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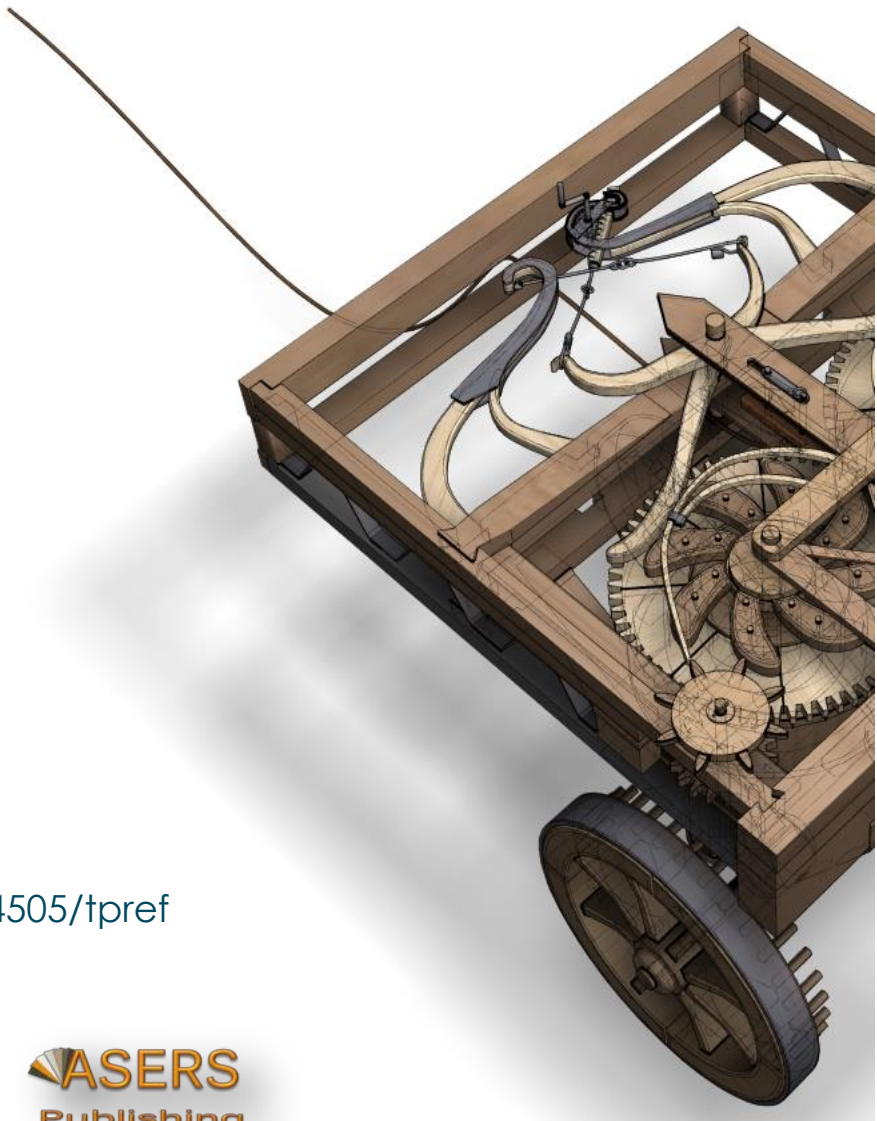

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Determinants of Total Factor Productivity in the EU-CEE. The Role of Intangible Assets and Institutional Quality

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Abstract: This study investigates the determinants of total factor productivity (TFP) in European Union (EU) countries, with a particular focus on the transition economies of Central and Eastern Europe (EU-CEE). Using a balanced panel dataset for 2013-2019, we apply fixed-effects panel regression with robust standard errors to assess the impact of four key factors intangible asset accumulation, business environment quality, information and communication technologies (ICTs), and knowledge workers on TFP growth. The results demonstrate that investment in intangible assets has a consistent and statistically significant positive effect on TFP across all model specifications. The quality of the business environment also significantly influences productivity, especially in EU-CEE countries, where institutional reforms and regulatory improvements have delayed but lasting effects. ICTs contribute positively to TFP, with a stronger lagged impact in countries where digital infrastructure and absorption capacity are still developing. Conversely, the share of knowledge workers does not show a statistically significant relationship with productivity unless complemented by investments in intangible and organizational capital. The findings confirm that intangible assets and institutional quality are decisive long-term drivers of productivity growth and convergence in the EU. The policy implications highlight the need for sustained support for intangible investment, ICT diffusion, and institutional strengthening to accelerate productivity and narrow regional disparities.

Keywords: intangible assets; innovation; total factor productivity.

JEL Classification: E23; O33; C23; O40; O34.

Introduction

Total factor productivity (TFP) is widely regarded as a core indicator of long-run economic growth. Since Solow's seminal contribution, which attributed most growth to technological progress rather than mere factor accumulation (Solow, 1957), the debate has evolved through the endogenous growth literature, which shows that technological change is itself the outcome of purposeful investment, especially in research and development (Romer, 1990; Aghion and Howitt, 1992). Conceptually, TFP captures the efficiency with which economies transform available inputs into outputs raising production without proportionate increases in labor or capital (van Beveren, 2012). In practice, sustained TFP growth is typically associated with technological progress, innovation, organizational change, institutional quality, and a supportive business environment (Gu and Tang, 2004; Masso and Vahter, 2012; Cortinovis and van Oort, 2018). The cumulative effect of these forces underpins the transition toward a knowledge economy, in which value added relies less on tangible inputs and more on intangibles such as innovation capacity and intangible assets. Innovation and TFP are closely linked. Innovation tends to increase TFP, yet its effectiveness depends on complementary conditions including the institutional framework and the stock of intangible assets (Corrado *et al.* 2009). Higher productivity, in turn, relaxes resource constraints and enables further investment in innovation, creating a reinforcing dynamic that warrants careful empirical evaluation.

