
Chemical sensors	Detect spoilage through chemical interactions as a part of smart intelligent packaging to monitor the quality of products.	Mahalik & Nambiar, 2010; Kuswandi et al., 2011; Kalpana et al., 2019.
Biosensors	Sense spoilage through a biological analyte and indicate alterations in foods by changing colour; also detect allergens or other pathogens ensuring food safety.	Fang et al., 2017; Mustafa & Andreescu, 2018.
Gas sensors	Detect gaseous and volatile compounds such as oxygen, carbon dioxide, and other gases to sense food spoilage in real-time.	Kalpana et al., 2019; Pereira et al., 2015; Zhai et al., 2018.
Data Carriers	Description	Source
Radio frequency identification (RFID) tags	A chip to store data applied on packaging and transmit through antennas to the reader; it is used for traceability and gathering information as well as for detecting any spoilage signs in packaged foods.	Bibi et al., 2017; Chen et al., 2008; Costa et al., 2013.
Barcodes	A machine-readable storage database for traceability of products; Information and data can be stored and read by an optical reader	Chen et al., 2008; Lin & Lin, 2013; Mahalik & Kim, 2016.

Source: developed by the authors.

2. Methodology

Since the research objective was to gather the essential information with the purpose of gaining knowledge without statistical validation (Chase & Murtha, 2019), this exploratory study employed interview methods within the framework of a qualitative research approach. Data was collected through interviews with Georgian food manufacturers following the exploratory approach design.

Applying exploratory approach to study the actors' perspective of packaging with enhanced features offers several advantages and drawbacks. First of all, this exploratory research helps in generating insights and understanding phenomena that are not well understood or defined, and it allows researchers to explore new avenues and generate hypotheses. Moreover, it helps in identifying problems or opportunities that may not be apparent initially. Besides, the exploratory research

methods facilitate a deeper understanding of complex phenomena by allowing researchers to delve into various factors influencing a situation or behaviour.

On the other hand, it is certain that the selected methods can have different drawbacks, such as (i) findings from exploratory research cannot be generalizable to the broader population or applicable in different contexts; (ii) since exploratory research involves qualitative methods such as interviews or observations, findings can be influenced by researcher bias or interpretation; (iii) the qualitative nature of exploratory research makes it challenging to replicate findings or conduct follow-up studies with the same level of depth.

Qualitative study approach is regarded as an appropriate method to explain a phenomenon with the question of “how” and profoundly examine the research questions (Yin, 2018). Through its flexible framework, this approach enables to gathering of comprehensive and descriptive information illustrating the research phenomenon (Patton, 2014). Given the research objectives, this research explores the phenomenon of innovative packaging systems for food products in Georgia. In addition, an interview method using a semi-structured interview guide was applied to examine the research questions. In-depth interview methods can collect rich information about the topic (Kvale, 2007).

Previous studies, aiming at explaining food packaging-related issues, frequently utilized interview methods within the qualitative approach (Kabadurmus et al., 2023; Afif et al., 2022; Svanes et al., 2010; Ryyänen & Rusko, 2015; Rundh, 2016).

For this study, purposive sampling was applied to recruit food manufacturers. The approach is widely used in nonprobability sampling and its size is determined by saturation (Guest et al., 2006). Interviews are terminated when no new information is provided by the respondents. According to Guest et al. (2006), essential themes appear within the first six interview sessions, and in general, saturation happens within the first twelve interviews. The eligibility criteria to choose respondents were the diverse food products produced by them or by their companies as well as their availability and willingness to participate in the study. Yin (2018) suggested selecting relevant respondents in accordance with the research aims. The interview informants were recruited through the nonprobability purposive sample technique (Patton, 2014), which allowed the researchers to attract participants who could report on the packaging issues of their food companies. Consequently, the choice of targeted food manufacturers is valid for the study objectives.

A semi-structured interview guide enabled to gather and compare relevant information (Eisenhardt & Graebner, 2007; Bernard et al., 2016). It covered four open-ended questions, which have been developed based on the literature review and previous studies in the field: (1) What are the most important factors of food packaging for you as a manufacturer or for your company? (2) How informed are you (and your company) about innovative solutions in the food packaging industry? (3) What types of innovative packaging does your company use or intend to use? (4) How important are certain features and indicators included in smart intelligent packaging for food packaging (the indicators were listed)? It should be noted that the participants were informed about the research aims and agreed to voluntarily take part in the interview sessions. Their confidentiality was ensured. Informed consent for participation in the study has been obtained from all participants.

Although consumer choice determines company decisions in the market, food producers can have their own preferences, requirements and criteria for purchasing appropriate packaging for their products. Smart intelligent packaging systems offer various attributes and features for different types of food. Since food producers' choice for smart packaging can also be a crucial factor for introducing smart packaging systems into the market, this research was interested in exploring their perspectives and investigating their understanding of the benefits of smart packaging specifically for their companies and their products. Thus, this research intends to reveal whether Georgian food producers are aware of innovative solutions in packaging systems and ever considered adopting them.

A total of fifteen individuals were interviewed, for fifteen to thirty minutes. The transcripts of recorded interviews were analysed. Finally, interviews were analysed through a systematic method to

examine themes, and categories and to discover associations with the research questions (Bernard et al., 2016; MacLure, 2013). Through thematic analysis, patterns and themes are identified to capture important ideas within the data (Braun & Clarke, 2006; Terry et al., 2017). Content analysis as a descriptive approach aims at describing features, patterns and themes in the collected material and providing categorized or classified elements of the data (Neuendorf, 2017; Drisko & Maschi, 2016). For this purpose, qualitative data analysis software NVivo for Mac was used as its features are suitable for content analysis. Although NVivo cannot analyse qualitative research completely, it considerably assists researchers with the organization of data and process of analysis. In addition, Excel was used for frequency analysis, and hence, the responses were evaluated in a partially quantitative manner.

3. Research results

Interview participants were selected to consider smart packaging from various points of view. Therefore, companies that produced meat and poultry, dairy, eggs, marinade, fish and seafood, frozen food, baked goods, fruits, vegetables, grains, beans and nuts, wine, and olive and olive oil were studied. The interview participants represented small (n=6; 40%), medium (n=5; 33%), and large (n=4; 27%) companies, within the age group between 26 and 55. Three respondents possess the position of director (n=3; 20%), nine of them work as managers (n=9; 60%), and three are employees (n=3; 20%). Eight respondents have a bachelor's degree, three have – Master's degree, and one holds a doctoral degree. The research results are divided into sections to illustrate the findings and respond to the main research questions.

The important factors of food packaging for Georgian food manufacturers. The respondents attach the greatest importance to certain factors of packaging for the food products that are produced by their companies. They mentioned that protectiveness, durability, and resistance to weather or environmental factors are essential for food packaging. Moreover, packaging should respond to their needs for profitability and weight to decrease transportation and other costs, while for consumers it should be functional and comfortable. Furthermore, the interviewees stated that packaging must maintain food quality and food freshness as well as be environmentally friendly (Table 2).

Table 2. Important factors for food packaging mentioned by Georgian food producers.

Themes	Count	Percentage
Protective	n=15	100%
Maintains food quality	n=15	100%
Maintains food freshness	n=15	100%
Functional	n=12	80%
Ecological	n=10	67%
Weight	n=7	47%
Profitable	n=6	40%
Resistant	n=6	40%
Durable	n=4	27%
Comfortable	n=4	27%

Source: Authors' own research results.

The respondents declared that some features of packaging are more important for their food companies. In this regard, they specified that the most significant feature of packaging is to ensure food safety and quality characteristics, followed by marking and labelling i.e., information on packaging. In addition, packaging compatibility with the legislation and meeting consumer requirements are of utmost importance for food manufacturers. Respondents stated that packaging enables communication about their products and hence, packaging shape, design, and capacity are significant facets. Furthermore, respondents confirm that different information about the product

should be on the packaging, which must be recognized by consumers. They also discussed the prominence of packaging closing and opening methods.

Although monitoring food conditions is essential for food manufacturers, respondents hardly refer to innovative solutions, smart functions, or new technologies related to packaging. Traceability of the food product and monitoring attribute on packaging is perceived as substantial but the interviewed food manufacturers possess less information about those features of food packaging. In addition, the respondents were asked to indicate how significant is the monitoring attribute in packaging. The majority (67%) of the respondents answered that the monitoring function of the packaging is the most important for food products.

The awareness of smart, active, and intelligent packaging among Georgian food manufacturers. The respondents admitted that they are less informed or absolutely uninformed about the innovative solutions existing in the food packaging industry. In addition, they are not informed about smart packaging, active packaging, or intelligent packaging for food products. They know though that new packaging solutions exist, and they are aware of new technologies used in packaging. Consequently, they acknowledge their needs to learn more about innovative packaging systems to use them for their food products.

Innovative packaging types of Georgian food companies use or intend to introduce. The interviewed representatives claimed that their companies are using smart packaging (n=2; 13%), and other types of packaging (n=3; 20%), while traditional packaging is used by the rest of the respondents (n=10; 67%). To the question, of whether their companies are going to use innovative packaging, most respondents reacted negatively. As one of them explained, “We are not going to use smart, intelligent, and active packaging as we don’t have information about such innovative types of food packaging and are not aware of its potential benefits for our company” (R4). Other respondents argued that “We have less knowledge about new types of packaging” (R6), and “We need to learn more about novel technologies used in food packaging” (R2).

The significance of certain indicators of smart, active, and intelligent packaging, for Georgian food manufacturers. In view of the interviewees, time-temperature indicators, freshness indicators, and pathogen indicators of food packaging are indispensable components. Besides, they connect breakage indicators, leak indicators, and colour indicators to their products and place a high value on them. As reported by the respondents, those elements can be included in the food products manufactured by their companies. In the same way, the respondents regarded carbon dioxide indicators and oxygen indicators as essential indicators that could be presented on food packaging. They corroborated the prominence of those indicators for their food products and expressed their willingness to introduce the food packaging to their companies.

Moreover, data carriers in packaging attracted the food manufacturers’ attention. Although they are already familiar with QR-code and Barcode, which have been actively used in the Georgian market, Radiofrequency identification tag (RFID) is new for food packaging. With respect to sensors, the respondents reasoned that Fluorescence-based oxygen sensors and Biosensors are crucial for food packaging. However, intelligent sensors and gas sensors can be equally important for their food products.

Thus, the demand for smart intelligent packaging is outlined among Georgian food manufacturers. Against this backdrop, Georgia represents an emerging market for innovative packaging solutions.

4. Discussion

This research envisioned unfolding the awareness of smart intelligent packaging among food manufacturers in Georgia and describing the features and functions of food packaging appreciated by manufacturers.

The food manufacturers in Georgia are informed that consumers no longer choose food based only on taste, but other factors come also into play such as packaging (Hartmann, 2021; Bou-Mitri et al., 2021; Kunz et al., 2020). Packaging impacts food companies to sell products in terms of branding,

differentiation strategies, and protecting food during transportation, storage, or retailing (Shao et al., 2021; Dopico-Parada et al., 2021; Firouz et al., 2021; Kwilinski, 2023). Due to the increased competition in the market, food producers require differentiation strategies through packaging form, function, and appearance among others (Bou-Mitri et al., 2021; Young et al., 2020; Chen et al., 2020). Packaging not only plays a logistics role but can also decrease the ecological impact of companies (García-Arca et al., 2014; Kuwornu et al., 2023; Silva & Pålsson, 2022). The research results demonstrated that Georgian food manufacturers pay attention to the above-mentioned packaging components.

Yet, it is worth mentioning that manufacturers have to balance different viewpoints as operations divisions may prioritize functional and user-friendly packaging, while the marketing department focuses on packaging appearance (Afif et al., 2020). Furthermore, packaging quality can have different meanings for different people. For organizations, the packaging quality is allied with its storage capability and costs, while for marketing it relates to visual aspects to improve the performance of a product on the market (Afif et al., 2020). Quality can also include sustainability and ecological notions. In a similar vein, quality perceptions vary across product categories. For meat and fish products, food protection and extending shelf-life is the higher priority, while for the bakery, visual appearance is considerably significant for selling the product (Afif et al., 2020). The high level of customizations of packaging prompts a more complex purchase decision process in organizations, and contrariwise, the high level of packaging standardization induces a more steady and faster purchase process (Afif et al., 2020). Against this background, Georgian food manufacturers should reinvent their marketing strategies including packaging solutions.

Poças et al. (2010) describe packaging function as “protection and containment, preservation, information, convenience and service”. The study results show that, for Georgian food manufacturers, packaging enables clean and safe distribution of products from their companies to end users. In this connection, intelligent technologies enable traceability and control of products enhancing the basic functions of packages. This makes packaging not only an effective communication tool in terms of providing relevant information about the history of a product’s journey from the production process to the selling point to consumers’ refrigerators, but also presents an attractive tool to distinguish a food product from competitors. However, consumers can be concerned about food safety due to packaging as they are afraid that chemical compounds or harmful substances might migrate from the package into foods (Shao et al. 2021; Cheng et al., 2022; Schmid & Welle, 2020; Poças et al., 2010).

The interviewed producers did not accentuate the costs of using smart packaging systems for their food products, though noted the profitability goals of a company, based on which the decision on packaging is made. The main disadvantage and barrier of smart packaging is the high cost of intelligent materials, indicators, sensors, and data carriers, which prevents its commercialization and effective introduction on the market. Therefore, food companies should evaluate the adoption of innovative packaging solutions in terms of the costs against benefits.

It is noteworthy that organizations are influenced by stakeholders when deciding on a certain packaging type. Packaging solutions can depend on companies’ size, revenues, board members, management, strategy, or product characteristics. Intelligent packaging might not be suitable for every product and company. External factors such as laws, regulations, or market requirements need to be considered as well. Technological advancement and competition also impose packaging solutions (Afif et al., 2020).

In addition to digitalization trends, sustainability tendencies should also be considered. Intelligent packaging contributes to attaining sustainable goals while reducing waste and satisfying consumer demands (Palazzo et al., 2023). It can respond to stakeholders’ environmental concerns by communicating information about a product through innovative packaging technologies (Popescu et al., 2023).

Correspondingly, innovations are core drivers in attracting consumers' attention. For this reason, food producers need to bear in mind changes in consumer preferences and follow trends in the market (Figiel & Kufel, 2016; Gigauri et al., 2024). For product innovation companies need internal resources such as technological competences and favourable external factors such as the appropriate environment including technological opportunities and industry context (Rammer & Schubert, 2018; Oh et al., 2022) as well as regional resources or country cultures (Rodríguez-Gulías et al., 2021). Smart intelligent packaging systems can be considered as marketing innovation that is able to generate demand by raising awareness, educating consumers, and creating the grounds for product differentiation (Kahn, 2018; Gigauri et al., 2024), which in turn improves companies' positions in the market and brings a competitive advantage. Thus, companies can meet consumer expectations for food safety and quality and achieve a differentiation strategy in the market through innovative packaging systems.

Georgian food manufacturers require up-to-date information about the benefits intelligent packaging can provide. This finding is consistent with prior studies confirming that companies tend to embrace innovative packaging if it brings value to their stakeholders (Zeng, 2022; Ferrara et al., 2020; Świda et al., 2018). In this context, heightening awareness about smart intelligent functions and the advantages of intelligent packaging among stakeholders can influence their acceptance.

Furthermore, based on the value co-creation in the service dominant logic theory, food manufacturers and consumers can collaborate through intelligent packaging. Co-creative value can be delivered through enhancing the experience offered by innovative packaging systems. In this sense, manufacturers should define value-creation sources of smart packaging, which are desired by consumers and perceived as a substantial component of food packaging. Thus, consumer loyalty and satisfaction will increase.

Conclusions

This research contributes to theory and practice by exploring smart packaging systems from food manufacturers' standpoints and by revealing the market potential of innovative packaging solutions in Georgia - a developing country. It evaluates new packaging solutions from food manufacturers' point of view and identifies the need for recognizing beneficial facets of intelligent packaging for the marketing strategy. The future of food packaging depends on intelligent systems of packages that go beyond protecting or maintaining a product inside. Intelligent packaging involves communication tools that address product marketing issues by embedding data carriers aiming at tracing commodities.

The results add knowledge to the literature on marketing by studying intelligent food packaging and examining its features and indicators that are demanded by food manufacturers.

Thus, the research findings will be beneficial to academics and practitioners. The study results will allow scholars and researchers to further explore the market potential of intelligent packaging solutions from the perspective of food manufacturers in different economies. In addition, research evidence will be of interest to policymakers introducing laws and regulations with the purpose of providing a supportive environment for innovations, leading-edge technologies, and enable sustainable economic development.

Moreover, this research responds to the scholar's request for more studies related to the role of food packaging within a marketing strategy to create value (Rundh, 2016; Dopico-Parada et al., 2021). Marketers can develop a product concept together with an intelligent packaging design that will lead to value creation and that will propose differentiation resulting in a competitive advantage.

The limitation of this study stems from the qualitative research method and hence, the findings may lack generalizability. Actually, qualitative interview methods are widely used in marketing and management research, but they also have certain limitations. First of all, the selected participants represent a specific organization, industry, and context, making it challenging to generalize findings

to a broader population. Secondly, interviewees may have provided socially desirable responses or withhold sensitive information during interviews, leading to biased or incomplete data. This bias can distort the accuracy of findings and compromise the validity of the study. Thirdly, the interviewer's characteristics, such as demeanor, tone, or questioning style, can influence respondents' answers and perceptions. Interviewer bias may inadvertently steer the conversation or lead to misinterpretation of responses.

The small sample size is another limitation. Notwithstanding these drawbacks, the study generates fresh insights and paves the way for further research given the importance of the topic. Future longitudinal research using follow-up interviews might explore the adoption of smart intelligent packaging in food manufacturers. Similarly, future large-scale quantitative research covering the supply chain members should explore barriers to the commercialization of smart intelligent packaging systems including technological and organizational obstacles as well as investigate technological readiness, expertise, investments, or other resources required to manufacture innovative packaging in the country. In order to illustrate the market potential of smart packaging systems, future quantitative surveys will investigate consumers' attitudes, preferences and perceptions in this regard, based on this research. In addition, further studies can investigate the factors influencing the buying decision of product packaging in different countries and economies. Finally, surveying packaging producers can elucidate challenges and opportunities that producers of smart, active, and intelligent packaging encounter in diverse country contexts.

Although the research is conducted in one country context, the implications can be extended to other contexts as well. Food producers' perspectives make a significant contribution when developing and marketing smart intelligent packaging for food products. In today's globalized world, the intelligent packaging features that food manufacturers demand for their products may be typical for companies in many countries. Furthermore, the global supply chain and competitive landscape imply that the research results from one country (i.e., Georgia) are transferable to another country setting. In addition, the need to raise awareness of smart, active, and intelligent packaging among food manufacturers in developing countries will lead to the adoption of innovative packaging solutions and hence, derive substantial benefit from it.

It should be pointed out that the specific country's context — its industry, regulations, technological infrastructure, and consumer behaviour plays a significant role. Consumer acceptance and demand create the market potential for smart intelligent packaging. Besides, legislative regulations related to packaging, labelling, and product safety, as well as health and safety regulations, environmental standards, and food industry-specific requirements can be met through smart intelligent packaging. Moreover, the technological landscape in the country is another factor companies may consider when adopting smart intelligent packaging. For instance, if smart packaging improves logistics efficiency, it can be particularly beneficial in countries with large geographical areas or complex supply chains.

Thus, the research investigated the types of packaging Georgian food companies intend to use and revealed the preferred indicators of intelligent packaging. The research results found the need to raise awareness of smart packaging systems among food manufacturers in Georgia to understand the benefits of innovative packaging solutions for their products and brands. The findings highlight that food producers are less informed about the concept of smart intelligent packaging; however, they recognize the benefits of some features and indicators for their food products. In this sense, monitoring and traceability attributes are emphasized. In addition, time-temperature, freshness, pathogen, oxygen, carbon dioxide, breakage, leak, and color indicators are remarked to be important; however, food producers acknowledge that more information about these and other indicators need to be obtained by their food companies in order to decide on smart packaging with specific features. Although the food producers are not ready yet for innovative packaging systems, the changes may

occur in conjunction with accelerated digitalization and sustainability trends as well as along with the consumers' demand and producers' understanding of its advantages.

Packaging as a marketing communication channel is widely recognized as it connects producers to customers by providing information such as brand name and manufacturing details, nutritional value, guidance about the usage or storage, expiration date, and so on (Kalpana et al., 2019; Gigauri & Palazzo, 2023). In this regard, intelligent packaging tools transfer information to consumers and manufacturers about the product through its ability to detect and record the changes outside and inside of foods (Fernandez et al., 2023). Moreover, perishable foods need extended shelf-life to sell under the circumstances of growing competition.

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Reference

1. Afif, K., Rebolledo, C., & Roy, J. (2022). Drivers, barriers and performance outcomes of sustainable packaging: A systematic literature review. *British Food Journal*, 124(3), 915–935. <https://doi.org/10.1108/bfj-02-2021-0150>.
2. Ahmad, S. N. B., & Juhdi, N. (2010). Organic food: A study on demographic characteristics and factors influencing purchase intentions among consumers in Klang Valley, Malaysia. *International Journal of Business and Management*, 5(2), <https://doi.org/10.5539/IJBM.V5N2P105>.
3. Azeredo, H. M., & Correa, D. S. (2021). Smart choices: Mechanisms of intelligent food packaging. *Current Research in Food Science*, 4, 932–936. <https://doi.org/10.1016/j.crfs.2021.11.016>.
4. Barska, A., & Wyrwa, J. (2017). Innovations in the food packaging market - intelligent packaging - a review. *Czech Journal of Food Sciences*, 35(1), 1–6. <https://doi.org/10.17221/268/2016-cjfs>.
5. Baruk, A. I., & Iwanicka, A. (2016). The effect of age, gender and level of education on the consumer's expectations towards dairy product packaging. *British Food Journal*, 118(1), 100–118. <https://doi.org/10.1108/BFJ-07-2015-0248>.
6. Bernard, H. R., Wutich, A., & Ryan, G. W. (2016). *Analyzing Qualitative Data: Systematic Approaches*. SAGE Publications.
7. Bibi, F., Guillaume, C., Gontard, N., & Sorli, B. (2017). A review: RFID technology having sensing aptitudes for food industry and their contribution to tracking and monitoring of food products. *Trends in Food Science & Technology*, 62, 91–103. <https://doi.org/10.1016/j.tifs.2017.01.013>.

8. Bou-Mitri, C., Abdessater, M., Zgheib, H., & Akiki, Z. (2021). Food packaging design and consumer perception of the product quality, safety, healthiness and preference. *Nutrition & Food Science*, 51(1), 71–86. <https://doi.org/10.1108/NFS-02-2020-0039>.
9. Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77–101. <https://doi.org/10.1191/1478088706qp0630a>.
10. Brizio, A. P. D.R. (2016). Use of Indicators in Intelligent Food Packaging. *Reference Module in Food Science*. <https://doi.org/10.1016/b978-0-08-100596-5.03214-5>.
11. Chase, K. S., & Murtha, B. (2019). Selling to Barricaded Buyers. *Journal of Marketing*, 83(6), 2–20. <https://doi.org/10.1177/0022242919874778>.
12. Chen, L.-S., Liu, C.-H., Hsu, C.-C., & Lin, C.-S. (2010). C-Kano model: a novel approach for discovering attractive quality elements. *Total Quality Management & Business Excellence*, 21(11), 1189–1214. <https://doi.org/10.1080/14783363.2010.529347>.
13. Chen, R. S., Chen, C. C., Yeh, K. C., Chen, Y. C., & Kuo, C. W. (2008). Using RFID technology in food produce traceability. *WSEAS Transactions on information science and applications*, 5(11), 1551–1560.
14. Chen, S., Brahma, S., Mackay, J., Cao, C., & Aliakbarian, B. (2020). The role of smart packaging system in food supply chain. *Journal of Food Science*, 85(3), 517–525. <https://doi.org/10.1111/1750-3841.15046>.
15. Cheng, H., Xu, H., McClements, D. J., Chen, L., Jiao, A., Tian, Y., Miao, M., & Jin, Z. (2022). Recent advances in intelligent food packaging materials: Principles, preparation and applications. *Food Chemistry*, 375, Article 131738. <https://doi.org/10.1016/j.foodchem.2021.131738>.
16. Choi, I., Lee, J. Y., Lacroix, M., & Han, J. (2017). Intelligent pH indicator film composed of agar/potato starch and anthocyanin extracts from purple sweet potato. *Food Chemistry*, 218, 122–128. <https://doi.org/10.1016/j.foodchem.2016.09.050>.
17. Costa, C., Antonucci, F., Pallottino, F., Aguzzi, J., Sarriá, D., & Menesatti, P. (2013). A Review on Agri-food Supply Chain Traceability by Means of RFID Technology. *Food and Bioprocess Technology*, 6(2), 353–366. <https://doi.org/10.1007/s11947-012-0958-7>.
18. Dainelli, D., Gontard, N., Spyropoulos, D., Zondervan-van den Beuken, E., & Tobback, P. (2008). Active and intelligent food packaging: legal aspects and safety concerns. *Trends in Food Science & Technology*, 19, S103–S112. <https://doi.org/10.1016/j.tifs.2008.09.011>.
19. Daş, E., Gürakan, G. C., & Bayındırlı, A. (2006). Effect of controlled atmosphere storage, modified atmosphere packaging and gaseous ozone treatment on the survival of *Salmonella Enteritidis* on cherry tomatoes. *Food Microbiology*, 23(5), 430–438. <https://doi.org/10.1016/j.fm.2005.08.002>.
20. Dopico-Parada, A., López-Miguens, M. J., & Álvarez-González, P. (2021). Building value with packaging: Development and validation of a measurement scale. *Journal of Retailing and Consumer Services*, 63, Article 102685. <https://doi.org/10.1016/j.jretconser.2021.102685>.
21. Drago, E., Campardelli, R., Pettinato, M., & Perego, P. (2020). Innovations in smart packaging concepts for food: An extensive review. *Foods*, 9(11), Article 1628. <https://doi.org/10.3390/foods9111628>.
22. Drisko, J. W., & Maschi, T. (2016). *Content analysis*. Pocket Guide to Social Work, Oxford University Press, Oxford.
23. Eisenhardt, K.M. & Graebner, M.E. (2007). Theory building from cases: opportunities and challenges. *Academy of Management Journal*, 50(1), 25–32. <https://doi.org/10.5465/amj.2007.24160888>.
24. Fang, Z., Zhao, Y., Warner, R. D., & Johnson, S. K. (2017). Active and intelligent packaging in meat industry. *Trends in Food Science & Technology*, 61(2), 60–71. <https://doi.org/10.1016/j.tifs.2017.01.002>.

25. Ferrara, C., Zigarelli, V., & De Feo, G. (2020). Attitudes of a sample of consumers towards more sustainable wine packaging alternatives. *Journal of Cleaner Production*, 271, Article 122581. <https://doi.org/10.1016/j.jclepro.2020.122581>.
26. Fernandez, C. M., Alves, J., Gaspar, P. D., Lima, T. M., & Silva, P. D. (2023). Innovative processes in smart packaging. A systematic review. *Journal of the Science of Food and Agriculture*, 103(3), 986–1003. <https://doi.org/10.1002/jsfa.11863>.
27. Figiel, S., & Kufel, J. (2016). Food product innovations and the main consumer trends. *Acta Scientiarum Polonorum. Oeconomia*, 15(3), 5–14.
28. Firouz, M. S., Mohi-Alden, K., & Omid, M. (2021). A critical review on intelligent and active packaging in the food industry: Research and development. *Food Research International*, 141, Article 110113. <https://doi.org/10.1016/j.foodres.2021.110113>.
29. García-Arca, J., Prado-Prado, C., & Garrido, A. T. G. (2014). “Packaging logistics”: Promoting sustainable efficiency in supply chains. *International Journal of Physical Distribution & Logistics Management*, 44(4), 325–346. <https://doi.org/10.1108/IJPDLM-05-2013-0112>.
30. Ghaani, M., Cozzolino, C. A., Castelli, G., & Farris, S. (2016). An overview of the intelligent packaging technologies in the food sector. *Trends in Food Science & Technology*, 51, 1–11. <https://doi.org/10.1016/j.tifs.2016.02.008>.
31. Gigauro, I., Palazzo, M., & Siano, A. (2024). Examining the Market Potential for Smart Intelligent Packaging: A Focus on Italian Consumers. *Virtual Economics*, 7(2), 89–116. [https://doi.org/10.34021/ve.2024.07.02\(5\)](https://doi.org/10.34021/ve.2024.07.02(5)).
32. Gigauro, I., & Palazzo, M. (2023). Intelligent Packaging as a Marketing Tool. Are Digital Technologies Re-shaping Packaging? *Agora International Journal of Economical Sciences*, 17(1), 14–23. <https://univagora.ro/jour/index.php/aijes/article/view/5757>.
33. Gréa, C., Turban, C., Roser, S., Genannt Bonsmann, S. S., & Hoffmann, I. (2023). Design and methods of the German monitoring of packaged food in the European context. *Journal of Food Composition and Analysis*, 121, Article 105405.
34. Grubor, A., Končar, J., Marić, R., Vukmirović, G., & Milićević, N. (2020). The Use of Intelligent Packaging in Supply Chain of Food Products. *Promet-Traffic&Transportation*, 32(5), 639–653. <https://doi.org/10.7307/ptt.v32i5.3388>.
35. Guest, G., Bunce, A., & Johnson, L. (2006). How Many Interviews Are Enough?: An Experiment with Data Saturation and Variability. *Field Methods*, 18(1), 59–82. <https://doi.org/10.1177/1525822X05279903>.
36. Han, J. W., Ruiz-Garcia, L., Qian, J. P., & Yang, X. T. (2018). Food Packaging: A Comprehensive Review and Future Trends. *Comprehensive Reviews in Food Science and Food Safety*, 17(4), 860–877. <https://doi.org/10.1111/1541-4337.12343>.
37. Hartmann, C., Lazzarini, G., Funk, A., & Siegrist, M. (2021). Measuring consumers’ knowledge of the environmental impact of foods. *Appetite*, 167, Article 105622. <https://doi.org/10.1016/j.appet.2021.105622>.
38. Hollywood, L., Wells, L., Armstrong, G., & Farley, H. (2013). Thinking outside the carton: Attitudes towards milk packaging. *British Food Journal*, 115(6), 899–912. <https://doi.org/10.1108/bfj-jul-2010-0127>.
39. Jinkarn, T., & Suwannaporn, P. (2015). Trade-off analysis of packaging attributes for foods and drinks. *British Food Journal*, 117(1), 139–156. <https://doi.org/10.1108/BFJ-08-2013-0231>.
40. Kabadurmus, O., Kayikci, Y., Demir, S., & Koc, B. (2023). A data-driven decision support system with smart packaging in grocery store supply chains during outbreaks. *Socio-Economic Planning Sciences*, 85, Article 101417. <https://doi.org/10.1016/j.seps.2022.101417>.
41. Kahn, K. B. (2018). Understanding innovation. *Business Horizons*, 61(3), 453–460. <https://doi.org/10.1016/j.bushor.2018.01.011>.

42. Kalpana, S., Priyadarshini, S. R., Maria Leena, M., Moses, J. A., & Anandharamakrishnan, C. (2019). Intelligent packaging: Trends and applications in food systems. *Trends in Food Science & Technology*, 93, 145–157. <https://doi.org/10.1016/J.TIFS.2019.09.008>.
43. Ketelsen, M., Janssen, M., & Hamm, U. (2020). Consumers' response to environmentally-friendly food packaging-A systematic review. *Journal of Cleaner Production*, 254, Article 120123. <https://doi.org/10.1016/j.jclepro.2020.120123>.
44. Kita, P., Maciejewski, G., Žambochová, M., Strelinger, J., & Kitová Mazalánová, V. (2021). Nutritional behaviour of households: an analysis of Slovak consumers. *Forum Scientiae Oeconomia*, 9(2), 73–94. https://doi.org/10.23762/FSO_VOL9_NO2_4.
45. Kunz, S., Haasova, S., & Florack, A. (2020). Fifty shades of food: The influence of package color saturation on health and taste in consumer judgments. *Psychology & Marketing*, 37(7), 900–912. <https://doi.org/10.1002/mar.21317>.
46. Kuswandi, B., Wicaksono, Y., Jayus, Abdullah, A., Heng, L. Y., & Ahmad, M. (2011). Smart packaging: Sensors for monitoring of food quality and safety. *Sensing and Instrumentation for Food Quality and Safety*, 5(3), 137–146. <https://doi.org/10.1007/s11694-011-9120-x>.
47. Kuwornu, J. K., Khaipetch, J., Gunawan, E., Bannor, R. K., & Ho, T. D. (2023). The adoption of sustainable supply chain management practices on performance and quality assurance of food companies. *Sustainable Futures*, 5, Article 100103. <https://doi.org/10.1016/j.sftr.2022.100103>.
48. Kvale, S. (2007). *Doing interviews*. SAGE Publications, Ltd <https://www.doi.org/10.4135/9781849208963>.
49. Kwilinski, A. (2023). E-Commerce and Sustainable Development in the European Union: A Comprehensive Analysis of SDG2, SDG12, and SDG13. *Forum Scientiae Oeconomia*, 11(3), 87–107. https://doi.org/10.23762/FSO_VOL11_NO3_5.
50. Lin, D. T., & Lin, C. L. (2013). Automatic location for multi-symbology and multiple 1D and 2D barcodes. *Journal of Marine Science and Technology*, 21(6), Article 6. <https://doi.org/10.6119/JMST-012-0829-6>.
51. MacLure, M. (2013). Classification or wonder? Coding as an analytic practice in qualitative research. *Deleuze and research methodologies*, 164–183.
52. Mahalik, N. P., & Nambiar, A. N. (2010). Trends in food packaging and manufacturing systems and technology. *Trends in Food Science & Technology*, 21(3), 117–128. <https://doi.org/10.1016/j.tifs.2009.12.006>.
53. Mahalik, N., & Kim, K. (2016). The Role of Information Technology Developments in Food Supply Chain Integration and Monitoring. *Innovation and Future Trends in Food Manufacturing and Supply Chain Technologies*, 21–37. <https://doi.org/10.1016/b978-1-78242-447-5.00002-2>.
54. Mohammadian, E., Alizadeh-Sani, M., & Jafari, S. M. (2020). Smart monitoring of gas/temperature changes within food packaging based on natural colorants. *Comprehensive Reviews in Food Science and Food Safety*, 19(6), 2885–2931. <https://doi.org/10.1111/1541-4337.12635>.
55. Mustafa, F., & Andreescu, S. (2018). Chemical and Biological Sensors for Food-Quality Monitoring and Smart Packaging. *Foods*, 7(10), Article 168. <https://doi.org/10.3390/foods7100168>.
56. Neuendorf, K. A. (2017). *The content analysis guidebook*. Sage Publications.
57. Nile, S. H., Baskar, V., Selvaraj, D., Nile, A., Xiao, J., & Kai, G. (2020). Nanotechnologies in Food Science: Applications, Recent Trends, and Future Perspectives. *Nano-Micro Letters*, 12(1), 1–34. <https://doi.org/10.1007/S40820-020-0383-9>.
58. Oh, G. E. G., Aliyev, M., Kafouros, M., & Au, A. K. M. (2022). The role of consumer characteristics in explaining product innovation performance: Evidence from emerging economies. *Journal of Business Research*, 149, 713–727. <https://doi.org/10.1016/j.jbusres.2022.05.060>.

59. Palazzo, M., Gigauri, I., & Ferri, M. A. (2023). Intelligent Packaging: A Strategy for Boosting Sustainable Marketing and Contributing to the Sustainable Development Goals. In I. Gigauri, M. Palazzo, & M. Ferri (Eds.), *Handbook of Research on Achieving Sustainable Development Goals With Sustainable Marketing* (pp. 1–17). IGI Global. <https://doi.org/10.4018/978-1-6684-8681-8.ch001>.
60. Patton, M. Q. (2014). *Qualitative Research & Evaluation Methods*. SAGE Publications.
61. Pavelková, A. (2013). Time temperature indicators as devices intelligent packaging. *Acta Universitatis Agriculturae Et Silviculturae Mendelianae Brunensis*, 61(1), 245–251. <https://doi.org/10.11118/actaun201361010245>.
62. Pereira, V. A., De Arruda, I. N. Q., & Stefani, R. (2015). Active chitosan/PVA films with anthocyanins from Brassica oleraceae (Red Cabbage) as Time–Temperature Indicators for application in intelligent food packaging. *Food Hydrocolloids*, 43, 180–188. <https://doi.org/10.1016/j.foodhyd.2014.05.014>.
63. Poças, M., Oliveira, J., Pinto, H., Zacarias, M., & Hogg, T. (2010). New paradigm for patterns of home packaged food intake. *British Food Journal*, 112(5), 500–510. <https://doi.org/10.1108/00070701011043754>.
64. Popescu, C., Ionescu, R., & Gigauri, I. (2023). The Past, Present, and Future of Sustainable Marketing. In I. Gigauri, M. Palazzo, & M. Ferri (Eds.), *Handbook of Research on Achieving Sustainable Development Goals With Sustainable Marketing* (pp. 18–40). IGI Global. <https://doi.org/10.4018/978-1-6684-8681-8.ch002>.
65. Rammer, C., & Schubert, T. (2018). Concentration on the few: mechanisms behind a falling share of innovative firms in Germany. *Research Policy*, 47(2), 379–389.
66. Robertson, G.L. (2013). *Food Packaging: Principles and Practice*. CRC Press, Boca Raton, FL.
67. Rodríguez-Gulías, M. J., Rodeiro-Pazos, D., Fernández-López, S., & Nogueira-Moreiras, M. Á. (2021). The effect of regional resources on innovation: a firm-centered approach. *The Journal of Technology Transfer*, 46(3), 760–791. <https://doi.org/10.1007/s10961-020-09811-8>.
68. Rundh, B. (2013). Linking packaging to marketing: How packaging is influencing the marketing strategy. *British Food Journal*, 115(11), 1547–1563. <https://doi.org/10.1108/BFJ-12-2011-0297>.
69. Rundh, B. (2016). The role of packaging within marketing and value creation. *British Food Journal*, 118(10), 2491–2511. <https://doi.org/10.1108/bfj-10-2015-0390>.
70. Ryyänen, T., & Rusko, E. (2015). Professionals' view of consumers' packaging interactions—a narrative analysis. *Packaging Technology and Science*, 28(4), 341–355. <https://doi.org/10.1002/pts.2107>.
71. Saliu, F., & Della Pergola, R. (2018). Carbon dioxide colorimetric indicators for food packaging application: Applicability of anthocyanin and poly-lysine mixtures. *Sensors and Actuators B: Chemical*, 258, 1117–1124. <https://doi.org/10.1016/j.snb.2017.12.007>.
72. Santeramo, F. G., Carlucci, D., De Devitiis, B., Seccia, A., Stasi, A., Viscecchia, R., & Nardone, G. (2018). Emerging trends in European food, diets and food industry. *Food Research International*, 104, 39–47. <https://doi.org/10.1016/j.foodres.2017.10.039>.
73. Schmid, P., & Welle, F. (2020). Chemical Migration from Beverage Packaging Materials—A Review. *Beverages*, 6(2), Article 37. <https://doi.org/10.3390/beverages6020037>.
74. Shao, P., Liu, L., Yu, J., Lin, Y., Gao, H., Chen, H., & Sun, P. (2021). An overview of intelligent freshness indicator packaging for food quality and safety monitoring. *Trends in Food Science & Technology*, 118, 285–296. <https://doi.org/10.1016/j.tifs.2021.10.012>.
75. Sharma, R., & Ghoshal, G. (2018). Emerging trends in food packaging. *Nutrition and Food Science*, 48(5), 764–779. <https://doi.org/10.1108/NFS-02-2018-0051>.
76. Silva, N., & Pålsson, H. (2022). Industrial packaging and its impact on sustainability and circular economy: A systematic literature review. *Journal of Cleaner Production*, 333, Article 130165. <https://doi.org/10.1016/j.jclepro.2021.130165>.

77. Spence, C., & Van Doorn, G. (2022). Visual communication via the design of food and beverage packaging. *Cognitive Research: Principles and Implications*, 7(1), Article 42. <https://doi.org/10.1186/s41235-022-00391-9>.
78. Stoma, M., & Dudziak, A. (2022). Eastern Poland Consumer Awareness of Innovative Active and Intelligent Packaging in the Food Industry: Exploratory Studies. *Sustainability*, 14(20), Article 13691. <https://doi.org/10.3390/SU142013691>.
79. Svanes, E., Vold, M., Møller, H., Pettersen, M. K., Larsen, H., & Hanssen, O. J. (2010). Sustainable packaging design: A holistic methodology for packaging design. *Packaging Technology and Science*, 23(3), 161–175. <https://doi.org/10.1002/pts.887>.
80. Świda, J., Halagarda, M., & Popek, S. (2018). Perceptions of older consumers regarding food packaging as a prerequisite for its improvement: A case study of Polish market. *International Journal of Consumer Studies*, 42(3), 358–366. <https://doi.org/10.1111/ijcs.12427>.
81. Taoukis, P., & Labuza, T. (2003). Time-temperature indicators (TTIs). IN R. Ahvenainen (Ed.) *Novel Food Packaging Techniques*, 103-126. Woodhead Publishing Series in Food Science, Technology and Nutrition. <https://doi.org/10.1533/9781855737020.1.103>.
82. Terry, G., Hayfield, N., Clarke, V., & Braun, V. (2017). Thematic analysis. *The SAGE handbook of qualitative research in psychology*, 2, 17–37.
83. Underwood, R. L. (2015). The Communicative Power of Product Packaging: Creating Brand Identity via Lived and Mediated Experience. *Journal of Marketing Theory and Practice*, 11(1), 62–76. <https://doi.org/10.1080/10696679.2003.11501933>.
84. Yin, R. K. (2018). *Case Study Research and Applications: Design and Methods* (6th ed.). SAGE Publications.
85. Yoshida, C. M., Maciel, V. B. V., Mendonça, M. E. D., & Franco, T. T. (2014). Chitosan biobased and intelligent films: Monitoring pH variations. *LWT - Food Science and Technology*, 55(1), 83–89. <https://doi.org/10.1016/j.lwt.2013.09.015>.
86. Young, E., Miroso, M., & Bremer, P. (2020). A systematic review of consumer perceptions of smart packaging technologies for food. *Frontiers in Sustainable Food Systems*, 4, Article 63. <https://doi.org/10.3389/fsufs.2020.00063>.
87. Young, E., Miroso, M., & Bremer, P. (2023). A conceptual model for food industry views on the 82ommercialization of active and intelligent packaging. *Packaging Technology and Science*, 36(11), 905–925. <https://doi.org/10.1002/pts.2766>.
88. Yousefi, H., Su, H.-M., Imani, S. M., Alkhalidi, K., M. Filipe, C. D., & Didar, T. F. (2019). Intelligent Food Packaging: A Review of Smart Sensing Technologies for Monitoring Food Quality. *ACS Sensors*, 4(4), 808–821. <https://doi.org/10.1021/acssensors.9b00440>.
89. Zeng, T. (2022). Impacts of consumers' perceived risks in eco-design packaging on food wastage behaviors. *British Food Journal*, 124(8), 2512–2532. <https://doi.org/10.1108/bfj-05-2021-0603>.
90. Zhai, X., Li, Z., Zhang, J., Shi, J., Zou, X., Huang, X., Zhang, D., Sun, Y., Yang, Z., Holmes, M., Gong, Y., & Povey, M. (2018). Natural Biomaterial-Based Edible and pH-Sensitive Films Combined with Electrochemical Writing for Intelligent Food Packaging. *Journal of Agricultural and Food Chemistry*, 66(48), 12836–12846. <https://doi.org/10.1021/acs.jafc.8b04932>.