Despite an extensive body of literature on the determinants of TFP, empirical evidence on how intangible assets, ICT, and institutional quality shape TFP in EU countries remains incomplete. Existing research concentrates mostly on advanced EU-15 economies, whereas the mechanisms driving productivity in EU-CEE countries shaped by structural aspects that are still insufficiently explored. EU-CEE possess less mature innovation systems, lower historical levels of intangible capital, and more volatile institutional environments. Their productivity growth is driven mainly by technology adoption rather than frontier innovation and is constrained by weaker absorptive capacity and regulatory quality. This study addresses this gap by comparing model specifications for EU-CEE economies and by integrating composite indicators of innovation, business environment quality, and human capital into a unified TFP framework. Based on this identified gap in the literature, we prepare research questions and hypothesis presented in method section.

Romer (1990) formalizes how technological advances shift the production possibility frontier, enabling greater output from the same inputs, whereas knowledge spillovers diffuse benefits beyond their originators (Griliches, 1998). Intangible assets including those related to digitization and ICT improve managerial efficiency and open new production possibilities (Corrado *et al.* 2009; Wang *et al.* 2024). Innovation also fosters more efficient resource allocation by directing labor and capital toward higher productivity uses, with spillover effects at broader spatial scales (Cortinovis and van Oort, 2018). Critically, the returns to innovation depend on the quality of the regulatory and institutional environment, where rules are predictable and enforcement credible, investments in new technologies are more likely to translate into TFP gains (North, 1990). Thus, the presence of innovation alone does not guarantee higher productivity, the economic and legal contexts in which innovation occurs are decisive for its impact on TFP.

The impact of innovation on TFP growth is not homogeneous. Cortinovis and van Oort (2018) demonstrated that the regional context and the RandD environment influence the relationship between innovation and productivity. Their analysis of EU-15 and EU-CEE countries revealed that, in Western Europe, the dominant driver of TFP is the interaction between intangible assets and innovation, whereas in Central and Eastern Europe, the decisive factors are the quality of the regulatory and business environment and the absorptive capacity of firms to adopt modern technologies. As shown by Wang *et al.* (2020), sectoral and regional characteristics imply that the effects of investment in research and development vary according to the level of regional development. The more advanced the economy is, the faster it can transform such investments into productivity gains. Conversely, less developed economies face barriers such as a weaker business environment and a lower ability to absorb new technologies. It is therefore essential to analyse the impact of innovation on TFP at the regional level, taking into account the quality of the business environment.

The relationship between innovation and TFP is not linear or isolated. Rather, it is shaped by interconnections and synergies among complementary factors. Moreover, the accumulation of intangible assets one of the key prerequisites for generating new innovations poses methodological challenges. While tangible capital is easily captured in accounting frameworks, intangible assets are more difficult to quantify and report. Underestimating the accumulation of intangible assets can therefore distort the empirical results. As Van Beveren (2012) noted, TFP estimates are highly sensitive to the chosen methodology, and innovation indicators often capture only part of the underlying reality. To address this, we use indexed variable values and multicriteria composite indicators to capture the level of innovation as comprehensively as possible.

Our research focuses on assessing the effects of innovation, the quality of the business environment, the quality of the workforce, and the level of intangible assets on total factor productivity. By employing indexed data and composite indices, we aim to represent the level of innovation and its impact on productivity in a comprehensive manner. The role of intangible assets in overcoming productivity stagnation is evident. Thus, analysing the accumulation of such assets is crucial. Using panel regression with fixed effects and robust standard errors, we seek to contribute to the understanding of the role of innovation in total factor productivity across EU countries particularly within the Central and Eastern European (EU-CEE) region where previous evidence suggests a distinct pattern in the effects of intangible assets and innovation compared with other EU regions.

The paper is structured into three main sections. The first section introduces the topic and provides a basic overview of innovation, total factor productivity, and intangible assets. The second section reviews the current state of knowledge and relevant literature. The methodological section outlines the research principles and describes the empirical approach, followed by an analytical section presenting the results of the panel regression and the resulting policy implications. The final section concludes with a summary of the main findings, an evaluation of the results, and a discussion of the study's limitations.

1. Literature Review

The empirical discussion on total factor productivity (TFP) and the role of innovation has evolved over several decades. The neoclassical production function presented by Solow (1957), suggests that most TFP growth results from technological progress rather than from capital and labor accumulation. However, technological progress has become endogenous. Theoretical models of endogenous growth (Romer, 1990) emphasize the central role of knowledge as an internal determinant of growth. Innovation thus emerges as an inexhaustible and increasingly productive growth factor. Technological progress is therefore viewed as the outcome of economic decisions, particularly those involving investments in research and development. Within the Schumpeterian growth model, Aghion and Howitt (1992), drawing on Schumpeter (1942), introduced the concept of creative destruction, which explains that technological progress arises from innovations that replace obsolete technologies.

Innovation has therefore become the driving force of total factor productivity and long-term economic growth. However, innovation is neither uniform in nature nor in its effects. The discussion of innovation has shifted towards evolutionary economics (Nelson and Winter, 1982), where innovation is understood as a cumulative process of learning and adaptation productivity becomes an expression of firms' capacity to innovate through continuous learning. Innovations are typically classified into three main categories: (i) product innovations are most often associated with advancing the technological frontier; (ii) process innovations enhance the efficiency of resource use, although their effects may be limited without corresponding organizational changes; (iii) organizational innovations play a crucial role in ensuring that technological advances are effectively utilized (Masso and Vahter, 2012; Lee *et al.* 2019).