Utilising AI Models to Analyse the Relationship between Battlefield Developments in the Russian-Ukrainian War and Fluctuations in Stock Market Values

Oleksandr Melnychenko¹

¹ The London Academy of Science and Business, London, the United Kingdom;

Gdansk University of Technology, Gdansk, Poland

ORCID: 0000-0002-7707-7888

e-mail: oleksandr.melnichenko@pg.edu.pl

Abstract

This study examines the impact of battlefield developments in the ongoing Russian-Ukrainian war, which to date has lasted over 1000 days, on the stock prices of defence corporations such as BAE Systems, Booz Allen Hamilton, Huntington Ingalls, and Rheinmetall AG. Stock prices were analysed alongside sentiment data extracted from news articles, and processed using machine learning models leveraging natural language processing (NLP). Although the main hypothesis was not confirmed due to methodological and data limitations, the study demonstrated that neural network-based models, specifically long short-term memory (LSTM) networks, effectively captured hidden temporal patterns. The model's performance was evaluated using root mean squared error (RMSE). Alternative models, including XGBoost, ARIMA, and VAR, were also tested but did not yield accurate forecasts. The findings highlight nonlinear patterns in the data and emphasise the importance of hyperparameter optimisation, such as tuning the number of epochs and LSTM layer sizes. Techniques such as Grid Search and Random Search significantly enhanced forecasting performance, resulting in stock price predictions with low RMSE. The full-scale war between Russia and Ukraine, which has been ongoing for more than 1000 days on European soil, triggered market reactions with the first shots fired on the Russian-Ukrainian border on 24 February 2022. Since then, Europe and other countries around the world have supported Ukraine militarily, humanitarily, and economically while revising their defence doctrines and strategies, as well as increasing and modernising their military capabilities. News of Russian aggression and new orders for military products sparked market reactions, particularly changes in the stock prices of defence companies that ramped up production and continue to expand it. This study selected several of the largest defence corporations, whose stock prices showed significant responses to the full-scale Russian invasion of Ukraine, to examine whether other battlefield events elicit similar stock price reactions as the first reports. To investigate this, artificial intelligence tools, including several machine learning methods, were employed. The purpose of this article is to examine the impact of battlefield developments in the Russian-Ukrainian war on stock volatility among major players in the global defence industry, while also identifying the most effective method for forecasting stock prices by testing various machine learning (ML) models. NLP was used to capture sentiment and analyse news about the Russian-Ukrainian war. Vector AutoRegression, the XGBRegressor, the Long Short-Term Memory (LSTM) neural network, and the ARIMA model were used for stock price forecasting. The main hypothesis that stock price changes are influenced by battlefield developments in the Russian-Ukrainian war was not confirmed due to methodological and data limitations. However, the research results indicate that, in this case, the Long Short-Term Memory (LSTM) model is well-suited for time series forecasting, effectively capturing nonlinear time patterns and long-term dependencies for major defence corporations.

Key words

Russian-Ukrainian war, machine learning, sentiment, forecasting.

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Introduction

Russian aggression against Ukraine has significantly impacted financial markets, particularly the stock prices of companies specialising in systems for the security industry. An initial analysis of major defence corporations, including the U.S.-based Boeing Co., Booz Allen Hamilton, Esterline Technologies Corporation, General Dynamics, Huntington Ingalls, Harris Corporation, L-3 Communications, and Rockwell Collins Inc.; the U.K.-based Babcock International Group, Lockheed Martin, Northrop Grumman, OSI Systems Inc., Textron Inc., United Technologies, and BAE Systems; the German-based Rheinmetall AG; and Israel's Elbit Systems Ltd., reveals that some of these companies experienced a significant increase ($>3\%$) in stock prices following the Russian invasion (Fig. 1).

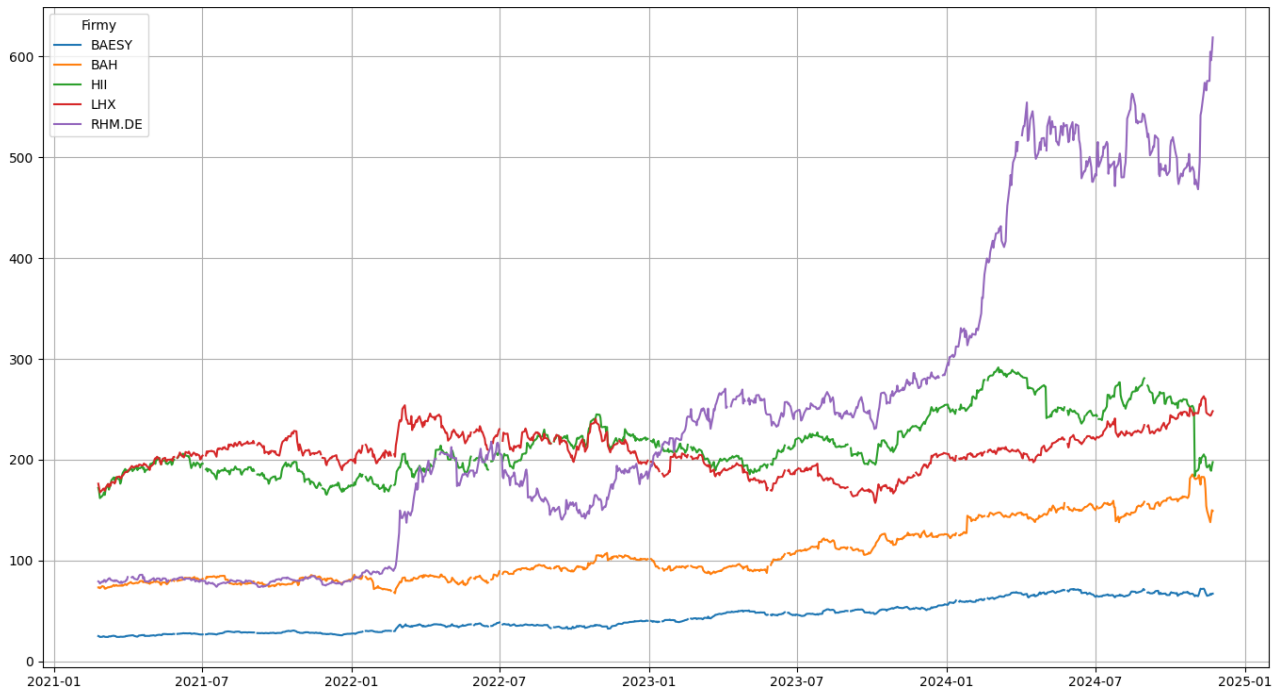


Figure 1. Stock prices (in EUR) of BAE Systems (BAESY), Booz Allen Hamilton (BAH), Huntington Ingalls (HII), Harris Corporation (LHX), and Rheinmetall AG (RHM.DE) from February 24, 2021 to November 25, 2024.

Source: Author's development based on (Yahoo Finance).

On 24 February 2022, when Russian troops and tanks crossed the Ukrainian border, stock prices fluctuated initially but soon exhibited an upward trend that continues to this day.

For Rheinmetall AG, the full-scale war in Ukraine also served as a catalyst for growth. As of 20 March 2023, Rheinmetall AG joined the DAX, Germany's benchmark index of 40 blue-chip companies.

In Figure 1, we observe changes in stock prices during February 2022, a time when the reality of war in Europe became evident, emphasising the urgent need to strengthen the EU's defence position.

The subsequent fluctuations in stock prices were influenced by various factors. However, this study focuses on predicting stock prices by analysing time series data and the sentiment of news related to Ukraine in the context of Russian aggression, using machine learning methods.

The hypothesis proposed in this study is that stock price changes are influenced by battlefield developments in the Russian–Ukrainian war. To test this hypothesis, the author analysed stock price data in conjunction with specific events related to the conflict. By leveraging artificial intelligence methods, the author aims to evaluate the significance of these events in shaping stock price movements.

1. Literature Review

Financial markets have historically reacted to geopolitical and military events, often showing significant abnormal returns on event days and the day following such events (Chen & Siems, 2004). Previous studies highlight the positive impact of war-related geopolitical events on stock returns for defence companies (Apergis & Apergis, 2016) and the negative impact of peace-related news (Shapiro et al., 1999). These findings underscore the influence of geopolitical risks on stock returns and market volatility (Alqahtani & Klein, 2021; Apergis et al., 2017; Umar et al., 2022; Klein, 2024).

Recent analyses, such as those employing Google Trends data (Halousková et al., 2022), have explored the impact of investor attention on asset price volatility during Russia's full-scale invasion of Ukraine, demonstrating significant index volatility and evidence of volatility spillover between different stock markets (Beraich et al., 2022). Notably, it is often not the event itself but the availability and dissemination of information online that significantly influences stock price changes and returns for defence companies (Klomp, 2020). This highlights the critical role of news feeds and the subjective reactions of investors to updates, such as the successes of the Ukrainian army supported by Western allies (Chowdhury & Humaira, 2023).

Earlier research on the impact of military, geopolitical (Nygaard & Sørensen, 2024; Alqahtani & Klein, 2021), and terrorist events (Papakyriakou et al., 2019) on defence stock prices and profitability focused primarily on the events as a whole. For example, studies examined the financial market reactions to the terrorist attacks of September 11 (Charles & Darné, 2006), the invasion of Iraq (Fernandez, 2009), and the Paris terrorist attacks (Apergis & Apergis, 2016; 2017), assessing their effects on market performance and specific financial instruments. Russia's ongoing war against Ukraine has drawn worldwide attention, as critical global issues related to world order, trade, and security are being decided on the battlefield (Melnychenko et al., 2022a; Melnychenko et al., 2022b). The growing interest in machine learning (ML) and artificial intelligence (AI) methods (see Figure 2) is particularly notable due to their broad applicability across various fields of science and practice. This interest is fuelled by modern computational capabilities and the rapid changes occurring in the global landscape (Melnychenko, 2019; 2020; 2021; Dabrock, 2024)).

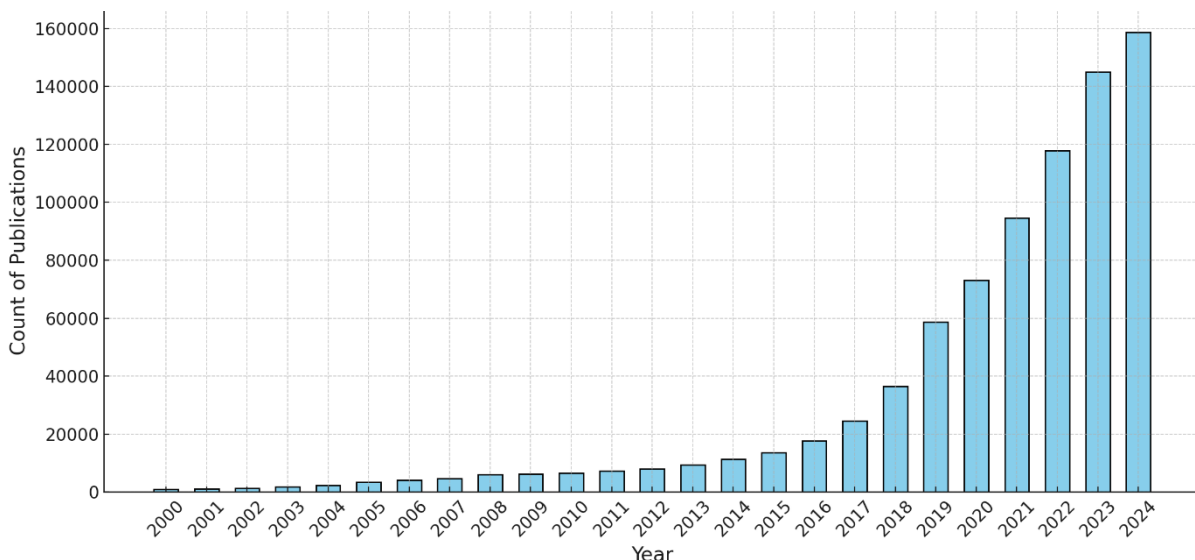


Figure 2. Scopus search results for the query "machine AND learning".

Source: Author's development based on (Scopus).

Furthermore, contemporary trends in the optimisation of cognitive functions across various methodological aspects of foresighting are comprehensively described in numerous scholarly works. These include studies on sustainability (Kharazishvili et al., 2020; Kwilinski, 2024b; Kwilinski & Vysochyna, 2024; Kwilinski et al., 2023b; 2023c; 2024b; 2024e), the interplay of factors influencing

entrepreneurial reflexivity (Berg & Spicka, 2023; Dacko-Pikiewicz, 2019b; Gigauri et al., 2024; Kwilinski et al., 2022; 2024f; Kyrylov et al., 2020; Lyulyov et al., 2020; Payonk et al., 2015; Surya et al., 2024; Zimbrow, 2023), energy management (Karpenko et al., 2018; Kharazishvili et al., 2021; Kwilinski, 2024a; Kwilinski et al., 2024a; Mlaabdal et al., 2024; Ziabina et al., 2023) and the correlation between the digitalisation process and various input and output indicators (Ayala-Mora et al., 2023; Boyko et al., 2024; Dementyev et al., 2021; Infante-Moro et al., 2022a; 2022b; Kharazishvili et al., 2022; Kwilinski, 2019; 2023; Kwilinski & Kardas, 2024a; Kwilinski et al., 2023a; 2023d; 2024c; 2024d; Labudova & Fodranova, 2024; Lyulyov et al., 2024b).

Thus, the purpose of this article is to examine the impact of battlefield developments in the Russia-Ukraine war on stock volatility among major players in the global defence industry, while also identifying the most effective method for forecasting stock prices by testing various machine learning (ML) models.

The remainder of the article is structured as follows: The next section outlines the methodology employed in this study, including a description of the data and their sources. The Research Results section presents the findings from evaluations, analyses and forecasts conducted using different machine learning models to identify the optimal approach for the dataset. Finally, the article concludes with a summary of the findings and a discussion of their implications.

2. Data and Methodology

In the absence of military intelligence data, publicly available information serves as the primary resource for analysing the relationship between stock prices and events related to the Russia-Ukraine war. One major challenge in identifying correlations between events and price fluctuations lies in the lack of data that numerically represent these events. A good solution to this issue is the application of machine learning methods, particularly those based on natural language processing (NLP), which have demonstrated great progress (Supriyono et al., 2024). NLP analyses text to determine sentiment on a scale from -1 to +1, where +1 represents positive sentiment, -1 represents negative sentiment, and 0 indicates neutrality. NLP-based sentiment analysis has been successfully applied in numerous disciplines, including financial market analysis (Rahman Jim et al., 2024), financial sentiment analysis (Du et al., 2025), accounting and auditing (Fisher et al., 2016), and more. Although the development of a domain-specific lexicon can enhance sentiment analysis in financial contexts (Yekrangi & Abdolvand, 2021), general sentiment analysis approaches have also proven effective (Nemes & Kiss, 2021).

Given the impracticality of analysing all individual articles from multiple sources, this study focuses on publications from *The Voice of America* (English version) and *The Guardian*. These sources frequently draw from reliable providers like Reuters and the BBC and are widely recognised for their credibility (Lewis & Cushion, 2017; Walsh, 2020; Nelson, 2018). Both outlets compile summaries of key events related to the Russian invasion of Ukraine under headings such as "Latest Developments in Ukraine", "Russia-Ukraine War Live: What We Know on Day ..." and "Ukraine War Briefing: ...", consolidating significant events on a single page. This structured presentation enables NLP tools to analyse major events daily and calculate sentiment scores for each trading day within the context of relevant developments. For sentiment analysis and related tasks, the Python programming language was employed, utilising libraries such as BeautifulSoup, NLTK (featuring the VADER tool, an unsupervised sentiment analysis algorithm), Pandas, ydata-profiling, and others. To improve the accuracy of sentiment calculations, common stopwords – such as "it", "they", "them", "what", "which", "while", "of", "at", "by", "for", "with" and "about" – were removed, as these words contribute little to the contextual meaning of the text (Chanda & Pal, 2023). Additionally, stock price data were retrieved using the *yfinance* library from Yahoo Finance.

The sentiment analysis of articles describing significant events in Ukraine related to Russian military aggression revealed predominantly negative tones, as expected given the nature of the

subject. Reports frequently highlighted war casualties, infrastructure destruction, and civilian suffering. However, on certain trading days, publications exhibited positive sentiment, occasionally reaching high scores (e.g. +0.9), often reflecting military successes or diplomatic achievements.

For this study, 705 articles from the selected sources were analysed, corresponding to 705 trading days and spanning 1000 days of the Russia-Ukraine war. Descriptive statistics for the sentiment analysis are presented in Table 1.

Table 1. Descriptive statistics of sentiment scores for publications from The Guardian and The Voice of America websites during the period from February 24, 2022 to November 25, 2024.

Parameters	Values	Parameters	Values
count	705	25%	-0.9980
mean	-0.8345	50%	-0.9946
std	0.4769	75%	-0.9795
min	-0.9999	max	0.9985

Source: Author's development based on (Guardian; VOA).

The author also utilises daily stock price data from major defence system suppliers, including BAE Systems (BAESY), Booz Allen Hamilton (BAH), Huntington Ingalls (HII), and Rheinmetall AG (RHM.DE), all of which experienced significant stock price increases on 24 February 2022, following the onset of the Russian invasion of Ukraine. Harris Corporation (LHX), however, did not exhibit price increases in alignment with the trends observed in other defence stocks (Figure 3).

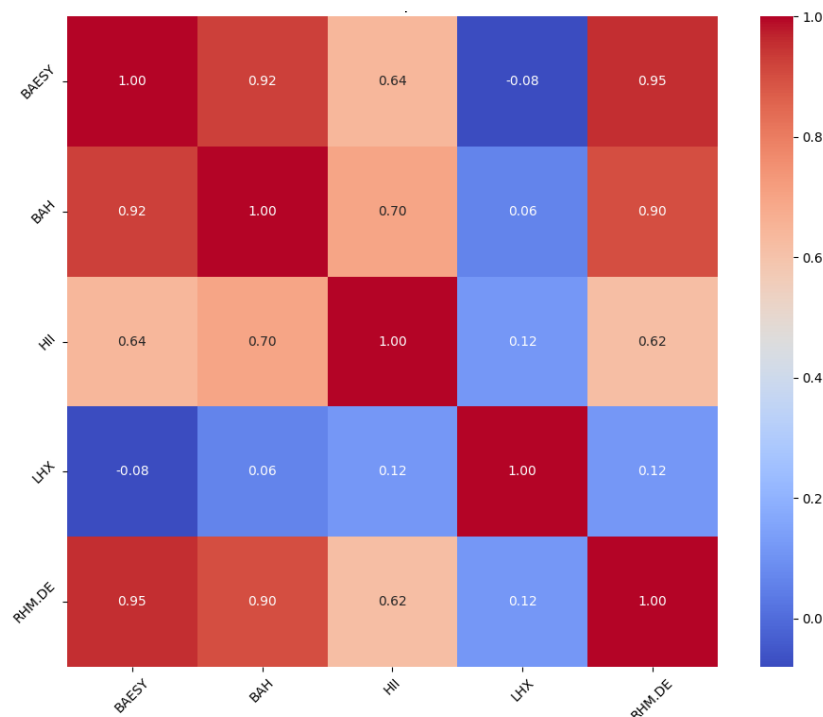


Figure 3. Correlation Heatmap of Stock Prices of BAE Systems (BAESY), Booz Allen Hamilton (BAH), Huntington Ingalls (HII), Harris Corporation (LHX), Rheinmetall AG (RHM.DE); Closing Share Price from February 24, 2022 to November 25, 2024

Source: Author's development based on (Yahoo Finance).

The data, sourced from the Yahoo Finance website, span the period from 24 February 2022 to 25 November 2024, and include share prices for each trading day. This timeframe captures the early stages of Russian military aggression against Ukraine and subsequent key events, resulting in 692 to 705 daily observations, depending on the stock exchange. To ensure data consistency, the study

utilised 685 trading sessions for subsequent calculations to exclude gaps in the dataset. Descriptive statistics for these data are presented in Table 2.

Table 2. Descriptive Statistics of BAE Systems (BAESY), Booz Allen Hamilton (BAH), Huntington Ingalls (HII), Harris Corporation (LHX), Rheinmetall AG (RHM.DE); Closing Share Price for Each Trading Day from February 24, 2022 to November 25, 2024.

Parameters	BAESY	BAH	HII	RHM.DE	Parameters	BAESY	BAH	HII	RHM.DE
count	692.00	692.00	692.00	705.00	25%	39.48	95.12	212.35	200.50
mean	51.59	117.82	233.50	305.36	50%	50.19	111.46	228.49	257.20
std	12.03	26.63	25.87	133.00	75%	64.98	145.13	253.77	468.30
min	33.97	75.14	184.96	100.05	max	72.46	186.00	296.43	619.00

Source: Author's development based on (Yahoo Finance).

For stock price forecasting of BAE Systems, Booz Allen Hamilton, Huntington Ingalls, Harris Corporation, and Rheinmetall AG, this study evaluated four methods: the VAR (Vector AutoRegression) model for multivariate time series, the XGBRegressor model for machine learning, the LSTM (Long Short-Term Memory) neural network model (utilising the tensorflow.keras library), and the ARIMA model. The results of these methods are presented in the Research Results section. To assess model performance, the study used RMSE (Root Mean Squared Error) as the primary evaluation metric (Braiek, Khomh, 2020).

3. Research Results

The correlation analysis of the stock prices of the selected companies indicates a low level of correlation. To ensure greater confidence in the findings, the correlation analysis was performed using the Pearson, Spearman, and Kendall methods, with the results presented in Tables 3–5.

Table 3. Correlation matrix (Pearson).

	BAESY	BAH	HII	RHM.DE	compound
BAESY	1	0.925213	0.641138	0.953614	-0.00078
BAH	0.925213	1	0.696697	0.901562	-0.00925
HII	0.641138	0.696697	1	0.619472	-0.01430
RHM.DE	0.953614	0.901562	0.619472	1	-0.01277
compound	-0.00078	-0.00925	-0.01430	-0.012770	1

Source: Author's development based on (Yahoo Finance).

Table 4. Correlation matrix (Spearman).

	BAESY	BAH	HII	RHM.DE	compound
BAESY	1	0.871084	0.542130	0.967084	0.4238580
BAH	0.871084	1	0.714909	0.826880	0.3766550
HII	0.54213	0.714909	1	0.512402	0.2097430
RHM.DE	0.967084	0.826880	0.512402	1	0.3984420
compound	0.423858	0.376655	0.209743	0.398442	1

Source: Author's development based on (Yahoo Finance).

Table 5. Correlation matrix (Kendall).

	BAESY	BAH	HII	RHM.DE	compound
BAESY	1	0.686842	0.356146	0.843057	0.286991
BAH	0.686842	1	0.534106	0.628106	0.248954
HII	0.356146	0.534106	1	0.337931	0.139066
RHM.DE	0.843057	0.628106	0.337931	1	0.267462
compound	0.286991	0.248954	0.139066	0.267462	1

Source: Author's development based on (Yahoo Finance).

Although the results of the Spearman correlation analysis indicated a moderate correlation with stock prices, further modelling of Rheinmetall AG (RHM.DE) revealed a very high RMSE level (Table 6), disproving the hypothesis of stock price dependency on battlefield events in the Russia-Ukraine war. This finding persists despite the significant price surge observed following initial reports of the onset of the war.

Among the tested models, only ARIMA (SARIMAX) demonstrated moderate accuracy. However, due to feasibility constraints, further research will not focus on improving this model or exploring additional connections.

Table 6. Root Mean Squared Error for each model was tested using Rheinmetall AG stock price with sentiment (compound) as an additional parameter.

Model	RMSE	Model	RMSE
ARIMA (SARIMAX)	37.2960	XGBoost	214.2886
VAR	196.6667	LSTM	254.6767

Source: Author's development.

During the search for the optimal model for forecasting the stock prices of the selected companies, it was observed that excluding sentiment (compound) as an explanatory variable still allowed the models to produce decent results when applied to time series data. This was particularly evident with the Long Short-Term Memory (LSTM) model, which is well-suited for capturing nonlinear time patterns and long-term dependencies. Each model was tested using the stock data of Rheinmetall AG to determine the most suitable approach for time series analysis without incorporating sentiment (compound) as a variable (Table 7).

Table 7. Root Mean Squared Error for each model was tested using Rheinmetall AG stock price.

Model	RMSE	Model	RMSE
LSTM	23.4788	ARIMA	37.0979
XGBoost	27.4883	VAR	96.8055

Source: Author's development.

In this case, the linear models (ARIMA and VAR) failed to forecast the RHM.DE variable effectively, suggesting the presence of nonlinear and more complex patterns in the data. The LSTM model outperformed both ARIMA and VAR, indicating that the data for RHM.DE contain nonlinear patterns that require advanced models, such as neural networks. The LSTM model effectively captured hidden temporal patterns in the data.

During the initial stage of running the LSTM model, the RMSE value obtained was 23.4788, which, despite being relatively high, was considered attractive for several reasons. First, it was the lowest RMSE value among the tested models. Second, the result was achieved despite the limited amount of data and the consideration of only one explanatory factor for the complex mechanism of stock price formation. Third, the testing was conducted on a stock with prices fluctuating between 100.05 and 619.

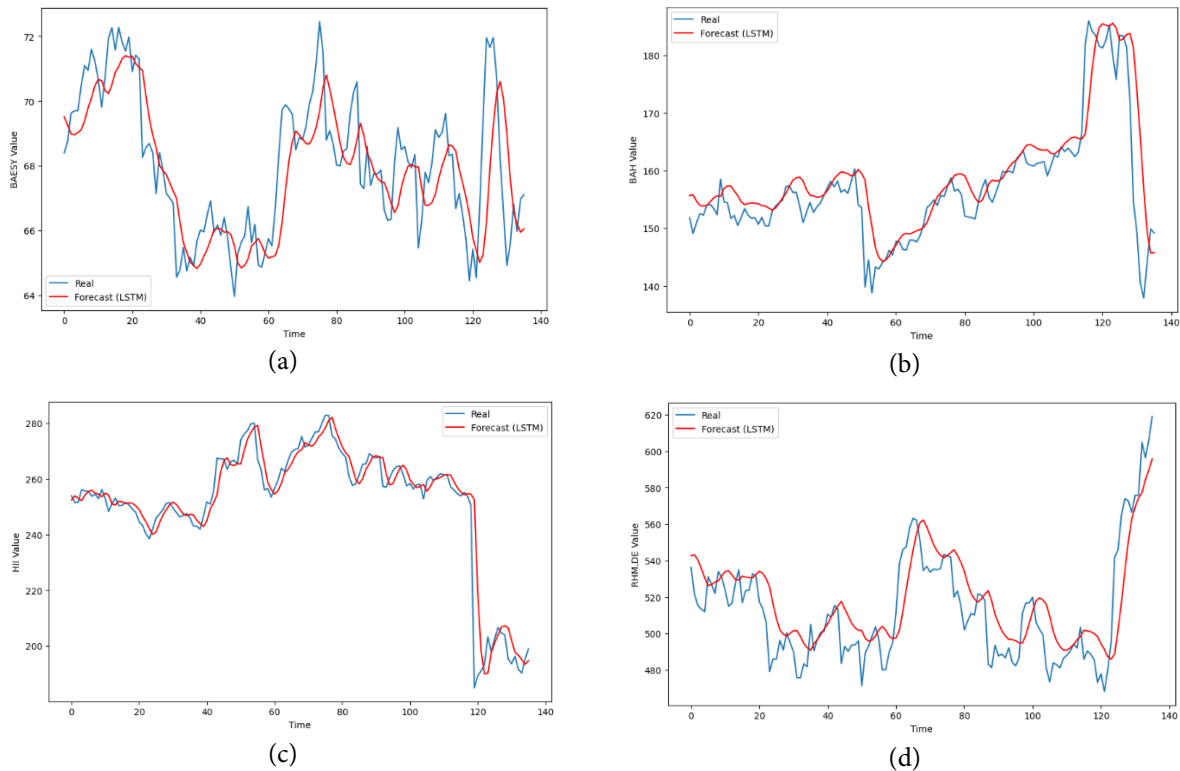
To improve these results further, the hyperparameters of the LSTM model were optimised. This involved adjusting the number of epochs, the size of the LSTM layers, and the lookback parameter, as well as employing Grid Search and Random Search for parameter tuning. After optimisation, the RMSE value for the RHM.DE stock forecast using the LSTM model improved to 17.8862.

Based on these improved results, a decision was made to apply the optimised LSTM model to the stock prices of the remaining companies in the dataset: BAE Systems, Booz Allen Hamilton, Huntington Ingalls, and Harris Corporation. The results are presented in Table 8 and Figure 4.

Table 8. Root Mean Squared Error for the LSTM model with optimising the hyperparameters of defence corporation stock prices.

Corporation	RMSE	Corporation	RMSE
BAESY	1.4648	HII	7.5409
BAH	5.4675	RHM.DE	17.8862

Source: Author's development.

**Figure 4.** Visualisation of the results from running the optimised LSTM model for (a) BAESY, (b) BAH, (c) HII, (d) RHM.DE.

Source: Author's development.

4. Discussion

This study demonstrates the potential of applying artificial intelligence at every stage of evaluating factors influencing stock prices. The analysis of news articles concerning the evolving situation in the Russia-Ukraine war was enabled by natural language processing (NLP) methods. Although, in this specific case, sentiment did not play a significant role in the changes in the stock prices of defence companies, the study presented an approach that can be utilised in other contexts where the sentiment level of publications shows a sufficient correlation with stock prices. Taking that into account, Caldara and Iacoviello (2022) demonstrated that the attention of "newspapers" to geopolitical events is an accurate measure of the perceptions of investors", underscoring the relevance of sentiment analysis as a tool for understanding market dynamics in geopolitically influenced scenarios. Using an extensive reading of news coverage over 120 years and a dictionary-based method, they developed the Geopolitical Risk (GPR) Index, which quantifies "the threat, realisation and escalation of adverse geopolitical events". Applying the news analysis methods used in this study could improve the speed and reliability of GPR calculations, leveraging AI capabilities for rapid information retrieval.

The testing of machine learning methods in this study identified an approach that is optimally suited for time series analysis. The tested methods have been widely applied in scientific literature, including:

- VAR (Vector AutoRegression): Utilised for the analysis of green equity indices (Cummins, Garry, Kearney, 2014), economic policy uncertainty, and stock market returns (Christou et al., 2017; Padhy et al., 2024).

- XGBRegressor Model: Applied for the accurate forecasting of corporate financial distress (Kristanti et al., 2024), stock market and price predictions (Lavanya, Gnanasekaran, 2023), and efficient portfolio management (Dezhkam, Manzuri, 2023).
- LSTM (Long Short-Term Memory) Neural Network Model: Implemented using the TensorFlow Keras library (Mohapatra et al., 2023), described as “offering robust and flexible tools for the design, training and evaluation of deep neural networks” (Villegas-Ch, Navarro, Sanchez-Viteri, 2024).
- ARIMA Model: Highlighted in many studies as an example of “advanced algorithmic forecasting techniques” (Kissell, 2014).

This research contributes to the growing body of knowledge by applying these well-established methods to time series data, demonstrating their strengths and potential use cases in various financial and economic contexts.

As previously highlighted, the Long Short-Term Memory (LSTM) method proved to be the best-performing approach. This is not the first instance where the model has demonstrated significantly lower root mean squared error (RMSE) values in stock market data forecasting (Dioubi et al., 2024).

Another study, by Li et al. (2024), examined the spillover effects of yields and volatility across 26 asset classes grouped into six markets: Stock, Gold, Energy, Food, Currency and Bond. Their analysis focused on the invasion of Ukraine by Russian troops on February 24, 2022, which they referenced 44 times. However, their focus did not extend to individual battlefield events nor subsequent impacts on the market.

It is important to note that Russia’s invasion of Ukraine began earlier, in 2014, with the annexation of Crimea and incursions into Donetsk and Luhansk. The focus on February 24, 2022, as the starting point likely influences how researchers interpret the importance of events in the ongoing war. Consequently, events before the February 2022 invasion are often overlooked in the scientific literature.

While the findings of this study suggest a relationship between battlefield developments and stock price fluctuations in major defence corporations, it is important to acknowledge several limitations that constrain the scope of the conclusions. Firstly, it would be overly simplistic to assume that the stock prices of large defence companies are influenced solely by a single indicator, such as sentiment derived from news reports. Stock prices are inherently multifactorial and can be impacted by a myriad of variables, including macroeconomic conditions, defence budgets, interest rates, geopolitical alliances, and broader market trends.

The sharp price surge observed following Russia’s full-scale invasion of Ukraine on 24 February 2022 is a notable market reaction that underscores the significance of immediate news. However, attributing this reaction solely to the sentiment of battlefield developments may overlook other influencing factors. For instance, market participants may also have been responding to anticipated government policy shifts, projected increases in defence spending, or speculative investment behaviours prompted by geopolitical instability.

Furthermore, this study’s reliance on sentiment analysis derived from the Python VADER module introduces methodological constraints. While VADER is a widely-used and practical tool for text sentiment analysis, it may not fully capture the nuanced and context-specific language often found in geopolitical news. The complexity of interpreting sentiment in articles that describe dynamic and multifaceted battlefield events may lead to inaccuracies or oversimplifications. Additionally, sentiment scores generated by such tools do not account for the subjective interpretations of news by different market actors.

Another limitation lies in the scope of this study, which primarily examined sentiment related to a single geopolitical event. This approach may not adequately generalise to other contexts or conflicts, as the market’s response to battlefield developments may vary depending on the scale, stakeholders involved, and global economic conditions at the time.

Lastly, while the study focuses on major defence corporations, the findings do not account for smaller defence companies or adjacent industries, which may exhibit different patterns of stock price movement. This could lead to a partial understanding of the overall impact of battlefield developments on the broader defence sector.

To address these limitations, future research should consider incorporating a wider array of variables, employing advanced sentiment analysis tools that leverage deep learning, and expanding the scope to include comparative analyses of different geopolitical events. By doing so, subsequent studies can provide a more holistic understanding of the intricate relationships between geopolitical developments, market sentiment and financial performance in the defence industry.

Conclusions

This study aimed to identify a model capable of predicting stock prices based on the battlefield developments during the Russia-Ukraine war. Sentiment data extracted from news articles describing the conflict in Ukraine were collected and analysed. The market reaction – specifically, the stock prices of some of the largest defence companies – to Russia's full-scale invasion of Ukraine in February 2022 was immediate and significant.

The study sought to investigate whether the market, and the same stocks, reacted as strongly to subsequent individual battlefield events in Ukraine, such as the successes or setbacks of the Ukrainian army. However, the applied methodology did not confirm the hypothesis of a correlation between stock prices and these events.

Nevertheless, success was achieved in testing various machine learning methods for forecasting stock prices of specific defence industry companies. The results demonstrate that for BAE Systems, Booz Allen Hamilton, Huntington Ingalls, and Rheinmetall AG, LSTM neural networks provide the best solution based on time series data. This was particularly evident after optimising hyperparameters, including the number of epochs and the size of the LSTM layers.

The findings of this study underline the robustness of LSTM models in capturing complex patterns in time series data, making them particularly effective in highly volatile and event-driven industries such as defence. However, the variations in model performance across different companies highlight the importance of tailoring machine learning models to the specific characteristics of individual stock behaviours and market dynamics.

In this study, the Python VADER module was used to assess the sentiment of news articles. While VADER is a practical tool, it is neither universal nor the most advanced option for text sentiment analysis. Future research should therefore explore alternative tools and methods for text analysis, with a particular emphasis on identifying the most effective approaches among machine learning models for analysing sentiment in geopolitically sensitive contexts.

Additionally, future studies should aim to identify other markers that reflect battlefield developments and demonstrate a clear correlation with stock prices. Expanding the range of indicators could provide deeper insights into the relationship between geopolitical events and financial market dynamics, enhancing the understanding of how specific events influence market reactions.

Further research should also focus on the integration of additional variables, such as macroeconomic indicators, defence budgets and international policy shifts, to enhance the predictive capabilities of machine learning models. Incorporating such factors could offer a more comprehensive understanding of the interplay between geopolitical events and financial markets, enabling more accurate and nuanced forecasts.

Finally, the study underscores the potential of machine learning in supporting investment decision-making and risk management in defence-related sectors. By leveraging AI-driven insights, stakeholders can better navigate the uncertainties of geopolitically sensitive industries, refine their strategic approaches to investment, and optimise policy formulation in response to rapidly changing global dynamics.

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References

1. Alqahtani, A., & Klein, T. (2021). Oil price changes, uncertainty, and geopolitical risks: On the resilience of GCC countries to global tensions. *Energy*, 236, Article 121541. <https://doi.org/10.1016/j.energy.2021.121541>.
2. Apergis, E., & Apergis N. (2016). The 11/13 Paris terrorist attacks and stock prices: The case of the international defense industry, *Applied Economics Letters*, 24(1), 45–48. <http://dx.doi.org/10.1080/13504851.2016.1158914>.
3. Apergis, E., & Apergis, N. (2017). The Impact of 11/13 Paris Terrorist Attacks on Stock Prices: Evidence from the International Defence Industry, *Applied Economics Letters*, 24(1), 45–48.
4. Apergis, N., Bonato, M., Gupta, R., & Kyei, C. (2017). Does Geopolitical Risks Predict Stock Returns and Volatility of Leading Defense Companies? Evidence from a Nonparametric Approach. *Defence and Peace Economics*, 29(6), 684–696. <https://doi.org/10.1080/10242694.2017.1292097>.
5. Ayala-Mora, J., Infante-Moro, A., & Infante-Moro, J. C. (2023). Electronic administration in the Council of the Judiciary of Ecuador [La administración electrónica en el Consejo de la Judicatura de Ecuador]. *RISTI - Revista Ibérica de Sistemas e Tecnologias de Informação*, 2023(E60), 511–523.
6. Beraich, M., Amzile, K., Laamire, J., Zirari, O., & Fadali, M. A. (2022). Volatility Spillover Effects of the US, European and Chinese Financial Markets in the Context of the Russia–Ukraine Conflict. *International Journal of Financial Studies*, 10(4), Article 95. <https://doi.org/10.3390/ijfs10040095>.
7. Berg, S., & Spicka, J. (2023). Shaping farm workers' political trust: The moderating role of misinformation exposure. *Central European Business Review*, 12(5), 177–199. <https://doi.org/10.18267/j.cebr.357>.
8. Boyko, A., Zimbroff, A., Mynenko, S., & Chen, Y. (2024). Anti-money laundering in the digital economy: Institutional, financial, and educational channels. *Virtual Economics*, 7(3), 59–80. [https://doi.org/10.34021/ve.2024.07.03\(4\)](https://doi.org/10.34021/ve.2024.07.03(4)).
9. Braiek, H.B., & Khomh, F. (2020). On testing machine learning programs. *Journal of Systems and Software*, 164, Article 110542. <https://doi.org/10.1016/j.jss.2020.110542>.
10. Caldara, D., & Iacoviello, M. (2022). Measuring Geopolitical Risk. *American Economic Review*, 112(4), 1194–1225. <https://doi.org/10.1257/aer.20191823>.
11. Chanda, S., & Pal, S. (2023). The effect of stopword removal on information retrieval for code-mixed data obtained via social media. *SN Computer Science*, 4, Article 494. <https://doi.org/10.1007/s42979-023-01942-7>.
12. Charles, A., & Darné, O. (2006). Large shocks and the September 11th terrorist attacks on international stock markets. *Economic Modelling*, 23(4), 683–698. <https://doi.org/10.1016/j.econmod.2006.03.008>.
13. Chen, A.H., & Siems, T.F. (2004). The effects of terrorism on global capital markets. *European Journal of Political Economy*, 20(2), 349–366. <https://doi.org/10.1016/j.ejpoleco.2003.12.005>.