Intangible assets represent an essential component of innovation. Professor Veblen (1904, 1908) already anticipated their irreplaceable role in innovation and productivity, emphasizing that knowledge, skills, and habits of thought constitute key production factors. He also highlighted the importance of the institutional environment rules, norms, and organizations that either enable or hinder the effective use of knowledge and new technologies. Acemoglu, Johnson, and Robinson (2001) demonstrated that variations in institutional frameworks, such as the enforceability of law and the protection of property rights, have a fundamental influence on economic development. Similarly, Hall *et al.* (1999) showed that social infrastructure including institutional quality, the legal environment, and market mechanisms is a major determinant of productivity differences across countries. Balcerzak and Pietrzak (2015) reported in a sample of EU countries that institutional quality affects TFP dynamics, stronger institutions promote convergence and higher productivity. Investments in intangible assets, when not supported by appropriate institutional and regulatory frameworks (*e.g.*, intellectual property protection), may fail to realize their full potential. These insights were further developed by Corrado *et al.* (2009), who showed investment in intangible assets exceeded that in tangible assets. Corrado *et al.* (2025) and the OECD (2021) confirmed this trend in EU countries and demonstrated that investment in intangible assets has a significant positive effect on productivity growth. The assumption that differentiated innovation impacts TFP based on regional disparities is therefore validated. In Western Europe (EU-15), innovation is embedded within a long-term system of RandD support, strong institutions, and a high share of investment in intangible assets key drivers of productivity growth according to Roth and Thum (2013). In contrast, in Central and Eastern European (EU-CEE) countries, the mere presence of investment in intangible assets may be insufficient. For these economies, the maturity of cybersecurity plays an increasingly important role, as insufficient protection of digital assets can weaken the absorptive capacity of firms and reduce the effectiveness of intangible assets. Consequently, we assume that institutional quality is the key determinant of productivity and long-term growth, as it defines the "rules of the game." Countries with stable legal frameworks and effective intellectual property protection experience a stronger impact of innovation on TFP, whereas the opposite holds true for countries with weaker institutional quality (North, 1990).

Innovation is a crucial factor influencing TFP. This positive relationship has been demonstrated by Gu and Tang (2004) and Masso and Vahter (2012), who showed that innovative firms experience higher TFP growth rates than those that do not create or implement innovations. An important complement to innovation activities is the accumulation of intangible assets. There is growing evidence that investments in intangible ICT assets (software and databases), intellectual property, brands, patents, organizational knowledge, and employee training have a significant effect on productivity growth and value added. Corrado *et al.* (2009) established a methodological classification of intangible assets. Bloch *et al.* (2024) reported that intangible assets significantly contribute to productivity growth in developed economies. Pekarčík *et al.* (2022) demonstrated the positive impact of intangible asset on value added in global value chains. O'Mahony and Vecchi (2009) reported that the impact of intangible assets on productivity varies across sectors and highlighted the spillover effects of these assets. Roth and Thum

(2013) confirmed a robust positive relationship between investment in intangible assets and labor productivity growth at the EU country level via the INTAN-Invest database. Corrado *et al.* (2022) reported that the level of intangible assets in the EU lags behind that of the United States and showed that expanding the definition of assets to include newly recognized intangibles changes the understanding of TFP growth sources. Haskel and Westlake (2018) analysed the transition from a tangible economy to an intangible economy. The question of why information technologies (IT) investments do not always result in immediate productivity growth was examined by Brynjolfsson and Hitt (2003), who reported that the benefits of IT are linked to complementary intangible assets such as organizational structures and workforce skills. They also demonstrated the delayed positive impact of intangible asset accumulation on productivity. In the transforming economies of Central and Eastern Europe, ICT both tangible and intangible has played an important role in enabling rapid modernization and integration into global value chains (Pekarčík *et al.* 2022). The role of intangible ICT assets and cybersecurity was examined by Gordon *et al.* (2015), who demonstrated that regulatory requirements stimulate investment in security and process quality, effectively making security an element of organizational capital. Cybersecurity has become a core component of intangible assets, its effectiveness reinforces firms' ability to adopt advanced technologies, protect knowledge and maintain uninterrupted production process. Weak cybersecurity capabilities under intangible assets can therefore limit the production gains from ICT investment, especially in countries where digital infrastructure is expanding rapidly. The quality of human capital and its impact on TFP remain relatively debated. The mere presence of knowledge workers is not sufficient. The crucial factor is the ability to transform this knowledge into innovation and to integrate it within organizational structures. Roth and Thum (2013) showed that a more comprehensive statistical measurement of intangible asset dimensions strengthens the estimated impact on productivity. In general, the accumulation of intangible assets and the level of innovation significantly influence productivity and consequently, global competitiveness. Their support and development are therefore essential for enhancing productivity and competitiveness in modern economies (OECD, 2013). The literature thus reveals a shift from early exogenous and endogenous models toward more detailed quantitative and econometric analyses of the mechanisms and types of innovation, the role of intangible assets, and their impact on productivity.

The preceding chapters underscore the central role of intangible assets, innovation, and institutional quality as the primary drivers of long-term economic and productivity growth. They demonstrate that productivity dynamics increasingly depend on a country's capacity to accumulate, develop, and effectively utilize intangible assets such as knowledge capital, intangible ICT assets, organizational capabilities, and digital technologies. Our objective is to assess the extent to which the accumulation of intangible assets, the quality of the business environment, the level of human capital, and the diffusion of ICT assets contribute to total factor productivity growth.