14. Christou, Ch. , Cunado, J., Gupta, R., & Hassapis, Ch. (2017). Economic policy uncertainty and stock market returns in PacificRim countries: Evidence based on a Bayesian panel VAR model. *Journal of Multinational Financial Management*, 40, 92–102. <https://doi.org/10.1016/j.mulfin.2017.03.001>.
15. Chowdhury, E.K., & Humaira, U. (2023). The Russia-Ukraine conflict and investor psychology in financial markets. *Economic Affairs*, 43(3), 388–405. <https://doi.org/10.1111/ecaf.12596>.
16. Cummins, M., Garry, O., & Kearney, C. (2014). Price discovery analysis of green equity indices using robust asymmetric vector autoregression. *International Review of Financial Analysis*, 35, 261–267. <https://doi.org/10.1016/j.irfa.2014.10.006>.
17. Dabrock, K., Pflugrad, N., Weinand, J.M., & Stolten, D. (2024). Leveraging machine learning to generate a unified and complete building height dataset for Germany. *Energy and AI*, 17, Article 100408. <https://doi.org/10.1016/j.egyai.2024.100408>.
18. Dacko-Pikiewicz, Z. (2019b). 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. *Polish Journal of Management Studies*, 19(1), 130–144. <https://doi.org/10.17512/pjms.2019.19.1.10>.
19. 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)).
20. Dioubi, F., Hundera, N.W., Xu, H., & Zhu, X. (2024). Enhancing stock market predictions via hybrid external trend and internal components analysis and long short term memory model. *Journal of King Saud University - Computer and Information Sciences*, 36(10), Article 102252. <https://doi.org/10.1016/j.jksuci.2024.102252>.
21. Du, K., Zhao, Y., Mao, R., Xing, F., & Cambria, E. (2025). Natural language processing in finance: A survey. *Information Fusion*, 115, Article 102755. <https://doi.org/10.1016/j.inffus.2024.102755>.
22. Dezhkam, A., & Manzuri, M.T. (2023). Forecasting stock market for an efficient portfolio by combining XGBoost and Hilbert–Huang transform. *Engineering Applications of Artificial Intelligence*, 118, Article 105626. <https://doi.org/10.1016/j.engappai.2022.105626>.
23. Fernandez, V. (2009). The behavior of stock returns in the mining industry following the Iraq war. *Research in International Business and Finance*, 23(3), 274–292. <https://doi.org/10.1016/j.ribaf.2008.11.004>.
24. Fisher, I.E., Garnsey, M.R., & Hughes, M.E. (2016). Natural Language Processing in Accounting, Auditing and Finance: A Synthesis of the Literature with a Roadmap for Future Research. *International journal of intelligent systems in accounting, finance & management*, 23(3), 157–214. <https://doi.org/10.1002/isaf.1386>.
25. Gigauro, I., Palazzo, M., & Siano, A. (2024). Examining the market potential for smart intelligent packaging: A focus on Italian consumers. *Virtual Economics*, 7(2), 89–116. [https://doi.org/10.34021/ve.2024.07.02\(5\)](https://doi.org/10.34021/ve.2024.07.02(5)).
26. Guardian. <https://www.theguardian.com/help/contact-us>.
27. Halousková, M., Stašek, D., & Horváth, M. (2022). The role of investor attention in global asset price variation during the invasion of Ukraine. *Finance Research Letters*, 50, Article 103292. <https://doi.org/10.1016/j.frl.2022.103292>.
28. Infante-Moro, A., Infante-Moro, J. C., & Gallardo-Pérez, J. (2022a). Key factors to raise cybersecurity awareness among employees [Factores claves para concienciar la ciberseguridad en los empleados]. *Revista de Pensamiento Estratégico y Seguridad CISDE*, 7(1), 69–79.
29. Infante-Moro, A., Infante-Moro, J. C., Gallardo-Pérez, J., & Martínez-López, F. J. (2022b). Key factors in the implementation of e-proctoring in the Spanish university system. *Sustainability*, 14(13), Article 8112. <https://doi.org/10.3390/su14138112>.

30. Karpenko, L., Serbov, M., Kwilinski, A., Makedon, V., & Drobyazko, S. (2018). Methodological platform of the control mechanism with the energy saving technologies. *Academy of Strategic Management Journal*, 17(5), 1–7.
31. 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)).
32. Kharazishvili, Y., Kwilinski, A., Grishnova, O., & Dzwigol, H. (2020). Social Safety of Society for Developing Countries to Meet Sustainable Development Standards: Indicators, Level, Strategic Benchmarks (with Calculations Based on the Case Study of Ukraine). *Sustainability*, 12(21), Article 8953. <https://doi.org/10.3390/su12218953>.
33. Kharazishvili, Y., Kwilinski, A., Sukhodolia, O., Dzwigol, H., Bobro, D., & Kotowicz, J. (2021). The Systemic Approach for Estimating and Strategizing Energy Security: The Case of Ukraine. *Energies*, 14(8), Article 2126. <https://doi.org/10.3390/en14082126>.
34. Kissell, R. (2014). Chapter 7 - Advanced algorithmic forecasting techniques. In R. Kissell (Ed.), *The science of algorithmic trading and portfolio management* (pp. 235–268). Academic Press. <https://doi.org/10.1016/B978-0-12-401689-7.00007-6>.
35. Klein, T. (2024). Investor behavior in times of conflict: A natural experiment on the interplay of geopolitical risk and defense stocks. *Journal of Economic Behavior & Organization*, 222, 294–313. <https://doi.org/10.1016/j.jebo.2024.04.020>.
36. Klomp, J. (2020). Killing the Deal. *Defence and Peace Economics*, 33(5), 548–562. <https://doi.org/10.1080/10242694.2020.1824363>.
37. Kristanti, F., Febrianta, M., Salim, D., Riyadh, H., Sagama, Y., & Beshr, B. (2024). Advancing financial analytics: Integrating XGBoost, LSTM, and Random Forest Algorithms for precision forecasting of corporate financial distress. *Journal of Infrastructure, Policy and Development*, 8(8), Article 4972. <http://dx.doi.org/10.24294/jipd.v8i8.4972>.
38. Kwilinski, A. (2019). Implementation of blockchain technology in accounting sphere. *Academy of Accounting and Financial Studies Journal*, 23(SI2), 1–6.
39. 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)).
40. Kwilinski, A. (2024a). Mapping global research on green energy and green investment: A comprehensive bibliometric study. *Energies*, 17(5), Article 1119. <https://doi.org/10.3390/en17051119>.
41. Kwilinski, A. (2024b). Understanding the nonlinear effect of digital technology development on CO2 reduction. *Sustainable Development*, 32(5), 5797–5811. <https://doi.org/10.1002/sd.2964>.
42. Kwilinski, A., & Kardas, M. (2024a). The role of the Pareto principle in quality management within Industry 4.0: A comprehensive bibliometric analysis. *Virtual Economics*, 7(3), 7–24. [https://doi.org/10.34021/ve.2024.07.03\(1\)](https://doi.org/10.34021/ve.2024.07.03(1)).
43. Kwilinski, A., & Vysochyna, A. (2024). Efficiency of healthcare financing: Case of European countries. *International Journal of Financial Studies*, 12(3), Article 87. <https://doi.org/10.3390/ijfs12030087>.
44. Kwilinski, A., Dalevska, N., & Dementyev, V. V. (2022). Metatheoretical issues of the evolution of the international political economy. *Journal of Risk and Financial Management*, 15(3), Article 124. <https://doi.org/10.3390/jrfm15030124>.
45. Kwilinski, A., Lyulyov, O., & Pimonenko, T. (2023a). The coupling and coordination degree of digital business and digital governance in the context of sustainable development. *Information*, 14(12), Article 651. <https://doi.org/10.3390/info14120651>.

46. Kwilinski, A., Lyulyov, O., & Pimonenko, T. (2023b). Unlocking Sustainable Value through Digital Transformation: An Examination of ESG Performance. *Information*, 14(8), Article 444. <https://doi.org/10.3390/info14080444>.
47. Kwilinski, A., Lyulyov, O., & Pimonenko, T. (2023c). Greenfield investment as a catalyst of green economic growth. *Energies*, 16(5), 2372. <https://doi.org/10.3390/en16052372>.
48. Kwilinski, A., Lyulyov, O., & Pimonenko, T. (2023d). Environmental Sustainability within Attaining Sustainable Development Goals: The Role of Digitalization and the Transport Sector. *Sustainability*, 15(14), Article 11282. <https://doi.org/10.3390/su151411282>.
49. Kwilinski, A., Lyulyov, O., & Pimonenko, T. (2024a). Reducing transport sector CO2 emissions patterns: Environmental technologies and renewable energy. *Journal of Open Innovation: Technology, Market, and Complexity*, 10(1), Article 100217. <https://doi.org/10.1016/j.joitmc.2024.100217>.
50. Kwilinski, A., Lyulyov, O., Pimonenko, T., & Pudryk, D. (2024b). Global image of countries and immigration flows. *Central European Business Review*, 13(4), 83–101. <https://doi.org/10.18267/j.cebr.359>.
51. Kwilinski, A., Merritt, P., & Wróblewski, Ł. (2024c). Advancing sustainable development goals through digital culture: A global research overview. *Cultural Management: Science and Education*, 8(1), 61–80. <https://doi.org/10.30819/cmse.8-1.04>.
52. Kwilinski, A., Szczepańska-Woszczyna, K., Lyulyov, O., & Pimonenko, T. (2024d). Digital public services: Catalysts for healthcare efficiency. *Journal of Open Innovation: Technology, Market, and Complexity*, 10(3), Article 100319. <https://doi.org/10.1016/j.joitmc.2024.100319>.
53. Kwilinski, A., Szczepańska-Woszczyna, K., Lyulyov, O., & Pimonenko, T. (2024e). Government effectiveness and immigrant outflows: Their role in advancing greenfield investment globally and regionally. *Polish Journal of Management Studies*, 29(2), 365–379. <https://doi.org/10.17512/pjms.2024.29.2.19>.
54. Kwilinski, A., Lyulyov, O., & Pimonenko, T. (2024f). Green economic development and entrepreneurship transformation. *Entrepreneurial Business and Economics Review*, 12(4), 157–175. <https://doi.org/10.15678/EBER.2024.120409>.
55. Kyrylov, Y., Hranovska, V., Boiko, V., Kwilinski, A., & Boiko, L. (2020). International tourism development in the context of increasing globalization risks: On the example of Ukraine's integration into the global tourism industry. *Journal of Risk and Financial Management*, 13(12), Article 303. <https://doi.org/10.3390/jrfm13120303>.
56. Labudova, V., & Fodranova, I. (2024). The impact of socio-economic factors on digital skills in the population of the EU 27 countries. *Virtual Economics*, 7(3), 81–101. [https://doi.org/10.34021/ve.2024.07.03\(5\)](https://doi.org/10.34021/ve.2024.07.03(5)).
57. Lavanya M., & P. Gnanasekaran. (2023). Prediction of Stock Price Using Machine Learning (Classification) Algorithms. In *International Conference on Advances in Computing, Communication and Applied Informatics (ACCAI)* (pp. 1-5). Chennai, India. <https://doi.org/10.1109/ACCAI58221.2023.10199307>.
58. Lewis, J., & Cushion, S. (2017). Think Tanks, Television News and Impartiality: The ideological balance of sources in BBC programming. *Journalism Studies*, 20(4), 480–499. <https://doi.org/10.1080/1461670X.2017.1389295>.
59. Li, Zh., Hu, B., Zhang, Y., & Yang, W. (2024). Financial market spillovers and investor attention to the Russia-Ukraine war. *International Review of Economics & Finance*, 96(A), Article 103521. <https://doi.org/10.1016/j.iref.2024.103521>.
60. Lyulyov, O., Us, Y., Pimonenko, T., Kwilinski, A., Vasylieva, T., Dalevska, N., Polcyn, J., & Boiko, V. (2020). The link between economic growth and tourism: COVID-19 impact. In *Proceedings of the 36th International Business Information Management Association (IBIMA)* (pp. 8070–8086). International Business Information Management Association.

61. Lyulyov, O., Pimonenko, T., Infante-Moro, A., & Kwilinski, A. (2024b). Perception of artificial intelligence: GSR analysis and face detection. *Virtual Economics*, 7(2), 7–30. [https://doi.org/10.34021/ve.2024.07.02\(1\)](https://doi.org/10.34021/ve.2024.07.02(1)).
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., Osadcha, T., Kovalyov, A., & Matskul, V. (2022a). Consequences of russia's military invasion of Ukraine for Polish-Ukrainian trade relations. *Journal of International Studies*, 15(4), 131–149. <https://doi.org/10.14254/2071-8330.2022/15-4/8>.
64. Melnychenko, O. (2020). Is Artificial Intelligence Ready to Assess an Enterprise's Financial Security? *Journal of Risk and Financial Management*, 13(9), Article 191. <https://doi.org/10.3390/jrfm13090191>.
65. Melnychenko, O., Matskul, V., & Osadcha, T. (2022b). The Dynamics of Trade Relations between Ukraine and Romania: Modelling and Forecasting. *Virtual Economics*, 5(2), 7–23. [https://doi.org/10.34021/ve.2022.05.02\(1\)](https://doi.org/10.34021/ve.2022.05.02(1)).
66. 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)).
67. Mlaabdal, S. M. A., Kulish, A., Kwilinski, A., & Chygryn, O. (2024). Sustainable energy policy and environmental responsibility: Clustering of key development patterns. *Journal of Sustainability Science and Management*, 19(8), 132–148. <https://doi.org/10.46754/jssm.2024.08.010>.
68. Mohapatra, P.R., Parida, A.K., Swain, S.K., & Basa, S.S. (2023). Gradient Boosting and LSTM Based Hybrid Ensemble Learning for Two Step Prediction of Stock Market. *Journal of Advances in Information Technology*, 14(6), 1254–1260. <https://doi.org/10.12720/jait.14.6.1254-1260>.
69. Nemes, L., & Kiss, A. (2021). Prediction of stock values changes using sentiment analysis of stock news headlines. *Journal of Information and Telecommunication*, 5(3), 375–394. <https://doi.org/10.1080/24751839.2021.1874252>.
70. Nelson, T. (2018). Quote counts as a success metric: quantifying a criticism of Voice of America. *The Journal of International Communication*, 25(1), 116–136. <https://doi.org/10.1080/13216597.2018.1517658>.
71. Nygaard, K., Sørensen, L.Q. (2024). Betting on war? Oil prices, stock returns, and extreme geopolitical events. *Energy Economics*, 136, 107659. <https://doi.org/10.1016/j.eneco.2024.107659>.
72. Padhy, N., Dharmireddi, S., Padhy, D. K., Saikrishna, R., & Raju, K. S. (2024). Stock market prediction performance analysis by using machine learning regressor techniques. In S. K. Panda, R. R. Rout, M. Bisi, R. C. Sadam, K. C. Li, & V. Piuri (Eds.), *Computing, communication and learning. CoCoLe 2023* (Vol. 1892, pp. 47–59). Springer, Cham. https://doi.org/10.1007/978-3-031-56998-2_4.
73. Papakyriakou, P., Sakkas, A., & Taoushianis, Z. (2019). The impact of terrorist attacks in G7 countries on international stock markets and the role of investor sentiment. *Journal of International Financial Markets, Institutions and Money*, 61, 143–160. <https://doi.org/10.1016/j.intfin.2019.03.001>.
74. Payonk, K., Lyashenko, V., & Kvilinskyi, O. (2015). Operation of a business entity in the context of globalization. *Economic Herald of the Donbas*, 4(42), 18–23.
75. Rahman Jim, J., Talukder, M. A. R., Malakar, P., Kabir, M. M., Nur, K., & Mridha, M. F. (2024). Recent advancements and challenges of NLP-based sentiment analysis: A state-of-the-art review. *Natural Language Processing Journal*, 6, Article 100059. <https://doi.org/10.1016/j.nlp.2024.100059>.
76. Scopus. (n.d.). <https://www.scopus.com/>.
77. Shapiro, C., & Varian, H. R. (1999). The Art of Standards Wars. *California Management Review*, 41(2), 8–32. <https://doi.org/10.2307/41165984>.

78. Supriyono, Wibawa, A.P., Suyono, & Kurniawan, F. (2024). Advancements in natural language processing: Implications, challenges, and future directions. *Telematics and Informatics Reports*, 16, Article 100173. <https://doi.org/10.1016/j.teler.2024.100173>.
79. Surya, B. K., Kot, S., Astawa, I. P., Rihayana, I. G., & Arsha, I. M. R. M. (2024). Unlocking sustainability through innovation: A green HR approach for the hospitality industry. *Virtual Economics*, 7(2), 50–62. [https://doi.org/10.34021/ve.2024.07.02\(3\)](https://doi.org/10.34021/ve.2024.07.02(3)).
80. Umar, Z., Bossman, A, Choi, S.-Y., & Teplova, T. (2022). Does geopolitical risk matter for global asset returns? Evidence from quantile-on-quantile regression. *Finance Research Letters*, 48, Article 102991. <https://doi.org/10.1016/j.frl.2022.102991>.
81. Villegas-Ch, W., Navarro, A.M., & Sanchez-Viteri, S. (2024). Optimization of inventory management through computer vision and machine learning technologies. *Intelligent Systems with Applications*, 24, Article 200438. <https://doi.org/10.1016/j.iswa.2024.200438>.
82. VOA. <https://www.voanews.com>.
83. Walsh, C. (2020). Constructing Experts Without Expertise: Fiscal Reporting in the British Press, 2010–2016. *Journalism Studies*, 21(15), 2059–2077. <https://doi.org/10.1080/1461670X.2020.1809496>.
84. Yahoo Finance. (n.d.). <https://finance.yahoo.com/>.
85. Yekrangi, M., & Abdolvand, N. (2021). Financial markets sentiment analysis: developing a specialized Lexicon. *J Intell Inf Syst* 57, 127–146. <https://doi.org/10.1007/s10844-020-00630-9>.
86. 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), Article 998. <https://doi.org/10.3390/en16020998>.
87. Zimbroff, A. (2023). The future of extension programming post-pandemic: The need for diverse approaches. *The Journal of Extension*, 61(2), Article 6. <https://doi.org/10.34068/joe.61.02.06>.

Mitigating CO₂ Emissions through Economic Growth, Green Finance, and Renewable Energy: Evidence from an ARDL Analysis

Elhachemi Abdelkader Hacine Gherbi ¹, Gamal Sayed Ahmed Khalifa ^{2*}, Aleksy Kwilinski ³

¹ Faculty of Business, Higher Colleges of Technology, AAF, Abu Dhabi, UAE

ORCID: 0000-0002-6192-8991

e-mail: egherbi@hct.ac.ae

² Faculty of Business, Higher Colleges of Technology, AAF, Abu Dhabi, UAE;

Faculty of Tourism and Hotels, Fayoum University, Egypt

ORCID: 0000-0003-1665-9291

e-mail: gkhalifa@hct.ac.ae

³ The London Academy of Science and Business, London, UK;

Institute for Sustainable Development and International Relations, WSB University, Dabrowa Gornicza, Poland

ORCID: 0000-0001-6318-4001

e-mail: a.kwilinski@london-asb.co.uk

* Corresponding author: Gamal Sayed Ahmed Khalifa, gkhalifa@hct.ac.ae

Abstract

This study examines the intricate long-term relationships between global CO₂ emissions and three pivotal factors: global gross domestic product (GDP), green finance flows in developing economies, and global renewable energy consumption. The study spans data from 2000 to 2021, addressing critical questions on sustainability and economic growth amidst growing environmental concerns. This investigation is timely as it aligns with international efforts to mitigate climate change and transition towards greener economies. The primary objective of this research is to analyse the interplay between economic growth, financial mechanisms, and renewable energy in influencing global CO₂ emissions. It aims to provide empirical insights into their dynamics and offer policy recommendations for sustainable development. Using the Autoregressive Distributed Lag (ARDL) model, the study investigates long-run and short-run relationships among these variables. The approach ensures robust statistical modelling of the time-series data while considering the complexities of cross-country variations. The findings reveal a significant positive correlation between global GDP and CO₂ emissions, indicating that a 1% increase in global GDP leads to a 0.48% rise in emissions. Conversely, renewable energy consumption exhibits a substantial negative relationship, where a 1% increase reduces CO₂ emissions by 0.77%. Notably, green finance in developing countries shows a positive but statistically insignificant impact on emissions, highlighting gaps in its current implementation and effectiveness. This study contributes to the Environmental Kuznets Curve (EKC) hypothesis by illustrating that the current global economy has not reached a maturity level that fosters emission reductions alongside economic growth. It underscores the role of renewable energy and green finance in shaping sustainable economic paradigms. The research highlights policy imperatives, urging governments to: (1) scale up investments in renewable energy to combat climate change effectively; (2) enhance the efficiency and governance of green finance mechanisms in developing economies to ensure impactful emission reductions; and (3) align economic growth strategies with environmental sustainability goals.

Key words

CO₂ emissions, renewable energy, green finance, economic growth, sustainability.

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Introduction

The development and worsening of the climate change problem have called for enhanced attention and demand from policymakers, researchers and industries to provide methods of minimising carbon production. Among the suggested measures, green finance, the consumption of renewable energy, and adapting sustainable economic development are some of the significant features that have become important in the process of countering adverse climate change impacts at the global level. Green finance, meaning financial flows towards green economy projects which are financed through the efficient management of financial resources, has been advocated as a key approach towards promoting the development of renewable energy conservation and other sustainable initiatives (Wu, 2023). As a result, green finance provides funds toward clean energy projects that can greatly minimise the utilisation of fossil products, which are among the key sources of global CO₂ emission (Ali et al., 2023). However, the efficacy and indeed applicability of green finance, particularly, but not exclusively, in developing nations, is still an open question, though some research has claimed that its current volume is insufficient to meaningfully move the needle on emissions reductions (Sun et al., 2023).

The use of renewable energy has been considered one of the potential options for CO₂ emission reduction. Clean energy investments such as the solar industry, wind industry, and hydropower have been shown to cause a decline in carbon emissions as they enhance the economy (Jin et al., 2023). For instance, renewable energy assists not only in shaping the sustainable generation of energy but also enables countries to meet their carbon neutrality goals by replacing fossil energy, which is the main source of emissions of greenhouse gases (Cooke, 2023). In addition, there are indications from other studies that renewable energy has an impact on employment generation, technological development, and sustainable economic growth and development for the long haul (Ali et al., 2023). Nevertheless, the utilisation of renewable energy has a number of issues, such as high initial investment costs and scarcity of green funding in emerging markets (Xu et al., 2023).

Economic development previously tied to emission increase based on industrialisation and the use of energy, has an ambiguous interaction with sustainable environment. Environmental Kuznets Curve (EKC) hypothesis postulates that economic progress first provokes pollution as the economy tries to industrialize; then pollution declines as incomes increase and use cleaner technologies (Khan et al., 2021). Although this hypothesis has been proved beyond doubt in some developed countries, particularly those which belong to the Organisation for Economic Cooperation and Development (OECD), it has remained a subject of debate in developing countries where the higher level of industrialisation results in higher levels of CO₂ emission but without a simultaneous transition to cleaner technologies (Jin et al., 2023). Hence, for developing countries to achieve enhanced economic growth, it is necessary for them to tap into green finance and renewable energy, but more importantly, firm institutional quality that supports environmental sustainability and good governance (Xu et al., 2023). Institutional quality and governance have also been recommended as key driving forces for green finance and low carbon emission. The general legal structures of a country accompanied by political stability and the efficiency of the regulatory framework support the growth of green finance. There is evidence that strong institutions are a blessing in terms of enabling the development of renewable energy and clean technologies required to support the change to a low-carbon economy (Xu et al., 2023). However, weak institutions hinder green finance development; resource allocation is not efficient, and emission reduction progress slows down (Ali et al., 2023). However, good governance may also increase the implementation efficiency of environmental policies, improve accountability, and promote joint efforts of civil society and business in countering climate change (Jin et al., 2023).

Previous studies (Xu et al., 2023; Ali et al., 2023; Jin et al., 2023) have reached conflicting conclusions on the impact of green finance on emission reduction, especially in developing countries where green

finance is weak or non-existent. According to Sun et al. (2023), green finance has been essential in advancing renewable energy initiatives in China; however, its influence in other developing areas has not been as pronounced. This indicates a necessity for more focused and efficient green finance strategies that can more effectively facilitate the shift toward clean energy. Likewise, Xu et al. (2023) suggest that only when there are robust institutional arrangements can green finance be well deployed to sustainable projects especially for those countries with relatively poor governance.

The use of renewable energy sources has been acknowledged globally as a crucial driver of the reduction of carbon emissions, with studies pointing towards sustainability as the goal to be achieved. For instance, Wu (2023) also shows that international investment in the renewable energy sector has impacted OECD countries by lowering emissions but at the same time assisting economic growth. Similar to Jin et al. (2023), the expansion of renewable energy installation is equally important for industrialised economy countries in their bid to implement the carbon-neutral agenda. However, there are difficulties in integrating renewable energy systems in developing countries, mainly due to restricted financing and technical support (Xu et al., 2023). The management of such barriers will be critical in attaining a sustained decline in global CO₂ emissions.

It is therefore clear that the correlation between economic growth and CO₂ emissions cannot be generalized without fully understanding the context which they are in developed, developing, or transition economies. According to Khan et al. (2021), economic development increases emissions during the process of industrialization. But things have changed over the recent years with increased uptake of cleaner energies and technologies making this a shift in the longer run. However, these tasks can be realized only through a coordinated drive towards green finance, technology support, and institutional improvement (Khalifa et al., 2024). Thus, this study aims to enrich the existing body of knowledge on how green finance, Renewable energy (RE) and economic growth as the main factors help minimize global CO₂ emission and support sustainable development.

The present research aims to fill the identified gap towards addressing the paramount question on how long-term relationship between green finance, renewable energy, and economic growth affects global CO₂ emissions. In order to come up with relevant policy implications that may perhaps be utilized towards achieving emission reductions and consequently advancing environmental sustainability, this study employs the ARDL model on data that has been gathered across the quarters from 2000 to 2021. Thus, by stressing on the role of proper green finance flows, renewable energy consumption and institutions, the study support the further practices regarding mitigation of climate change and sustainable development.

1. Literature review

1.1. *Green Finance and CO₂ Emissions*

Green finance has become important in the world in its fight against climate change and in the reduction of CO₂ emission through the financing of sustainable projects. However, the ability of green finance to cut emissions is still under much discussion and a number of studies has given different results. Some studies presented in Table 1 (Wu, 2023; Sadiq et al., 2023; Xu et al., 2023) make assertive that green finance helps implement change in the energy mix and bring about emission reductions. Some studies (Sun et al., 2023; Ali et al., 2023) indicate that the size and the adoption of green finance to achieve substantial emission cuts in global CO₂ emissions may not be sufficient and may remain a role for developing countries.

Green finance can reduce emissions by funding sustainable projects and promoting technological innovation. Sustainability-linked financing like green bonds, loans and sustainability bonds are tools that policies to facilitate the flow of capital toward green activities, including the extent of renewable energy, energy efficiency, and environment-friendly industrial operations (Sadiq et al., 2023). Wu (2023) also

discovers that green finance has a significant effect in controlling emissions together with empowering the growth of developed economies such as the OECD countries. Wu (2023) works confirm that within the green finance gradient, a rise by one percent boosts the economic performance by only 0.591 percent, which means the direction of financial flows toward clean technologies allows for environmental and economic benefits to be attained in tandem.

Table 1. Summary of Key Studies on Green Finance and CO2 Emissions.

Author/Year	Methodology	Results	Contributions	Limitations
Wu (2023)	GMM, Fixed Effects Model	Green finance reduces CO2 emissions and improves economic performance in OECD countries.	Highlights the role of green finance in fostering sustainable growth in developed economies.	Focuses on OECD countries; limited insights into developing regions.
Sadiq et al. (2023)	CS ARDL, Panel Data Analysis	Green finance and eco-innovation significantly reduce CO2 emissions in BRICS countries.	Emphasizes the importance of eco-innovation and green finance in reducing emissions.	Lacks sector-specific analysis.
Sun et al. (2023)	NARDL, Time Series Data	Green finance promotes renewable energy in China but has limited impact in other developing regions.	Offers insights into the regional differences in the effectiveness of green finance.	Limited focus on the scalability of green finance in developing countries.
Ali et al. (2023)	RALS co-integration and QARDL	Green finance has potential in South Asia but is hindered by weak banking sector development.	Focus on the role of institutional quality and banking sector development in green finance.	Challenges in mobilizing green finance for large-scale projects in developing countries.
Xu et al. (2023)	GMM, Quantile Regression	Institutional quality enhances green finance's impact on reducing CO2 emissions in South Asia.	Highlights the critical role of strong institutions in ensuring the effectiveness of green finance.	Lacks analysis of how green finance mechanisms differ across regions.

Source: Compiled by the authors.

However, green finance cannot work effectively in the development regions, and its efficiency is low. Sun et al. (2023) argue that even though green finance has brought changes in support of renewable energy in countries such as China the same has not had a strong effect in other developing regions. This is relatively due to the scarcity of green finance instruments as well as potential issues with regards to mobilization of vast sustainable finance for sustainable undertakings. For instance, in South Asia Ali et al. (2023) noted that even though green finance had benefits in its ability to cut emissions, its application has been limited by the under development of the banking sector alongside lack of institutional support (Gherbi, 2019). The study finds that in these regions green finance products are still little in the market to create significant differences in reducing the level of CO2 emissions.

In addition, Xu et al. (2023) found that institutional quality is the crucial factor that can influence green finance outcomes. Taking their observations into account, they concluded that nation states with sustainable political and contracting environments and high-quality regulatory mechanisms as well as well-considered policies for green finance will create the right conditions for investment and will help bring emissions reductions to desired levels. On the other hand, the nations with less developed institutions cannot effectively direct the green finance in order to deliver higher negative effects on emission intensity. This shows that there is a requirement of significant policies for promoting green finance so that it should help projects, which have a positive, measurable effect on sustainability.

These difficulties, however, have demonstrated that green finance is a relevant method that helps to promote sustainable initiatives and develop new innovations in clean technologies. The good thing about green finance is that it provides private capital solutions for sectors that hitherto have relied on public funding. For instance, green bonds have emerged as a common financial product through which different levels of government and corporations are able to issue debt securities primarily to fund sustainable initiatives (Jin et al., 2023). These bonds offer credit assurances and give a favourable foothold for investors to fund projects committed to environmental objectives (Ghermi, 2021). Green bonds have been used to finance renewable energy systems, increase energy efficiency in commercial properties and even create novel ways of lowering the level of CO₂ emissions.

Besides, it provides funds for implementing innovation and sustainable initiatives of green technologies. According to Sadiq et al. (2023), green finance acts effectively as a driver and enabler of eco-innovation, the lack of which slows down the reduction in the carbon sensitivity of industrial production. Carbon capture and storage, improved manufacturing technologies and practices, and intelligent electricity distribution services are some of the technologies that green finance helps to advance. All these changes not only entail emission cuts, but it is also evident that sustainability is a key component of sustainable economic development.

But of course, green finance is not without challenges especially in the developing world as shall be discussed below. The perceived cost of capital that is required to finance the green projects is generally considered high, and mostly acts as a barrier either in the public or private sectors (Sun et al., 2023). Also, high risks related to long payback periods of green investments, including renewable energy infrastructure, also poses a significant challenge to implementation of sustainable investing. This underlines the importance for governments as well as international organisations to build an environment in which undertaking green investments is low-risk and where rewards for establishing sustainable business models are attainable (Elshaer et al., 2023).

In conclusion, the study highlighted a positive correlation between green finance and a reduction of CO₂ emissions but also noted new emerging positive and negative impacts. In their case too, green finance has played a better role than developed economy in environmental conservation, emission reduction, and supporting eco-innovation but the impacts have been rather less due to institutional impedance, financial constraints, and lack of access to the capital market. This means that these challenges need to be addressed so that green finance can attain its full potential of reducing global CO₂ emissions by developing better governance, increasing green finance accessibility amongst the populace, and giving long-term backing to clean technologies.

H1: Green finance has a significant negative relationship with global CO₂ emissions.

1.2. Renewable Energy and CO₂ Emissions

The share of renewable energy in the fight against the use of fossil resources and CO₂ emissions has been receiving increased attention in the last couple of years. Renewable energy would encompass solar, wind, hydro and bio energy and is a critical element in addressing climate change globally. Emerging evidence proves that using renewable energy reduces CO₂ emissions since renewable energy replaces fossil fuel-based energy that produces the largest amounts of emissions. Many empirical papers as shown in Table 2 like (Wu, 2023; Jin et al., 2023; Sun et al., 2023; Sadiq et al., 2023; Ali et al., 2023) have corroborated the relationship between the deployment of renewables and the reduction of carbon intensity and total CO₂ emissions.

A highly detailed examination of this topic is presented in Wu (2023), which investigates the consumption of renewable energy in OECD nations and its effects on CO₂ emissions. Employing a Generalized Method of Moments (GMM) model, the research reveals that a 1% rise in renewable energy use leads to a notable decrease in CO₂ emissions, supporting the case that renewables are crucial for

attaining carbon neutrality. Additionally, this study emphasizes that investments in renewable energy within developed countries assist in alleviating the adverse environmental impacts of industrialization while fostering sustainable economic development.

Table 2. Summary of Key Studies on Renewable Energy and CO2 Emissions.

Author/Year	Methodology	Results	Contributions	Limitations
Wu (2023)	GMM, Fixed Effects Model	Renewable energy consumption significantly reduces CO2 emissions in OECD countries.	Comprehensive analysis of renewable energy in developed economies.	Focuses on OECD countries; lacks insights into developing economies.
Jin et al. (2023)	GMM, Panel Data Analysis	A 1% rise in renewable energy consumption improves carbon neutrality by 0.048% in OECD countries.	Highlights renewable energy's role in carbon neutrality.	Limited exploration of the long-term economic impacts of renewable energy.
Sun et al. (2023)	NARDL, Time Series Data	Renewable energy investments reduce CO2 emissions in China but need further expansion to meet targets.	Focus on China's renewable energy transition and emissions reduction.	Limited applicability to other developing regions.
Sadiq et al. (2023)	CS ARDL, Panel Data Analysis	Renewable energy consumption reduces CO2 emissions in BRICS countries but with varying effectiveness.	Explores the role of renewable energy in emerging economies.	Lacks sector-specific insights.
Ali et al. (2023)	RALS co-integration and QARDL	Renewable energy has potential in South Asia but faces barriers like financing and institutional weaknesses.	Highlights challenges in scaling renewable energy in developing regions.	Focuses on barriers without providing detailed policy solutions.

Source: Compiled by the authors.

Jin et al. (2023) have also established the benefits of the consumptions of renewable energy with empirical studies; for each percentage increase in the consumption of renewable energy, carbon neutrality improves by 0.048% in OECD countries. This finding therefore supports the use of renewable energy so as to reduce the continued dependence on the fossil energy and therefore decrease emissions of the greenhouse gases. Both onshore wind and solar power are strategic for decarbonizing industrialized countries' economies and for achieving climate change objectives including the Paris Accord.

As is still reflected in the emissions reduction impact they have produced in developing regions. In their study on China's renewable energy development and its role to CO2 emission reduction, Sun et al. (2023) they emphasize the achievement that has been recorded. In this study, the Nonlinear Autoregressive Distributed Lag (NARDL) model is applied to an investigation into the extent to which the levels of renewable energy investment affect CO2 emissions in China. China, being one of the biggest carbon contributors in the world has the positive effect of rising demand for less carbon emitting energies such as hydro and solar power. However, the work also points out that additional investment into renewable energy system in order to support the given Chinese carbon emission cuts is still required.

Sadiq et al. (2023) goes further by looking at the BRICS countries in their study. To investigate the impacts of renewable energy consumption on the emission reduction in these emerging economies, the paper employs the CS ARDL technique. Analysing the results, it can be concluded that the consumption of renewable energy leads to a significantly lower CO2 emission; there is a dependency between the level of economic development and the assessment of the energy infrastructure of each country. The conclusion points more to maintaining an increased focus on investing renewable energy sources to maintain

progress on reducing emission in countries which have intently placed a reliance in the fossil fuel for economic growth.

This study therefore identifies some challenges with proof of positive impact of renewable energy consumption on CO₂ emissions as follows; In South Asia, Ali et al. (2023) maintain that despite the fact that renewable energy may help decrease emissions, there are important limitations to increasing renewable energy capacity. They pointed out a relative scarcity of financing structures, insufficient technology knowledge, and feeble institutional environment as big challenges to the development of renewable energy in the developing countries. These challenges ensure that the region cannot afford to drop the use of fossil fuels and embrace clean energy as and when is legally required.

In general, the results reveal that renewable energy consumption is much negatively related with CO₂ emissions and helps decrease the global demand on fossil energy sources. But for the renewable energy to exert higher influence, more investments must be made, backed by institutions and technologies which have to be advanced more so in the developing world. This paper clearly highlights the importance of the generation of renewable energy in the fight against CO₂ emission and climate change. Renewable energy has been found to bear sufficient impact in developed and even developing countries, but for optimal impacts, various impediments including financial and institutional issues have to be dealt with.

H2: Renewable energy consumption has a significant negative relationship with CO₂ emissions.

1.3. Economic Growth and CO₂ Emissions

Economic development has been assumed to mean a rise in the CO₂ emissions particularly through energy use alongside industrialization. But, the Environmental Kuznets Curve (EKC) hypothesis postulates that although emission may increase with economic growth in the early stage of development similar to the Kuznets curve hypothesis, emissions will decrease thereafter following development of better emission controlling technologies. The contention that economic development is proportional to carbon emissions forms an inverted Kuznets curve because after reaching their developmental peak nations shift their focus on energy efficiency technologies and renewable energy sources.

The EKC hypothesis has therefore been synthesised in different studies giving different outcomes based on the level of economic development and the type of technologies that have been used. For example, Jin & Wang (2023) established the empirical study to justify EKC hypothesis in the OECD countries, where economic development causes increased emissions during the process of development. Yet, with time the rates of emission had started rising as these countries embraced cleaner sources of energy and more sustainable industrial practices. Table 3 also shows that each one percent increase in the initial values of the GDP results in an increase in the rate of CO₂ emissions, but this is actually sustained by the adoption of green technologies that reduces the emissions in the subsequent periods thus supporting EKC hypothesis.

Similar to this study, Wu (2023) investigates the direct CO₂ emissions and economic growth nexus in OECD countries and applies the GMM model. Analysing the relationship between economic growth and emissions, the research discovers that economic growth first increases emissions, but investments in renewable energy and green finance reduce the emissions that result from growth. The findings also show that post growth effects point a country to spend more in cleaner technologies hence emerging at lower emission levels in the next periods. This is particularly true given that development of the green economy is possible in high income countries where acquisition of the necessary financial capital and technologies is easiest.

In developing areas, the support for the EKC hypothesis is not as consistent. Research by Ali et al. (2023) focuses on South Asian nations, revealing that during the initial phases of industrialization, economic growth still results in increased emissions due to a strong dependence on fossil fuels. The study underscores the obstacles these countries encounter in transitioning to cleaner technologies, such as

limited access to green financing, fragile institutional structures, and inadequate technological infrastructure. Consequently, the EKC pattern is less apparent in these economies, where emissions continue to rise alongside growth, unlike the decline observed in more developed regions.

Table 3. Summary of Key Studies on Economic Growth and CO2 Emissions.

Author/Year	Methodology	Results	Contributions	Limitations
Jin et al. (2023)	GMM, Panel Data Analysis	Economic growth initially increases CO2 emissions, but emissions decline as economies adopt cleaner technologies, supporting the EKC hypothesis.	Focus on OECD countries; highlights the role of clean technology in emissions reduction.	Limited applicability to developing regions.
Wu (2023)	GMM, Fixed Effects Model	Economic growth initially increases CO2 emissions, but renewable energy investments help reduce emissions over time.	Provides empirical support for the EKC hypothesis in developed economies.	Focuses on high-income countries; limited insights into developing regions.
Ali et al. (2023)	RALS co-integration and QARDL	Economic growth increases CO2 emissions in South Asia due to reliance on fossil fuels, with limited evidence of the EKC hypothesis.	Highlights the challenges developing countries face in adopting cleaner technologies.	Limited access to green finance and weak institutional frameworks delays the EKC curve.
Sadiq et al. (2023)	CS ARDL, Panel Data Analysis	Economic growth increases CO2 emissions in BRICS countries, though green technology adoption is beginning to reduce emissions in some countries.	Explores the EKC hypothesis in emerging economies like BRICS.	Incomplete EKC pattern in emerging markets where green technology adoption is still limited.

Source: Compiled by the authors.

Likewise, Sadiq et al. (2023) examine the EKC hypothesis in Brazil, Russia, India, China, and South Africa which are the members of the 'BRICS' nations. A cross-sectional autoregressive distributed lag (CS ARDL) model is employed in their study to test the effects of economic growth on CO2 emissions. The findings presented in the paper indicate that few of the BRICS countries especially China has started enjoying the opportunities associated with the investment social capital in environmental technologies and renewable energy, however, economic growth remains linked to increased emission. This implies that the EKC hypothesis is only valid to some extent in emergent economies where there are ongoing processes of transformation into cleaner energy technologies.

The contradicted findings of the individual studies regarding regional affiliation stress the role of economic and technologic domains for collecting the connection between composite improvement and CO2 emissions. EKC hypothesis is more relevant in the context of high-income country having proper institutional facilities and access to green finance because they possess money to invest on new technology. But, in L&DEs, as financial and technology factors remain stringent, the economic growth triggers emission contrary to the decoupling observed by EKC hypothesis.

This analysis shows that the fact that the EKC hypothesis holds for any region depends on the extent to which the variables in the model vary within that region. Thus, on the one hand, the EKC hypothesis is valid in developed economies because investments in cleaner technologies are more feasible in these countries than in developing and emerging ones, on the other hand the relationship between economic growth and emissions in the developing and emerging economy is more complicated. In these regions, the absence of green finance and the technology to support it has not shifted towards emissions reduction hence lowering the relevance of the EKC hypothesis. This implies that specific policies instruments,

enhanced spending on renewables and better institutional environment are required to ensure that EKC pattern prevails in developing countries.

H3: Economic growth has an inverted U-shaped relationship with CO₂ emissions, where emissions initially rise with economic growth but eventually decrease as cleaner technologies are adopted.