2. Method

We apply a panel regression model with fixed effects to examine the impact of intangible asset accumulation, the quality of the business environment, the level of human capital, and ICT assets on total factor productivity (TFP). On the basis of the literature review, the research question is defined as follows:

How do innovation, the business environment, and intangible assets contribute to TFP growth?

The role of innovation and intangible assets in TFP growth has been extensively studied, yet further investigation is needed particularly regarding regional differences. Therefore, this paper employs two models: one covering all EU countries and another focused specifically on Central and Eastern European (EU-CEE) countries. Building on the theoretical foundations presented in the previous sections, we formulate three hypotheses:

H1: The accumulation of intangible assets has a positive effect on total factor productivity (TFP) growth in EU countries.

H2: Information and communication technologies (ICTs) contribute positively to TFP growth in EU-CEE countries.

H3: The quality of the business environment (BE) has a positive effect on TFP in EU-CEE countries.

Data for the total factor productivity variable are obtained from the Penn World Table database (Feenstra *et al.* 2025), which provides standardized national accounts data indexed to 2017=100. Data on intangible assets are sourced from the EU-KLEMS database (Bontandini *et al.* 2023), where we use the accumulation of total intangible assets (INTANG), which is also indexed. Data on the quality of the business environment and knowledge workers are derived from the Global Innovation Index (GII) compiled annually by the World Intellectual Property Organization (WIPO, 2025). Within the business environment category, the indexed data capture aspects such as regulatory quality, institutional efficiency, the legal framework, the tax burden, and access to finance. The knowledge workers variable reflects the quality of human capital, including research capacity, education and skills, and knowledge absorption. These composite indicators are suitable proxies for quantifying both the quality of the business

environment and human capital. All the data are standardized on a scale of 0–100. Indexed dataset allows the analysis to focus on relative dynamics rather than absolute levels, which is essential for the purpose of this article to capture structural relationships affecting TFP. We acknowledge that the main risk associated with indexation is the potential reduction of cross-sectional variance and the possibility of bias. To mitigate this, the models employ country fixed effects and robust standard errors, which limit the impact of heterogeneity loss and ensure consistent coefficient estimates. The dataset covers the period 2013-2019 and includes the following countries: Bulgaria, Croatia, the Czech Republic, Hungary, Poland, Romania, Slovakia, Slovenia, Estonia, Latvia, Lithuania, Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden, and the United Kingdom. The total number of observations is 182, and the panel is balanced. The variance of the TFP variable is relatively low, whereas the other variables exhibit sufficient variability to allow meaningful estimation.

Table 1. Descriptive statistics

Tranche	N	Average	St. Dev	Min.	Max.
TFP	182	0.977	0.042	0.835	1.160
Business Environment (BE)	182	76.2	14.1	17.9	93.1
Knowledge workers (KW)	182	55.6	12.8	22.4	81.8
ICT	182	66.2	13.5	27.5	91.0
Intangibles	182	45.8	15.2	10.4	78.6

Source: Authors' calculations. Notes: Robust SEs clustered by country are in parentheses. ***, **, * denote p<0.01, p<0.05, and p<0.10, respectively. All the models include country FEs; year FEs are included in the robustness checks.

Table 1 presents the descriptive statistics for the variables used in the analysis. The TFP variable has an average value of 0.977 and a standard deviation of 0.042. The difference between the minimum (0.835) and maximum (1.160) values indicates a relatively narrow range. However, it still reflects notable differences among individual countries and time periods. The low degree of volatility corresponds to the fact that the data are indexed. The gap between the minimum and maximum values represents an approximately 40% difference in productivity, which is economically significant. The values for the business environment reveal marked heterogeneity among the countries studied. The lowest scores reflect a weaker institutional and regulatory framework, whereas higher scores represent more advanced and stable environments. A similar pattern is observed for the Knowledge Workers variable. Some countries exhibit a relatively low proportion of skilled labor, whereas others possess a highly developed knowledge base. The greater dispersion of this variable enables the identification of potentially strong effects of both the business environment and human capital quality. On average, values above 50 suggest that most countries qualify as knowledge economies, although several EU-CEE countries fall below this threshold. Importantly, a greater share of knowledge workers does not automatically guarantee higher productivity the key lies in transforming knowledge into innovation and process improvement.

The ICT variable shows that certain EU countries continue to lag in terms of digitalization and the adoption of modern ICTs across both the private and public sectors. In the literature, ICTs are recognized as general-purpose technologies with the potential to significantly influence TFP through process improvements. The degree of variability observed in ICT makes it possible to identify its effect on TFP, particularly in EU-CEE countries transforming economies in which ICT development is progressing rapidly and enabling modernization of products and processes. Finally, the intangible assets variable displays a relatively high degree of variability, which is expected given the differing national intensities of investment in this category.

3. Research Methodology

The main objective of this study is to analyse the dynamic relationships between innovation, the business environment, intangible assets and total factor productivity (TFP) across countries and over time. The Hausman test (Hausman, 1978) produced a value of 0.0000, confirming the appropriateness of the fixed effects model, which aligns with the assumption that country-specific factors influence productivity outcomes. Accordingly, we employ a fixed effects panel regression based on an extended production function that incorporates key determinants of productivity growth. This approach enables control for unobserved, time-invariant heterogeneity across countries through fixed effects, thereby mitigating potential estimation bias. At the same time, it captures structural differences

between national economies. Endogeneity may arise if institutional quality, ICT, or intangible assets jointly evolve with TFP. We address this risk by using a fixed-effects model and robust standard errors, which limits bias from time-invariant heterogeneity and serial correlation. A balanced panel dataset is used, and the time span is sufficient to identify the delayed effects of innovation, intangible assets, ICT, and institutional variables (BE and KW). On this basis, the main equation of Model (1) defines the econometric specification of the fixed effects panel regression:

$$TFP_{it} = \alpha_i + \beta_1 \mathrm{BE}_{it} + \beta_2 \mathrm{KW}_{it} + \beta_3 \mathrm{ICT}_{it} + \beta_4 \mathrm{INTANG}_{it} + u_{it} \quad (1)$$

where i indexes countries and t years (2013-2019); $\mathrm{TFP_{it}}$ = Total Factor Productivity; BE = Business Environment; KW = Knowledge Workers; ICT = Information and communication technologies; INTANG = Total Intangibles assets; $\mathrm{u_{it}}$ = Error; and α_i = fixed effect (country).

A total of four models are estimated. The first model includes all EU countries with 182 observations and excludes lagged effects. The second model focuses solely on EU-CEE countries, with 156 observations and no lag structure. The third and fourth models introduce one-year lagged effects for the EU and EU-CEE samples, respectively. This design allows us to capture the dynamic nature of the relationship between inputs and productivity while reducing the risk of endogeneity. Lagged variables (Brynjolfsson *et al.* 2000; O'Mahony and Vecchi, 2009) are particularly appropriate for variables such as the business environment, knowledge workers, and the accumulation of ICT and intangible assets, whose effects often materialize with a delay.

Diagnostic testing confirmed the presence of heteroscedasticity and autocorrelation in the model residuals. Given the violation of homoscedasticity and independence assumptions, coefficients were estimated via the fixed effects method with robust standard errors clustered at the country level (Arellano, 1987), ensuring the consistency of the estimates. Multicollinearity was assessed via the variance inflation factor (VIF) test, which yielded a value of 1.77, indicating that there was no significant multicollinearity. The correlation matrix revealed a relatively greater correlation between BE and ICT, but this relationship remained within acceptable limits and did not distort the coefficient estimates.

4. Research Results and Discussion

We conduct an econometric analysis of the impacts of intangible asset accumulation, business environment quality, the human capital level, and ICT infrastructure on total factor productivity (TFP) via a fixed-effects panel regression model. The Hausman test confirmed this specification by rejecting the consistency of random effects estimates. The analysis is performed for all EU countries and separately for the EU-CEE subgroup. We assume that TFP is determined by a combination of structural factors. The quality of the business environment, the level of knowledge workers, ICT infrastructure, and the accumulation of intangible assets. Furthermore, we assume that these effects may not occur instantaneously. Therefore, a panel regression model with a one-year lag is applied to capture delayed impacts.

Figure 1 illustrates the development of total factor productivity (TFP) in Western European countries (EU-15) and the transition economies of Central and Eastern Europe (EU-CEE) between 2009 and 2019. All values are indexed to 2017 = 100. In 2010, the EU-CEE countries started from a significantly lower level of TFP, but their growth rate surpassed that of the EU-15 in 2016. The EU-15 countries have maintained a higher long-term TFP level, reflecting Western Europe's historical advantages in technological sophistication, human capital, and institutional quality. During the observed period, TFP in the EU-15 region remained relatively stable, whereas EU-CEE countries recorded steady gains since 2009. This trend suggests a catching-up effect, as transforming economies have managed to adopt new technologies more rapidly, improve their business environments, and leverage cost advantages in human capital. The pattern also indicates that TFP growth in EU-CEE countries is largely driven by the diffusion and adaptation of technologies developed elsewhere mainly in the EU-15 or globally.

For the EU-15 countries, the main challenge lies in the low dynamics of productivity growth, despite strong innovation potential. Conversely, for EU-CEE countries, the key challenge is to connect productivity growth more closely to their own innovation capacity to sustain convergence. Figure 1 thus illustrates both the convergence process of EU-CEE countries and the structural barriers that differentiate their productivity trajectories from those of Western Europe.

The most important and robust finding is the consistent statistical significance of the variable representing the growth of intangible assets (Intangibles). In both unlagged models for EU and EU-CEE countries, the coefficient equals 0.005 with a robust standard error of 0.001 at the 1% significance level, clearly confirming the strong positive relationship between investment in intangible assets and TFP. The coefficient for intangible assets (0.005) indicates that a ten-point increase in intangible asset accumulation corresponds to an estimated 5% increase in TFP. These results support the first hypothesis, namely, that the accumulation of intangible assets positively affects total factor

productivity growth in EU countries. A similar positive result is observed when one-year lagged effects are incorporated.

Figure 1. Development of TFP in the EU and EU-CEE, 2017=100

Source: Authors' calculations

These findings are consistent with the well-established view that intangible assets play a crucial role in contemporary economies, particularly in driving productivity and supporting the transition toward a knowledge-based economy (Corrado, Hulten, and Sichel, 2009; Haskel and Westlake, 2018). Our results confirm these arguments and further show that, even within the EU-CEE region, the productivity growth model is founded on the accumulation of intangible assets. The model with lagged effects indicates that this influence is persistent over time, which is consistent with the conclusions of Roth and Thum (2013). The role of the regulatory and institutional environment proves to be particularly significant in transition economies. Our findings suggest that regulatory and institutional reforms do not immediately affect productivity but rather exhibit a delayed effect once new rules and frameworks have been stabilized and begin influencing the business environment. This result aligns with the argument of Acemoglu, Johnson, and Robinson (2001), who demonstrated that institutional quality is a fundamental determinant of economic performance. The same conclusion applies to the business environment more broadly, which constitutes a key determinant of a country's capacity to absorb and apply foreign technologies (Griffith, Redding, and Van Reenen, 2004; Stettler *et al.* 2024). The business environment coefficient differs between the EU and EU-CEE models. For the EU-CEE sample, the coefficient of 0.002 is statistically significant at the 5% level. A positive and stronger impact is also evident in the lagged models, where the coefficient remains significant at the 1% level. Specifically, a one-point increase in the GII business environment index is associated with a 0.2% increase in TFP, whereas a ten-point improvement corresponds to an average 2-3% increase in TFP in EU-CEE countries comparable in magnitude to the impact of intangible asset accumulation. These magnitudes underscore the economic significance of business environment and intangible investment, confirming that both variables exert substantial and policy-relevant effects on productivity. These results confirm the third hypothesis. Furthermore, the persistence of these effects indicates that improvements in institutional quality contribute to sustained productivity growth and enhance convergence within the EU-CEE region through multiplier effects.