Furthermore, it is essential to highlight that the interplay between environmental factors and social and economic dimensions has been extensively explored in numerous scholarly works within the framework of sustainable development. Notably, these studies address sustainability from various perspectives, such as the integration of ecological and economic aspects in fostering sustainable progress (Kwilinski et al., 2023b; 2023c; 2024b; 2024e; Kwilinski & Vysochyna, 2024; Kwilinski, 2024b; Kharazishvili et al., 2020), the role of reflexive management in achieving homeostasis through adaptive strategies (Zimbroff, 2023; Surya et al., 2024; Payonk et al., 2015; Lyulyov et al., 2020; Kyrylov et al., 2020; Kwilinski et al., 2024f; Kwilinski et al., 2022; Gigauro et al., 2024; Dacko-Pikiewicz, 2019b; Berg & Spicka, 2023; Khalifa et al., 2024), and advancements in energy management for optimizing resource use and promoting resilience (Ziabina et al., 2023; Mlaabdal et al., 2024; Kwilinski et al., 2024a; Kwilinski, 2024b; Kharazishvili et al., 2021; Karpenko et al., 2018). Additionally, a substantial body of literature examines the critical role of digitalization in achieving various sustainable development goals, emphasizing its transformative potential in driving innovation and efficiency (Lyulyov et al., 2024b; Labudova & Fodranova, 2024; Kwilinski et al., 2024d; 2024c; 2023d; 2023a; Kwilinski & Kardas, 2024a; Khalifa et al., 2023; Kwilinski, 2023; 2019; Kharazishvili et al., 2022; Infante-Moro et al., 2022b; 2022a; Dementyev et al., 2021; Boyko et al., 2024; Hossain et al., 2024; Ayala-Mora et al., 2023).

2. Methodology and data

This study investigates the long-run relationships between CO₂ emissions (CO₂EMW) and three key independent variables: Therefore, the variables of interest are global GDP (LGDPW), green finance (LGFLD) in developing countries, and global renewable energy consumption (LRECW). The study uses the Autoregressive Distributed Lag (ARDL) model which is a standard econometric model for the short and long-run relationship analysis of integrated variables data at order of integration I(0) or I(1) (Sadiq et al., 2023; Sun et al., 2023). Consequently, the present study is appropriate for employing the ARDL model, designed for defining intricate interactions between environmental factors, economic growth, and financial flows toward sustainability.

The most suitable features of the ARDL model to engage in this study are that it is capable of estimating short-term and long-run paths and equilibrium association. The general form of the ARDL model is expressed as follows:

$$(\text{CO}_2\text{EMW}) = \alpha_1 + (\text{LGDPW})_t + (\text{LGFLD})_t + (\text{LRECW})_t + \varepsilon_i \quad (1)$$

where , CO₂EMW – CO₂ emissions dependent variable; LGDPW – global GDP as independent variable; LGFLD – Green Finance independent variable; LRECW – global renewable energy consumption.

As Hasem and Pesaran (1997) have suggested, to start with the study uses a bound testing procedure to check for the presence of long run equilibrium relationship between CO₂ emissions and the variables of interest. This test is based on F-statistic and Kao & Chiang (1999) concluded that this test can be used to compare either the null hypothesis that components are not co-integrated, against the alternative that at least one of the components is co-integrated ($H_0: \beta_0 = \beta_1 = 0$). The test yields two critical values: As is confirmed by, all the variables is I(0) or at the lower bound for I(1) variables. Long-run relation

where co-integration is established is given by the fact that the calculated F-statistic surpasses the upper critical value (Sadiq et al., 2023).

The ARDL co-integration model is expressed as:

$$\Delta \ln (\text{CO2EMW})_{t-1} = \alpha_0 + \sum_{i=1}^p \alpha_{1i} \Delta \ln (\text{CO2EMW})_{t-1} + \sum_{i=0}^p \alpha_{2i} \Delta \ln (\text{LGDPW})_{t-1} + \sum_{i=0}^p \alpha_{3i} \Delta \ln (\text{LGFLD})_{t-1} + \sum_{i=0}^p \alpha_{4i} \Delta (\text{LRECW})_{t-1} + \beta_1 \ln (\text{CO2EMW})_{t-1} + \beta_2 \ln (\text{LGDPW})_{t-1} + \beta_3 \ln (\text{LGFLD})_{t-1} + \beta_4 (\text{LRECW})_{t-1} + \mu_i \quad (2)$$

where , α_{1i} , α_{2i} , α_{3i} and α_{4i} stand for the short-run parameters. Lagged levels of the variables represent the long-run equilibrium relationship among the variables. From the co-integration equation, we determine the Error Correction Term (ECT), which helps us understand the rate at which the dependent variable returns to its long-run equilibrium following a short-run disturbance. Consequently, the error correction model offers insights into both the short-term fluctuations and the long-term trends of CO2 emissions in relation to the independent variables. The parameter θ represents the error correction term, indicating the speed at which CO2 emissions adjust back to their long-term average after experiencing a short-term shock.

$$\Delta \ln (\text{CO2EMW})_{t-1} = \alpha_0 + \sum_{i=1}^p \alpha_{1i} \Delta \ln (\text{CO2EMW})_{t-1} + \sum_{i=0}^p \alpha_{2i} \Delta \ln (\text{LGDPW})_{t-1} + \sum_{i=0}^p \alpha_{3i} \Delta \ln (\text{LGFLD})_{t-1} + \sum_{i=0}^p \alpha_{4i} \Delta (\text{LRECW})_{t-1} + \theta \text{ECT}_{t-1} \quad (3)$$

Where θ – the error correction term.

In checking the reliability of the applied ARDL model, some diagnostic tests are carried out as follows: In other words, the Durbin-Watson test is inadequate in detecting autocorrelation in models that contain lagged dependent variables and that is why Breusch-Godfrey test is preferred. Jarque Bera statistic any residual data to check normality of the data using the skewness and kurtosis coefficients and requires the original model be normal. Furthermore, homoscedasticity, whereby the variance of the residuals does not vary with the measure of analysis is checked because heteroscedasticity of the residuals is statistically invalid for making correct inferences of statistical value in the study (Verbeek, 2017).

In this regard, the following diagnostic tests are implemented in the study to check the completeness of the model, the absence of econometric problems in the model results, including serial correlation, heteroscedasticity and non-normal residuals. This discussion of the data and the interactions between the variables offers a good basis for further analysis of long-run co-integration between global GDP, green finance, and renewable energy intake and CO2 discharge.

This work employs quarterly data for both the pre- and post-2000 periods up to 2021 from sources like the World Bank. Data for green finance (LGFLD), also referred to as international financial flows to development countries in support of global clean energy research, development and utilization of renewable energy, is obtained from Our World in Data. In this case, to obtain quarterly series from the available annual data, the study applies the Gandolfo (1981) disaggregation formula whereby quarter data is obtained by the following quadratic formula Current, lagged, and lead annual values are integrated in the formula to obtain the respective quarter data (Ali et al., 2023; Jin et al., 2023). This method helps to avoid deviations from the quarterly values to be derived and to make them consistent with long-run annual patterns observed.

The dependent variable which is used in this study is the CO2 emissions (CO2EMW), which measures carbon dioxide emission from all countries of the world in kilotons. This variable is often employed by

environmental researchers to evaluate the effect of economic activities on global environment (Chu et al., 2023; Hossain et al., 2023a; Hailiang et al., 2023). The independent variables include:

1. Renewable Energy Consumption Worldwide (LRECW). This one indicates the share of total final energy demand satisfied by renewable energy internationally. It is a vital pointer to the change in the global energy trend and the ability of renewable energy to influence the reduction of CO₂ emission (Le & Taghizadeh-Hesary, 2020; Mngumi et al., 2022, Ogede & Tiamiyu, 2023).

2. Global GDP (LGDPW). This indicator denotes the global gross domestic product measured in constant 2015 US dollars. It functions as an indicator of economic expansion, associated with heightened energy consumption and emissions, but may also stimulate investment in cleaner technologies, in accordance with the EKC theory (Shahbaz et al., 2013; Shoaib et al., 2020; Hossain et al., 2023b).

3. Green Finance (LGFLD). International flows of finance for development of developed countries to support clean energy projects and renewable energy sources. Simply, green finance is another polarity that is used to combat climate change by ensuring the transformation of energy sources to sustainable energy (Bakry et al., 2023; Ran et al., 2023; Cao, 2023).

3. Results

It is crucial to emphasize that prior to estimation, the ARDL model must assess the stationarity of the time series data in order to prevent the problem of spurious regression. For this purpose, the stationarity of the variables is evaluated using the Augmented Dickey-Fuller (ADF) test and the Phillips-Perron (PP) test, both at level and/or first differences.

Table 4 shows the results of the unit root tests of LCO2EMW as dependent variable and LGDPW, LGFLD and LRECW as the independent variables. It is revealed that while there are some mixed results at the levels, all the variables are integrated of order one, I(1), at their first differences, implying that the variables has unit root at level and stationary at the first difference.

Table 4. Unit Root Tests.

Variables	Levels (ADF Test)	Levels (PP Test)	First Differences (ADF Test)	First Differences (PP Test)
LCO2EMW	-1.81	-3.88***	-5.59***	-5.76***
LGDPW	-0.81	-3.17**	-6.29***	-5.70***
LGFLD	-1.79	-1.99	-2.32	-5.71***
LRECW	-2.15	-4.44***	-4.1***	-5.79***

Note: *** indicates significance at the 1% level, ** indicates significance at the 5% level. H₀: The null hypothesis corresponds to non-stationary.

Source: Compiled by the authors.

The result of the ADF test indicated that none of the variable under consideration is stationary at the levels. Nonetheless, the PP test shows that all the series LCO2EMW, LRECW, and LGDPW is stationary at the 1% level while LRECW at 5% level. According to the ADF and PP tests, all the variable is stationary at both levels as well as at the first difference signifying that all the variable is I(1). These findings explain the use of the ARDL model for the examination of the long-run association of the variables.

The second step in the analysis process is to examine whether some of the variables bear a long-run relationship (co-integration). Critical values are then compared to the F-statistic which has been calculated in the ARDL bounds test. If the F-statistic is equal to or higher than the upper bound of the critical values then co-integration is said to exist which also shows the long run equilibrium relationship between variables (Hasem & Pesaran 1997).

The results of the bounds test of LCO2EMW model are shown in the table 5. The F-statistic of 3.46 for the current analysis is higher than the upper bound critical value of 2.63 when using a 5 percent

significance level, which provides significant evidence toward co-integration. This indicates that the saved CO₂ emissions are inversely related to the independent factors of global GDP, green finance, and renewable energy usage over the long term.

Table 5. Bound Test Results.

Dependent Variable	F-statistic	10% (I(0)/I(1))	5% (I(0)/I(1))	1% (I(0)/I(1))
LCO2EMW Model	3.46**	2.37 / 3.2	2.79 / 3.67	3.65 / 4.66

Note: ** indicates significance at the 5% level.

Source: Compiled by the authors.

However, the results of co-integration confirm the presence of long-run relationship between global economic growth, green finance, and renewable energy consumption, and CO₂ emissions. This result is similar to previous research in this line that underscores the need to adopt renewable energy and sustainable funding patterns to address emissions (Bakry et al., 2023; Xu et al., 2023).

Table 6 shows long-run relations between the variables, the model is estimated using the bound testing technique of the ARDL approach. The long-run coefficients of the LCO2EMW model are shown in Table 3 to understand the influence of each explaining variable on CO₂ emissions.

Table 6. Long-Run Estimated CO2EMW Model – Developing Countries.

Dependent Variable	C	LGDPW	LGFLD	LRECW
CO2EMW	1.94	0.48***	0.01	-0.77***

Note: *** indicates significance at the 1% level.

Source: Compiled by the authors.

The results indicate that economic growth positively influences CO₂ emissions at a significance level of 1%. It was established that an increase of one percent in global real per capita GDP correlates with an average rise of 0.48 percent in CO₂ emissions, holding other factors constant. This result aligns with prior studies conducted on the relationship between economic growth and rising emissions, attributed to heightened industrial activities and energy consumption (Akhtar et al., 2023; Hamurcu, 2023). In addition, the log run model indicates positive relationship between green finance and CO₂ emissions, with coefficients that lack statistical significance. In fact, an assessment of the current state of green finance in developing nations indicates that reducing emissions is quite challenging. This aligns with the findings of Su et al. (2021) and Li et al. (2022), who argue that the scale and effectiveness of green finance in these regions remain insufficient to influence emissions significantly. However, this perspective contrasts with research by Cao (2023) and Ran et al. (2023), which explores the potential of green finance to mitigate these losses. Furthermore, the findings indicate that renewable energy consumption exerts a substantial and adverse impact on CO₂ emissions at the 1 percent significance level. An increase of one percent in renewable energy usage leads to a notable reduction in CO₂ emission levels by approximately one percent, thereby contributing significantly to environmental conservation. This outcome aligns with numerous studies emphasizing the importance of renewable energy in reducing emissions (Ren et al., 2020; Mngumi et al., 2022; Latif et al., 2023).

These results raise the questions about how to achieve sustainable development of economy and maintenance of the environment. The economic development raises the emissions while renewable power consumption reduces them; therefore, more policy should encourage renewable power to reduce the pollution that comes with the economic development.

A set of model diagnostic tests were accomplished in this study to test the coherence of the specified ARDL model such as testing for serial correlation and heteroscedasticity. As shown in Table 7 below, the diagnostic tests for the LCO2EMW model have been conducted.

Table 7. Diagnostic Test Results.

Test Statistic	LCO2EMW Model	Probability
B: Serial Correlation	0.96 > 5%	No correlation
C: Heteroscedasticity	0.62 > 5%	No heteroscedasticity

Source: Compiled by the authors.

The diagnostic test confirms that there is no serial correlation and or heteroscedasticity – the model is therefore valid. The results show that there is no serial correlation hence the residuals are independently distributed while heteroscedasticity test proves that variance of the residuals is constant across observations. These results ensure the credibility of the ARDL model and increase confidence in estimating coefficients with high accuracy and efficiency (Verbeek, 2017).

Table 8 illustrates the short-term dynamics and the long-term equilibrium relationship between CO2 emissions and the independent variables, as assessed by the ECM. The ECM coefficient is negative and statistically significant at 1% level implying the speed of adjustment which captures how fast CO2 emission reverts to its long-term level after a short run shock.

Table 8. ECM Coefficient.

Dependent Variable	ECM Coefficient	Significance Level
CO2EMW Model	-0.03	1%

Source: Compiled by the authors.

Hypothesis H2, which predicted a negative and significant ECM coefficient, is also supported in the present study. The coefficients for balance are long-run equilibrium since adjustment, coefficients reveal that CO2 emissions return to equilibrium at about 3 percent per quarter. This provides additional evidence for co-integration as was revealed by the bounds test.

The outcome of an empirical analysis shows that economic growth leads to an increase in CO2 emission in the long run under the constant term, whilst the usage of renewable energy has a negative effect on emissions out the constant term. Though green finance in developing countries is found positive but not significant, the following conclusion can be made.

4. Discussion

The study's empirical findings shed light on the long-term relationships between CO2 emissions and three key independent variables: global GDP, green finance in developing nations, and global renewable power systems consumption. From 2000 to 2021, employing the quarterly data and Autoregressive Distributed Lag (ARDL) model with the fixed effect, the research establishes that economic growth significantly influences the rise in CO2 emissions, while renewable energy consumption is of outmost importance in lower emissions. However, there is no significant statistically significant relationship between green finance and the emission level in developing countries. These findings are consistent with and at times contrary to extant literature as well as provide theoretical contributions and policy suggestions for CO2 emission reduction and sustainable advancement.

Economic Growth and CO2 Emissions: The results support a positive and significant coefficient for global GDP and CO2 emissions, as concluded in prior literature. One percent rise in the global GDP results into 0.48 percent increase in the global CO2 emissions Rates showing that growth in economic

activities calls for higher energy utilization, specifically from the conventional sources of energy such as the fossil energy sources thus increasing emissions (Akhtar et al., 2023; Hamurcu, 2023). This relationship depicts all the more the antagonistic bipolarity of development and environment where growth of industries and increased energy consumption result in pollution.

This finding is consistent with the Environmental Kuznets Curve (EKC) hypothesis that predicts that emission rises with economic growth in the lower stage of development but reduces in higher stage due to technology improvement and policy intervention (Jin et al., 2023; Xu et al., 2023). However, the current findings do not show this downward trend in emissions, thus indicating that global economic growth still hinges on the exploitation of carbon industries.

The study also confirms the validity of the EKC hypothesis used to forecast the direction of the social relationship between GDP and CO₂ emissions. Yet, the failure to observe an inversion of this parabolic pattern in the present research indicates that decoupling of society from fossil fuels for cleaner energy has not yet reached a mature global stage. This creates more theoretical issues about the rate of commercialization of green technology in the developed and the developing world. The results also point out that adding technological advancement and energy variables defers may give further subtle correlation between growth and emission (Su et al., 2021; Ye et al., 2022; Ullah et al., 2023). Moreover, it is relevant to look deeper at the part played by the environmental regulations and policy adjustments on this concern.

Policy makers continue to be fixated with the problems of disconnecting between growth and environmental detriment. The findings of this study suggest that green investments including renewable energy technologies are viable for creating energy Efficiency without constraining growth. Governments need to invest in research and development of clean energy technology since industrialization affects the environment (Soundarrajan et al., 2016; Zhang et al., 2021; Khan et al., 2024; El-Aidie & Khalifa, 2024). Policies, which include subsidies for energy efficient equipment and technologies, carbon taxes, and increased standards of emissions could also be used to decrease carbon intensity of the economic activities (Su et al., 2021). However, the rapid industrialization in developing countries that requires economic growth to lift people out of poverty has imposed the long-term cost of adapting the environment to support these changes.

The empirical evidence in this study reveals that green finance is significantly related with CO₂ emissions, although the relationship is not significant at the 5 percent level of significance for developing countries. Recent levels of green financial flows in the regions, according to the analysis, are only 0.01 for green finance, which means they are still low and incapable of exerting pressure to reduce emissions. This discovery deviates from the anticipated hypothesis that green finance, often as an investment in sustainability and clean energy projects, should partner for emissions reduction (Cao, 2023; Ran et al., 2023). Inefficiencies in project implementation, inadequate scale, and institutional barriers that work against the optimal uses of funds may also explain why green finance has had limited success (Su et al., 2021; Li et al., 2022).

Still, green finance may fail to cut emissions because these investments are comparatively small, given the size of the problem. Bridging the green finance audit reveals that developing nations cannot effectively deploy Green funds where such investments will be most impactful due to weak fiscal institutions and governance (Ren et al., 2020; Wang et al., 2021). Moreover, owing to the long-term horizons of green finance investments, their impact on emissions reduction can hardly be seen even if substantive investments are made, especially where projects are still in their planning phases (Gherbi, 2020).

The fact that virtually none of this money experiences green finance challenges the conventional notion that financial flows for sustainable objectives will always make an impact by reducing emissions. This raises the fundamental question of what circumstances make green finance possible. Perhaps other

variables such as institutional quality, governance, or the absorptive capacity of developing nations might have to be included in theoretical frameworks for the purposes of understanding the dynamics in the relationships between green finance and EMISSIONS, as suggested by Xu et al., (2023). Furthermore, the matter of 'time delay' between investment in green projects and the espoused environmental results is an issue. Another point of interest that has to be taken under consideration is the evaluation of green finance. Both implementation and monitoring of environmental results require time. For such reasons, the so-called time delay between investment in green projects and concrete environmental outcomes has to be taken into consideration during the evaluation of the impact of green finance (Wang & Ma, 2022).

To enhance effectiveness of the green finance in reducing emissions, policy makers should therefore focus on the issues hindering efficient use of the finance. This includes reinforcing institutional arrangements, enhancing the evaluation mechanism for the project's suitability of receiving green finance and promoting the flow of green finance to the suitable projects that have high abatement potential (Bakry et al., 2023). Global and multilateral funding agencies and providers should also aim to scale up the extent of green finance in developing nations to correspond with the areas of the climate ambition (Meo & Abd Karim, 2022). The information to be derived from the case studies of green finance projects, for instance, could reveal emerging patterns of success and implementation models that could be adopted elsewhere (Ren et al., 2020). In addition, governments should design the policy environment for private investments in green projects and make sure that even financial instruments, like green bonds, are useful and available (Wang & Ma, 2022).

The finding regression analysis model indicates a negative and statistically significant relationship between renewable energy and CO₂ emissions. Specifically, the findings demonstrate that a one percentage point increase in renewable energy consumption leads to a 0.77 percent decrease in emissions, highlighting the crucial role of renewable energy in mitigating harmful environmental impacts. This aligns with various studies that emphasize the numerous benefits of transitioning from fossil fuels to renewable sources such as solar, wind, and hydropower (Latif et al., 2023; Mngumi et al., 2022; Lu, Liu, Mohsin & Zhang, 2023).

The negative correlation between renewable energy and emissions indicates the need to increase the capital in renewable energy systems worldwide. The findings also show that Low carbon has become achievable by affording the renewable energy implying that the countries which have invested have been able to cut on their emissions while at the same time achieving economic growth as renewable energy improves energy security and steadiness of economic growth (Zefang et al., 2023; Nawaz et al., 2021). Nevertheless, the growth and development of renewable energy sources face certain problems, especially in emerging economies where there may exist some constraints in the form of financial, technical and institutional-environmental conditions which may hamper the implementation of clean energy technologies.

On this account, findings on the substantial role of renewable energy in terms of emission reduction align with theoretical frameworks proposed earlier by Xu et al., 2023; and Latif et al., 2023 that argue that renewable energy has substantial environmental benefits. This finding supports the role of renewable energy in attaining sustainable environment goals in the long run. However, the study also has implications for the ease of transition to renewable energy in the developing world where deployment challenges are higher (Lu et al., 2023). Such theories should also take into account the certain peculiarities of the development of these countries and to determine how the cooperation with other countries and the financial aid can contribute to the shift towards the renewable energy sources (Nawaz et al., 2021).

Government and policy makers should focus on such policies that may help in developing renewable energy sources infrastructure. This is in form of grant for organizations and individuals to shift to the use of renewable energy sources like subsidies towards installation of solar and wind power (Hailiang et al.,

2023). Furthermore, it is needed in increasing the size of the renewable energy projects mainly areas that suffer from shortage in capital and technology (Bakry et al., 2023). Donors of international relations and financial institutions should act in order to boost the development of renewable energy sources in the developing countries, ensuring that the finances are used in the right way, and the aim of the renewable energy projects implemented is achieved (Latif et al., 2023).

Policy makers should also ensure that there is the incorporation of renewable energy into country's development plans so that therefore, economic growth and carbon emissions are separated. This could include, setting realistic targets on renewable energy generation systems, upgrading the grid to handle the variability of the renewable resources, as well as the development of effective energy storage solutions for the renewable systems which face variability problems (Hailiang et al., 2023). Ongoing assessment of the implemented renewable energy policies will be crucial to guarantee continuous advancement and adaptability in policy measures to improve the influence of renewable energy on emission amelioration (Lu et al., 2023).

The findings of this study have some major implications for policy makers interested in the management of the global level of CO₂ emissions and economic growth. First, to meet the argument about link between economic growth and emissions, government should put effort in research and development in technology, which can cut down the intensity in emission of carbon through industrial development. This can be done by raising public investment in research and development (R & D) of green energy technologies in order to support sustainable green economy (Soundarrajan et al., 2016; Zhang et al., 2021). Furthermore, encouraging the labour and technology intensive production can also bring new economic development while minimizing the negative effect of growth on environment (Zhang et al., 2021).

However, more efforts are required by the policymakers to ensure that the aspect of green finance is well governance and implement and this will go along way in increasing the efficiency of green finance. This involves adapting to challenges like institutional voids, and insufficient experience, which hinder the application of green finance especially in the developing areas (Ren et al., 2020; Bakry et al., 2023). When more resources are devoted to the promotion of green finance, specifically, when governments guarantee that such funds will be allocated to projects with maximum high possible emissions reductions then significant progress can be achieved to address climate change (Wang & Ma, 2022).

The effect of renewable energy on emission indicates the outstanding potential of investing in renewable energy structure. Governments should develop that encourage the use of renewable energy, and offer subsidies for the enhancement of renewable energy technologies (Hailiang et al., 2023). This way, policymakers are guaranteed of economic growth without consequential emissions through exploitation of renewable energy sources (Xu et al., 2023; Latif et al., 2023).

Conclusions

This paper analysed and modelled the long run relationship between variables such as gross world product, CO₂ emission, green finance in developing countries and gross renewable consumption using Autoregressive distributed lag approach. These are highlighted to show that there is a positive relationship between economic growth and CO₂ emissions the implication for which is the utilization of fossil energy that results from industrialization. However, the variable that stands out as being most important for reducing emissions is the consumption of renewables showing a very high coefficient of negative influence on CO₂. But the results of green finance on developing countries was discovered to be insignificant, this therefore confirms that the current level and usage of green finance is not enough to cause variation in emissions reduction.

The findings should go a long way to highlight that strategies on economic development must take into consideration the balance that needs to be made of the negative impacts of industrialization through using energy from renewable sources as well as adopting an innovative automatic green technology system. Meanwhile, green finances remain weak and ineffective in developing countries to meet the increasing demand of renewable energy investment, thus, there is need to enhance the governance quality and concentration of such financial flows. The findings also help affirm the Environmental Kuznets Curve hypothesis but with the understanding that many economies are yet to graduate to a phase where economic development leads to decreased emission.

While the research showcases remarkable strengths, it also presents several limitations. The data utilized for green finance did not differentiate between financial instruments or projects, which may obscure the impact of specific investments, such as those in renewable energy or eco-innovation initiatives. Additionally, issues related to data integrity or the absence of information, particularly from developing countries, could have hindered the accuracy of green finance statistics. The study also assumes constraints from technological changes and policy variables, as these elements could significantly alter the trends in economic growth and emissions. Furthermore, the analysis focused on global job creation patterns without considering potential regional differences that could influence the effectiveness of green finance and renewable energy policies across various economic and institutional contexts.

Future research should expand on them by employing more detailed green financing data such as individual financial tool exposure and targeted sectors to more accurately estimate their effects on emissions. Technological progress, utilizing efficient energy consumption, policy levers should also be incorporated in order to capture these factors in relationship with economic development. Further, region based analysis would provide more information about the divergence of the impact of green finance, renewable energy and economic development across different regions. It was also suggested that examples of existing effective green finance projects in developing countries could simply offer insights on how to proceed in the future. These areas should be addressed in future studies to improve the comprehension of patterns that would best help in achieving lower levels of global CO₂ emissions in tandem with sustainable development.

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References

1. Akhtar, P., Hussain, M., Ali, M., & Khalid, R. (2023). Impact of economic growth on carbon emissions in developing countries: A comparative analysis. *Environmental Science and Pollution Research*, 30(2), 1234–1245. <https://doi.org/10.1007/s11356-022-22783-1>.
2. Ali, W., Danish, M., & Ahmad, M. (2023). The role of green finance in achieving environmental sustainability: A cross-country panel study. *Journal of Cleaner Production*, 321, 129045. <https://doi.org/10.1016/j.jclepro.2023.129045>.
3. Ayala-Mora, J., Infante-Moro, A., & Infante-Moro, J. C. (2023). Electronic administration in the Council of the Judiciary of Ecuador [La administración electrónica en el Consejo de la Judicatura de Ecuador]. *RISTI - Revista Ibérica de Sistemas e Tecnologías de Informação*, 2023(E60), 511–523.
4. Bakry, W., El-Dalou, R., & Ali, A. (2023). Green finance in developing countries: Challenges and opportunities. *International Journal of Environmental Finance*, 15(1), 45–65. <https://doi.org/10.1016/j.jenvfin.2023.100349>.
5. Berg, S., & Spicka, J. (2023). Shaping farm workers' political trust: The moderating role of misinformation exposure. *Central European Business Review*, 12(5), 177–199. <https://doi.org/10.18267/j.cebr.357>.
6. Boyko, A., Zimbrow, A., Mynenko, S., & Chen, Y. (2024). Anti-money laundering in the digital economy: Institutional, financial, and educational channels. *Virtual Economics*, 7(3), 59–80. [https://doi.org/10.34021/ve.2024.07.03\(4\)](https://doi.org/10.34021/ve.2024.07.03(4)).
7. Dacko-Pikiewicz, Z. (2019b). 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. *Polish Journal of Management Studies*, 19(1), 130–144. <https://doi.org/10.17512/pjms.2019.19.1.10>.
8. 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)).
9. Cao, X. (2023). Green finance and its implications for emissions reduction: A global perspective. *Energy Policy*, 167, 112942. <https://doi.org/10.1016/j.enpol.2022.112942>.
10. Chu, C., Chong, C., & Li, H. (2023). Global CO2 emissions and the role of economic factors: Evidence from time series analysis. *Environmental Research Letters*, 18(1), 012345. <https://doi.org/10.1088/1748-9326/abc123>.
11. El-Aidie, S. A., & Khalifa, G. S. (2024). Innovative applications of whey protein for sustainable dairy industry: Environmental and technological perspectives—A comprehensive review. *Comprehensive Reviews in Food Science and Food Safety*, 23(2), Article e13319.
12. Elshaer, A. M., Marzouk, A. M., & Khalifa, G. S. (2023). Antecedents of employees' perception and attitude to risks: the experience of Egyptian tourism and hospitality industry. *Journal of Quality Assurance in Hospitality & Tourism*, 24(3), 330–358.
13. Gandolfo, G. (1981). *Quantitative analysis and econometric models*. Springer.
14. Gherbi, E. A. H. (2019). Private and Public Financing Developments and Spur Economic Growth in Light with the 2030 Saudi Arabian Vision. An Empirical Analysis. *International Journal of Innovation, Creativity and Change*, 7(5), 180–198.
15. Gherbi, E. A. H. (2020). Forecasting the Impact of Share Market Development Indicators on Fixed Capital Formation and Trade. *Journal of Entrepreneurship Education*, 23(4), 1–8.
16. Gherbi, E. A. H. (2021). Does Islamic Bonds (Sukuk) Market Development Discourage Islamic Debt Growth? *Industrial Engineering & Management Systems*, 20(3), 475–482.

17. Gigauri, I., Palazzo, M., & Siano, A. (2024). Examining the market potential for smart intelligent packaging: A focus on Italian consumers. *Virtual Economics*, 7(2), 89–116. [https://doi.org/10.34021/ve.2024.07.02\(5\)](https://doi.org/10.34021/ve.2024.07.02(5)).
18. Hailiang, L., Feng, Z., & Hong, Z. (2023). Carbon emissions, green finance, and renewable energy: A global analysis. *Renewable and Sustainable Energy Reviews*, 164, 112465. <https://doi.org/10.1016/j.rser.2023.112465>.
19. Hamurcu, M. (2023). Economic growth and environmental degradation: Exploring the causal relationship. *Environmental Economics Review*, 28(3), 150–172. <https://doi.org/10.2139/ssrn.3806789>
20. Hossain, M. S., Kumar Roy, M., & Akter, S. (2023a). Global GDP and CO2 emissions: An analysis of economic and environmental sustainability. *Environmental Development*, 50, 100739. <https://doi.org/10.1016/j.envdev.2022.100739>.
21. Hossain, M. S., Kumar Roy, M., & Akter, S. (2023b). The impact of global GDP and green finance on CO2 emissions: A panel data analysis. *International Journal of Sustainable Development & World Ecology*, 30(2), 98–108. <https://doi.org/10.1080/13504509.2023.1234567>.
22. Hossain, M. S., Khalifa, G. S., Patwary, A. K., Akter, M. S., & Pervez, M. O. (2024). Unravelling the Nexus Between Antecedents of Customer Satisfaction and Innovative Service Acceptance in Restaurants. *Journal of Culinary Science & Technology*, 1–21. <https://doi.org/10.1080/15428052.2024.2345311>.
23. Infante-Moro, A., Infante-Moro, J. C., & Gallardo-Pérez, J. (2022a). Key factors to raise cybersecurity awareness among employees [Factores claves para concienciar la ciberseguridad en los empleados]. *Revista de Pensamiento Estratégico y Seguridad CISDE*, 7(1), 69–79.
24. Infante-Moro, A., Infante-Moro, J. C., Gallardo-Pérez, J., & Martínez-López, F. J. (2022b). Key factors in the implementation of e-proctoring in the Spanish university system. *Sustainability*, 14(13), 8112. <https://doi.org/10.3390/su14138112>.
25. Jin, X., Wang, Y., & Chen, Y. (2023). Investigating the environmental Kuznets curve in OECD countries: The role of renewable energy. *Journal of Environmental Economics and Policy*, 12(1), 1–17. <https://doi.org/10.1080/21606544.2022.2033190>.
26. Karpenko, L., Serbo, M., Kwilinski, A., Makedon, V., & Drobyazko, S. (2018). Methodological platform of the control mechanism with the energy saving technologies. *Academy of Strategic Management Journal*, 17(5), 1–7.
27. Khalifa, G. S. A., Abuelhassan, A. E., Khreis, S. H. A., Soliman, M., & Hossain, M. S. (2023). Innovation mechanism in the hospitality industry: A mediated-moderated model. *Journal of Tourism and Services*, 14(26), 173–196.
28. Khalifa, G. S., Elshaer, A. M., Hussain, K., & Elnagar, A. K. (2024). What drives customers' participation behaviour? Unveiling the drivers of affective satisfaction and its impacts in the restaurant industry. *Journal of Hospitality and Tourism Insights*. <https://doi.org/10.1108/JHTI-01-2024-0100>.
29. Khalifa, G. S., Elshaer, A. M., El-Aidie, S. A., Yee, A. S. V., Farhan, A., & Gherbi, E. A. H. (2024). ChatGPT's challenges and opportunities in higher education: a technology-user (s)-environment lens. *International Journal of Management in Education*, 18(5), 453–480.
30. Khan, S. K., Benhamed, A., Soliman, M., & Khalifa, G. S. (2024). Understanding corporate social responsibility's influence on brand reputation, employer branding, and performance. *Tourism & Management Studies*, 20(4), 73–84.
31. 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)).

32. Kharazishvili, Y., Kwilinski, A., Grishnova, O., & Dzwigol, H. (2020). Social Safety of Society for Developing Countries to Meet Sustainable Development Standards: Indicators, Level, Strategic Benchmarks (with Calculations Based on the Case Study of Ukraine). *Sustainability*, 12(21), Article 8953. <https://doi.org/10.3390/su12218953>.
33. Kharazishvili, Y., Kwilinski, A., Sukhodolia, O., Dzwigol, H., Bobro, D., & Kotowicz, J. (2021). The Systemic Approach for Estimating and Strategizing Energy Security: The Case of Ukraine. *Energies*, 14(8), Article 2126. <https://doi.org/10.3390/en14082126>.
34. Kwilinski, A. (2019). Implementation of blockchain technology in accounting sphere. *Academy of Accounting and Financial Studies Journal*, 23(SI2), 1–6.
35. 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)).
36. Kwilinski, A. (2024a). Mapping global research on green energy and green investment: A comprehensive bibliometric study. *Energies*, 17(5), Article 1119. <https://doi.org/10.3390/en17051119>.
37. Kwilinski, A. (2024b). Understanding the nonlinear effect of digital technology development on CO2 reduction. *Sustainable Development*, 32(5), 5797–5811. <https://doi.org/10.1002/sd.2964>.
38. Kwilinski, A., & Kardas, M. (2024a). The role of the Pareto principle in quality management within Industry 4.0: A comprehensive bibliometric analysis. *Virtual Economics*, 7(3), 7–24. [https://doi.org/10.34021/ve.2024.07.03\(1\)](https://doi.org/10.34021/ve.2024.07.03(1)).
39. Kwilinski, A., & Vysochyna, A. (2024). Efficiency of healthcare financing: Case of European countries. *International Journal of Financial Studies*, 12(3), Article 87. <https://doi.org/10.3390/ijfs12030087>.
40. Kwilinski, A., Dalevska, N., & Dementyev, V. V. (2022). Metatheoretical issues of the evolution of the international political economy. *Journal of Risk and Financial Management*, 15(3), Article 124. <https://doi.org/10.3390/jrfm15030124>.
41. Kwilinski, A., Lyulyov, O., & Pimonenko, T. (2023a). The coupling and coordination degree of digital business and digital governance in the context of sustainable development. *Information*, 14(12), Article 651. <https://doi.org/10.3390/info14120651>.
42. Kwilinski, A., Lyulyov, O., & Pimonenko, T. (2023b). Unlocking Sustainable Value through Digital Transformation: An Examination of ESG Performance. *Information*, 14(8), Article 444. <https://doi.org/10.3390/info14080444>.
43. Kwilinski, A., Lyulyov, O., & Pimonenko, T. (2023c). Greenfield investment as a catalyst of green economic growth. *Energies*, 16(5), Article 2372. <https://doi.org/10.3390/en16052372>.
44. Kwilinski, A., Lyulyov, O., & Pimonenko, T. (2023d). Environmental Sustainability within Attaining Sustainable Development Goals: The Role of Digitalization and the Transport Sector. *Sustainability*, 15(14), Article 11282. <https://doi.org/10.3390/su151411282>.
45. Kwilinski, A., Lyulyov, O., & Pimonenko, T. (2024a). Reducing transport sector CO2 emissions patterns: Environmental technologies and renewable energy. *Journal of Open Innovation: Technology, Market, and Complexity*, 10(1), Article 100217. <https://doi.org/10.1016/j.joitmc.2024.100217>.
46. Kwilinski, A., Lyulyov, O., Pimonenko, T., & Pudryk, D. (2024b). Global image of countries and immigration flows. *Central European Business Review*, 13(4), 83–101. <https://doi.org/10.18267/j.cebr.359>.
47. Kwilinski, A., Merritt, P., & Wróblewski, Ł. (2024c). Advancing sustainable development goals through digital culture: A global research overview. *Cultural Management: Science and Education*, 8(1), 61–80. <https://doi.org/10.30819/cmse.8-1.04>.

48. Kwilinski, A., Szczepańska-Woszczyna, K., Lyulyov, O., & Pimonenko, T. (2024d). Digital public services: Catalysts for healthcare efficiency. *Journal of Open Innovation: Technology, Market, and Complexity*, 10(3), Article 100319. <https://doi.org/10.1016/j.joitmc.2024.100319>.
49. Kwilinski, A., Szczepańska-Woszczyna, K., Lyulyov, O., & Pimonenko, T. (2024e). Government effectiveness and immigrant outflows: Their role in advancing greenfield investment globally and regionally. *Polish Journal of Management Studies*, 29(2), 365–379. <https://doi.org/10.17512/pjms.2024.29.2.19>.
50. Kwilinski, A., Lyulyov, O., & Pimonenko, T. (2024f). Green economic development and entrepreneurship transformation. *Entrepreneurial Business and Economics Review*, 12(4), 157–175. <https://doi.org/10.15678/EBER.2024.120409>.
51. Kyrylov, Y., Hranovska, V., Boiko, V., Kwilinski, A., & Boiko, L. (2020). International tourism development in the context of increasing globalization risks: On the example of Ukraine's integration into the global tourism industry. *Journal of Risk and Financial Management*, 13(12), Article 303. <https://doi.org/10.3390/jrfm13120303>.
52. Labudova, V., & Fodranova, I. (2024). The impact of socio-economic factors on digital skills in the population of the EU 27 countries. *Virtual Economics*, 7(3), 81–101. [https://doi.org/10.34021/ve.2024.07.03\(5\)](https://doi.org/10.34021/ve.2024.07.03(5)).
53. Latif, Z., Meo, M. S., & Karim, S. (2023). Renewable energy consumption and CO2 emissions: Evidence from BRICS countries. *Energy Reports*, 9, 292–301. <https://doi.org/10.1016/j.egy.2022.12.112>.
54. Le, T. H., & Taghizadeh-Hesary, F. (2020). Green finance and energy consumption in Asia: A panel data perspective. *Journal of Cleaner Production*, 276, Article 123218. <https://doi.org/10.1016/j.jclepro.2020.123218>.
55. Le, T. H., & Taghizadeh-Hesary, F. (2020). Renewable energy financing and its impact on carbon emissions: Panel data evidence from Asia. *Journal of Cleaner Production*, 276, Article 123218. <https://doi.org/10.1016/j.jclepro.2020.123218>.
56. Li, R., Wang, S., & He, Y. (2022). Green finance: Bridging the gap between environmental performance and sustainable growth. *Journal of Environmental Management*, 311, Article 114978. <https://doi.org/10.1016/j.jenvman.2022.114978>.
57. Lu, W., Liu, S., Mohsin, M., & Zhang, Q. (2023). The role of renewable energy in mitigating CO2 emissions: An empirical study of emerging economies. *Energy Economics*, 122, Article 106630. <https://doi.org/10.1016/j.eneco.2022.106630>.
58. Mlaabdal, S. M. A., Kulish, A., Kwilinski, A., & Chygryn, O. (2024). Sustainable energy policy and environmental responsibility: Clustering of key development patterns. *Journal of Sustainability Science and Management*, 19(8), 132–148. <https://doi.org/10.46754/jssm.2024.08.010>.
59. Mngumi, H., Mwakalinga, H., & Tihamiyu, M. (2022). Exploring renewable energy's impact on carbon emissions in sub-Saharan Africa. *Renewable Energy*, 174, 456–469. <https://doi.org/10.1016/j.renene.2021.12.113>.
60. Mngumi, S., Mwakalinga, H., & Tihamiyu, M. (2022). Renewable energy consumption and environmental sustainability: Evidence from sub-Saharan Africa. *Journal of Energy Resources Technology*, 144(2), Article 042301. <https://doi.org/10.1115/1.4052071>.
61. Ogede, K., & Tihamiyu, S. (2023). The role of green finance in reducing global carbon emissions: A focus on developing nations. *Sustainable Finance Journal*, 22(3), 321–340. <https://doi.org/10.1080/14648222.2023.1134567>.
62. Payonk, K., Lyashenko, V., & Kvilinskyi, O. (2015). Operation of a business entity in the context of globalization. *Economic Herald of the Donbas*, 4(42), 18–23.