Our results also reveal that, for EU-CEE countries, the ICT variable (0.001) has a statistically significant lagged effect at the 5% level. The findings also suggest that in digitally converging EU-CEE economies, the productivity effect of ICT may depend not only on diffusion and absorptive capacity but increasingly on the quality of cybersecurity practices, which protect digital intangible assets. However, historically EU-CEE economies have operated at lower levels of technological development, where ICT adoption yields high marginal benefits. Consequently, ICT expansion contributes to greater efficiency and modernization of production and business processes. In contrast, EU-15 countries having implemented ICT infrastructure much earlier experience productivity gains from ICT only when complemented by additional investments in organizational innovation and human capital (Brynjolfsson and Hitt, 2003).

van Ark, O'Mahony, and Timmer (2008) reported that U.S. firms were able to leverage complementary intangible assets more effectively to increase productivity. Our results are consistent with this evidence, in

economies where ICT is still developing, its contribution to productivity is especially pronounced. The heterogeneous regional effects are further supported by Rehman and Nunziante (2023), who showed that the expansion of the digital economy contributes positively to TFP at the regional level, although this contribution varies across regions. Collectively, these findings confirm the second hypothesis.

Table 1. Panel regression fixed effect results

	Depend variable: TFP			
	EU no lag	EU-CEE no lag	EU lag	EU-CEE Lag
	1.	2.	3.	4.
Intangibles	0.005***	0.005***	0.004***	0.004***
	(0.001)	(0.001)	(0.001)	(0.001)
Business Environment	0.001	0.002**	0.003***	0.002***
	(0.001)	(0.001)	(0.001)	(0.001)
Knowledge workers	0.003	0.000	0.001	-0.001
	(0.003)	(0.000)	(0.000)	(0.000)
ICT	0.001	0.001**	0.0003	0.001**
	(0.004)	(0.000)	(0.000)	(0.001)
No.	182	77	156	66
Adjusted R2	0.520	0.748	0.425	0.716
F stat.	56.287***	60.001***	35.941***	44.507***

Source: Authors' calculations Notes: Robust SEs clustered by country in parentheses. ***, **, * denote p<0.01, p<0.05, and p<0.10, respectively. All the models include country FEs; year FEs are included in the robustness checks.

The Knowledge Workers variable does not show statistical significance in any of the models. The GII indicator captures the supply of skilled labor but not the conditions that determine whether this human capital is effectively used within firms. Our results also suggest qualified workers contribute to TFP only when they have been supported by complementary intangible assets, organisational practices, and a stable institutional environment. In their absence in EU-CEE region the impact of knowledge workers on productivity remains limited. Although a positive relationship is observed, it is not statistically significant. The assumption that a high level of knowledge workers automatically enhances TFP growth is therefore not supported. However, the results confirm that the mere presence of highly qualified human capital is insufficient if it is not complemented by concurrent investments in intangible assets such as training, education, and economic competencies as well as organizational innovations. At the firm level, Syverson (2011) similarly reported that differences in productivity among firms often do not reflect the number of skilled workers but rather the quality of management, which determines how effectively these workers are utilized. The model itself explains a substantial share of TFP variability. The F statistics across the models confirm that the estimated regression relationships are statistically significant. The panel regression results provide important insights into the differentiated sources of TFP growth in EU countries, particularly between Western and Central and Eastern European (EU-CEE) regions. Our findings confirm that the determinants of TFP growth vary by development level. In EU-CEE countries, alongside the accumulation of intangible assets, both the quality of the business environment and ICT infrastructure play critical roles. Promoting the accumulation of intangible assets should therefore be a key policy priority. This includes fostering investment in research and development, software and databases, intellectual property, and organizational capital. Our analysis further confirms that a high-quality business environment is essential for supporting TFP growth. Consequently, EU-CEE countries should prioritize improving institutional frameworks and regulatory quality. Without such reforms, sustaining higher rates of productivity growth will be difficult.

Efforts to enhance human capital quality should focus not only on expanding education but also on improving conditions for the effective employment of knowledge workers particularly through the creation of innovation ecosystems. The results also confirm that the effects of intangible asset accumulation and business environment

quality are delayed, implying that economic policy should be designed from a long-term perspective. Overall, the different results across EU regions highlight the need for distinct economic policy strategies. Stable and predictable decision making in these areas is essential. In progressive digitalisation of production in EU-CEE the strengthening of cybersecurity frameworks could become an increasingly important complementary factor that protect digital intangible assets and support durability of ICT driven productivity growth. For EU-CEE countries, institutional reforms, investment in ICT infrastructure, and the accumulation of intangible assets remain key to accelerating convergence and sustaining greater TFP growth.