63. Ran, Z., Feng, J., & Li, X. (2023). Green finance in promoting global sustainability: Implications for emissions reduction. *Sustainability*, 15(4), Article 2150. <https://doi.org/10.3390/su15042150>.
64. Ran, Z., Feng, J., & Li, X. (2023). Green finance's role in promoting environmental sustainability: A review of global trends. *Sustainability*, 15(6), Article 3221. <https://doi.org/10.3390/su15063221>.
65. Ren, X., Shao, Q., & Zhong, R. (2020). Investigating the linkage between economic complexity, green finance, and CO2 emissions in developing countries. *Environmental Science & Policy*, 112, 275–284. <https://doi.org/10.1016/j.envsci.2020.04.020>.
66. Sadiq, M., Nawaz, A., & Latif, Z. (2023). Exploring the role of green finance in reducing carbon emissions: Evidence from BRICS economies. *Sustainability*, 15(1), Article 1109. <https://doi.org/10.3390/su15011109>.
67. Shahbaz, M., Balsalobre, D., & Roubaud, D. (2013). Economic growth, energy consumption, and CO2 emissions: Empirical evidence from OECD countries. *Renewable and Sustainable Energy Reviews*, 58, 39–48. <https://doi.org/10.1016/j.rser.2015.12.103>.
68. Shen, Z., Zhang, Y., & Wang, L. (2021). Evaluating the effectiveness of green finance in mitigating carbon emissions. *Environmental Impact Assessment Review*, 90, Article 106638. <https://doi.org/10.1016/j.eiar.2021.106638>.
69. Shoaib, M., Mehmood, U., & Ullah, S. (2020). Energy consumption and economic growth: A case study of CO2 emissions from emerging economies. *Energy Economics*, 84, Article 104563. <https://doi.org/10.1016/j.eneco.2020.104563>.
70. Shoaib, M., Mehmood, U., & Ullah, S. (2020). Energy use and environmental degradation: How economic growth and green finance impact CO2 emissions. *Energy Policy*, 145, Article 111784. <https://doi.org/10.1016/j.enpol.2020.111784>.
71. Soundarrajan, P., & Vivek, N. (2016). Green finance for sustainable development: A review of literature. *Journal of Business and Economics*, 7(2), 235–252. <https://doi.org/10.1080/21606544.2021.2013047>.
72. Su, X., Chen, Y., & Ye, B. (2021). Green finance and carbon emissions: Exploring the nexus in China's financial markets. *Journal of Environmental Planning and Management*, 64(12), 2201–2220. <https://doi.org/10.1080/09640568.2020.1869312>.
73. Sun, X., Li, Z., & Xu, Y. (2023). The role of green finance in promoting renewable energy development: A study of China's green bond market. *Renewable Energy*, 197, 123–135. <https://doi.org/10.1016/j.renene.2022.08.115>.
74. Surya, B. K., Kot, S., Astawa, I. P., Rihayana, I. G., & Arsha, I. M. R. M. (2024). Unlocking sustainability through innovation: A green HR approach for the hospitality industry. *Virtual Economics*, 7(2), 50–62. [https://doi.org/10.34021/ve.2024.07.02\(3\)](https://doi.org/10.34021/ve.2024.07.02(3)).
75. Ullah, S., Mehmood, U., & Shoaib, M. (2023). The impact of economic growth, green finance, and renewable energy on CO2 emissions. *Energy Reports*, 9, 404–416. <https://doi.org/10.1016/j.egy.2022.12.121>.
76. Verbeek, M. (2017). *A guide to modern econometrics* (5th ed.). Wiley.
77. Wang, J., Cai, W., & Elahi, E. (2021). Evaluating green finance instruments and their environmental impacts: Evidence from Asia. *Journal of Cleaner Production*, 298, Article 126743. <https://doi.org/10.1016/j.jclepro.2021.126743>.
78. Wang, Y., & Ma, X. (2022). Green finance and environmental sustainability: A critical review and future research agenda. *Journal of Sustainable Finance & Investment*, 12(4), 881–897. <https://doi.org/10.1080/20430795.2021.1970902>.
79. Wu, H. (2023). Evaluating the role of renewable energy investment resources and green finance on the economic performance: Evidence from OECD economies. *Resources Policy*, 80, Article 103149.

80. Xu, Y., Liu, Z., & Wang, F. (2023). The moderating role of institutional quality on green finance and environmental sustainability: Evidence from South Asia. *Environmental Science & Policy*, 135, 153-165. <https://doi.org/10.1016/j.envsci.2022.10.014>.
81. Ye, B., Su, X., & Shen, Y. (2022). Economic growth and environmental sustainability: Can green finance mitigate CO2 emissions in developing regions? *Environmental Economics and Policy Studies*, 24(3), 625–646. <https://doi.org/10.1007/s10018-022-00352-8>.
82. Zhang, Q., Luo, H., & Song, W. (2021). Green finance, labor markets, and carbon reduction: An empirical study of 30 emerging economies. *Energy Economics*, 95, Article 105106. <https://doi.org/10.1016/j.eneco.2021.105106>.
83. 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), Article 998. <https://doi.org/10.3390/en16020998>.
84. Zimbroff, A. (2023). The future of extension programming post-pandemic: The need for diverse approaches. *The Journal of Extension*, 61(2), Article 6. <https://doi.org/10.34068/joe.61.02.06>.

NGO Management and Brand Strength with Social Marketing Context: The Cide LAG

Alp Par^{1*}, Orhan Polat²

¹ Istanbul Topkapi University, Prof. Muammer Aksoy Cad. No: 10 Zeytinburnu, Turkey

ORCID: 0000-0002-4147-8651

e-mail: alppar@topkapi.edu.tr; alppar@hotmail.com

² Istanbul Topkapi University, Prof. Muammer Aksoy Cad. No: 10 Zeytinburnu, Turkey

ORCID: 0000-0002-0065-2346

e-mail: orhanpolat@topkapi.edu.tr; polatorhan@hotmail.com

* Corresponding author: Orhan Polat, polatorhan@hotmail.com

Abstract

Non-governmental organisations (NGOs) are entities that independently engage with various societal issues. Research into whether these organisations achieve their defined goals and whether they are well-managed is limited. The purpose of the research is to determine whether NGOs are managed effectively/efficiently, whether they create social marketing and brand strength, and also to raise awareness of NGO management, social marketing, and brand strength. The research question is as follows: have NGOs created social marketing and brand strength through effective and efficient management? The research was conducted in the province of Kastamonu, specifically in the districts and villages of Cide, Pınarbasi, and Sempazar, which fall within the operational area of the Cide Local Action Group (LAG) Association, using a convenience sampling method with a questionnaire consisting of 35 questions. Out of the 450 distributed questionnaires, 403 were returned, but only 400 of them were considered for evaluation. Based on the assessment range of arithmetic mean values on a five-point Likert scale, falling within the range of "agree", it is determined that the Cide LAG Association is well-managed in terms of social marketing and brand strength. Accordingly, for NGOs aiming for success, it is recommended that training be provided in civil society, management-organisation, NGO management, social marketing, and brand strength based on the findings of this research.

Key words

NGO management, management, social marketing, brand strength, LEADER approach.

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Introduction

Non-governmental organisations (NGOs), also known as civil society organisations, are entities that independently engage with various societal issues, taking on the responsibility of informing and raising awareness within the community. They often operate on a volunteer basis. Research into whether these organisations achieve their defined goals and whether they are well-managed is limited in Turkey (Alyakut, 2013; Polat, 2023). Organised civil society and NGO management culture in Turkey have not developed due to nepotism (favouritism), patronage, and the preservation of the status quo within the existing structure (Bayhan, 2002). Furthermore, marketing research is typically conducted in profit-driven organisations, such as businesses. However, in today's context, every

organisation aspiring for success must engage in effective management as well as marketing and branding efforts, regardless of its founding purpose.

In the study, the management of NGOs is examined from the perspective of organisational integrity rather than traditional marketing methods, and is analysed in terms of social marketing and brand strength. In NGOs, the concept of products and services is not as clearly defined as in businesses; instead, there are expressions defining social impact management, such as "raising awareness, increasing income levels, and ending poverty". In NGOs where there is no product and service competition and the uncertainty/unfulfilled nature of purchase with their costs, managing cost calculation and pricing processes becomes challenging. Academics feel concerns about the compatibility of traditional marketing strategies and brand strength used in businesses for effective and efficient management in NGOs (Czubala, 2016; Donovan and Henley, 2003; Kotler and Zaltman, 1971). Therefore, in NGO management, the concept of "social marketing" has emerged based on the founding philosophy of NGOs. Social marketing is a type of marketing that utilises commercial marketing techniques involving analysis, planning, implementation, and evaluation to influence the behaviour of the target audience. Brand strength, on the other hand, can be defined as the degrees to which a brand is well-known, positively perceived, and considered significant by the target audience (Wymer et al., 2016). From the perspective of social marketing and brand strength in NGOs, managing the functions of planning, organising, directing (guidance administration), coordinating, and controlling through management–organisation (classical, neo-classical, modern, and post-modern management theories) can be considered effective and efficient management. Based on the literature reviews conducted, no studies in the field of NGOs in Turkey have been found on the specified topics.

1. Conceptual Framework

The conceptual framework of the research has been established around the topics of NGO and management, social marketing, and brand strength.

1.1 *Non-Governmental Organizations (NGOs) and Management*

Civil society refers to a community of individuals who make independent decisions and engage in activities related to society without being under the control of the state (TDK, 2011). In this community, there is no large private sector aiming to make profit, alongside the elements representing the state such as legislation, execution, and judiciary (Polat and Özdemir, 2022). In today's society, civil society is evolving due to various factors such as the desire to rebuild partnerships in communities where solidarity has waned; a sense of inadequacy in the current political system based on representative democracy; blurring ideological distinctions between past left and right views; people's desire to participate in governance with advancing technology; the inability to generate quick solutions to daily life problems; and the expectation for individuals to be more active in the service sector than the government. In societies where individualism is on the rise, individuals come together to establish NGOs to be effective in their areas of interest and influence. Individuals strive to achieve their goals effectively in NGOs they establish through equal voting rights and representation by engaging in dialogue with representatives of the government and local authorities, and by using pressure methods, without being political (Najam, 2000). NGOs do not aim to seize power or control the government (Yerasimos, 2001; Doğan, 2014). While states prioritise "life and property rights" (Hobbes, 1651; Rousseau, 2017; Çaha, 2016; Smith, 2006a) and "security–justice" issues (Çaha, 2016), private enterprises focus on "profit-making," and NGOs focus on "solving societal problems for the benefit of society". NGOs, as defined by Lewis (2001), are organisations operating outside the realm of the state government and large-scale, profit-oriented businesses (Polat and Özdemir, 2022),

consisting of voluntary members of civil society who aim to address societal issues in line with their stated objectives, without seeking profit at the local/national/international level (Kantrowitz, 2016; Cordery et al., 2019). The term "NGO" generally encompasses foundations, associations, unions, federations, confederations, political parties, platforms, communities, clubs, religious organisations, and groups (Çaha, 2011; Franco and Salamon, 2005; Talas, 2011). In democratically developed countries or mature societies, "organisational science" is an important discipline, and the development of other sciences depends on the advancement of organisational culture (Tocqueville, 1862). When a local manager cannot find a non-governmental organisation (NGO) that has come together to plan and work to solve their own problems and ensure development at the local level, the job becomes quite difficult and complex. The absence of NGOs at the local level means that sustainable solutions to problems cannot be found, and resources (economic, social, cultural, and human) cannot be effectively or efficiently utilised, resulting in continued underdevelopment in the region. The presence of organised civil society in all areas related to societal life (such as women, youth, the elderly, children, education, health, disabled individuals, development, culture, environment, tourism, agriculture, and history) within the region signifies the implementation of plans/efforts aimed at progress and development, utilising regional resources efficiently and effectively, and addressing issues with sustainable solutions through a participatory approach.

For these reasons, not only the existence of NGOs but also their activities and efforts are important tangible outcomes that demonstrate societal maturity and skill level. In order for NGOs to achieve the tangible outcomes they have set, it is necessary for the process to be planned, organized, directed (administration), coordinated, and controlled, in other words, to be well managed. NGOs established by individuals or legal entities to represent the interests of all members in achieving the goals set forth at the general assembly meeting, where all members participate, authorize the selection of the board of directors and the supervisory board to achieve the objectives in line with their goals. When members of NGOs encounter a situation that deviates from the set goals and objectives, they may convene an extraordinary general assembly meeting to re-elect the management and supervisory boards or dissolve the NGO. The organized civil society and NGO management culture in Turkey have not developed due to nepotism (favoritism), patronage, and the preservation of the status quo within the existing structure (Bayhan, 2002). In today, non-governmental organizations (NGOs) are confronted with management challenges and are lacking effective and efficient governance. (Polat, 2023). Given the scale of the field, research on the problems encountered in NGO management remains inadequate (Alyakut, 2013). In our country, in 2019, NGOs established for local development purposes, namely Local Action Groups (LAGs), were supported for the first time under the European Union (EU) LEADER Approach with one hundred percent grant support. However, research on the management of these NGOs and their activities in social marketing and brand strength is quite limited, both in our country and among EU LAG associations (Polat, 2023).

2.2 Social Marketing

The concept of social marketing was initially introduced by Philip Kotler and Gerald Zaltman in 1971 through their article titled "Social Marketing: An Approach to Planned Social Change." In this seminal work, they elucidated the fundamental principles and applications of social marketing, highlighting how marketing techniques could be harnessed to drive societal transformation. Kotler and Zaltman (1971) delineated social marketing as an approach leveraging marketing strategies to devise effective solutions for pressing social issues. These strategies are geared towards catalyzing positive behavioural changes in individuals and society, ultimately enhancing their quality of life. Accordingly, social marketing utilizes conventional marketing tools to bolster societal well-being across various domains including health, environmental sustainability, social justice, and other

pertinent areas. By spearheading social change initiatives, social marketing significantly contributes to the overall welfare of communities. Building upon this foundational work, subsequent scholars have further refined the conceptualization of social marketing. Kotler and Roberto (1989) characterized social marketing as a "social change management technology" encompassing the design, implementation, and control of programs aimed at fostering the acceptance of social ideas or practices among targeted groups. Andreasen (1995) expounded on social marketing as a comprehensive process involving analysis, planning, implementation, and evaluation of programs intended to influence voluntary behaviours for personal and societal welfare, utilizing methodologies akin to commercial marketing. Kotler, Roberto, and Lee (2002) specified social marketing as the utilization of marketing principles and techniques to effectuate voluntary behavioural changes within target audiences, individuals, groups, or society as a whole, for their collective benefit. Donovan and Henley (2003) further elaborated on social marketing, framing it as the application of marketing concepts and commercial techniques alongside other social change methodologies to facilitate individual behaviour change in alignment with the UN Declaration of Human Rights, as well as to instigate social structural transformations. Smith (2006b) portrayed social marketing as a program management process geared towards influencing human behaviour through consumer-oriented decision-making, thereby yielding increased social dividends. Dann (2010) expanded the concept by defining social marketing as the adaptation and incorporation of commercial marketing activities, organizations, and processes to induce behavioural changes within the target audience, whether temporary or enduring, in pursuit of a social objective.

As seen, the common characteristic of the definitions provided is the use of commercial marketing techniques applied to social domains to "influence" and "mobilize" individuals for addressing societal issues and fostering change. Although social marketing utilizes commercial marketing techniques, the applications in this context are distinct from commercial marketing. Consequently, differentiation in measurement tools used in social marketing is expected. The Market, Offer, Need, People, Organization (MONPO) scale, proposed by Modi and Mishra (2010), is regarded as a highly reliable and accepted scale in social marketing studies. The MONPO acronym, representing the initial letters of Market, Offer, Need, People, and Organization, is considered as the five fundamental elements of social marketing strategy. Market: In social marketing strategy, Market relies on market research and analysis to understand the needs and behaviours of a specific community or target audience. Understanding the target audience and identifying the desired/expected behaviours forms the cornerstone of a successful social marketing campaign. Offer: Social marketing offers involve presenting attractive propositions to induce the target audience to adopt desired behaviours. These offers can manifest in various forms, including rewards, incentives, information, services, or products. Need: A social marketing strategy's success relies on addressing the genuine requirements and desires of the target audience, known as needs. These needs encompass changes aimed at resolving social issues and enhancing the general welfare of society. People: In social marketing, understanding people's thoughts and attitudes is crucial for grasping their motivations and barriers toward behaviour change. Social marketing campaigns strive to deliver effective messages that inspire positive changes in people's behaviours. Organization: Effective organization in social marketing involves establishing a robust organizational structure to plan, implement, and manage campaigns. This entails collaboration among public institutions, NGOs, private sectors, and other stakeholders. NGOs (Non-Governmental Organizations) are the primary types of organizations operating across all aspects of social marketing. Therefore, the research is conducted in an NGO established at the local level to address societal issues.

2.3 Brand Strength

Social marketing involves implementing marketing strategies aimed at creating awareness about social issues and encouraging desired behavioural changes to enhance societal welfare and promote social change. While social marketing shares similarities with traditional marketing strategies, its primary objective is to improve the well-being and welfare of society, necessitating a different perspective. The concept of branding is also crucial in social marketing, akin to its significance in commercial marketing (French and Gordon, 2015). Brand strength plays an important role in building credibility and reputation in social marketing campaigns. The support of a well-known and trusted brand helps in effectively conveying campaign messages and goals to the target audience. This is important for encouraging desired behaviour changes, as people tend to respond more positively to brands, they trust and respect (Donovan and Henley, 2003). The potential of a strong brand to reach the target audience with social marketing messages is higher. Moreover, it has broader access to advertising and communication channels, which increases the visibility of social marketing campaigns. Reaching more people increases the potential to achieve the desired behaviour change. The prestige and appeal behind a strong brand increase interest in social marketing activities and lead to higher participation. Participation in social marketing activities is a crucial step for behaviour change, and brand strength can help people approach such activities more positively (Kotler et al., 2002). Brand strength can represent specific values and norms within society. A strong brand not only provides support to social marketing messages but also reinforces the perception that a particular behaviour is socially accepted or desired. This can enhance the effectiveness of social marketing campaigns. The efforts of strong brands in social responsibility and sustainability further enhance the credibility of social marketing campaigns. When a brand contributes to society and demonstrates environmental sensitivity, people perceive the brand more positively and are more willing to respond to social marketing messages (Lefebvre, 2013). Numerous studies have shown that positive marketing outcomes positively influence brand strength (Aaker, 1991; Srivastava and Shocker, 1991; Keller, 1993; Yoo et al., 2000; Keller, 2009; Gorska-Warsewicz, 2023). Therefore, there is a direct relationship between social marketing and brand strength. Consequently, it is important to research how NGOs build brand strength in the areas they serve.

The purpose of the research is to determine whether NGOs are managed effectively/efficiently, whether they create social marketing and brand strength, and to raise awareness on NGO management, social marketing, and brand strength. The research main question: have NGOs created social marketing and brand strength through effective and efficient management? In line with this purpose, the following research sub questions have been asked: 1) Does the Cide LAG Association implement as an effective application providing a source of donation orientation from social marketing sub-headings, inter-organizational communication coordination within the institution, volunteer acquisition beneficiary orientation, and peer orientation relationship building, with good NGO management and social marketing? 2) Does the Cide LAG Association implement as an effective application providing brand familiarity, brand attractiveness, and brand attitude from brand strength sub-headings, with good NGO management?

3. Methodology of the Research

Research data was collected through face-to-face interviews conducted by interviewers using convenience sampling survey method. The collected data was uploaded to Microsoft Excel and SPSS 19.0 programs for analysis; Cronbach's Alpha test was conducted first to measure the reliability of the scale, followed by frequency distributions, median, central tendency techniques, and factor analysis related to demographic characteristics were utilized in the analysis process.

The research was conducted between January and April 2023 in the districts and villages of Kastamonu province, Cide, Pinarbasi, and Senpazar, which are within the region of the Cide Local Action Group (LAG) Association, using the convenience sampling survey method. The Cide LAG Association was selected by the researchers because it is a successful association operating in three different districts (Cide, Senpazar, and Pinarbasi) and received full grant support for the first time in 2019 under the European Union (EU) LEADER Approach in our country (Polat, 2023). The population of Cide is 22.179, Senpazar is 4.268, and Pinarbasi is 5.787. The total population of these districts is 32.234 (Kastabil, 2022). With a main population of 50.000 (+/-) a 5% sampling error ($p=0.5$; $q=0.5$), at least 381 samples are required for a 95% sampling accuracy (Singh and Masuku, 2014). Therefore, 450 surveys were distributed, 403 of which were returned, but only 400 were evaluated. The demographic characteristics section of the survey form, consisting of 13 questions, was prepared by the researchers based on comprehensive literature review findings, while 13 questions related to social marketing (Modi and Mishra, 2010) and nine (9) questions related to brand strength (Wymer et al., 2016) were adapted to the field, resulting in a total of 35 questions.

As a result of the analysis, it was found that the scale, which obtained a value of 0.978, has a highly reliable Cronbach's Alpha. According to the Kaiser-Meyer-Olkin (KMO) and Bartlett Tests (KMO=0.941, Bartlett's Test of Sphericity= 13518.467, $df= 231$, p (sig)=0.000), the results indicate that the KMO value allows for factor analysis of the data, and the Bartlett test result suggests high correlations among variables and that the data are derived from a multivariate normal distribution. Communalities represent the amount of variance shared by a variable with other variables in a factor analysis. A factor loading value of 0.5 or higher is expected in the analysis. The factor loading values for the 22 questions ranged from at least 0.746 to a maximum of 0.922 for all questions (Karagoz, 2021).

4. Results

The research findings are evaluated under two main headings: findings related to demographic characteristics and findings related to the research questions. The survey was conducted in the districts and villages of Cide, Senpazar, and Pinarbasi within the scope of the Cide LAG Association. The participation status from the districts of Cide, Senpazar, and Pinarbasi is presented in Table 1.

Table 1. Participation status in the survey according to residing district, residing place, and gender.

Inhabited District			Place of Residence				Total	District Percent	Total Percent
			Village	District	Province	Out-of-Province			
Cide	Female	Count	13	70	0	1	84	47.5	57.1
		Percent	15.5	83.3	0	1.2	100		
	Male	Count	39	53	0	1	93	52.5	36.8
		Percent	41.9	57	0	1.1	100		
	Total	Count	52	123	0	2	177	100	44.2
		Percent	29.4	69.5	0	1.1	100		
Senpazar	Female	Count	9	15	0	0	24	36.7	16.3
		Percent	37.5	62.5	0	0	100		
	Male	Count	7	35	0	0	42	63.6	16.6
		Percent	16.7	83.3	0	0	100		
	Total	Count	16	50	0	0	66	100	16.5
		Percent	24.2	75.8	0	0	100		
Pinarbasi	Female	Count	11	19	3	0	33	22.9	22.5
		Percent	33.3	57.6	9.1	0	100		
	Male	Count	20	90	0	1	111	77.1	43.9
		Percent	18	81.1	0	0.9	100		

Inhabited District		Place of Residence				Total	District Percent	Total Percent
			Village	District	Province	Out-of-Province		
Other	Total	Count	31	109	3	1	144	100
		Percent	21.5	75.7	2.1	0.7	100	
	Female	Count	1	0	3	2	6	46.2
		Percent	16.7	0	50	33.3	100	
	Male	Count	0	0	3	4	7	53.8
		Percent	0	0	42.9	57.1	100	
	Total	Count	1	0	6	6	13	100
		Percent	7.7	0	46.2	46.2	100	
	Female	Count	34	104	6	3	147	0
		Percent	23.1	70.7	4.1	2	100	
Total	Male	Count	66	178	3	6	253	0
		Percent	26.1	70.4	1.2	2.4	100	
	Total	Count	100	282	9	9	400	100
		Percent	25	70.5	2.3	2.3	100	

Source: data output.

The survey included a total of 177 participants from Cide district, consisting of 84 women and 93 men; from Senpazar district, there were 66 participants, including 24 women and 42 men; from Pinarbasi district, there were 144 participants, with 33 women and 111 men; additionally, 13 participants, 6 women and 7 men, were from other unspecified locations. Overall, there were 400 participants, comprising 147 women (36.8%) and 253 men (63.2%). Regarding the locations, 100 participants (25%) were from villages in the specified districts, including 34 women and 66 men; 282 participants (70.7%) were from district centers, with 104 women and 178 men; 9 participants (2.3%) were from the provincial center, including 6 women and 3 men; and 9 participants (2.3%) were from outside the province, with 3 women and 6 men. Overall, participation was received from various locations associated with the LAG association.

The evaluation of responses to the survey questions was based on the intervals provided in Table 1. It was assumed that the intervals were equal, and a score range of 0.80 was calculated for arithmetic means (Score Range = (Highest Value – Lowest Value)/5 = (5 – 1)/5 = 4/5 = 0.80) (Pimentel, 2010). According to this calculation, the assessment range for arithmetic means is provided in Table 2.

Table 2. Evaluation Range of Arithmetic Averages According to the 5-Point Likert Scale.

Scale	Options
1.000-1.800	Strongly disagree
1.801-2.600	Disagree
2.601-3.400	Undecide
3.401-4.200	Agree
4.201-5.000	Totally agree

Source: developed by the authors.

According to the research findings, the averages of opinions regarding social marketing and brand strength, along with the standard deviations showing how far the data in this group are concentrated from the average, are presented in Table-3. Additionally, the average participation rates for the relevant opinions are provided in Table-4.

Table 3. Averages and Standard Deviations of Opinions on Social Marketing and Brand Strength.

Questions Number	Mean	Std. Deviation	N
Q14	3.89	0.790	400
Q15	3.89	0.808	400
Q16	3.94	0.826	400
Q17	4.11	1.021	400
Q18	3.97	0.825	400
Q19	4.09	1.046	400
Q20	3.90	0.851	400
Q21	3.98	0.799	400
Q22	3.97	0.836	400
Q23	3.99	0.796	400
Q24	4.05	0.847	400
Q25	4.01	0.839	400
Q26	4.05	0.880	400
Q27	3.72	1.057	400
Q28	3.58	1.010	400
Q29	3.68	0.984	400
Q30	3.76	0.943	400
Q31	3.83	0.915	400
Q32	3.82	0.937	400
Q33	3.97	0.938	400
Q34	3.96	0.914	400
Q35	3.98	0.926	400

Source: data output.

The participation levels for opinions related to social marketing are as follows (Table 4):

(1) Participation level for donor-oriented views on resource generation (SM1): minimum 3.89 (Q14), maximum 3.94 (Q16), and overall average 3.904. This ratio indicates agreement with the views, in other words, the association implements donor-oriented resource generation under the subheading of social marketing.

Table 4. Views on Social Marketing and Brand Strength

Expressions Used in the Survey	Mean
SM- Views on Social Marketing	3.983
SM1- Fundraising donor orientation questions (questions 14, 15, 16)	3.904
SM2- Questions on communication and coordination between the institutional bodies of the association (questions 17, 18, 19)	4.056
SM3- Relationship building peer orientation questions (questions 20, 21, 22, 23)	3.960
SM4- Voluntary earning beneficiary orientation questions (questions 24, 25, 26)	4.036
BS-Insights on Brand Strength	3.811
BS1- Brand familiarity questions (questions 27, 28, 29)	3.662
BS2- Brand attention grabbing questions (questions 30, 31, 32)	3.802
BS3- Brand attitude questions (questions 33, 34, 35)	3.969

Source: data output.

(2) Participation level for inter-organizational communication and coordination-oriented views (SM2): minimum 3.97 (Q18), maximum 4.11 (Q17), and overall average 4.05. This ratio indicates

agreement with the views, signifying that the association implements inter-organizational communication and coordination under the subheading of social marketing.

(3) Participation level for peer-oriented views on relationship building (SM3): minimum 3.90 (Q20), maximum 3.99 (Q23), and overall average 3.96. This ratio indicates agreement with the views, implying the association implements peer-oriented relationship building under the subheading of social marketing.

(4) Participation level for beneficiary-oriented views on volunteer recruitment (SM4): minimum 4.01 (Q25), maximum 4.05 (Q26), and overall average 4.03. This ratio indicates agreement with the views, meaning the association implements beneficiary-oriented volunteer recruitment under the subheading of social marketing.

The participation levels for opinions related to brand strength are as follows (Table-4):

(1) Participation level for views expressing brand familiarity (BS1): minimum 3.58 (Q28), maximum 3.72 (Q27), and overall average 3.66. This ratio indicates agreement with the views, meaning the association achieves brand familiarity under the subheading of brand strength.

(2) Participation level for views expressing brand attractiveness (BS2): minimum 3.76 (Q30), maximum 3.83 (Q31), and overall average 3.80. This ratio indicates agreement with the views, implying the association achieves brand attractiveness under the subheading of brand strength.

(3) Participation level for views expressing brand attitude (BS3): minimum 3.96 (Q34), maximum 3.98 (Q35), and overall average 3.97. This ratio indicates agreement with the views, signifying that the association implements brand attitude under the subheading of brand strength.

The survey participants' demographics, types of residence (village, district, province, outside the province), including their districts of residence (Cide, Senpazar, Pinarbasi, other), birth years, education status (graduate), monthly income status, occupations (item a-f) with One way-ANOVA-Test and gender, internet usage status, smartphone usage, continuous high-speed internet connection from home, participation in LEADER Approach (Local Development) training, participation in NGO and management training, membership status in the LAG association (item g-l), with T-Test along with the main and subheadings related to social marketing and brand strength, have been examined via SPSS and presented in Table A1 in Annex A.

In this study, two different methods were employed for multiple comparisons in one-way ANOVA tests (items a-f). For items with a homogeneity test p-value > 0.005 , Scheffe's test was applied. This test controls the alpha error rate and does not assume equal group sizes. For items with a homogeneity test p-value < 0.005 , Tamhane's T-test was used, which simultaneously compares k means pairwise using a common error approach in the case of heterogeneous group variances. Significant differences were evaluated as $p < 0.05$ in one-way ANOVA and T-tests, and $p > 0.005$ was considered non-significant (Karagoz, 2021). In the main headings of social marketing and brand strength, the following subjects are examined (Table A1 in Annex A):

- a. The fact that the survey participants live in the village, district, province, and outside the province does not create significant differences in the SM1, SM3, SM4, SM and BS1, BS2, BS3, BS dimensions. However, in the SM2-questions on communication and coordination between the institutional bodies of the association sub-dimension, it is seen that those living in the village have significant differences in their perceptions compared to those living in the district.
- b. Survey participants residing in Cide, Senpazar, Pinarbasi, and other locations create a significant difference in the perception levels regarding the management, social marketing (SM1, SM2, SM3, SM) and brand strength (BP1, BP2, BP3, BP) conducted by the association. Residents of Cide have a perception level significantly higher than the average regarding the

activities conducted by the association and the perception of social marketing and brand strength headings, the perception of residents in Senpazar district is lower than the other.

- c. The birth years of the survey participants do not create significant differences in the SM1, SM2, SM3, SM4, SM and BS2, BS3 dimensions. However, in the BS1– brand familiarity questions sub-dimension and the BS- insights on brand strength main dimension, those born between 1966-1979 perceive the activities at a higher level compared to those born between 1945–1965.
- d. The educational status of the survey participants does not create significant differences in the SM1-fundraising donor orientation questions and BS3-brand attitude questions dimensions. However, the fact that the participants are primary school, secondary school, high school, and bachelor-above graduates creates a significant difference among themselves in the management and social marketing and brand strength main and sub-dimensions (except SM1 and BS3) carried out by the association. Bachelor-above, and primary school graduates perceive the activities carried out at a higher level compared to secondary school and high school graduates.
- e. The monthly income status of the survey participants does not create significant differences in the SM1, SM2, SM3, SM4, SM and BS1, BS2, BS3, BS dimensions.
- f. The occupations of the survey participants do not create significant differences in the SM2-questions on communication and coordination between the institutional bodies of the association and BS3-Brand attitude questions dimensions. The fact that the occupations of the survey participants are farmer, tradesman, public employee, worker, and retired creates significant differences in the management and social marketing and brand strength main and sub-dimensions (except SM2 and BS3) carried out by the association. The perception of the activities carried out by the association and the brand strength title of those whose occupation is farmer and public employee is higher than that of the retirees. The perception of the social marketing title of the activities carried out by the association of those whose occupation is public employee is higher than that of workers and retired.
- g. The gender of the survey participants does not create significant difference in the SM2-questions on communication and coordination between the institutional bodies of the association dimension. The perception of female regarding the activities carried out by the association, social marketing (except SM2) and brand strength is higher than that of male.
- h. The fact that the survey participants use the internet and smartphones, have uninterrupted internet access from home, and receive EU LEADER training and NGO and management training creates a significant difference in the SM1, SM2, SM3, SM4, SM and BS1, BS2, BS3, BS dimensions. Those who use the internet and smartphones, have uninterrupted internet access from home, and have received EU LEADER training, NGO and NGO management training have a higher perception of the activities carried out by the association, social marketing and brand strength compared to those who do not.
- i. The fact that the survey participants are members of the LAG or not does not create significant differences in the SM1, SM2, SM3, SM4, SM and BS1, BS2, BS3, BS dimensions.

Conclusion

This study is one of the first field research studies conducted in Turkey on NGO management, social marketing in NGOs, and brand power in NGOs, which are areas that are not well-managed and have a very limited number of field research studies. In this respect, it is highly valuable. Cide LAG association generally operates within the scope of NGO management, brand strength, and social marketing contexts as indicated in the research questions. In other words, it generally accomplishes successful NGO management.

There are differing perceptions among various groups regarding the success of activities carried out by the association. Residents in villages, compared to those in towns, those in towns compared to those in cities, women compared to men, internet users compared to non-users, smartphone users compared to non-users, those with uninterrupted high-speed internet connection at home compared to those without, and tend to perceive the activities conducted by the association as more or less successful based on their demographic characteristics. Residents in villages and towns, who generally have fewer social, cultural, infrastructure, and economic opportunities, may perceive even the smallest activity to have a greater impact. Furthermore, these findings are significant when examining social entrepreneurship aiming to solve unresolved societal issues and socio-cultural environments. According to Hofstede's cultural analysis, Turkish society is considered to be highly collectivist and emphasizes femininity (Robbins and Judge, 2013). Thus, situations that may be negative in terms of entrepreneurship tend to have a positive impact on solving societal issues (Dan, 2019; Polat and Ozdemir, 2022).

While the success level of the NGO is perceived to be higher in the Cide district, it is observed to be below average in the Senpazar district. The headquarters of the LAG association is located in Cide. The association is actively open during office hours and provides free project consultancy to the local community in addition to its own activities. The findings indicate that the association demonstrates successful activities in Cide. However, the same level of success is not observed in the Senpazar district.

Individuals with bachelor and above education degrees perceive the NGO to be more successful compared to individuals with other education levels. It is more challenging to persuade individuals with a questioning and critical thinking perspective gained through bachelor education. The majority of the population living in the villages are primary school graduates, and they are directly affected by the activities carried out. While individuals with this level of education find the association successful, they perceive it to be less successful compared to others.

Farmers and public servants perceive the NGO to be more successful compared to other occupational groups. The fact that farmers and public servants perceive the association to be more successful may be attributed to the higher awareness of these groups about the activities carried out. In other words, it can be concluded that the LEADER Approach projects and implementations, which constitute a multi-sectoral local development program, cover other sectors to a lesser extent.

Those who have not received EU LEADER training or NGO management training perceive the NGO to be less successful. NGO managers and residents living in the local communities should have knowledge in NGO management and addressing unresolved societal issues (Polat and Ozdemir, 2022).

NGOs can create social marketing and brand strength through effective and efficient management by doing the following:

NGOs should disseminate their successful practices to groups that have received negative results by developing different methods and approaches.

NGOs operating in rural areas should increase their activities in villages or focus primarily on activities in villages to create a greater impact in a short period.

To publicize NGO activities and events, emphasis should be placed on on-site digital literacy training for those who do not use the internet. Additionally, efforts should be made to provide access to the internet or high-speed, uninterrupted internet connections in areas where residents do not have internet access. Until this is achieved, traditional media such as printed posters and monthly newsletters should be utilized.

Practices should be developed to encourage everyone to become members of the LAG association, or activities aimed at members should be extended to residents in the region.

The LAG association should replicate the management model implemented in Cide in other districts. This includes planning, organizing, directing, coordinating, and controlling the association's activities.

NGO activities and events should be planned and implemented with consideration for the educational levels of the population, adopting a participatory approach. Tailored approaches should be implemented to appeal to each educational group.

Activities aimed at recruiting donors from the high-income group in the region should be carried out.

The LEADER Approach projects and implementations, which constitute a multi-sectoral local development program, should be expanded to encompass other sectors.

Training sessions on NGO, NGO management, EU LEADER Approach, social marketing, and brand strength should be conducted in the region, both face-to-face and online (via live remote sessions), planned to include all segments of society, and delivered by academic experts in the field to facilitate learning.

Civil society is the fundamental source that constitutes organizations such as the state, businesses, and NGOs. The more mature the civil society is, the better all the organizations in that society are managed. In high schools and universities, education on NGOs, NGO management, social entrepreneurship, social marketing, and brand power in NGOs should be added to the curriculum, and academics should conduct more scientific research on these topics. Additionally, the management department should not be a sub-discipline under the business administration department, but rather a separate main discipline with sub-disciplines of public administration, business management, and NGO management. Research on the mentioned topics should be conducted by academics.

Like in other marketing practices, social marketing also needs to segment its members into various relevant categories and conduct tailored marketing communication. As seen in this study, the demographic segmentation method that the mentioned non-profit organization could utilize has been established as a fundamental starting point for them. For instance, individuals with bachelor and above degrees are thought to have a more questioning and analytical thinking tendency compared to others. Therefore, social marketing content targeting these individuals is expected to be customized to appeal more to their interests. For individuals who do not use the internet, do not have internet access at home, or have yet to use mobile smart devices, relevant social marketing content can be simultaneously delivered through online and offline channels based on their media consumption habits. The involvement of other groups in the high value obtained by groups already familiar with the non-profit organization's activities, such as farmers and public servants, in terms of social marketing and brand strength, can only be achieved through a holistic social marketing communication strategy that further highlights the organization's overall brand strength.

In many studies, there is a general consensus among experts that for the success and memorability of a brand, it should be present in at least three different channels capable of conducting brand communication. Integrated Marketing Communications is a strategic approach that emphasizes the importance of a consistent message across various channels. This approach helps reinforce the brand message, making it more memorable. Research by Belch and Belch (2018) in their book "Advertising and Promotion: An Integrated Marketing Communications Perspective" highlights the effectiveness of using multiple channels to create a unified brand message. Also consumers interact with brands across various touchpoints, including social media, websites, emails, and physical stores. Multi-channel campaigns can improve brand recall and drive better marketing outcomes (Nielsen, 2016; Alba and Chattopadhyay, 1986). The study notes that brands using multiple channels see a higher impact on consumers' purchase decisions. Research published in the Journal of Advertising Research

by Naik and Raman (2003) discusses the concept of cross-media synergy, where the combined effect of multiple media channels can enhance the overall impact on consumers. Their findings suggest that brands present across various channels can achieve higher effectiveness compared to single-channel campaigns. If the non-profit organization invests in enhancing its brand strength, it can influence and garner support from more people. This means the organization can disseminate its work to a wider audience.

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Annex A

Table A1. Comparison of Independents Variable in Terms of Opinions on Social Marketing and Brand Strength and Sub-Headings with One Way Anova Test and T-Test.

a. Place of Residence	n	SM1	SM2	SM3	SM4	SM	BS1	BS2	BS3	BS
F (3, 396)		1.625	3.650	0.839	0.671	1.763	0.780	1.302	0.999	1.090
p		0.183	0.013*	0.473	0.570	0.154	0.506	0.273	0.393	0.353
Test of Homogeneity		0.065	0.018	0.001	0.012	0.005	0.000	0.002	0.007	0.000
Mean Difference (I-J)		-	1,2	-	-	-	-	-	-	-
Village ¹	100	4.043	4.260	4.040	4.117	4.115	3.770	3.940	4.053	3.921
District ²	Mean 282	3.861	4.002	3.935	4.010	3.952	3.624	3.752	3.933	3.770
Province ³	9	3.705	3.519	3.722	3.852	3.699	3.482	3.667	3.815	3.654
Out-of Province ⁴	9	3.926	3.963	4.083	4.185	4.039	3.852	4.000	4.333	4.062
b. Inhabited District	n	SM1	SM2	SM3	SM4	SM	BS1	BS2	BS3	BS
F (3, 396)		79.768	53.208	59.255	82.034	89.152	59.174	73.785	65.042	78.199
p		0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*
Test of Homogeneity		0.156	0.000	0.015	0.001	0.001	0.004	0.179	0.058	0.201
Mean Difference (I-J)		1,2,3,4	1,2,3,4	1,2,3	1,2,3,4	1,2,3	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4
Cide ¹	177	4.396	4.544	4.418	4.582	4.485	4.211	4.373	4.522	4.369
Senpazar ²	Mean 66	3.177	3.460	3.405	3.333	3.344	2.778	3.025	3.172	2.992
Pınarbasi ³	144	3.637	3.785	3.648	3.690	3.690	3.394	3.454	3.664	3.504
Other ⁴	13	3.872	3.410	4.000	4.026	3.827	3.667	3.846	3.872	3.795
c. Years of Birth	n	SM1	SM2	SM3	SM4	SM	BS1	BS2	BS3	BS
F (4, 395)		3.088	1.454	2.909	1.773	1.276	5.428	2.601	2.150	3.062
p		0.016*	0.216	0.021*	0.031*	0.044*	0.000*	0.011*	0.034*	0.003*
Test of Homogeneity		0.569	0.066	0.830	0.917	0.985	0.963	0.596	0.309	0.460
Mean Difference (I-J)		-	-	-	-	-	2,3	-	-	2,3
1944 before ¹	11	3.727	4.030	3.841	3.940	3.881	3.3939	3.364	3.546	3.434
1945-1965 ²	99	3.808	4.084	3.806	3.892	3.890	3.3502	3.653	3.838	3.614
1966-1979 ³	Mean 127	4.076	4.087	4.112	4.194	4.117	3.9580	4.011	4.129	4.032
1980-1999 ⁴	132	3.796	3.942	3.903	3.960	3.900	3.629	3.740	3.904	3.758
2000 after ⁵	31	4.032	4.323	4.113	4.215	4.171	3.688	3.850	4.161	3.900
d. Education Status (Graduate)	n	SM1	SM2	SM3	SM4	SM	BS1	BS2	BS3	BS
F (4, 395)		3.050	6.320	3.939	4.776	5.162	2.467	3.683	2.405	3.089
p		0.017*	0.000*	0.004*	0.001*	0.000*	0.044*	0.006*	0.049*	0.016*

Test of Homogeneity		0.098	0.184	0.000	0.000	0.001	0.000	0.000	0.013	0.000
Mean Difference (I-J)		-	1,2,3,5	1,2,3,5	1,2,3,5	1,2,3,5	1,2,3,5	1,2,5	-	1,2,3,5
Primary ¹	122	4.019	4.254	4.035	4.123	4.108	3.740	3.937	4.052	3.910
Secondary ²	54	3.642	3.728	3.653	3.661	3.671	3.340	3.451	3.679	3.490
High School ³	121	3.865	3.926	3.946	4.072	3.952	3.697	3.760	3.989	3.815
Associate ⁴	34	3.794	3.873	3.838	3.833	3.835	3.480	3.686	3.784	3.650
Bachelor&above ⁵	69	4.029	4.275	4.152	4.217	4.169	3.807	3.971	4.106	3.961
e. Monthly Income Status		SM1	SM2	SM3	SM4	SM	BS1	BS2	BS3	BS
F (3. 396)		2.249	1.695	2.066	2.862	1.931	2.256	0.338	1.950	1.497
p		0.082	0.167	0.104	0.037*	0.124	0.081	0.798	0.121	0.215
Test of Homogeneity		0.182	0.023	0.057	0.350	0.352	0.157	0.068	0.007	0.010
Mean Difference (I-J)		-	-	-	-	-	-	-	-	-
1-8500	144	3.796	4.093	3.856	3.898	3.911	3.514	3.762	3.852	3.709
8501-17000	208	3.981	4.040	4.022	4.123	4.042	3.761	3.829	4.058	3.883
17001-25500	45	3.933	4.074	4.044	4.119	4.043	3.719	3.837	3.978	3.844
25501 above	3	3.333	3.000	3.417	3.444	3.299	3.11	3.444	3.333	3.296
f. Occupations		SM1	SM2	SM3	SM4	SM	BS1	BS2	BS3	BS
F (9. 390)		4.271	3.151	6.092	4.467	5.056	7.034	4.356	3.327	5.296
p		0.000*	0.001*	0.000*	0.000*	0.000*	0.000*	0.000*	0.001*	0.000*
Test of Homogeneity		0.079	0.062	0.299	0.524	0.450	0.119	0.335	0.515	0.144
Mean Difference (I-J)		4,5,9	-	2,4,5,9	4,9	4,5,9	1,2,4,5,9	4,9	-	1,4,9
Farmer ¹	27	4.247	4.432	4.333	4.444	4.364	4.259	4.284	4.432	4.325
Tradesmen ²	71	3.793	3.991	3.828	3.995	3.902	3.502	3.662	3.944	3.703
Housewife ³	50	3.900	3.893	3.990	4.067	3.963	3.773	3.933	4.060	3.922
Public Employee ⁴	68	4.279	4.343	4.397	4.392	4.353	4.216	4.181	4.275	4.224
Worker ⁵	68	3.696	3.985	3.783	3.887	3.838	3.534	3.642	3.833	3.670
Unemployed ⁶	7	3.529	3.857	3.536	3.619	3.634	3.143	3.143	3.619	3.302
Business Person ⁷	9	3.630	3.444	3.556	3.482	3.528	3.333	3.333	3.444	3.370
Student ⁸	21	4.095	4.381	4.131	4.175	4.195	3.746	3.889	4.079	3.905
Retired ⁹	70	3.738	3.910	3.700	3.752	3.775	3.214	3.562	3.676	3.484
Other ¹⁰	9	3.926	3.815	4.111	4.185	4.009	3.333	3.741	3.815	3.630
g. Gender	n	SM1	SM2	SM3	SM4	SM	BS1	BS2	BS3	BS
t		2.853	1.921	3.048	3.282	3.115	4.193	4.273	4.122	4.441
p		0.005*	0.055	0.002*	0.001*	0.002*	0.000*	0.000*	0.000*	0.000*
Mean Difference		0.223	0.168	0.238	0.275	0.226	0.418	0.384	0.382	0.393
Female	147	4.045	4.161	4.111	4.211	4.130	3.923	4.045	4.211	4.060
Male	253	3.822	3.993	3.873	3.935	3.903	3.511	3.661	3.829	3.667
h. Internet Usage Status		SM1	SM2	SM3	SM4	SM	BS1	BS2	BS3	BS
t		5.814	4.875	6.507	6.723	6.621	5.666	6.300	7.096	6.780
p		0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*
Mean Difference		0.607	0.569	0.669	0.742	0.646	0.721	0.676	0.771	0.723
Yes	342	3.992	4.137	4.057	4.144	4.081	3.767	3.901	4.081	3.916
No	58	3.385	3.569	3.388	3.402	3.432	3.046	3.224	3.310	3.194
i. Using a Smart Cell Phone		SM1	SM2	SM3	SM4	SM	BS1	BS2	BS3	BS
t		5.950	5.150	6.623	6.565	6.730	6.083	6.989	5.983	7.233
p		0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*
Mean Difference		0.625	0.603	0.685	0.732	0.661	0.704	0.690	0.748	0.714
Yes	343	3.993	4.141	4.058	4.141	4.083	3.763	3.901	4.076	3.913
No	57	3.368	3.538	3.373	3.409	3.422	3.058	3.211	3.328	3.199
j. Uninterrupted Internet Connection at Home		SM1	SM2	SM3	SM4	SM	BS1	BS2	BS3	BS
t		4.923	5.933	5.912	5.669	6.237	5.535	6.187	5.896	6.346
p		0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*
Mean Difference		0.413	0.542	0.487	0.505	0.487	0.551	0.560	0.583	0.565
Yes	293	4.015	4.200	4.090	4.172	4.119	3.810	3.952	4.1251	3.963
No	107	3.601	3.657	3.603	3.667	3.632	3.259	3.393	3.5421	3.398
k. LEADER Training		SM1	SM2	SM3	SM4	SM	BS1	BS2	BS3	BS
t		13.737	9.548	13.34	11.823	12.92	17.035	15.92	13.641	16.24

p			0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*
Mean Difference			1.032	0.859	0.985	0.898	0.943	1.366	1.201	1.026
Yes	Mean	72	4.750	4.759	4.767	4.773	4.762	4.782	4.787	4.810
No		328	3.719	3.900	3.783	3.875	3.819	3.417	3.586	3.785
l. Training on NGO and Management			SM1	SM2	SM3	SM4	SM	BS1	BS2	BS3
t			11.431	7.378	11.83	11.216	10.88	14.57	13.93	11.349
p			0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*
Mean Difference			0.937	0.721	0.909	0.846	0.853	1.2468	1.116	0.956
Yes	Mean	83	4.647	4.627	4.681	4.707	4.666	4.651	4.687	4.727
No		317	3.710	3.905	3.771	3.861	3.809	3.404	3.571	3.771
m. LAG Association Membership			SM1	SM2	SM3	SM4	SM	BS1	BS2	BS3
t			0.631	-0.379	0.384	0.617	0.296	1.459	0.725	0.757
p			0.528	0.710	0.701	0.538	0.768	0.145	0.469	0.449
Mean Difference			0.120	-0.105	0.073	0.126	0.053	0.348	0.161	0.170
Yes	Mean	17	4.020	3.961	4.029	4.157	4.042	4.000	3.961	4.137
No		382	3.900	4.066	3.957	4.031	3.989	3.652	3.800	3.967

Source: data output.

Reference

1. Aaker, D. A. (1991). *Managing brand equity: Capitalizing on the value of a brand name*. The Free Press.
2. Alba, J. W., & Chattopadhyay, A. (1986). Salience effects in brand recall. *Journal of marketing research*, 23(4), 363–369. <https://doi.org/10.1177/002224378602300406>.
3. Alyakut, B. (2013). *Sivil toplum kuruluşları için stratejik yönetim*. İstanbul: Cinius Yayınları.
4. Andreasen, A. R. (1995). *Marketing social change: Changing behavior to promote health, social development, and the environment*. San Francisco: Jossey-Bass.
5. Bayhan, V. (2002). Demokrasi ve sivil toplum örgütlerinin engelleri: Patronaj ve nepotizm. *Cumhuriyet University Journal of Social Sciences*, 26(1), 1–13.
6. Belch, G. E., & Belch, M. A. (2018). *Advertising and promotion: an integrated marketing communications perspective*. McGraw-Hill Education. <https://thuvienso.hoasen.edu.vn/handle/123456789/8039>.
7. Caha, Ö. (2011). Kamu kurumu niteliğindeki meslek kuruluşları ve sivil toplum, A. Yayla & Ş. Bican (Eds). *Türkiye’de kamu kurumu niteliğindeki meslek kuruluşları, sivil toplum ve demokrasi* (pp. 85-124). Ankara: Liberal Düşünce Topluluğu Derneği. <http://liberal.org.tr/uploads/yuklemeler/Raporanametin.pdf>.
8. Caha, Ö. (2016). *Sivil Toplum ve Devlet*. Ankara: Orion Kitabevi.
9. Cordery, C., Belal, A. R., & Thomson, I. (2019). NGO accounting and accountability: past, present and future. *Accounting Forum*, 43(1), 1–15. <https://doi.org/10.1080/01559982.2019.1593577>.
10. Czubała, A. (2016). Corporate social responsibility in marketing. *Forum scientiae oeconomia*, 4(1), 103–111. <https://ojs.wsb.edu.pl/index.php/fso/article/view/239>.
11. Dan, H. (2019). Culturally green – an investigation into the cultural determinants of environmental performance. *Forum Scientiae Oeconomia*, 7(2), 107–126. https://doi.org/10.23762/FSO_VOL7_NO2_7.
12. Dann, S. (2010). Redefining social marketing with contemporary commercial marketing definitions. *Journal of business research*, 63(2), 147–153. <https://doi.org/10.1016/j.jbusres.2009.02.013>.
13. Donovan, R., & Henley, N. (2003). *Social marketing: Principles & practice*. Melbourne, Australia: IP Communications.

14. Franco, R. C., & Salamon, L. M. (2005). Defining the nonprofit sector: Portugal (Vol. 43). *Johns hopkins university center for civil society studies*. <https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=bee072bd271c045af6c26f593f02160bd1b0eca1>.
15. French, J., & Gordon, R. (2015). *Strategic social marketing*. New York: Sage Publications.
16. Gorska-Warsewicz, H. (2023). Brand authenticity as a basis for creating perceived value in the management of the most valuable polish brands. *Forum Scientiae Oeconomia*, 11(4), 205–225. https://doi.org/10.23762/FSO_VOL11_NO4_10
17. Hobbes, T. (1651). *Leviathan*. London: The Green Dragonin St. Pauls Church-yard, <https://historyofeconomicthought.mcmaster.ca/hobbes/Leviathan.pdf>.
18. Kantrowitz, R. E. (2016). United Nations: definitions and terms. *American Psychology Association*, 21(09). <https://www.apa.org/international/united-nations/acronyms.pdf>.
19. Karagöz, Y. (2021). *SPSS AMOS META uygulamalı biyoistatistik* (3. baskı). Ankara: Nobel Akademik Yayıncılık.
20. Kastabil, İlçelere Göre Nüfus Verileri 2022 . <https://www.kastabil.gov.tr/veritablolari/kastamonu/nufus/ilcelere-gore-nufus-verileri-adnks-2018>.
21. Keller, K. L. (1993). Conceptualizing, measuring, and managing customer-based brand equity. *Journal of Marketing*, 57(1), 1–22. <https://doi.org/10.1177/002224299305700101>.
22. Keller, K. L. (2009). Building strong brands in a modern marketing communications environment. *Journal of marketing communications*, 15(2-3), 139–155. <https://doi.org/10.1080/13527260902757530>.
23. Kotler, P., & Roberto, E. L. (1989). *Social marketing: Strategies for changing public behavior*. New York: The Free Press.
24. Kotler, P., & Zaltman, G. (1971). Social Marketing: An Approach to Planned Social Change. *Journal of Marketing*, 35(3), 3–12. <https://www.healthedpartners.org/ceu/hm/d04socialmarketingplannedsocialchange.pdf>.
25. Kotler, P., Roberto, N., & Lee, N. (2002). *Social marketing: Improving the quality of life* (2nd ed.). Thousand Oaks, CA: SAGE.
26. Laidler-Kylander, N., Quelch, J. A., & Simonin, B. L. (2007). Building and valuing global brands in the nonprofit sector. *Nonprofit Management and Leadership*, 17, 253–277. <https://doi.org/10.1002/nml.149>.
27. Lefebvre, R. C. (2013). *Social marketing and social change: strategies and tools for improving health, well-being, and the environment*. San Francisco: John Wiley & Sons.
28. Lewis, D. (2001). *The Management of Non-Governmental Development Organizations*. New York: Routledge.
29. Modi, P., & Mishra, D. (2010). Conceptualising market orientation in non-profit organisations: Definition, performance, and preliminary construction of a scale. *Journal of Marketing Management*, 26(5/6), 548–569.
30. Naik, P. A., & Raman, K. (2003). Understanding the impact of synergy in multimedia communications. *Journal of Advertising Research*, 43(4), 376–388.
31. Najam, A. (2000). The Four C's of government third sector-government relations. *Nonprofit management and leadership*, 10, 375–396. <https://doi.org/10.1002/nml.10403>.
32. Nielsen (2016). The Nielsen Total Audience Report. <https://www.nielsen.com/insights/2016/the-nielsen-total-audience-report-q2-2016/>
33. Pimentel, J. L. (2010). A note on the usage of Likert Scaling for research data analysis. *USM R&D Journal*, 18(2), 109–112.

34. Polat, O. (2023). Sivil toplum kuruluşlarının yönetim perspektifinden incelenmesi: Türkiye yerel eylem grubu (YEG) dernekleri örneği. *Akademik Hassasiyetler*, 10(23), 167–199. <https://doi.org/10.58884/akademik-hassasiyetler.1329581>.
35. Polat, O. & Özdemir, L. (2022). *Etkinlik teorisi bağlamında yerel kalkınma amaçlı sivil toplum kuruluşlarında sosyal girişimciliğin incelenmesi: Türkiye örneği*, Ankara: Detay Yayıncılık
36. Robbins, S. P., & Judge, T. A. (2013). *Organizational behavior* (15th ed.). Boston: Pearson.
37. Rousseau, J. J. (2017). *Toplum sözleşmesi* [Social Contract] (V. Günyol, Trans.). İstanbul: İşbankası Kültür Yayınları.
38. Singh, A. S., & Masuku, M. B. (2014). Sampling techniques & determination of sample size in applied statistics research: An overview. *International Journal of economics, commerce and management*, 2(11), 1–22. <https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=ed039f87c11fc5b1e17dab7ab79c26b3cf1f9ebb>.
39. Smith, S. B. (2006a). *Thomas Hobbes*. <http://www.acikders.org.tr/file.php/109/Lectures/PDF/Ders12.pdf>.
40. Smith, W. A. (2006b). Social marketing: An overview of approach and effects. *Injury Prevention*; 12(Suppl. 1), i38–i43. <https://doi.org/10.1136/ip.2006.012864>.
41. Srivastava, R. K., & Shocker, A. D. (1991). Brand equity: A perspective on its meaning and measurement. In A. A. Aaker & D. A. Aaker (Eds.), *Brand equity & advertising* (pp. 68–81). Lawrence Erlbaum Associates.
42. Talas, M. (2011). Sivil toplum kuruluşları ve Türkiye perspektifi. *Türklük Bilimi Araştırmaları*, 29, 387–401. <https://dergipark.org.tr/tr/pub/tubar/issue/16970/177312>.
43. Tocqueville, A. D. (1862). *Democracy in America*, Vol. 2 (H. Reeve, Trans.). London: Longman, Green, Longman, and Roberts. https://database-download.worldlibrary.org/090AFD72CFB21431AA1C90F6E10408AA_wplbn0004254890.pdf.
44. Türk Dil Kurumu (TDK). (2011). *Türkçe sözlük* [Turkish dictionary] (11th ed., Ş. H. Akalın & R. V. Toparlı, Eds.). Ankara: Türk Dil Kurumu Yayınları.
45. Uysal, A. (2016). *Toplumsal hareketler sosyolojisi*. İstanbul: Tezkire Yayıncılık.
46. Wymer, W., Gross, H., & Helmig, B. (2016). Nonprofit brand strength: What is it? How is it measured? What are its outcomes? *Voluntas: International Journal of Voluntary & Nonprofit Organizations*, 27(3), 1448–1471. <https://doi.org/10.1007/s11266-015-9641-8>.
47. Yerasimos, S. (2001). Sivil toplum Avrupa ve Türkiye. S. Yerasimos, G. Seufert & K. Vorhoff (Ed) *Türkiye'de sivil toplum ve milliyetçilik* (pp. 13–23). İstanbul: İletişim Yayınları.
48. Yoo, B., Donthu, N., & Lee, S. (2000). An examination of selected marketing mix elements and brand equity. *Journal of the Academy of Marketing Science*, 28(2), 195–211. <https://doi.org/10.1177/0092070300282002>.

The Role of Social Security and Appreciative Inquiry in the Work of a Social Service Manager

Jozef Mlynski¹, Lukasz Sulkowski², Robert Seliga³, Joanna Wojcik-Chodorowska^{4,*}, Stanislaw Jung-Konstanty⁵

¹ University of the Commission of National Education in Cracow, Cracow, Poland

ORCID: 0000-0002-2475-9658

e-mail: jozef.mlynski@uken.krakow.pl

² WSB University, Dabrowa Gornicza, Poland

ORCID: 0000-0002-1248-2743

e-mail: lsulkowski@wsb.edu.pl

³ WSB University, Dabrowa Gornicza, Poland

ORCID: 0000-0003-3306-904X

e-mail: robert.seliga@wsb.edu.pl

⁴ WSB University, Dabrowa Gornicza, Poland

ORCID: 0009-0004-9924-5899

e-mail: joanna.wojcikchodorowska@wsb.edu.pl

⁵ University of the Commission of National Education in Cracow, Cracow, Poland

ORCID: 0000-0003-0425-5193

e-mail: stanislaw.jung-konstanty@uken.krakow.pl

* Corresponding author: Joanna Wojcik-Chodorowska, joanna.wojcikchodorowska@wsb.edu.pl

Abstract

The article focuses on the importance of social security and appreciative inquiry in the work of social service managers, with particular emphasis on the role of social workers. The first part of the article contains a theoretical section describing issues related to social security and presenting the basic assumptions of appreciative inquiry. The second part is devoted to the presentation of the methodological assumptions of the study, while the third part discusses the research findings and conclusions from a quantitative study conducted among employees of the Social Services Centre in Tarnów in 2024. The aim of the article is to examine the relationship between the role of social service managers and the use of appreciative inquiry as a tool to support work efficiency and social security. The research results indicate that the appreciative approach supports managers in effectively managing teams and implementing changes. The study has identified that the most significant roles of appreciative inquiry in the work of social service managers include boosting self-esteem by focusing on an individual's strengths, determining steps that the individual can take to achieve their set goals, and developing coping skills to deal with obstacles that may arise during the implementation of these goals. The article presents the concept of appreciative inquiry as a management tool and a means of creating positive change in the context of social services. It highlights the role of social service managers in shaping organisational reality through dialogue and collaboration, as well as the importance of positive emotions and visions of the future in the organisational transformation of the social services sector. The results of the study have practical implications and can contribute to the improvement of social service quality, ultimately raising the standard of living in various social contexts. The article also presents recommendations for implementing a monitoring and evaluation system to assess the effectiveness of actions taken by social service managers to enhance social security.

Key words

management, social security, appreciative inquiry, appreciative discourse, social work, social policy.

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Introduction

The article analyzes two key issues related to management in social services: the importance of social security and the application of Appreciative Inquiry (AI). This topic is crucial because ensuring social security and effectively managing staff support societal development and the effectiveness of social assistance. The article is based on a literature review and describes the theory of Appreciative Inquiry, with particular emphasis on its application in team management and organizational transformation in the social services sector. To achieve this goal, the 4-D model and key principles of the method are presented and discussed. The article also discusses definitional aspects related to social security which include ensuring basic living conditions, protection from social exclusion, and risks such as unemployment, poverty, and homelessness. The paper emphasizes that ensuring social security is closely related to the tasks of social workers as managers, who manage staff and motivate them to work effectively.

The main research question presented in the article is how social security and appreciative dialogue play a role in the work of social service managers. In this context, social security is understood as a state free from threats, and Appreciative Inquiry is seen as a perspective that allows the identification of strengths, the development of vision, and the implementation of positive changes in the work of social service managers.

The research gap identified in the article concerns the lack of empirical analysis on the role of Appreciative Inquiry in the work of social service managers. Key aspects of this research gap include: the lack of detailed studies on the application of Appreciative Inquiry in social service management, the shortage of empirical data on the impact of the appreciative approach on employee engagement, and limited knowledge about the specific needs of local communities in the context of social service management.

The authors focused on addressing the above-mentioned gap by conducting research in a local context (Tarnow), considering the specific challenges faced by social service managers. The article presents, among other things, the research findings concerning the relationship between the use of Appreciative Inquiry and the self-esteem and motivation of social service employees.

The studies presented emphasize that they were conducted only in Tarnow, which limits the generalizability of the results to other cities or regions. The local social, economic, and cultural context may significantly influence respondents' answers, meaning there is a need for similar studies and analyses in other locations. Therefore, the research presented in the article can serve as a basis for future analyses regarding the implementation of Appreciative Inquiry in the social services sector.

The structure of the article includes a literature review and theoretical presentation regarding the Appreciative Inquiry and social security, presentation of methodological assumptions, presentation of research results, presentation of discussions and conclusions with recommendations.

1. Literature Review

1.1. *The Role of Social Security in the Work of Social Service Managers*

The primary factor for individuals in need of help and support, especially in life-threatening situations, is ensuring their social security (Goryń, 2020). According to Domański (2017), social security refers to “the protection of the existential foundations of people's lives, ensuring the ability to meet individual material and spiritual needs, the realization of life aspirations by creating conditions for work and education, health protection, and retirement guarantees.” The *PWN Encyclopedia* defines it as “real guarantees for meeting the social needs of individuals and families, a state of freedom from scarcity or a lowered standard of living caused mainly by so-called social risks (e.g., loss of the ability to earn, illness, disability, old age, increased family burdens, helplessness) or other random events” (Nowa Encyklopedia Powszechna PWN, 2005,). Meanwhile, Rysz-Kowalczyk (2002) states it is “a state of freedom from threats, the consequence of which is the lack or insufficiency of means of livelihood”.

In this understanding, social security appears to be strongly correlated with various types of threats (Gierszewski, 2018). This is because its goal is to ensure survival, well-being, and sustainable development within society, as well as to provide a proper standard of living for individuals, families, and social groups, and to safeguard against social exclusion (Oliwkiewicz, 2023). It is achievable in areas such as unemployment, lack of resources to maintain housing, poverty, homelessness, and addiction (Łubiński, 2018). For this reason, social security is a state of freedom from threats that condition the lack of means of subsistence and housing in various life circumstances.

Ensuring social security, which is associated with the role of the social worker in managing staff, requires effective use of Appreciative Inquiry. In this context, it becomes important to define the connection between the social worker's role as a manager and the need for conducting appreciative dialogue to ensure the aforementioned social security. In other words, for the social worker to effectively manage the staff and support those in need, it becomes crucial to skillfully appreciate—i.e., an appreciative dialogue that helps social workers engage more effectively in their work and better support their clients. Without this, appropriate management and the implementation of social tasks might be less effective. The appreciative inquiry in management is becoming increasingly popular because it allows building on positive experiences and engaging employees in transformational processes.

For a social worker as a manager of social services, appreciative dialogue is also connected to motivational interviewing, which appears as the primary and most determining tool of action. In social work, it is interpreted as "an innovative approach (...) promoting a model of using social assistance that strengthens the client's internal motivation to act and repeat efforts to find a way out of difficult situations" (Jaraczewska & Krasiejko, 2012, p. 39). The understanding of motivational dialogue in social work takes on at least three meanings: "a collaborative style of conversation aimed at strengthening a person's own motivation and commitment to change" (Miller & Rollnick, 2014, p. 32), "a person-centered way of helping in relation to the common problem of ambivalence towards change" (Miller & Rollnick, 2014, p. 44), and "a collaborative, goal-oriented way of communication, focusing particularly on the language of change" (Miller & Rollnick, 2014, p. 54).

Managing a team of employees requires proper appreciation of each professional group. Effective motivation translates into a positive attitude toward work, which ensures that employees perform their duties diligently and carefully (Kowalczyk & Białas, 2020). Every manager should develop a method of motivating employees so that they treat their work not only as a source of livelihood but also find satisfaction in it. Proper handling of the team helps unlock their potential, enabling them to demonstrate creativity, innovation, and commitment to the tasks at hand. It is, therefore, the task of the manager, leader, or director of an institution to create conditions based on their knowledge that will effectively motivate the team to work (Mazur, 2013, p. 156).

1.1. The importance and application of Appreciative Inquiry in the work of a social service manager

Appreciative discourse plays a central role in Appreciative Inquiry (AI) methodology, which was developed in the 1980s by David Cooperrider and Suresh Srivastva. In understanding this concept, it is crucial to recognize two meanings. First, Appreciative understood as the act of recognizing the best in people or the surrounding world, finding confirmation of past and present strengths, bringing out successes and potentials. Second, Inquiry identified with exploration, discovery, asking questions, being open to seeing potentials and opportunities (Cooperrider & Whitney, 2005, pp. 156-182). Thus, AI can be considered a kind of methodological stance based on a specific approach to studying and changing organizations, going far beyond the technique or tool itself, and representing a set of beliefs and practices focusing on the positive aspects, opportunities and strengths of organizations.

In simple terms, an appreciative approach can be described as "a method of researching and reflecting on change in social systems (groups, organizations, communities) that advocates collective insights into what works best in order to envision how things could be, in order to collectively design

a desired future state that proves so irresistible that no encouragement, coercion or persuasion is needed for the planned changes to occur” (Bushe, 2013, pp. 41-44).

The way to positively channel an organization's energy to meet new challenges is to build on recognition and celebration of its key strengths and capabilities. Appreciative Inquiry is a unique approach that views “the glass as half full, not half empty” (Lewis & Van Tiem, 2004).

A key element of AI is an organization's “positive core” (Positive Core), which consists of, among other things, future and current achievements, strategic capabilities, technical and financial assets, breakthrough innovations, elevated thoughts, the collective wisdom of people, best business practices, leadership capabilities, cultivated values and traditions, relational resources, collective community spirit, positive emotions, social capital and visions of a positive future, and even customer loyalty and business partnerships (Cooperrider & Whitney, 2005, pp. 8-9).

Positive transformation within AI is based on the 4-D model, which describes the process of making organizational changes based on the positive aspects and strengths of the organization. The cycle consists of the following phases:

- Discovery- the first step is to mobilize the entire organizational system and involve all members of the organization in identifying the best experiences, successes and strengths. At this stage, participants in the process discover what works well and what constitutes the positive core of their organization;
- Dream- participants spin a vision about the organization's ideal future, imagining how the discovered potential (the discovery occurred in the Discovery phase) can lead to the development of the organization's strengths and its growth;
- Design- concrete action plans are created that will make it possible to transform the vision (created in the Dream phase) into reality. At this stage, work takes place on designing new organizational systems and structures that will make possible what has so far been in the realm of dreams;
- Destiny- the final step of the process is the realization of the vision, i.e. the implementation of the designed changes, their consolidation and the creation of a new dimension of the organization based on them, which is open to development and the achievement of positive results (Cooperrider & Whitney, 2005, p. 16).

The positive core of an organization is thus constructed through all phases of the 4-D cycle. In the Discovery phase, it is Discovered, Dream- Enlisted, Design- Designed, Destiny- Implemented (Cooperrider & Whitney & Stavros, 2008, pp. 34-35).

At the core of the Appreciative Inquiry (AI) philosophy are five key principles that are designed to help an organization and its leaders achieve lasting, sustainable and positive change. Through these tenets, an organization has the opportunity to transform, increase employee engagement and create a positive and effective work culture (Cooperrider & Whitney & Stavros, 2008, p. 8).

The first principle of constructivism (The Constructionist Principle) assumes that social and organizational realities are interconnected and created through interaction and conversation. How we speak about an organization impacts its reality, meaning that positive conversations construct a positive future. Being a leader of good change is inherently linked to the art of analyzing the organization and understanding it as a living, human construct (Cooperrider, Whitney, & Stavros, 2008, p. 8). This principle relates to the social constructivism theory developed by Peter L. Berger and Thomas Luckmann, which explains how social reality is constructed through continuous exchange of interactions, communication, and the shared meanings individuals assign to their experiences. According to this theory, reality does not exist objectively and independently of humans, but is created through social and cultural processes (Berger & Luckmann, 1966, pp. 43-61). According to this principle, a social services manager becomes, in a sense, a leader of good change, who, by engaging in dialogue with the team and stakeholders, shapes the organization's reality. Thus, it is created through the process of interaction, which positively impacts support for those in need.

The second principle, the Principle of Simultaneity, states that change begins with a question, which serves as the foundation for what we learn. The question plays a key role in Appreciative Inquiry (AI), as it leads to contemplation and reflection, which drive change. The process of asking questions is, therefore, part of the change process (Cooperrider, Whitney, & Stavros, 2008, p. 9). In the context of a social services manager's work, the process of asking questions is particularly important. Properly asked questions increase the chances of extracting more information, leading to a deeper diagnosis and ultimately resulting in change.

The third principle, the Poetic Principle, refers to the metaphor of the organization as an "open book." The relationship between poetry and the organization is based on the possibility of continuous reinterpretation and rediscovery, with the present and future serving as sources of inexhaustible knowledge and inspiration. The founders of the principles state that in this case, the perspective is broad and can focus on the nature of alienation or the joy of being part of a community within the organization (Cooperrider, Whitney, & Stavros, 2008, p. 9). Thanks to this principle, a social services manager can create an organization open to change, support an atmosphere of free development, and strengthen a sense of belonging and community.

The fourth principle, the Anticipatory Principle, acknowledges that actions are shaped by images of the future, and if these images are positive, they motivate achieving the desired outcomes. Organizations exist because the people who lead and maintain them share a common vision of what the organization is, how it will function, what it will achieve, and what it will become (Cooperrider, Whitney, & Stavros, 2008, p. 9). In the work of a social services manager, this principle also finds reflection, as visions of the organization's future help shape strategic goals in the social care sector. Guided by a positive vision of the future, the manager inspires the team, supports them in realizing ambitious goals, and ultimately contributes to improving the quality of life in the community.

The fifth principle, the Positive Principle, considered the most concrete, emphasizes that positive emotions and engagement are the "driving force" behind long-lasting and effective changes. Focusing on positive aspects, such as hope, inspiration, and joy, leads to greater creativity and effectiveness in achieving intended goals (Cooperrider, Whitney, & Stavros, 2008, pp. 9-10). In the work of a social services manager, applying this principle also seems obvious. By promoting a culture based on positive emotions, the manager can inspire employees to innovate and achieve better results in working with those in need.

These principles were expanded upon in the book *The Power of Appreciative Inquiry* by Diana Whitney and Amanda Trosten-Bloom. The authors introduced three additional principles that, in their view, help better understand AI and the potential application of this approach in various contexts and communities. The principles highlighted by the researchers are outlined below.

The Wholeness Principle, which encompasses the "experience of wholeness," focusing holistically on the system and emphasizing the importance of collaboration and integration of all members of the organizational community in the change process (Whitney & Trosten-Bloom, 2010, p. 66). In the work of a social services manager, having a comprehensive view of the situation and ensuring the coherence of actions is crucial. A leader, guided by this principle, ensures that each team member feels like an integral part of the organization and has an influence on its development. This also translates into achieving the shared goals of the organization and complementary actions aimed at improving social services.

The Enactment Principle, according to which change occurs by living in the present through the vision of what we desire in the future. The authors refer to M. Gandhi's statement: "Be the change you wish to see." In other words, change begins when members of the organization start acting in alignment with the new vision or values they wish to implement (Whitney & Trosten-Bloom, 2010, p. 68). A social services manager implementing a new organizational vision should not only set goals but also take actions aligned with the values they want to make central in their work.

The Free-Choice Principle, which asserts that organizations develop when their members have broad freedom of choice. Creating a democratic work environment involves treating people as

volunteers, as voluntary participation and the freedom to choose the mode of action lead to increased responsibility and individual engagement (Whitney & Trosten-Bloom, 2010, p. 71). In the context of a social services manager's work, this principle can be applied when the leader allows employees to choose their methods of work. The awareness of this choice increases initiative, strengthens engagement, and supports the effectiveness of social support efforts.

These principles can be applied in various organizations, not only in business but also in healthcare, public administration, the social services sector (as proposed above), and education. One example in the education field is the use of AI as a pedagogical tool to support development and change in the context of business schools (Grandy & Holton, 2010). Another example, from a more niche application of AI principles, can be found in the work of researcher and practitioner Maureen Sullivan, who focuses on implementing Appreciative Inquiry principles to create a positive organizational culture in library environments (Sullivan, 2004). To adapt the philosophy of AI to the specific context of libraries, M. Sullivan identified and described eight principles of Appreciative Inquiry (AI) to adjust D. Cooperrider's assumptions to her research contexts (Sullivan, 2004).

Another example could be the use of Appreciative Inquiry (AI) as a tool for conducting interviews in field research, carried out by Sarah Michael, which focused on non-governmental organizations (NGOs) in Africa. According to the researcher, interview participants, who were NGO directors, were more likely to provide detailed and valuable information about organizational activities and their own work when the appreciative approach was applied (Michael, 2005).

Another example of using the appreciative approach comes from studies conducted by Italian researchers, including those at the University of Padua. Their work examined the application of AI among employees of care homes. The research revealed that the appreciative approach had a positive impact on work well-being, task management, and interpersonal relationships. As a result, healthcare services were improved, and the quality of services provided was enhanced, including in a social dimension (Dal Corso et al., 2021). In this article, the authors refer to the assertions made by Chris Laszlo and colleagues (Dal Corso et al., 2021), emphasizing that global challenges, such as the COVID-19 pandemic and climate change, can be catalysts for positive transformation within organizations. By implementing positive appreciation, organizations can not only overcome crises and strengthen their market position but also shift towards more sustainable and socially responsible practices (Laszlo, Cooperrider, & Fry, 2020).

Social security and appreciative discourse are closely linked in the work of a social services manager. Social security refers to providing stable working conditions and support to employees, which is crucial for their well-being. In contrast, appreciative inquiry promotes a positive management approach, focusing on team strengths. A manager applying AI strengthens employee engagement and motivation, which, combined with social security, creates an environment conducive to effectiveness and job satisfaction. Integrating these two approaches helps build trust, improve relationships, and foster a positive organizational culture, which is essential in the social services sector.

Appreciative discourse is grounded in positive psychology, especially in the context of organizational change management. This subdiscipline was developed by Martin Seligman, who formulated its key principles in the late 1990s. "Positive psychology studies subjective experiences (such as happiness, pleasure, gratification, fulfillment, well-being), positive individual traits (such as character, talent, interests, values), and positive institutions (such as family, school, business, community, society), which enable the existence of positive traits and experiences" (Peterson & Seligman, 2003). Instead of focusing solely on treating disorders and negative emotions, positive psychology examines what makes individuals and communities thrive and grow. As a result, positive psychology addresses areas directly related to appreciation and recognition, such as research on positive emotions, character strengths, positive deviations, and positive social relationships (Lewis et al., 2016). Positive emotions, which form the foundation of positive psychology, also impact resilience and effective functioning (Lewis, Passmore, & Cantore, 2016). In the context of social services

management, where supporting vulnerable groups is often a priority, an approach based on triggering positive emotions can lead to better outcomes in providing social support. This is also an important aspect of skillfully appreciating positive deviations—behaviors that deviate from widely accepted social norms, leading to better results when working with individuals in need of support.

The work of a social services manager is also linked to Appreciative Leadership, defined as "the relational ability to mobilize creativity and potential and the skill to translate this into positive energy that strengthens trust, brings energy, enthusiasm, and enhances performance" (Whitney, Trosten-Bloom, & Rader, 2010). This definition assumes the existence of four key ideas: first, appreciative leadership practices are relational; second, they are positive and affirm life; third, such leadership has the ability to transform potential into positive results; and fourth, it contributes to change (Whitney & Trosten-Bloom, 2016). Referring to this, it can be stated that appreciative leadership also plays an important role in the work of a social services manager, who leads teams in challenging conditions, often dealing with limited human resources and emotional burdens. This makes it essential for social services managers to focus on appreciating employees' strengths and building on them to achieve success in the social sector.

In creating positive change, the strength of the entire organization working together towards sustainable solutions in the face of global challenges is essential (Sulkowski, Kolasinska-Morawska, Morawski & Seliga, 2021). "The best qualities of human systems are most naturally revealed... when people collectively experience the whole of their system, when strength amplifies strength, in configurations of appropriate and engaged stakeholders—both internal and external" (Cooperrider & McQuaid, 2012). In this context, the social services manager plays a key role, as in addition to coordinating actions within the organization, they must also ensure social security, which forms the foundation of the entire system's stability. Only when employees and stakeholders have guaranteed basic social needs, such as job security and healthcare, can full engagement and effective collaboration toward sustainable solutions be achieved.

2. Methodology

The results presented in this article pertain to research conducted among the employees of the Social Services Centre (CUS) in Tarnow. The main goal (CG) of the research was to determine the role of social security and appreciative discourse in the work of social services managers. To achieve this goal, several specific objectives were set. These included: determining the role of appreciative discourse in the work of social services managers (CS1), identifying the most frequently practiced tasks of social services managers in their daily work (CS2), defining the goals of the social security being implemented (CS3), and identifying areas that pose a threat to the implementation of social security measures (CS4).

To achieve the stated objectives, a main research question and detailed research questions were formulated. Main Question (PG): What role does social security and appreciative discourse play in the work of social services managers? Detailed Questions (PS): What role does motivational dialogue play in the work of social services managers (PS1)? What are the most frequently practiced tasks of social services managers in their daily work (PS2)? What is the most important goal of the implemented social security (PS3)? Which areas pose a threat to the implementation of social security measures (PS4)?

The research used quantitative methods to determine the scale of the phenomenon under study. The technique employed was a survey, with the research tool being a self-designed questionnaire, conducted using the CAWI technique (data collection using an online questionnaire). This enabled quick access to the study group. The questionnaire was anonymous, consisting of 11 closed-ended questions (single and multiple-choice), and concluded with a demographic section. The sample selection was purposive and exhaustive, as all CUS employees in Tarnow participated in the study, totaling 52 social services managers.

Analyzing the profile of the participants, most were women (94.2%), aged up to 35 years (38.5%), with higher education, and had been working as social workers for up to 5 years (38.5%). Most were married (65.4%), generally expressed satisfaction with their work as social workers (42.3%), and would rather recommend working at CUS in Tarnow to their family/friends if necessary (34.6%). Detailed breakdowns are presented in Table 1.

Table 1. Sociodemographic Profile of Respondents (data in numbers and %).

Respondent Profile		n	%	Respondent Profile		n	%	n
Gender	Female	49.00	94.20	Job Satisfaction as a Social Worker	Definitely dissatisfied	3.000		5.800
	Male	3.000	5.800		Rather dissatisfied	4.000		7.700
Age	Up to 35 years	20.00	38.50		Hard to say	14.00		26.90
	36-45 years	17.00	32.70		Rather satisfied	22.00		42.30
	Over 45 years	15.00	28.80		Definitely satisfied	9.000		17.30
Education	Secondary	9.000	17.30	Recommendation of the job in the Social Services Center in Tarnow to family/friends	Definitely not	4.000		7.7000
	Higher	43.00	82.70		Rather not	10.00		19.20
Work Experience	Up to 5 years	20.00	38.50		Hard to say	13.00		25.00
Marital Status	6-20 years	19.00	36.50		Rather yes	18.00		34.60
	Over 20 years	13.00	25.00		Definitely yes	7.000		13.50
Marital Status	Married	34.00	65.40			Total		
	Unmarried	18.00	34.60			52.00		100.00

Source: Authors' own work.

Statistical calculations were performed using the SPSS Statistics software, while the application of Pearson's Chi-square test of independence, Pearson's correlation r , Student's t -test, and ANOVA analysis allowed for the identification of statistically significant relationships between different groups of variables.

3. Research results

In the initial stage of the research, employees of the Social Services Center in Tarnow were asked to identify the most important roles that, in their opinion, Appreciative Inquiry discourse plays in the work of a social services manager. The frequency analysis revealed that respondents most often pointed to boosting self-esteem by focusing on an individual's strengths, skills, and past achievements, with 57.7% of responses indicating this role. Over half of the respondents also highlighted the importance of determining the steps an individual can take to achieve their set goals and developing skills to cope with challenges or difficulties that may arise during goal realization, with 55.8% and 51.9% respectively. On the other hand, respondents less frequently identified roles such as stimulating individual reflection by considering personal goals, values, and priorities (25% of responses), as well as creating commitments to specific actions, which are crucial for maintaining engagement and appreciation in action (15.4% of responses). Detailed breakdowns are presented in Table 2.

Table 1. The Most Important Roles of Appreciative Inquiry in the Work of a Social Services Manager According to Respondents (data in %).

Roles of Appreciative Inquiry in the Work of a Social Services Manager	Indicate	
	Yes	No
Enhancing self-esteem by focusing on an individual's strengths, skills, and past achievements.	57.70	42.30
Defining the action steps that an individual can take to achieve their set goals.	55.80	44.20
Developing skills to cope with challenges and difficulties that may arise during goal realization.	51.90	48.10
Creating awareness of goals, helping to understand what objectives one aims to achieve.	48.10	51.90
Building relationships and an atmosphere of support between the social services manager and the individual.	30.80	69.20
Stimulating individual reflection by considering personal goals, values, and priorities	25.00	75.00
Creating commitments to specific actions, which is essential for maintaining engagement and appreciation in action.	15.40	84.60

Note: N = 52.