Conclusions and Further Research

The aim of this study was to analyse the determinants of total factor productivity (TFP) in EU countries, with particular attention given to the transition economies of Central and Eastern Europe (EU-CEE). Using panel regression with fixed effects and robust standard errors, we examined the relationships between TFP and four key factors: the quality of the business environment (BE), the development of information and communication technologies (ICTs), the quality of knowledge workers (KW), and the accumulation of intangible assets (Intangibles). By employing indexed variables as proxies, the analysis captured the multidimensional nature of institutional and business environment quality as well as human capital. The fixed effects specification ensures the econometric validity and robustness of the estimated results.

The most consistent and robust finding is the strong significance of the variable representing the growth of intangible assets. The results confirm that both the quality of the business environment and the accumulation of intangible assets are key determinants of total factor productivity growth. Productivity in the EU is therefore largely driven by investment in intangible assets, which exert a stable and statistically significant effect across all the models. This finding highlights the irreplaceable role of intangible investments as a principal source of productivity growth, which is consistent with Corrado, Hulten, and Sichel (2009). A similarly significant effect was observed for the business environment variable, particularly within the EU-CEE group, underscoring the differentiated determinants of TFP across regions. Institutional reforms and improvements in the quality of the business environment are thus crucial to sustaining productivity growth in these countries.

This study is subject to several limitations. The availability and timeliness of macroeconomic data particularly the conceptual consistency of national account data and supplementary EU-KLEMS information may influence the results. Potential biases may also arise from the use of indexed variables, which can obscure national-level heterogeneity. The fixed effects model captures structural relationships but does not allow for dynamic interactions among variables. Methodological extensions such as panel VAR or other dynamic panel models could uncover effects between intangible assets, ICT, institutional quality, and productivity. Future research should therefore focus on the detailed application of microeconomic data, such as firm-level datasets, to better capture the mechanisms of intangible asset accumulation and its effects. Given the short time span of the dataset, more advanced estimators such as Hausman-Taylor, or GMM could not be applied reliably, but they represent suitable extensions for future research once longer and harmonised new data become available. Moreover, future analyses could incorporate interaction variables, which according to the literature play a critical role in generating synergy effects among innovation-related factors.

Declarations

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Credit Authorship Contribution Statement:

Marek Pekarčík: Conceptualization, Investigation, Methodology, Software, Formal analysis, Writing – original draft, Data curation, Validation.
Leoš Šafár: Conceptualization, Methodology, Project administration, Supervision, Writing – review and editing, Funding acquisition.
Tatiana Taňkošová: Formal analysis, Data curation, Supervision, Writing – review and editing, Visualization.

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Research on the Evolution and Transformation of Administrative Discretion Regulation: A Systematic Review of Literature

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Abstract: This study discusses the development history, recent research, and future directions of regulating the exercise of administrative discretion. Through a systematic literature review, we identified 47 papers published between 1983 and 2025. These studies primarily analyzed the evolution of administrative discretion, the relationship between administrative discretion and the administrative environment, and regulatory approaches for subjects at different levels of administrative discretion. Based on the analysis, we identify a future normative logic for regulating the exercise of administrative discretion that will emphasize a legal focus supplemented by rationality. Administrative discretion is increasingly integrated with ICT, leading to a separation between its consideration and implementation, necessitating a corresponding distinction in its regulation. This study further summarizes current research challenges, including instrumental fragmentation, a lack of evaluation, and insufficient adaptability. We recommend strengthening theoretical integration, empirical research, and localization to promote the systematic development of administrative discretion regulation. This study is the first to systematically integrate multi-dimensional normative research findings at the micro, meso, and macro levels, constructing an interdisciplinary holistic analytical framework for the normative exercise of administrative discretion. By revealing the intrinsic connections and evolution of normative logic at different levels, this study not only enriches the theoretical foundation for the rational exercise of administrative discretion but also provides new explanatory paths and operational insights for institutional design and practical improvement of discretion in the context of digital transformation.

Keywords: administrative discretion; regulation; normative logic; systematic literature review.

JEL Classification: D73; J18; Y40.

Introduction

From its inception, administrative discretion has often been associated with negative concepts such as arbitrariness, corruption, and procedural impropriety (Gao, 2019; Adinda *et al.* 2024; Bhagwat, 1998). As a result, it is frequently labeled as “unnecessary.” However, legal norms can be either strict and explicit or adopt an “open-ended” formulation, leaving room for interpretation and requiring administrative officials to make decisions without prior, explicit, and binding legal standards (Gardner, 1987; Leenes, 2003). This provides a legitimate basis for administrative agencies to retain discretionary power in actual implementation (Galligan, 1990; Sigma, 1999). From the perspectives of legal theory and administrative management, eliminating discretion is nearly unattainable (Galligan, 1990; Hart, 1961). In any power system, discretionary authority plays an indispensable role (Varavithya and Esichaikul, 2006). Therefore, the research focus has gradually shifted from “whether it should exist” to “how to restrict and regulate it.” In the coexistence of traditional bureaucratic and post-bureaucratic models, governments

still rely on administrative discretion to address complex and dynamic governance challenges (Banerjee and Chau, 2004). Thus, regulating the exercise of administrative discretion has become an unavoidable research issue. With the advancement of digitized governance and diversified oversight mechanisms, research on its regulation has continued to evolve. Against this backdrop, it is necessary to systematically organize and analyze existing fragmented studies through a comprehensive literature review.

1. Research Background

The term “regulation” as used in this study is briefly explained here. Derived from regulatio, meaning “to adjust” or “to manage,” it is related to the Latin word regula. Originally, regula referred to a “ruler” - an instrument used to restrain objects and materials - and later extended to signify a restraining force on thought and behavior (Oxford University Press, 2024). Beyond laws and discipline, doctrines, theories, and mathematical models are also regulatory in nature, and even ethics can be considered a form of regulation. In this study, “regulation” functions as both a verb and a noun, consistently referring to the restraining force or action exerted on thought and behavior.