Source: Authors' own work.

When examining the relationship between the key roles of Appreciative Inquiry in the work of social services managers and the respondents' profiles, only one statistically significant correlation was found. It appears that the more respondents were willing to recommend working at the Center for Social Services (CUS) in Tarnow to family or friends, the more likely they were to agree that a key role of AI is enhancing self-esteem by focusing on an individual's strengths, skills, and past achievements (r -Pearson = 0.439, p = 0.001).

In the next part of the survey, respondents were asked to rate the frequency of various tasks performed by social services managers in their daily work on a five-point Likert scale. A rating of "1" indicated a frequency of once a year or less, while "5" indicated once a week or more. Among the tasks assessed, respondents most frequently cited promoting healthy lifestyles, independence, and social skills—average rating of 2.35. Other frequently performed tasks included actions aimed at eliminating social inequalities and coordinating efforts during crises or emergency social situations—average ratings of 2.06 and 2.04, respectively. On the other hand, tasks like recruiting, training, and managing social workers and other social services specialists (average rating of 1.65), creating new social programs in response to changing community needs (average rating of 1.65), and implementing innovative projects to improve effectiveness (average rating of 1.63) were rated as much less frequent. Detailed data can be found in Table 3.

Table 3. Frequency of Practicing Social Services Manager Tasks in Daily Work According to Respondents' Opinions (data in %).

Frequency of Practicing Social Services Manager Tasks in Daily Work	1	2	3	4	5	Aver.
Promoting a healthy lifestyle, independence, and social skills	32.70	28.80	21.20	5.800	11.50	2.350
Taking actions to eliminate social inequalities	50.00	21.20	13.50	3.800	11.50	2.060
Coordinating actions in the event of crises or emergency social events	50.00	19.20	15.40	7.700	7.700	2.040
Building and maintaining partnerships with non-governmental organizations, public institutions, and the private sector	46.20	25.00	17.30	5.800	5.800	2.000
Preparing reports on activities, results, and funding of social services	59.60	15.40	7.700	5.800	11.50	1.940
Ensuring effective coordination of various teams and social services within the organization	50.00	25.00	17.30	3.800	3.800	1.870
Conducting regular evaluations and analyses of the effectiveness of delivered social services	55.80	19.20	15.40	1.900	7.700	1.870
Analyzing and identifying social problems in the community and developing strategies to solve them	59.60	15.40	15.40	1.900	7.700	1.830
Organizing educational programs for the community to raise awareness about available social services	63.50	11.50	17.30	3.800	3.800	1.730
Developing and managing the budget for social services	63.50	15.40	13.50	1.900	5.800	1.710
Assessing staff performance and adjusting tasks to individual skills	61.50	19.20	13.50	1.900	3.800	1.670
Developing long-term strategies and action plans for social services	61.50	19.20	13.50	1.900	3.800	1.670
Recruiting, training, and managing social workers and other social service specialists	67.30	13.50	11.50	1.900	5.800	1.650
Creating new social programs in response to the changing needs of the community	65.40	15.40	13.50	0.000	5.800	1.650
Implementing innovative projects for better effectiveness of actions	63.50	21.20	9.600	0.000	5.800	1.630

Note: N = 52; 1 – once a year or less often; 2 – several times a year; 3 – several times a month; 4 – several times a week once; 5 – a week or more frequently; Aver. – average.

Source: Authors' own work.

When making between-group comparisons regarding the frequency of practicing individual tasks of a social services manager in their daily work, it can be observed that male respondents significantly more often indicated the preparation of reports on actions, results, and funding of social services (mean = 3.67 compared to 1.84 for women, t -Student = -2.276, p = 0.027), as well as the coordination of actions in the event of crisis situations or urgent social events (mean = 3.67 compared to 1.94 for women, t -Student = -2.334, p = 0.024).

Interesting conclusions can be drawn from comparing the two previous questions. The Pearson correlation showed that the more often respondents indicated that the most important role of appreciative discourse in the work of a social services manager is to develop skills in coping with adversity and difficulties that may arise during the achievement of set goals, the less frequently they practiced in their daily work ensuring effective coordination of various teams and social services in the organization ($r\text{-Pearson} = -0.300$, $p = 0.031$), conducting regular assessments and analyses of the effectiveness of delivered social services ($r\text{-Pearson} = -0.330$, $p = 0.017$), building and maintaining partnerships with non-governmental organizations, public institutions, and the private sector ($r\text{-Pearson} = -0.360$, $p = 0.009$), and promoting a healthy lifestyle, independence, and social skills ($r\text{-Pearson} = -0.277$, $p = 0.047$).

Employees of the Social Services Center in Tarnow who participated in the study were also asked whether there are areas where they need additional support or training. In this case, nearly a quarter of respondents (23.1%) answered affirmatively. Among them, training on working with people with mental disorders, cooperation with non-governmental organizations, agreements and protocols, and working with people with mental illnesses were mentioned. On the other hand, one in five respondents disagreed, stating they did not need such support or training (19.2%). Furthermore, more than half of the respondents (57.7%) had difficulty providing a clear answer in this area. Detailed breakdowns are presented in Table 4.

Table 4. The Need for the Introduction of Areas Requiring Additional Support or Training in the Work of a Social Services Manager, According to Respondents (data in %).

The Need for the Introduction of Areas Requiring Additional Support or Training in the Work of a Social Services Manager	n	%
Yes	12.00	23.10
No	10.00	19.20
Difficult to say	30.00	57.70
Total	52.00	100.00

Note: N = 52.

Source: Authors' own work.

When comparing the issue of the need for additional support or training with the variables defining the respondent profile, no statistically significant relationships were found ($p > 0.05$).

In the open-ended question, respondents were asked to provide answers to the question: What challenges related to social services management do they see in their workplace from the perspective of a social worker? The most frequently mentioned challenges included: lack of continuous contact with social service providers, insufficient internal team communication, too few places for people seeking social services, lack of an adequate system for gathering information, lack of financial resources, adapting social services to the changing needs of clients, motivating people to cooperate, challenges related to disabilities, and limited cooperation between social workers and the coordinator of individual social service plans.

An important element of the study was also determining the most important goals related to the implementation of social security. The frequency analysis revealed that the most frequently mentioned response was ensuring access to basic needs such as food, housing, clothing, and healthcare (67.3% of responses). About one in three respondents also pointed to creating conditions for full social integration for marginalized groups, such as people with disabilities, migrants, and the homeless (34.6%), reducing social inequalities by eliminating economic and social barriers (32.7%), poverty reduction and elimination through social programs (32.7%), and ensuring access to healthcare and preventive measures (32.7%). The least frequently mentioned goal of social security was ensuring equal access to high-quality education for all, regardless of economic or social status, which received 13.5% of responses. Detailed breakdowns are presented in Table 5.

Table 5. The Most Important Goals in the Area of Social Security in the Opinion of Respondents (data in %).

Goals in the Area of Social Security	Yes	No
Ensuring access to basic needs such as food, housing, clothing, and healthcare	67.30	32.70
Creating conditions for full social integration for marginalized groups, such as people with disabilities, migrants, or homeless individuals	34.60	65.40
Striving to reduce social inequalities by eliminating economic and social barriers	32.70	67.30
Reducing and eliminating poverty through the introduction of social programs	32.70	67.30
Guaranteeing access to healthcare and preventive measures	32.70	67.30
Ensuring safe and decent working conditions, protecting workers' rights, and providing support for individuals affected by unemployment	25.00	75.00
Striving to eliminate all forms of discrimination and social injustice to ensure equal opportunities and rights for everyone	23.10	76.90
Enabling a dignified pension for the elderly to ensure stable living conditions after the end of their professional career	21.20	78.80
Ensuring equal access to high-quality education for all, regardless of economic or social status	13.50	86.50

Note: N = 52.

Source: Authors' own work.

Upon reviewing the detailed summaries regarding the most important goals related to social security, it appears that individuals with higher education more frequently indicated the provision of access to basic needs, such as food, housing, clothing, and healthcare (74.4% vs. 33.3% among individuals with secondary education, chi-square=5.709, $p=0.017$). On the other hand, those with secondary education were more inclined to focus on reducing and eliminating poverty through the introduction of social programs (77.8% vs. 22.3% among individuals with higher education, chi-square=10.054, $p=0.002$). Furthermore, individuals who were not married more frequently stated that the goal of social security was to ensure equal access to high-quality education for all, regardless of economic or social status (27.8% vs. 5.9% among married individuals, chi-square=4.843, $p=0.028$). The more often respondents were willing to recommend working at the CUS in Tarnow to family and friends, the more likely they were to agree that a goal of their work was to create conditions for the full social integration of marginalized individuals, such as those with disabilities, migrants, or the homeless (r -Pearson=0.288, $p=0.039$).

Finally, it is worth reviewing the respondents' answers related to areas that pose a threat to the implementation of social security actions on a national and international scale from the perspective of a social worker. Once again, respondents were asked to express their opinions on a five-point Likert scale, where a rating of 1 indicated a very small threat, and a rating of 5 indicated a very large threat. The analysis showed that the most frequently indicated threat was the aging of society and demographic changes that could increase the burden on pension and healthcare systems, with an average rating of 4.29. Respondents also frequently indicated the growing threat posed by an increase in the number of migrants and the need for social integration, which may present challenges for social systems, with an average rating of 3.94. In contrast, respondents were less likely to identify threats such as the automation and restructuring of the labor market, which could lead to cost savings and increased unemployment, and weather phenomena related to climate change, which could increase the risk of poverty and food insecurity, with average ratings of 3.52 and 3.31, respectively. Detailed summaries are presented in Table 6.

When comparing the groups regarding areas that pose a threat to the implementation of social security actions on a national and international scale from the perspective of a social worker, it was observed that individuals with higher education more frequently indicated changes in political directions regarding public expenditure cuts (average 3.91 vs. 3.11 among those with secondary education, t -Student=-2.541, $p=0.011$), weather phenomena related to climate change that may increase the risk of poverty and food security (3.49 vs. 2.44 among those with secondary education, t -Student=-2.538, $p=0.014$), as well as pandemics and health crises that may increase the need for social

support and require adjustments to social programs in response to changing health conditions (3.91 vs. 2.67 among those with secondary education, $t\text{-Student}=-3.048$, $p=0.004$).

Table 6. Areas Threatening the Implementation of Social Security Actions on a National and International Scale from the Perspective of Social Workers, According to Respondents (data in %)

Areas Threatening the Implementation of Social Security Actions on a National and International Scale from the Perspective of Social Workers	1	2	3	4	5	Aver.
Aging of the population and demographic changes that could increase the burden on pension and healthcare systems	1.900	3.800	5.800	40.40	48.10	4.290
Increase in the number of migrants and the need for social integration, which may pose challenges for social systems	1.900	1.900	26.90	38.50	30.80	3.940
Lack of sufficient financial resources to effectively implement social programs	9.600	1.900	17.30	34.60	36.50	3.870
Economic crises and instability in financial markets that could affect countries' ability to fund social programs and provide financial support to those in need	1.900	1.900	28.80	44.20	23.10	3.850
Changes in political directions regarding public spending limitations	1.900	5.800	25.00	48.10	19.20	3.770
Increase in social inequalities that could threaten the effectiveness of social actions	1.900	7.700	30.80	36.50	23.10	3.710
Pandemics and health crises that could increase the need for social support and require adjustments to social programs to changing health conditions	5.800	9.600	26.90	25.00	32.70	3.690
Technological progress that carries the risk of social exclusion for people who cannot access modern technologies	1.900	9.600	32.70	30.80	25.00	3.670
Automation and restructuring of the labor market, which could lead to cost savings in labor and an increase in unemployment	3.800	9.600	36.50	30.80	19.20	3.520
Weather phenomena related to climate change that could increase the risk of poverty and food security	7.700	13.50	40.40	17.30	21.20	3.31

Note: N = 52; 1 – very small threat; 2 – small threat; 3 – hard to say; 4 – large threat; 5 – very large threat; Aver. – Average

Source: Authors' own work.

Additionally, an increase in social inequalities that may threaten the effectiveness of social actions was more frequently indicated by individuals with less than 5 years of experience at the CUS (average 4.20 compared to 3.32 among those with 6-20 years of experience, $ANOVA=4.918$, $p=0.00411$). Meanwhile, individuals who were not married more often pointed to weather phenomena related to climate change that could increase the risk of poverty and food insecurity (3.83 vs. 3.03 among married individuals, $t\text{-Student}=-2.448$, $p=0.018$).

Interesting conclusions were drawn by comparing the most important goals related to social security and areas that pose a threat to the implementation of social security actions on a national and international scale from the perspective of a social worker. It appears that the more frequently respondents considered providing a decent pension for the elderly to ensure stable living conditions after career completion as an important goal, the less the threat posed by aging societies and demographic changes that could increase the burden on pension and healthcare systems ($r\text{-Pearson}=-0.275$, $p=0.048$), an increase in social inequalities threatening the effectiveness of social actions ($r\text{-Pearson}=-0.478$, $p=0.000$), and technological progress posing a risk of social exclusion for those unable to use modern technologies ($r\text{-Pearson}=-0.390$, $p=0.004$). On the other hand, the more respondents considered eliminating all forms of discrimination and social injustice to be an important goal of social security, the greater the threat posed by insufficient financial resources for the effective implementation of social programs ($r\text{-Pearson}=0.287$, $p=0.039$), an increase in the number of migrants and the need for social integration, which may pose challenges to social systems ($r\text{-Pearson}=0.286$, $p=0.040$), and weather phenomena related to climate change that may increase the risk of poverty and food insecurity ($r\text{-Pearson}=0.285$, $p=0.040$).

4. Discussion

It is important to emphasize that the conducted research indicates the existence of several areas where improvements can be made in the work of social services managers. Training programs for social workers should be strengthened (Dacko-Pikiewicz & Walancik, 2016), focusing on appreciative discourse. Investing in workshops to develop interpersonal and technical skills could bring measurable benefits. Additionally, in the context of promoting a healthy lifestyle, educational activities and social campaigns supporting independence and social skills among social service clients should be introduced.

Referring to the area of social security and motivational dialogue, Lesniak-Berek (2020) points out that a key aspect of direct social work is dialogue, whose important elements are openness and attentiveness toward the individual. These qualities enable a deeper understanding of the personal meanings behind the difficulties experienced by clients. Moreover, motivational dialogue, focused on fostering internal motivation for change, is a fundamental element of modern active social policy. In this model, the client is no longer treated as a passive recipient of material support; instead, greater emphasis is placed on working on internal motivation. This approach bridges the gap in client interaction, enabling more effective assistance in pursuing change.

Social security systems are the foundation for combating poverty, inequality and social exclusion. The topic of the pandemic, such as COVID-19, is also part of this (Kulikowski, Przytuła & Sułkowski, 2022). It also creates many challenges, as exemplified by e-learning (Kulikowski, Przytuła & Sułkowski 2021). Social service managers have a key role in translating public policies into practice, which means not only complying with regulations, but also tailoring activities to the individual needs of beneficiaries. Effective management requires building partnerships with public institutions, NGOs and local communities to ensure that social security benefits reach those most in need (Taylor-Gooby, 2004).

In addition, the ability to effectively manage social security systems helps managers cope with resource pressures and financial constraints, which is referred to in the literature as “managing in times of scarcity” (Van de Walle & Lahat, 2021). In-depth knowledge of social security systems enables better defense of the interests of both customers and employees of the organization, leading to improved overall performance.

Research indicates that Appreciative Inquiry supports the building of a positive organizational culture, increasing employee satisfaction and reducing turnover (Reed, 2006). For example, instead of focusing solely on the barriers faced by customers, Appreciative Inquiry encourages the identification of examples of success and perseverance that can inspire future action. This approach increases the sense of empowerment among both customers and employees.

Combining social security with Appreciative Inquiry in the practice of social service management brings tangible benefits. A manager who combines knowledge of social security systems with an appreciative Appreciative Inquiry approach is better able to deal with the challenges of resource allocation, employee motivation and client empowerment. Research by Watkins et al. (2011) indicates that organizations using Appreciative Inquiry I in their social benefit delivery process have seen an increase in customer satisfaction. These results confirm that a strengths-based approach increases the sense of dignity and autonomy in dealing with the social security system.

However, it is worth noting that the integration of social security and Appreciative Inquiry also faces some difficulties. Rigid bureaucratic frameworks can limit the flexibility needed to apply Appreciative Inquiry, and implementing this methodology in resource-limited environments requires significant time and effort for training (Grant & Humphries, 2006).

In the face of the growing number of migrants and the need for their integration, it is essential to develop programs that support multiculturalism and counteract discrimination. Cooperation with non-governmental organizations and local institutions can significantly contribute to better social integration.

Moreover, regular analyses of demographic structure and the aging society should be crucial for adapting social support systems. Pension and health programs must be developed to address demographic changes.

Social security and appreciative discourse share a common ground, which is improving the quality of life for individuals and supporting society as a whole. In this context, appreciative discourse addresses the increasing social challenges, such as migrant integration and an aging society, which require understanding the specific needs of social service recipients. Appreciative approaches, focusing on strengths rather than analyzing barriers and limitations, can lead to the development of a new strategy for integrating migrants, based on treating cultural differences as a social resource. Furthermore, the role of mutual support, understanding, and openness to innovation is practically significant, translating into the ability to cope with difficulties and social changes. In the long term, appreciative discourse can enhance the engagement of social services managers and strengthen the overall effectiveness of the social support sector.

An important step is also the implementation of a monitoring and evaluation system to assess the effectiveness of actions taken by social services managers, which would allow evaluating their impact on social security. Regular assessments of program effectiveness will enable modifications in response to changing needs. Finally, promoting cooperation between the public, private, and non-profit sectors is essential for creating integrated support programs that will be more effective in responding to social security challenges.

Implementing these recommendations could significantly improve the quality of social services and the effectiveness of managers' actions, ultimately contributing to better support for those in need in various social contexts.

Conclusions

Summarizing the results of the conducted research, it should be emphasized that the most important roles of the appreciative discourse in the work of social services managers are: enhancing self-esteem by focusing on an individual's strengths, skills, and past achievements (57.7% affirmative responses), outlining actions that the individual can take to achieve their set goals (55.8%), and developing skills to cope with challenges and difficulties that may arise during goal realization (51.9%).

The most frequently practiced tasks in the daily work of a social services manager are promoting a healthy lifestyle, independence, and social skills (mean = 2.35), taking actions to eliminate social inequalities (mean = 2.06), and coordinating activities during crisis situations or sudden social events (mean = 2.04).

When identifying areas where additional support or training is felt to be necessary, almost one-quarter of the respondents (23.1%) expressed a need for it, while 19.2% disagreed, stating they did not require such support or training. Moreover, more than half of the respondents (57.7%) had difficulties providing a clear response to this question.

Regarding social security and the most important goals resulting from its implementation, respondents most often pointed to ensuring access to basic needs such as food, housing, clothing, and healthcare (67.3%).

The areas that, according to respondents, pose the greatest threats to the implementation of social security actions on both a national and international scale from a social worker's perspective include: the aging of society and demographic changes that may increase the burden on pension and healthcare systems (mean = 4.29), and the increase in the number of migrants and the need for social integration, which may pose challenges to social systems (mean = 3.94).

The fact that the research was conducted only in Tarnow has several important implications. First and foremost, the results of this study may be specific to the local social, economic, and cultural conditions. For example, the demographic structure, economic situation, and local social policies in Tarnow can significantly influence the responses of the participants. Therefore, it is difficult to

generalize the results to other cities or regions without conducting similar studies in different contexts. Nevertheless, these results may provide valuable insights for local policymakers and organizations involved in social welfare, reflecting the unique challenges and needs of the Tarnow community. It would therefore be important to extend the research to other regions in the future to gain a broader picture of the situation. For social services managers working in Tarnow, the results could serve as an invaluable source of knowledge about the specific needs of this community. However, managers in other cities should be cautious when applying these results to their local contexts without first analyzing the local conditions. Conducting research in one location could also serve as a starting point for future comparisons. If the study is repeated in other cities, it will be possible to identify differences and similarities in the approach to social security and appreciative discourse. Finally, limiting the research to Tarnow may affect the potential for collaboration with other institutions and organizations operating in different regions. Cooperation and knowledge exchange with other locations could significantly enrich practice and the effectiveness of actions. In conclusion, while the research in Tarnow provides valuable information, it is important to treat its results as contextual and highlight the need for further studies in various locations.

It is also worth noting that appreciative discourse represents a valuable dimension in research related to the management of social services. Given the work of social services managers, this approach can help in building employee engagement and contribute to improving team relationships. The role of appreciative discourse in designing innovative solutions to meet the growing social needs is also noteworthy. Examples of such solutions could be support in promoting a healthy lifestyle or minimizing social inequalities. Appreciative discourse significantly impacts work effectiveness and can also strengthen employee morale, influencing the development of an organizational culture based on support and interpersonal relationships, which appear to be key in the work of social services managers. In this context, it is important to underline that implementing appreciative discourse can also lead to better alignment of social support activities with the needs of local communities.

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Reference:

1. Berger, P. L., & Luckmann, T. (1966). *The social construction of reality: A treatise in the sociology of knowledge*. Penguin Books.
2. Bushe, G. (2013). Appreciative inquiry model. In E. H. Kessler (Ed.), *Encyclopedia of management theory* (pp. 41–44). SAGE Publications.
3. Cooperrider, D. L., & McQuaid, M. (2012). The positive arc of systemic strengths: How appreciative inquiry and sustainable designing can bring out the best in human systems. *Journal of Corporate Citizenship*, 46, 71–102.
4. Cooperrider, D. L., Whitney, D., & Stavros, J. M. (2008). *Appreciative inquiry handbook: For leaders of change* (2nd ed.). Crown Custom Publishing; Berrett-Koehler Publishers.
5. Cooperrider, D. L., & Whitney, D. (2005). *Appreciative inquiry: A positive revolution in change*. Berrett-Koehler Publishers.

6. Dacko-Pikiewicz, Z., & Walancik, M. (2016). The economic or social dimension of lifelong learning. *Forum Scientiae Oeconomia*, 4(2), 13–25.
7. Dal Corso, L., De Carlo, A., Carluccio, F., Piccirelli, A., Scarcella, M., Ghersetti, E., & Falco, A. (2021). Make your organization more positive: The power of appreciative inquiry. *TPM*, 28(1), 47–63. <https://doi.org/10.4473/TPM28.1.4>
8. Domański, Z. (2017). Bezpieczeństwo socjalne. *Journal of Modern Science*, 2(33), 367–384.
9. Gierszewski, M. (2018). Bezpieczeństwo społeczne jako dziedzina bezpieczeństwa narodowego. *Historia i Polityka*, 23(30), 21–38. <https://doi.org/10.12775/HiP.2018.002>
10. Goryń, P. (2020). Bezpieczeństwo społeczne – jedno czy wiele? In D. Boćkowski, P. Goryń, & K. Gorynia (Ed.), *Bezpieczeństwo i jego percepcja w dyskursie społecznym i militarnym* (pp.47-61). Wydawnictwo Uniwersytetu w Białymstoku.
11. Grandy, G., & Holton, J. (2010). Mobilizing change in a business school using appreciative inquiry. *The Learning Organization*, 17(2), 178–194. <https://doi.org/10.1108/09696471011019880>
12. Grant, S., & Humphries, M. (2006). Critical Evaluation of Appreciative Inquiry: Bridging an Apparent Paradox. *Action Research*, 4(4), 401–418.
13. Jaraczewska, J. M., & Krasiejko, I. (2012). *Dialog motywujący w teorii i praktyce. Motywowanie do zmiany w pracy socjalnej i terapii*. Wydawnictwo "Adam Marszałek".
14. Kowalczyk, B., & Białas, A. (2020). Narzędzia motywacyjne w pracy socjalnej. *Praca Socjalna*, 3(35), 65–90. <https://doi.org/10.5604/01.3001.0014.3145>
15. Kulikowski, K., Przytuła, S., & Sułkowski, Ł. (2022). E-learning? Never again! On the unintended consequences of COVID-19 forced e-learning on academic teacher motivational job characteristics. *Higher Education Quarterly*, 76(1), 174–189. <https://doi.org/10.1111/hequ.12314>
16. Kulikowski, K., Przytuła, S., & Sułkowski, Ł. (2021). The motivation of academics in remote teaching during the Covid-19 pandemic in polish universities—Opening the debate on a new equilibrium in e-learning. *Sustainability*, 13(5), Article 2752. <https://doi.org/10.3390/su13052752>
17. Laszlo, C., Cooperrider, D., & Fry, R. (2020). Global challenges as opportunities to transform business for good. *Sustainability*, 12(19), Article 8053. <https://doi.org/10.3390/su12198053>
18. Leśniak-Berek, E. (2020). *Pomagając w zmianie: dialog motywujący w pracy socjalnej*. Uniwersytet Śląski.
19. Lewis, J., & Van Tiem, D. (2004). Appreciative inquiry: A view of a glass half full. *Performance Improvement*, 43(8), 19–24. <https://doi.org/10.1002/pfi.4140430807>
20. Lewis, S., Passmore, J., & Cantore, S. (2016). *Appreciative inquiry for change management: Using AI to facilitate organizational development* (2nd ed.). Kogan Page.
21. Łubiński, P. (2018). Bezpieczeństwo społeczne. In O. Wasiuta, R. Klepska, & R. Kopeć (Ed.), *Vademecum bezpieczeństwa* (pp. 147-153). Libron.
22. Mazur, M. (2013). Motywowanie pracowników jako istotny element zarządzania organizacją. *Nauki Społeczne Social Sciences*, 2(8), 156–182.
23. Michael, S. (2005). The promise of appreciative inquiry as an interview tool for field research. *Development in Practice*, 15(2), 222–230. <https://doi.org/10.1080/09614520500042094>
24. Miller, W. R., & Rollnick, S. (2014). *Dialog motywujący. Jak pomoc ludziom w zmianie*. Wydawnictwo Zielona Sowa.
25. Oliwkiewicz, B. (2023). Godziwe wynagrodzenie jako element bezpieczeństwa społecznego młodych pracowników. *Bezpieczeństwo. Teoria i Praktyka*, 4(LIII), 95–110. <https://doi.org/10.48269/2451-0718-btip-2023-4-006>
26. Peterson, C., & Seligman, M. E. P. (2003). Positive organizational studies: Lessons from positive psychology. In K. S. Cameron, J. E. Dutton, & R. E. Quinn (Ed.), *Positive organizational scholarship: Foundations of a new discipline* (pp. 14-27). Berrett-Koehler Publishers.
27. Reed, J. (2006). *Appreciative inquiry: Research for change*. Sage publications.

28. Rysz-Kowalczyk, B. (Ed.). (2002). *Leksykon polityki społecznej*. Oficyna Wydawnicza ASPRA-JR.
29. Sullivan, M. (2004). The promise of appreciative inquiry in library organizations. *Library Trends*, 53(1), 218–229.
30. Sułkowski, Ł., Kolasieńska-Morawska, K., Seliga, R., & Morawski, P. (2021). Smart learning technologization in the economy 5.0—The Polish perspective. *Applied Sciences*, 11(11), Article 5261. <https://doi.org/10.3390/app11115261>
31. Taylor-Gooby, P. (2004). *New Risks, New Welfare: The Transformation of the European Welfare State*. Oxford University Press.
32. Watkins, J. M., Mohr, B. J., & Kelly, R. (2011). *Appreciative Inquiry: Change at the Speed of Imagination*. Pfeiffer.
33. Whitney, D., & Trosten-Bloom, A. (2010). *The power of appreciative inquiry: A practical guide to positive change* (2nd ed.). Berrett-Koehler Publishers.
34. Whitney, D., & Trosten-Bloom, A. (2016). Appreciative leadership: Responding relationally to the questions of our time. *AI Practitioner*, 18(3), 61–68. <https://doi.org/10.12781/978-1-907549-28-1-10>
35. Whitney, D., Trosten-Bloom, A., & Rader, K. (2010). *Appreciative leadership: Focus on what works to drive winning performance and build a thriving organization*. McGraw-Hill.

Trade Resilience of Central and Eastern European Countries to the Shock Caused by the Russia-Ukraine War

Joanna Kos-Labedowicz ^{1*}, Sylwia Talar ²

¹ University of Economics in Katowice, Poland
ORCID: 0000-0002-9523-9609
e-mail: joanna.kos@ue.katowice.pl

² University of Economics in Katowice, Poland
ORCID: 0000-0002-4051-6453
e-mail: sylwia.talar@ue.katowice.pl

* Corresponding author: Joanna Kos-Labedowicz, joanna.kos@ue.katowice.pl

Abstract

The instability of the world economy in the 21st century demands that more interest be paid to the nature of emerging disruptions, their effects, and the ways to ensure the appropriate reactions of affected parties. Research on the economic resilience of various kinds is more prominent as a result, with certain exceptions—trade resilience studies are among those that require more attention, both theoretically, methodically, and empirically. Recent trade resilience studies have focused mostly on the effects of the shock caused by the COVID-19 pandemic, either on a global scale or a particular country scale. The goal of our study is to examine how the external shock caused by the Russia-Ukraine war influenced the trade resilience of Central and Eastern European (CEE) countries. The methodology used in our research is an elaboration on and modification of approaches used by previous studies on both economic and trade resilience. On the basis of statistical data from the period 2016–2023, we propose the original Trade Vulnerability Index (TVI), adapted for the shock originating from the Russia-Ukraine war. For the resistance index used for measuring CEE countries' trade resilience, we applied a known but not previously implemented approach. The obtained results showed that all CEE countries' trade was resistant to the disruption caused by the armed conflict in the initial year, with few exceptions (Baltic States and Poland) in the following (2023) period. Even the trade of countries with high TVI scores (Slovakia and Czechia) has proven to be resilient. The main theoretical contribution of this study is the confirmation of the lack of dependence between the vulnerability of trades to disruptions and their resistance to war in the example of war shock and CEE countries. The implications of the obtained results can be helpful in developing nation-specific policies to increase trade resilience and the effectiveness of structural changes.

Key words

trade resilience, trade vulnerability, external shock, Russia-Ukraine War, Central and Eastern European Countries, composite indices.

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Introduction

The instability of the world economy in the 21st century is determined not only by economic factors but also by natural and political shocks. These include, first and foremost, the COVID-19 pandemic, Russia's aggression against Ukraine, and the escalation of political tensions between the world's major powers and the conflict in the Middle East. Figure 1 shows the changes in the World Uncertainty Index in connection with phenomena that contribute to the growth of uncertainty and instability.

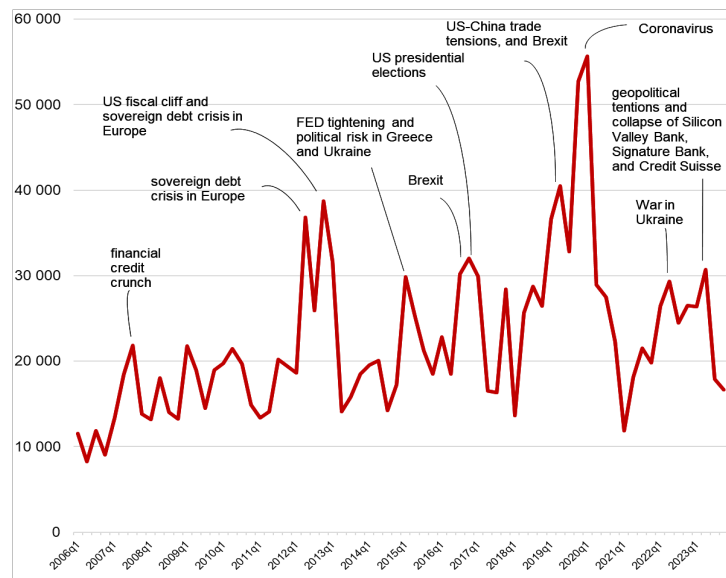


Figure 1. World Uncertainty Index 2006Q1 to 2023Q4.

Source: Ahir et al., 2022.

In turbulent, uncertain times, when rapid changes are taking place and violent shocks are occurring, the interest of both practice and science is focused on issues related to coping with these difficult times and building security and stable development (Atkinson et al., 2022), of which economic resilience is a part. Focusing our research on the nature of emerging shocks, their economic effects, the response of socioeconomic systems to them, and the factors determining their behaviour seems to further this common interest.

The economic shocks caused by the COVID-19 pandemic and the conflict in Ukraine have renewed the debate on the benefits and risks of international trade (Arriola et al., 2024). The situation of uncertainty has implications for international trade, which, under the current high degree of interdependence, is crucial for the development and even the normal functioning of entire national economies. Consequently, the resilience of foreign trade to disturbances has become a subject of particular interest. In the analysis of trade resilience, the main goal is to identify how shocks affect the functioning of trade and what dependencies exist in this process. Owing to the diverse natures (types) and scales of shocks, their impacts may also vary. On the other hand, individual economic systems, including international trade, may react differently to these shocks depending on their type and, for example, may be resilient to some shocks and not to others. Trade resilience studies should therefore consider the specifics of a particular disturbance and the system whose resilience is being analysed. We assume that shocks that cause international trade disruption are diverse in nature and scope. Consequently, their effects, although negative for world trade, will vary depending on the specific type of shock, and individual countries will experience them to different extents.

Most of the studies related to trade resilience are relatively new and tend to address the disruption caused by the COVID-19 pandemic shock, referring to international trade or the exports and/or imports of individual countries. Despite the growing number of studies on the impact of conflicts in Ukraine on international trade, there are still significant gaps identified by Paryan & Hashfi (2023). This research gap is related to the lack of studies referring to trade resilience and the focus on either Western European states or the participants in the conflict themselves. These two issues are considered in our study. The authors' review of the literature also pointed to existing ambiguities in defining trade resilience and the possibility of measuring it. A critical analysis of the available and hitherto used methods of measuring trade resilience indicated the need to modify existing tools and propose new tools, which has been done and is an additional contribution to our work.

The aim of this study is to assess the resilience of Central and Eastern European (CEE) countries' trade to external disturbances, using the example of a shock caused by Russia's war with Ukraine. The resilience of both the exports and imports of CEE countries will be examined. The countries of the

CEE region, including Bulgaria, Czechia, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, and Slovakia, were selected for the study because of their location (geographical proximity), historical ties and psychological distance from the countries involved in the conflict. Consequently, the countries analysed are among the most vulnerable to the disruption caused by Russia's war with Ukraine. Moreover, the selected countries share similar economic, political, and historical characteristics. They share a common history of being part of a bloc of socialist states, with the Baltic States being part of the Soviet Union. Today, these countries, despite some differences, are at a similar level of development, are all members of the European Union (EU), share similar institutional characteristics and are relatively similar in size, i.e., belong to the group of small and medium-sized economies.

Our study is preliminary and characterizes the trade responses of CEE countries to disruptions caused by a regional shock of a political nature and the relationship between the ability of these countries to resist and the objective vulnerability of their trade to such a shock. The research questions posed are as follows:

1. What is the trade resilience of CEE countries to a war shock in the region?
2. Is there a relationship between the resilience of trade to disturbances caused by a war shock and the vulnerability of CEE countries to this type of shock?
3. Do CEE countries differ in terms of their vulnerability to a war shock in the region?
4. Do the results of resilience, vulnerability, and the relationship between them differ for exports and imports?

The analysis included statistical data on the value and structure of the foreign merchandise trade of CEE countries from 2016–2023. The study of the resilience of CEE countries' trade to the shock caused by the Russia–Ukraine war includes, in order, the following stages: 1) operationalization and calculation of the composite Trade Vulnerability Index to the war shock, respectively, for exports and imports of the analysed countries; 2) calculation of the Resistance Index also separately for exports and imports of these countries; and 3) examination of the correlation between vulnerability and resistance and testing its statistical significance. The results obtained allow us to determine the vulnerability to trade disturbances and the resilience of CEE countries in the period under study to disturbances caused by the economic shock related to the war in Ukraine.

The paper is structured as follows: Section 1 presents a literature review on economic shocks (1.1) and resilience, with a particular emphasis on problems of definition (1.2). Section 2 is devoted to methodological issues, especially the applied modifications resulting in the development of the trade vulnerability index and the adopted method for measuring trade resilience. Section 3 presents the obtained results, which are discussed in more detail in Section 4. Section 5 summarizes and indicates further directions for research.

1. Literature review

1.1. *Shocks – nature and their effects*

In economic terms, a shock is an unforeseen event that has positive or negative consequences for the economy (Fahad & Abdurrazzaq, 2022). A shock is assumed to be an unforeseen (unplanned) singular or short-term event affecting the environment/economy on a large scale (Fahad & Abdurrazzaq, 2022). Another characteristic attributed to shocks, on which there is no consensus among researchers, is the source of the impulse causing the shock. Two main types of shocks are endogenous (caused within and affecting a particular economic system or sector) or exogenous (caused by factors outside the economic system or sector, such as a natural disaster or armed conflict). An approach linking the two can also be found in the literature, indicating that a shock caused by an exogenous factor (e.g., an armed conflict) triggers adjustment changes to new conditions (e.g., monetary, foreign, trade policy), which are endogenous in nature (Ramey, 2016). Economic shocks, owing to the nature of the impulse/factor causing them, are most often divided into demand, supply, political, financial, or technological shocks (Shevchenko, 2020).

In the contemporary global economy, which is a network of more or less tightly interconnected elements, economic shocks, regardless of their source or nature, tend to spill over to other elements of the interconnected system, with trade being one of the potential transition channels. Research conducted by the OECD (Arriola et al., 2024) indicates which sectors and countries, depending on their location in global value chains (GVCs), show greater resilience to the effects of disruptions originating from foreign shocks. Individual economic shocks can be characterized by their origin, nature, incidence of a disturbance, and scale, nature and duration thereof (Martin & Sunley, 2020; 2015), which allows for the assessment of, among other factors, their intensity, potential duration and aspects of the economy that were most affected by the shock.

An economic shock caused by an armed conflict first affects the actors involved and then spreads to varying degrees to other parties. In either case, it is an exogenous shock of a political nature, triggering the need to adapt to the resulting change in conditions, and can affect supply, demand, finance, etc. There are two strands of research in the literature on the links between economic performance and conflict (including armed conflict), most often examining how a conflict situation affects the economy of an area or the potential for spillover effects on neighbouring states/regions and how economic performance can lead to a conflict situation (Leepipatpiboon et al., 2023).

Russia's attack on Ukraine in February 2022 came as a shock to the global economy and prompted an immediate (March 2, 2022) response from the United Nations in the form of a declaration demanding the cessation of aggression (confirmed by a later declaration on October 12, 2022). Condemnation in the international public forum was quickly backed by the implementation of a series of economic sanctions on Russia by most OECD and EU countries (Darvas & Martins, 2022). On 24 June 2024, the EU adopted a 14th package of sanctions on Russia supplementing and tightening earlier measures (European Commission, 2024). The trade-related sanctions significantly restrict both Russia's access to specific groups of goods (especially products, technologies and services that may have military applications) and its ability to export to reduce its ability to finance the conduct of further military operations (European Council, 2024).

The shock of Russia's war with Ukraine, unlike the COVID-19 pandemic, is more long-lasting in nature. Since the outbreak of the war in February 2022, it has extended to at least 2023. Studies conducted on its impact on the global economy indicate, among other things, a deterioration of macroeconomic conditions and global financial stability (Tong, 2024), international food production and availability (Laber et al., 2023), commodity markets and energy commodity prices (Aizenman et al., 2023; Ozili, 2024), stock markets (Czech et al., 2023) and many others. The sheer number of studies on the impact of Russian military action in Ukraine on international trade is so large that systematic literature reviews in this area are already available, pointing to existing research gaps. An important research gap is the focus on specific sectors or product groups and individual countries and the lack of a more systematic approach to studying changes and adjustments in trade flows in response to the shock of military action in Ukraine (Paryan & Hashfi, 2023). Our study on the trade resilience of the CEE region to the shock of armed conflict aims to address this research gap, as it focuses on a certain region and potential changes in trade flows.

1.2. Resilience—the interpretation and dimensions of resilience

In the context of emerging shocks, disruptions or disturbances, interruptions and perturbances, resilience is one of the main categories used to describe the characteristics of systems or organisms affected by them. The concept of resilience is used in different scientific fields and has no uniform interpretation. Martin & Sunley (2020; 2015), Rose (2017) and Pendall et al. (2009) explore concepts of resilience, including engineering, ecological, extended ecological, psychological, geographic, disaster, political, social (human communities), organisational and planning approaches. They also pointed to changes in the meaning of the concept over time and the uncertainties that are associated with the interpretation of some of the definitions used. As Fisher (2015) noted, there are at least 70 different approaches to understanding resilience.

In a general sense, resilience means the ability to resist shock or disturbances. There are also many notions that can be used interchangeably or are closely synonymous with resilience, such as resistance, robustness, responsiveness, and volatility, and there is often a lack of clear delineation between them. For example, in complex adaptive system (CAS) theory, the concept of resilience does not appear at all, and the primary term is robust. However, resilience is the most popular concept used in the literature, and it was also adopted in our study. In economics, the interpretation of a notion of resilience draws from virtually all previously indicated scientific fields and is considered from both a macroeconomic and a microeconomic perspective, as well as combining both. In this area, too, there is 'no universally agreed' (Martin & Sunley, 2015) or 'commonly accepted' (Montrimas et al. 2023) definition of resilience. Economic resilience research is most often undertaken in the fields of economic geography and regional studies. It concerns the entire socioeconomic system in a specific spatial dimension. Given the multifaceted nature of the concept of resilience, the key issue is to provide a precise interpretation of this notion. Trade resilience is very rarely the subject of conceptual elaboration and empirical research compared with, for example, economic resilience, as is clearly pointed out by Mena et al. (2022) and Shahnazi et al. (2023). Therefore, our work has also contributed to the conceptualization of this notion and its operationalization.

Mena et al. (2022), examining the impact of the COVID-19 pandemic on international trade, define a country's trade resilience as 'a country's ability to both resist disruptions to international trade and recover from disruptions', adopting the concept proposed by Melna et al. (2022) for studying supply chain resilience. In this approach, two distinctive but complementary aspects of resilience are included. The first, called robustness (Mena et al., 2022) or resistance (Melnyk et al., 2014), means the ability to resist a disruption and minimize the impact of a shock, and the second, called responsiveness (Mena et al., 2022) or recovery (Melnyk et al., 2014), is understood as the ability to recover after a shock and return to functionality. In this approach, the impact of the shock is divided into two phases, where the first (initial) covers the period of impact (duration) of the shock and the second the period after its disappearance (after disruption). A study by Mena et al. (2022) covered the impact of macroeconomic factors on trade dynamics during the COVID-19 pandemic. A more comprehensive definition of trade resilience, which is based on Martin & Sunley's (2020) approach, is employed in the analysis of Polish export resilience against noneconomic external shocks (Talar, 2023). In this study, four dimensions of resilience are taken into account, i.e., resistance, responsiveness, adaptability and transformation. The first three types of resilience were subjected to empirical analysis on the basis of export dynamics, similar to the study by Melnyk et al. (2014).

In an even more holistic approach presented by Martin & Sunley (2020; 2015), resilience is treated as a process consisting of the following elements: vulnerability, shocks, resistance, robustness, and recoverability. Vulnerability, understood as the sensitivity or propensity of a system to a shock (Martin & Sunley, 2015), undoubtedly has a significant effect on resilience. Resistance in this process approach concerns the scale of the system's response to shock and has a quantitative dimension. Robustness, on the other hand, refers to the extent of adaptive change, particularly structural change that occurs over a somewhat longer period of time. Recoverability refers to a return to the preshock or the new reference state and is identifiable over a longer period of time after the disturbance has ceased. As Martin & Sunley (2020) noted, with the prolonged duration of the disturbance caused by the shock but also depending on the intensity of the shock, conditions are created for adaptive actions to occur in the direction of system readjustment. These changes aim at a flexible adaptation of the system to the new conditions created by the shock and have the characteristic of adaptive changes. This interpretation of resilience is referred to as 'adaptive resilience' in the literature and is found, among others, in behavioural psychology (Wright et al., 2013) and is part of the complex adaptive systems (CAS) theory applied to different types of systems (Jen, 2023). Rose & Krausmann (2013) propose a similar definition of economic resilience, but they introduce the term 'static resilience' as the ability of systems to maintain their functions during shock and 'dynamic resilience' in reference to the efficient allocation of resources for repair and recovery following disruption.

Economic vulnerability to shock refers to the exposure of a country to external shock arising from intrinsic inherent, permanent, or quasipermanent features of the economy (Briguglio, 2016; Briguglio & Galea, 2003). The heterogeneity of individual economies means that they are sensitive to emerging disturbances to varying degrees. There is an assumption that economies that are less vulnerable are more resilient (Fingleton et al., 2012), yet research by Briguglio (2016) indicates that even with high levels of vulnerability, economies can, through the pursuit of appropriate policies, also be resilient to disturbances. Vulnerability, however, increases the risk of disturbances in the economy caused by external shocks but does not determine resilience, which also depends on the nature of the implemented policy (policy-induced) (Briguglio & Galea, 2003).

2. Methodology

In our study of trade resilience to the shock of Russia's war with Ukraine, we adopt the approach of Martin & Sunley (2020; 2015). As only data up to 2023 can be included and we are still in the midst of the disruption induced by the still ongoing hostilities and the introduction of further trade sanctions, we cannot include an element of robustness and recovery after the shock in our study. We therefore interpret trade resilience as vulnerability to shock and resistance against it, i.e., as the ability of a country to maintain its performance of exporting and importing against disruption (so-called 'absorptive resilience').

In studies of the vulnerability of the economy to external shocks, Briguglio (2016) and Briguglio et al. (2009) constructed a composite index of "economic vulnerability". This index consists of four components: trade openness, export concentration, dependence on strategic imports and proneness to natural disasters. Owing to the occurrence of shocks of different natures and magnitudes, the vulnerability of a system to a given type of shock may be influenced by different factors. Moreover, the determinants of vulnerability depend on the specifics of the system under analysis (Ram et al., 2019). In the analysis of the economic resilience of CEE and Black Sea countries from a defence perspective, variables such as trade partner concentration, the share of selected partners in trade, the trade balance, and, in the area of 'trade dependence', indicators characterizing the product structure of trade and, in particular, reliance on strategic goods in foreign trade are mentioned as determinants of foreign trade vulnerabilities (Constantinescu, 2023).

When examining the trade vulnerability of countries to war shocks, we have to adjust the components (variables) of the index according to this specific case. For the purpose of constructing our composite trade vulnerability index (TVI), we adopted methods and procedures described by the OECD (2008), Mazziotta & Pareto (2013) and Guillaumont (2009). In the first step, we identify and select quantitative variables appropriate for describing trade vulnerability against war shocks. We then normalize the selected variables while taking into account the direction of their influence on the created index. In the next step, we assign weighting coefficients to the adopted variables. The procedure ends with the aggregation and calculation of composite indices for each country.

The TVI is calculated separately for exports (ExVI) and imports (ImVI). On the basis of the literature review, we selected the following four variables as determinants of CEE countries' trade vulnerability to the shock of Russia's war against Ukraine:

- 1) exports and imports to/from Russia and Belarus as percentages of total exports ($R+B_{ex}$) and imports ($R+B_{im}$) of reported countries, respectively
- 2) trade partner concentration ratio ($CR3_c$), i.e., three main leading markets for exports ($CR3_{c_{ex}}$) and imports ($CR3_{c_{im}}$) as shares of total reporting countries' exports and imports, respectively
- 3) concentration ratio for the product structure of trade ($CR3_p$), which is calculated as the share of the three largest commodity groups in the total reporting country's exports ($CR3_{p_{ex}}$) and imports ($CR3_{p_{im}}$) (i.e., sectoral specialization).
- 4) product complexity, estimated via the product complexity index (PCI) for $CR3_p$ for imports (PCI_{im}) and the economic complexity index for exports (based on a country's export basket)

(PCI_{ex}) on the basis of data and methodology developed by Harvard Growth Lab (Hausmann, 2013; Growth, 2024).

The inclusion of the shares of Russia and Belarus in the trade of the analysed countries as components of the TVI results directly from the specificity of the studied shock. As a result of Russia's attack on Ukraine and the continuation of military operations against that country and the emergence of a kind of alliance between Russia and Belarus, these two countries became sources of regional shock or even geopolitical disturbances. As a result, Russia and Belarus are subject to trade sanctions by most countries, particularly the European Union and the USA (Darvas & Martins 2022). Therefore, their share in the reporting trade of CEE countries is highly important for their vulnerability to this shock.

The next variables selected for the TVI are concentration ratios, which are related to the dependency of a country on a few major partners and products and are commonly used in vulnerability analyses. This approach is also based on research confirming the importance of concentration for resilience as a result of the emergence of high dependence on trade with a limited number of trading partners as well as trade with a limited number of products (Briguglio & Galea, 2003; Haddad et al., 2013; Rodrik, 1998; Caselli et al., 2020).

The inclusion of the product complexity variable in the construction of the TVI results from relatively new research confirming the importance of economic complexity in reducing vulnerability by reducing dependence on a narrow range of products, in conjunction with the ability to introduce new products affecting the diversification of the conducted activity (Balland et al., 2023; Hausmann et al., 2021). The product complexity index we adopted is based on the number of countries that produce a given product and their economic complexity. A high level of this indicator indicates that only a few highly complex countries produce a given product. In exports, this will reduce vulnerability, whereas in imports, it will increase exposure to disturbances in trade.

The selected TVI component variables were then normalized via the Max-Min method, which is often used in the construction of these types of indices (e.g., Briguglio, 2016). All the variables after this normalization take an identical range of values between 0 and 1. We use a popular formula for this transformation, which is for stimulants:

$$z_{ij} = (x_{ij} - \text{Min}x_j) / (\text{Max}x_j - \text{Min}x_j) \quad (1)$$

and for destimulants:

$$z_{ij} = (\text{Max}x_j - x_{ij}) / (\text{Max}x_j - \text{Min}x_j) \quad (2)$$

where z_{ij} is the normalized value, x_{ij} is the current input value (observed variable) for country i and component j , and Min , Max are the minimum and maximum values among the analysed observations (Zeliaś, 2002).

To weight the importance of the four selected variables, we choose the most commonly used technique, equal weighting (OECD, 2008). To calculate the TVI value, we use a linear aggregation procedure and arithmetic averaging.

The TVI is calculated for 2021 as the year before the shock. Data for all component variables are taken from The Atlas database (The Growth, 2024). The variable CR3p was calculated for commodity groups at the level 4 digit HS product classification (the Harmonized Commodity Description and Coding System referred to as the 'Harmonized System'). The correlation between the TVI components was examined to verify the validity of their selection; the lack of statistically significant high-strength relationships between the ExVI and ImVI components (Table 1) confirms the validity of their selection.

Table 1. Correlation of the TVI component variables.

	(R+Bex)	CR3c_ex	CR3p_ex	PCl _{ex}	(R+Bim)	CR3c_im	CR3p_im	PCl _{im}
(R+Bex)	1	-0.688	-0.291	-0.476	0.825	-0.096	0.440	-0.569
CR3c_ex		1	0.309	0.648	-0.600	0.675	-0.254	0.712
CR3p_ex			1	0.626	-0.274	0.532	0.436	0.705
PCl _{ex}				1	-0.669	0.715	0.004	0.871
(R+Bim)					1	-0.310	0.604	-0.549
CR3c_im						1	0.056	0.666
CR3p_im							1	-0
PCl _{im}								1

Source: Own elaboration on the basis of WTO (2024), The Growth (2024).

To measure resistance, a reference state (or reference position) is needed, understood as a certain level or trend of changes in the variable describing the behaviour of the system under study. We operationalize the concept of resistance on the basis of the absolute effects of the shock. This is an alternative and oppositional approach to the comparative or relative measure of resilience, which is estimated by comparing the performance of the system under study to a selected average (particular system-wide shock, e.g., nationwide shock) or the performance of other systems. Here, the reference position is often the national benchmark. These relative measures are often used in regional studies for both economic resilience (e.g., Martin et al., 2016; Martin & Gardiner, 2019) and trade resilience (Li et al., 2024; Arbolino et al., 2023). Among the few trade resilience studies, attention should be given to the analysis by Luo et al. (2023), which uses an absolute measure of ‘absorptive resilience’ (although it is defined as robustness rather than resistance) and calculates the resilience indices for exports and imports separately. In this study, the average trade growth rate of the two years preceding the shock was used as the reference position. We used a different approach, which is based on the trend of changes in the value of trade turnover.

To assess absolute trade resilience, we construct the resistance index (RESIS) as a singular measure and rely on the methods of Martin & Sunley (2015). The reference position in this index is a hypothetical trade value forecasted via an autoregressive time series model of the preshock growth path. The RESIS index represents the ratio of the value of trade (exports or imports) achieved by a given economy during a shock or disturbance to the value of the reference position at the same time. We construct the RESIS index separately for exports and imports. To the best of our knowledge, this is the first study of trade resilience in absolute terms using a preshock growth path as a reference position. The formula of trade resistance for exports is as follows:

$$RESIS_c^{Ex} = \frac{Ex_c^{ts}}{Ex_c^e} \quad (3)$$

and correspondingly for imports:

$$RESIS_c^{Im} = \frac{Im_c^{ts}}{Im_c^e} \quad (4)$$

where Ex_c^{ts} and Im_c^{ts} refer to the export and import values of country c , respectively, at time t during shock s , whereas Ex_c^e, Im_c^e represents the expected value of exports and imports at time t_s , which is estimated on the basis of the preshock path growth of exports and imports. A RESIS index value is cantered at approximately 1 and, if it is equal to or greater than 1, indicates resistance (resilience) of the exports or imports of a country in the face of a shock; if it is less than 1, it indicates that it is not resistant, i.e., the export or import value in the year during a shock is lower than expected according to the preshock trend line.

The advantage of this approach to resistance testing is that it is an appropriate benchmark for each economy on the basis of differential trends in foreign trade development compared with relative estimates on the basis of a ratio to the average of, for example, a selected group of countries. The

results of this index are influenced by the choice of preshock period of study, but this is a limitation that also occurs in all relative measures. We used international trade time series data covering the 2016–2023 period to calculate the *RESIS* index. The export and import value data include only goods (merchandise trade) and come from the WTO database (WTO, 2024). To estimate the preshock growth path via the autoregressive time series model, we chose the period from 2016–2021. Although there was a shock from the COVID-19 pandemic during this period and therefore a decline in international trade in 2020, in 2021, this decline was compensated for by an increase in world trade, and this shock can be treated as some eventually balanced disturbance in the growth path. In turn, 2016, as the beginning of the period, was chosen because of the decline in the value of trade in 2015 and is the year in which the trend changed; therefore, it can be considered to mark the beginning of a new trend in trade growth after the disturbances in 2015–2016.

3. Research results

The calculations of the export and import vulnerability indices for the CEE countries and their *RESIS* indices are presented in Table 2, while Table 3 contains descriptive statistics of both the vulnerability variables and the *RESIS* index.

Table 2. Trade resilience of CEE in terms of vulnerability (ExVI, ImVI) and resistance index (*RESIS*) for exports and imports.

Country	ExVI	ImVI	<i>RESIS</i> _c ^{Ex}		<i>RESIS</i> _c ^{Im}		Trade <i>RESIS</i> ¹	
	2021		2022	2023	2022	2023	2022	2023
Bulgaria	0.35	0.15	1.15	1.05	1.19	1.04	1.17	1.05
Czechia	0.37	0.59	1.02	1.04	1.06	0.99	1.04	1.01
Estonia	0.45	0.71	0.98	0.81	1.06	0.88	1.02	0.85
Hungary	0.27	0.41	1.02	1.04	1.10	0.98	1.06	1.01
Latvia	0.54	0.62	1.08	0.95	1.14	0.99	1.11	0.97
Lithuania	0.48	0.50	1.08	0.93	1.17	0.98	1.12	0.96
Poland	0.39	0.35	0.99	0.99	1.05	0.96	1.02	0.97
Romania	0.33	0.35	1.07	1.07	1.08	1.02	1.07	1.05
Slovakia	0.49	0.72	1.00	1.05	1.04	1.01	1.02	1.03

Note: ¹ trade *RESIS* is the simple average of *RESIS*_c^{Ex} and *RESIS*_c^{Im}.

Source: Own elaboration on the basis of WTO (2024), The Growth (2024).

The *RESIS* results indicate that both export and import resistance were lower on average in 2023 than in 2022 (Table 3).

Table 3. Descriptive statistics of the variables of vulnerability (ExVI, ImVI) and resistance (*RESIS*).

Indices	Mean	Std.Dev.	Min	Max
ExVI	0.41	0.08	0.27	0.54
ImVI	0.49	0.18	0.15	0.72
<i>RESIS</i> _c ^{Ex} 2022	1.04	0.05	0.98	1.15
<i>RESIS</i> _c ^{Ex} 2023	0.99	0.08	0.81	1.07
<i>RESIS</i> _c ^{Im} 2022	1.10	0.05	1.04	1.19
<i>RESIS</i> _c ^{Im} 2023	0.98	0.04	0.88	1.04

Source: Own elaboration on the basis of WTO (2024), The Growth (2024).

The averaged indices also show that only in 2023 did CEE countries show a lack of resistance, and in 2022, only Estonian and Polish exports were not resistant (Table 2 – a *RESIS* index value below 1, marked in red, indicates a lack of resistance). Compared with exports, imports had lower resistance in 2023. In terms of shock vulnerability, significantly greater volatility among CEE countries occurs with respect to imports than with respect to exports (Table 3).

In exports, above-average vulnerability was shown primarily by the Baltic countries, with Slovakia additionally in this group (Figure 1 and Table 2). Despite the relatively high vulnerability of Slovakia's exports to war shocks, it has also shown high absorption resistance to these disturbances (Table 2).

Slovakia is therefore a country that stands out in this respect. Poland, on the other hand, is the only country with a lack of export resistance (Table 2) among countries with below-average vulnerability (Table 3).

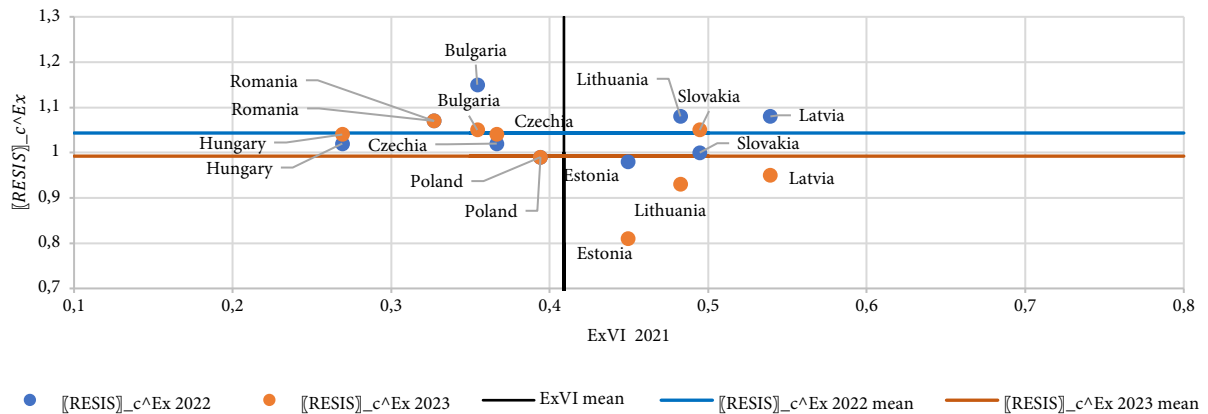


Figure 1. $RESIS_c^{Ex}$ and $ExVI$ for CEE countries.

Source: Own elaboration on the basis of WTO (2024), The Growth (2024).

Countries with above-average import vulnerability included the Baltic States, Slovakia and, additionally, Czechia (Figure 2). In 2023, the imports of these countries, with the exception of Slovakia, also showed a lack of resistance. From the group of economies with lower vulnerability to the impact of war shocks on imports, Poland again showed a lack of resistance but was joined in this case by Hungary. In imports, the best vulnerability and resistance results were achieved by Bulgaria (Table 2).

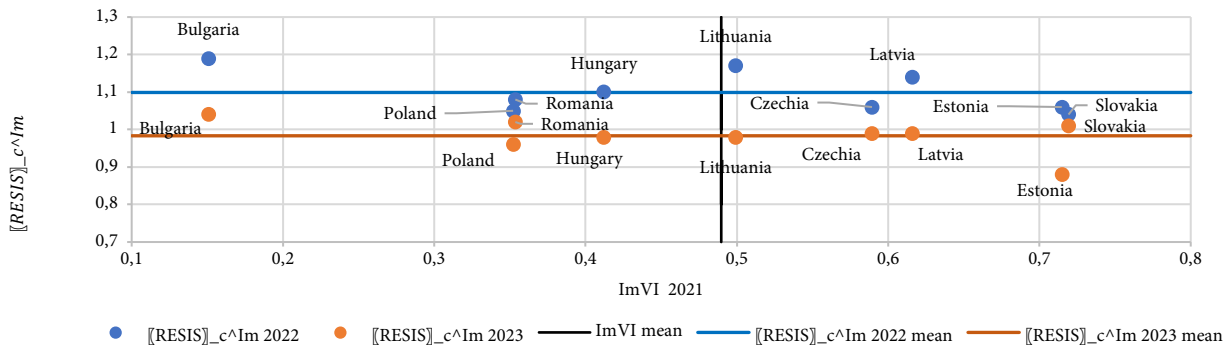


Figure 2. $RESIS_c^{Im}$ and $ImVI$ for CEE countries.

Source: Own elaboration on the basis of WTO (2024), The Growth (2024).

In summary, several characteristic and distinctive groups can be identified among the CEE countries:

- the Baltic countries, which are both highly exposed to the impact of the war shock on their trade and do not have sufficient ability to rebound from this shock, especially in exports;
- Slovakia and Czechia, which are characterized by high vulnerability but also high resistance;
- Poland and partly Hungary (in particular in imports), which are not so exposed to shock, but their resistance results, especially those of Poland, are weak;
- Bulgaria and Romania stand out in terms of both low vulnerability and resistance. This grouping, as it turns out, largely corresponds to the division of these countries on the basis of geographical-political-historical factors. However, this relationship needs to be examined to determine whether it is merely coincidental.

To test the potential links between vulnerability indicators and import and export resistance, a Pearson's coefficient correlation analysis was conducted for two different levels of significance, and the results are presented in Table 4.

Table 4. Pearson coefficient across CEE countries between resistance (RESIS) and vulnerability (TVI) for exports and imports

	ExVI	ImVI	RESIS ^{Ex} _c _2022	RESIS ^{Ex} _c _2023	RESIS ^{Im} _c _2022	RESIS ^{Im} _c _2023
ExVI	1.000	0.648	- 0.050	- 0.524	0.064	- 0.220
ImVI		1.000	- 0.613	- 0.488	- 0.495	- 0.519
RESIS ^{Ex} _c _2022			1.000	0.305	0.893**	0.678*
RESIS ^{Ex} _c _2023				1.000	- 0.010	0.872**
RESIS ^{Im} _c _2022					1.000	0.390
RESIS ^{Im} _c _2023						1.000

Note: * = significant at $\alpha=0.05$ (bilateral), ** = significant at $\alpha=0.01$ (bilateral),

Source: Own elaboration on the basis of WTO (2024), The Growth (2024).

The results of the correlation analysis of the vulnerability and resistance measures used and the testing of their statistical significance (Table 4) indicate the following:

- fairly strong and statistically significant (at the $\alpha=0.01$ level) relationships between export and import resistance in 2022 and 2023 and moderate and statistically significant (at the $\alpha=0.05$ level) relationships between export resistance in 2022 and import resistance in 2023;
- no statistically significant relationship between export resistance in 2022 and 2023 and, similarly, for imports;
- no statistically significant relationship between export and import vulnerability;
- there is no statistically significant relationship between resistance and objective vulnerability for exports in both years studied, and there is a similar relationship for imports.

4. Discussion

The correlation analysis of the RESIS and TVI indices revealed no statistically significant correlation between the export resistance of CEE countries and the exposure of their exports to the shock caused by the war between Russia and Ukraine, as well as their imports in both years studied, which is consistent with the results obtained by Steinbach (2023) regarding the impact of this conflict on the relocation of global trade flows, which mainly affected the parties directly involved in the conflict and, to a limited extent, other countries. The results indicate that there is no correlation between resistance and vulnerability, which can be considered to be in line with the results of Briguglio's (2016) study on economic resilience, which indicated that despite high vulnerability, countries can be characterized by high resilience as 'a result of resilient-conditional policies'. Thus, trade resilience, understood as absorptive resilience and the ability to maintain trade performance, is influenced by the internal conditions of individual countries, including macroeconomic factors and actions taken at the firm level. We assume, therefore, that the achievement of higher-than-average resistance scores with a higher objective vulnerability to disruption is the result of endogenous actions occurring simultaneously with disruption to reduce negative effects, which may relate primarily to the redirection of trade to other geographic markets, including not only diversification but also trade concentration, particularly when we increase sales in markets where we are already present and where there is high demand or supply. Slovakia's high vulnerability to trade distortions is due to its economy's high dependence on trade links with Germany (Baláž & Hamara, 2016), but it did not translate into the lack of trade resilience of this country.

All CEE countries showed trade resilience in 2022; in a few cases (Baltic States and Poland), the decrease in resilience did not occur until 2023. The results obtained can be justified in several ways. First, the (regional) war shock was not strong enough, especially in 2022, to disrupt the trade turnover of the countries in the region, and given the 12.2% increase in the value of world exports in 2022

(WTO, 2024), it should also be assumed that it did not significantly affect the other partner countries of CEE countries. It was only in 2023 that there was a decline in world trade turnover, which could have translated into the observed decrease in resilience for several CEE countries. Second, the trade effects of external shocks and disturbances are heterogeneous in nature, and many other factors also influence the reactions of the trading system. This means that sectoral and geographic concentration does not necessarily imply greater vulnerability to external disturbances, which, with respect to the impact of these structural factors on a country's income volatility, was confirmed by Caselli et al. (2020) in their research regarding the impact of these structural factors on a country's income volatility, thus justifying the often diverse results of empirical research in this area in the literature. The lack of a statistically significant relationship between indicators of product and partnership (geographic) structure diversification and production volatility and sales stability at the firm level in CEE countries during the 2009–2012 crisis was also shown by Čede et al. (2016) in their study.

The observed effects in the CEE trade regime under war shock conditions may also not match expectations because of the ineffectiveness of trade sanctions and the varying extent to which they are circumvented by individual countries, as indicated by both Steinbach (2023) for the current situation and the earlier sanctions imposed on Russia, which did not affect Czech exports (Coufalová, 2020). For the Baltic states, the observed lack of trade resilience in 2023 is in line with the trend observed by Veebel & Markus (2018) related to changes in their trade flows in earlier cases of Western countries imposing sanctions on Russia. The disruptions caused by the war shock are also compounded by other processes and phenomena causing instability that have been present in the global economy for a long time (such as, for example, the uncertainty of the political situation or increasing digitalization (Zhu & Ye, 2024)), affecting different actors in the global economy to varying degrees (Gorynia et al., 2024).

Conclusions

Like economic or regional resilience, trade resilience is a very complex concept influenced by many different factors (Martin et al., 2016, Martin & Sunlay, 2015; Mena et al., 2022). The obtained results allowed us to address the adopted research questions, indicating that regional wars may not have a significant effect on disturbances in the trade exchange of the countries of the region, regardless of whether they are strongly or weakly exposed to disturbances due to their product and partner concentration or/and the product complexity of traded goods. The shock of war caused an abrupt change in the situation, but in addition to the necessity of severing trade links with some countries, it also brought many opportunities and created possibilities for boosting exchanges with friendly countries that were also looking for new trade partners. Their flexibility, adaptability, and effectiveness may determine trade performance to the greatest extent and, therefore, the resilience of trade to this type of disruption. The impact of political shocks, especially regional shocks, may therefore differ significantly from the impact of economic shocks on trade.

The conducted study, in addition to answering the research questions regarding the resilience of the trade of CEE countries to disruptions resulting from the conflict in Ukraine, allowed the authors' innovative approach to measuring the resilience of trade to disruptions caused by an external shock of the Russia–Ukraine war to be tested. We used a methodological approach including two separate and original indicators (ExVI and ImVI) of trade vulnerability adapted to a specific shock for the selected region. Owing to the lack of such studies, our work has also contributed to the conceptualization of this notion and its operationalization. An additional adopted methodical modification is the use of an approach based on the trend of changes in the value of trade turnover as a reference position when examining the resilience of CEE trade. To the best of our knowledge, this is the first study of trade resilience in absolute terms using the preshock growth path as a reference position. The advantage of this approach to resilience studies is that a reference point is appropriate for each economy on the basis of differential trends in the development of foreign trade compared with relative estimates on the basis of the ratio to the average of, for example, a selected group of

countries. A thorough description of the adopted methodology allows it to be further modified and used for studies of other types of shocks or other regions, which can be helpful in developing nation-specific policies to increase economic resilience and structural reform effectiveness.

The limitation of the conducted study is the components adopted for the trade vulnerability index typical for this shock—they will need to be modified for other shocks. Another limitation is the short time adopted, which did not allow the study to include elements related to recovery after the shock and the focus on a small group of countries (only that particular region). Other limitations are the relatively large discrepancies in the product structure data (from several to a dozen or so per cent of the share of unclassified products and with differences in data), which may distort the structural data for the developed sensitivity indicators, and the inclusion of only the merchandise trade.

As a preliminary study, it opens the way for further considerations, including for example, studies involving more countries and comparisons for more shocks or different types of shocks. It is also worth considering changes to the methodology by including additional variables, for example, the product structure in the longer term or considering political and regulatory factors.

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Reference

1. Arbolino, R., Boffardi, R., & Di Caro, P. (2023). Measuring and Exploring Regional Trade Resilience in Italy During Different Crises. *Italian Economic Journal*, 9, 1027–1047. <https://doi.org/10.1007/s40797-023-00250-6>.
2. Atkinson, A., Grandi M., & Vaklinova G. (2022). *Resilience, human security, and the protection of civilians: A critical approach for future urban conflict*. International Order and Conflict Policy Paper. Washington, DC: The Stimson Center. https://www.stimson.org/wp-content/uploads/2022/06/Stimson_Resilience_ProofA1-1.pdf.
3. Balland, P., Broekel, T., Diodato, D., Giuliani, E., Hausmann, R., O'Clery, N., & Rigby, D. (2022). The new paradigm of economic complexity. *Research Policy*, 51(3), Article 104450. <https://doi.org/10.1016/j.respol.2021.104450>.
4. Briguglio, L., & Galea, W. (2003). Updating the economic vulnerability index. *Occasional chapters on islands and small states*. Malta: Islands and Small States Institute, University of Malta, 4, 1–15. <https://www.um.edu.mt/library/oar/handle/123456789/18371>.
5. Briguglio, L., Cordina, G., Farrugia, N., & Vella, S. (2009). Economic vulnerability and resilience: concepts and measurements. *Oxford Development Studies*, 37(3), 229–247. <https://doi.org/10.1080/13600810903089893>.
6. Briguglio, L.P. (2016). Exposure to external shocks and economic resilience of countries: evidence from global indicators. *Journal of Economic Studies*, 43(6), 1057–1078. <https://doi.org/10.1108/JES-12-2014-0203>.
7. Caselli, F., Koren, M., Lisicky, M., & Tenreyro, S. (2020). Diversification Through Trade. *The Quarterly Journal of Economics*, 135(1), 449–502. <https://doi.org/10.1093/qje/qjz028>.

8. Čede, U., Chiriacescu, B., Harasztosi, P., Lalinsky, T., & Meriküll, J. (2016). Export Characteristics and Output Volatility: Comparative Firm-Level Evidence for CEE Countries (May 11, 2016). *ECB Working Paper*, Article 1902. <http://dx.doi.org/10.2139/ssrn.2778600>.
9. Constantinescu, M. (2023). Measuring economic resilience for the CEE and Black Sea countries in the framework of comprehensive defence. *Security and Defence Quarterly*, 44(4), 55–83. <https://doi.org/10.35467/sdq/175379>.
10. Fingleton, B., Garretsen, H., & Martin, R. (2012). Recessionary shocks and regional employment: Evidence on the resilience of UK regions. *Journal of Regional Science*, 52(1), 109–133. <https://doi.org/10.1111/j.1467-9787.2011.00755.x>.
11. Fisher, L. (2015). More than 70 ways to show resilience. *Nature*, 518, Article 35. <https://doi.org/10.1038/518035a>.
12. Guillaumont, P. (2009). An economic vulnerability index: its design and use for international development policy. *Oxford Development Studies*, 37(3), 193–228. <https://doi.org/10.1080/13600810903089901>.
13. Haddad, M., Lim, J.J., Pancaro C., & Saborowski, Ch. (2013). Trade openness reduces growth volatility when countries are well diversified. *Canadian Journal of Economics*, 46(2), 765–790. <https://doi.org/10.1111/caje.12031>.
14. Hausmann, R., Hidalgo, C., Bustos, S., Coscia, M., Chung, S., Jimenez, J., Simoes, A., & Yildirim, M. (2013). *The Atlas of Economic Complexity*. MIT Press.
15. Hausmann, R., Santos, M., Macchiarelli, C., & Giaconet, R. (2021). *What economic complexity theory can tell us about the EU's pandemic recovery and resilience plans*. European Politics and Policy. Cambridge, MA: Growth Lab.
16. Jen, E. (2003) Stable or robust? What is the difference? *Complexity*, 8, 12–18. <https://doi.org/10.1002/cplx.10077>.
17. Li, Y., Zhang, P., Yang, Q., & Chu, N. (2024). Specialization or Diversification: Which is More Conducive to Foreign Trade Resilience? Evidence from China-Russia Border Regions in Northeast China. *Chinese Geographical Science*, 34, 1144–1157. <https://doi.org/10.1007/s11769-024-1450-9>.
18. Luo, W, He L, Yang, Z, Zhang, S, Wang, Y, Liu, D, Hu, S, He, L, Xia, J, & Chen, M. (2023). Spatiotemporal heterogeneity in the international trade resilience during COVID-19. *Applied Geography*, 154, Article 102923. <https://doi.org/10.1016/j.apgeog.2023.102923>.
19. Martin, R., & Sunley, P. (2015). On the notion of regional economic resilience: conceptualization and explanation. *Journal of Economic Geography*, 15(1), 1–42. <https://doi.org/10.1093/jeg/lbu015>.
20. Martin, R., & Sunley, P., 2020. Regional economic resilience: evolution and evaluation. In: B. Bristow & A. Healy (Ed.), *Handbook on Regional Economic Resilience* (pp. 10-35). Edward Elgar Publishing.
21. Martin, R., Sunley, P., Gardiner, B., & Tyler, P. (2016). How regions react to recessions: Resilience and the role of economic structure. *Regional Studies*, 50(4), 561–585. <https://doi.org/10.1080/00343404.2015.1136410>.
22. Mazziotta M., & Pareto A. (2013). Methods For Constructing Composite Indices: One For All Or All For One? *RIEDS - Rivista Italiana di Economia, Demografia e Statistica - The Italian Journal of Economic, Demographic and Statistical Studies*, 67(2), 67–80. <https://EconPapers.repec.org/RePEc:ite:iteeco:130210>.
23. Melnyk, S. A., Closs, D. J., Griffis, S. E., Zobel, C. W., & Macdonald, J. R. (2014). Understanding supply chain resilience. *Supply Chain Management Review*, 18(1), 34–41.
24. Mena, C., Karatzas, A., & Hansen, C. (2022). International Trade Resilience and the COVID-19 Pandemic. *Journal of Business Research*, 138, 77–91. <https://doi.org/10.1016/j.jbusres.2021.08.064>.

25. OECD/European Union/EC-JRC (2008). *Handbook on Constructing Composite Indicators: Methodology and User Guide*. OECD Publishing. <https://doi.org/10.1787/9789264043466-en>.
26. Pendall, R., Foster, K., & Cowell, M. (2009). Resilience and regions: building understanding of the metaphor. *Cambridge Journal of Regions, Economy and Society*, 3(1), 71–84. <https://doi.org/10.1093/cjres/rsp028>.
27. Ram, J., Cotton, J., Frederick, R., & Elliott, W. (2019). A Multidimensional Vulnerability Index for the Caribbean. *CDB Working Paper 2019/01*.
28. Rodrik, D. (1998). Why Do More Open Economies Have Bigger Governments? *Journal of Political Economy*, 106(5), 997–1032. <https://doi.org/10.1086/250038>.
29. Rose, A. (2017). *Defining and Measuring Economic Resilience from a Societal, Environmental and Security Perspective*. Springer. https://doi.org/10.1007/978-981-10-1533-5_6.
30. Rose, A., & Krausmann, E. (2013). An economic framework for the development of a resilience index for business recovery. *International Journal of Disaster Risk Reduction*, 5, 73–83. <https://doi.org/10.1016/j.ijdrr.2013.08.003>.
31. Shahnazi R., Sajedianfard, N., & Melatos, M. (2023). Import and export resilience of the global oil trade network. *Energy Report*, 10, 2017–2035. <https://doi.org/10.1016/j.egy.2023.08.065>.
32. Talar S. (2023). Resilience of Polish exports to noneconomic external shocks. *Studia Sieci Uniwersytetów Pogranicza*, 7, 239–254. <http://hdl.handle.net/11320/16486>.
33. The Growth Lab at Harvard University. (2024). The Atlas of Economic Complexity. <http://www.atlas.cid.harvard.edu>.
34. Wright, M. O., Masten, A. S., & Narayan, A. J. (2013). Resilience processes in development: Four waves of research on positive adaptation in the context of adversity. In S. Goldstein & R. B. Brooks (Eds.), *Handbook of resilience in children* (2nd ed., pp. 15–37). Springer Science + Business Media. https://doi.org/10.1007/978-1-4614-3661-4_2.
35. WTO. (2024). International Trade Statistics. <https://stats.wto.org>.
36. Zeliaś, A. (2002). Uwagi na temat wyboru metody normowania zmiennych diagnostycznych. In T. Kufel, M. Piłatowska (Ed.), *Analiza szeregów czasowych na początku XXI wieku* (pp. 25-42). UMK w Toruniu.
37. Fahad, A. Y., & Abdurrazaq, T. O. (2022). Analysing Causes of International Trade Shocks. *International Journal of Professional Business Review*, 7(6), Article e01119. <https://doi.org/10.26668/businessreview/2022.v7i6.1119>.
38. Ramey, V.A. (2016). Chapter 2 - Macroeconomic Shocks and Their Propagation. In J. B. Taylor & H. Uhlig (Ed.), *Handbook of Macroeconomics Volume 2* (pp. 71-162). Elsevier. <https://doi.org/10.1016/bs.hesmac.2016.03.003>.
39. Shevchenko, V. (2020). Economic Shocks of the Pandemic Impact: the European Case. *Three Seas Economic Journal*, 1(2), 53–59. <https://doi.org/10.30525/2661-5150/2020-2-9>.
40. Arriola, C., Kowalski, P., & van Tongeren, F. (2024). Shocks in a Highly Interlinked Global Economy. *OECD Trade Policy Papers* 283. OECD Publishing, Paris, <https://doi.org/10.1787/4a2f0127-en>.
41. Leepipatpiboon, P., Castrovillari, C., & Mineyama, T. (2023). *Macroeconomic Shocks and Conflict*. IMF Working Papers WP/23/68.
42. Darvas, Z., & Martins, C. (2022). *The impact of the Ukraine crisis on international trade*. Working Paper 20/2022. Bruegel.
43. European Council (2024). EU sanctions against Russia explained. <https://www.consilium.europa.eu/en/policies/sanctions-against-russia/sanctions-against-russia-explained/#exportban>.
44. European Commission (2024). EU adopts 14th package of sanctions against Russia for its continued illegal war against Ukraine, strengthening enforcement and anti-circumvention measures. https://ec.europa.eu/commission/presscorner/detail/en/ip_24_3423.

45. Laber, M., Klimek, P., Bruckner, M., Yang, L., & Thurneet, S. (2023). Shock propagation from the Russia–Ukraine conflict on international multilayer food production network determines global food availability. *Nature Food*, 4, 508–517. <https://doi.org/10.1038/s43016-023-00771-4>.
46. Tong, E. (2024). Repercussions of the Russia-Ukraine war. *International Review of Economics & Finance*, 89(A), 366–390. <https://doi.org/10.1016/j.iref.2023.07.064>.
47. Aizenman, J., Lindahl, R., Stenvall, D., & Uddin, G. S. (2024). Geopolitical shocks and commodity market dynamics: New evidence from the Russia-Ukraine conflict. *European Journal of Political Economy*, 85, Article 102574. <https://doi.org/10.1016/j.ejpoleco.2024.102574>.
48. Ozili, P. K. (2024). Global Economic Consequences of Russian Invasion of Ukraine. In P. Pietrzak (Ed.), *Dealing With Regional Conflicts of Global Importance* (pp. 195–223). IGI Global. <https://doi.org/10.4018/978-1-6684-9467-7.ch010>.
49. Czech, K., Wielechowski, M., & Barichello, R. (2023). The shock of war: do trade relations impact the reaction of stock markets to the Russian invasion of Ukraine?. *Ekonomista*, 1, 14–27. <https://doi.org/10.52335/ekon/161832>.
50. Paryan, P., & Hashfi, M. (2023). Unveiling the Impacts of the Russia Ukraine War on International Trade: A Systematic Literature Review. *Journal Ilmiah Manajemen Kesatuan*, 11(2), 371–382. <https://doi.org/10.37641/jimkes.v11i2.2044>.
51. Montrimas, A., Bruneckienė, J., & Gizienė, V. (2023). Measuring Economic Resilience through Industrial Portfolio: The Cases of New EU Member States Since 2004. *Engineering Economics*, 34(5), 593–611. <https://doi.org/10.5755/j01.ee.34.5.35515>.
52. Martin, R., & Gardiner, B. (2019). The resilience of cities to economic shocks: A tale of four recessions (and the challenge of Brexit). *Papers in Regional Science*, 98(4), 1801–1833. <https://doi.org/10.1111/pirs.12430>.
53. Steinbach, S. (2023). The Russia–Ukraine war and global trade reallocations. *Economics Letters*, 226, Article 111075. <https://doi.org/10.1016/j.econlet.2023.111075>.
54. Coufalová, L. (2020). Sanctions by Western Countries and Russian Countermeasures: Impact on Czech Exports. *Politická ekonomie*, 68(3), 348–366. <https://doi.org/10.18267/j.polek.1283>.
55. Baláž, P., & Hamara, A. (2016). Export Dependency of Slovakia on German's Economy. *Politická ekonomie*, 64(5), 573–590. <https://doi.org/10.18267/j.polek.1088>.
56. Veebel, V., & Markus, R. (2018). The bust, the boom and the sanctions in trade relations with Russia. *Journal of International Studies*, 11(1), 9–20. <https://doi.org/10.14254/2071-8330.2018/11-1/1>.
57. Zhu X., & Ye Y. (2024). Economic policy uncertainty and enterprise export resilience in China: Does the digital economy matter? *Heliyon*, 10(10), Article e31091. <https://doi.org/10.1016/j.heliyon.2024.e31091>.
58. Gorynia, M., Nowak, J., Trąpczyński, P., & Wolniak, R. (2024). What drives export resilience? The case of posttransition country firms in the context of the COVID-19 pandemic. *Entrepreneurial Business and Economics Review*, 12(1), 119–133. <https://doi.org/10.15678/EBER.2024.120107>.
59. Ahir, H., Bloom, N., & Furceri, D. (2022). World Uncertainty Index. NBER Working Paper. https://worlduncertaintyindex.com/wp-content/uploads/2024/07/WUI_Data.xlsx.



WSB University

Dąbrowa Górnicza, Ciepłaka 1c, tel.: +48322959359, e-mail: wydawnictwo@wsb.edu.pl