This study aims to achieve two specific objectives through a systematic review and meta-analysis of the current scientific literature: first, to systematically organize academic achievements related to the normative use of administrative discretionary power, clarifying the different levels of normative approaches and methods proposed and adopted by the academic community to date. Second, to systematically assess relevant experiences and empirical evidence on a global scale in order to construct a more comprehensive theoretical framework, thereby gaining deeper insights into the various pathways and mechanisms for regulating administrative discretionary power. This will help identify areas for optimization, promote continuous improvement of the regulatory framework, and ultimately enhance governmental governance capacity while safeguarding citizens' rights. To achieve these objectives, this study poses the following three core research questions:

Q1 What are the current means of regulating the exercise of administrative discretion, and what stage of development are related studies at?

Q2 How has the underlying logical framework for regulating administrative discretion evolved?

Q3 What areas for improvement exist in current research regarding regulatory pathways or analytical methods?

The structure of this study is as follows: Chapter 1, Introduction, outlines the research background and formulates the research questions. Chapter 2, Methodology, details the specific processes and results of literature retrieval and screening. Chapter 3, Discussion, addresses the first and second research questions, examines the current discourse on regulating administrative discretionary power, and traces the evolution of its regulatory logic. Chapter 4, Exploration, summarizes the key issues in existing research and proposes corresponding improvement pathways. Finally, the study offers suggestions for future research, focusing on enhancing the normative framework for administrative discretionary power and providing practical insights to improve government governance and safeguard citizens' rights and interests.

2. Methodology

2.1. Systematic Literature Review

There are two main reasons for conducting this literature review. First, the standardization of the use of administrative discretion is still in the process of continuous improvement in the field of public management and public administration. Particularly, in the course of the COVID-19, which was a global public emergency, a large number of emergencies requiring administrative discretion to resolve emerged, and the frequency of the use of administrative discretion has never been higher. Therefore, a comprehensive review is necessary. Organize relevant concepts and methods to consolidate what we know as the current state of what is often considered to be a fragmented discourse. Second, to date, no systematic literature review of the norms governing the exercise of administrative discretion exists, despite the need for more systematic research. Even in research focusing on a single relationship, differences in adopted methodological components and research procedures can lead to varying degrees of congruent and heterogeneous outcomes (Babalola and Nwanzu, 2021), further underscoring the need for systematic reviews. A systematic literature review helps to consolidate the conceptual foundations and clarifies unclear logical relationships in previous studies. This consolidation will help guide future research to more effectively inform policy. The goal of a systematic literature review is to present the current state of knowledge in a given field of study, emphasizing the most central and widely shared concepts and conclusions, and highlighting important gaps in the discourse and unresolved issues from previous research (Tranfield *et al.* 2003).

The review reports on the regulation of the exercise of administrative discretion are very limited and tend to be intentionally limited in scope as a way to achieve the effect of refining and focusing the subject matter of the

study. For example, Agostino et al. (2020) conducted a systematic literature review of 232 articles from an e-government perspective, exploring emerging issues of digital accountability and identifying future research directions, with a focus on administrative discretionary authority, accountability, and inclusion in a digital context. Busch and Henriksen (2018), from a digital bureaucracy perspective, reviewed 44 articles on digital discretion, discussing the intrinsic characteristics of technology and concluding that the scope of street-level bureaucracy is shrinking, with many transforming into digital bureaucracies. This review frames administrative change through the lens of e-government, whereas other literature reviews on administrative discretion often adopt a judicial perspective. Prek and Lefevre (2019), categorize administrative discretion into “discretion” or “assessment power” and “technical discretion” or “margin of appreciation” granted to the executive branch by treaty or legislature, emphasizing the need for different levels of judicial review. “or “margin of appreciation”, emphasizing the need for different levels of judicial review. Leonelli (2021) defines the precautionary principle as an inherent limitation of the broad discretion of the EU institutions in the field of EU risk regulation, concluding that it is difficult for judicial review to do justice to the precautionary principle as it applies to the risk management process and underpins the EU legislative framework.

This study differs from previous studies in that it synthesizes existing normative research findings on various levels of administrative discretion without being bound to a single normative approach or a single discipline. The practicality emphasized in this study provides a new framework for thinking about the regulation of the use of administrative discretion. By integrating the norms on the exercise of administrative discretion at the micro, meso and macro levels, exploring the logical changes in the norms, and improving the research on how administrative discretion can be used rationally, it will provide empirical support for the norms on administrative discretion after the digital transformation.

2.2. Inclusion Criteria

The literature search for this systematic review included scholarly studies published in peer-reviewed academic journals up to December 1, 2025. The search strategies and databases used in this review included Web of Science, Scopus, and JSTOR. To ensure that no core studies were overlooked, multiple databases and sources were searched to maximize coverage and reduce the risk of omission bias, thereby enhancing the reliability of the retrieved data. The search combined two key themes: first, administrative discretion as identified in the literature, and second, explicit normative research. Theme 1 search terms included "administrative discretion" and "executive discretion." Theme 2 search terms included: normative, norm, control, regulatory, standard, code, regulation, management, supervision, governance, enhancement, constraint, restriction, bound, guidance, instruction, evaluation, assessment, reform, reconstruction, law, mechanism, ethic, and morality. The initial dataset was obtained by applying the Boolean operator “AND” across these related terms, resulting in 1,632 studies on the norms governing the use of administrative discretion.

Table 1. Search strategies

Databases	Theme 1	Theme 2	Search Results
WoS	administrative discretion and executive discretion	normative(norm), control, regulatory, standard, code, control, regulation, management, supervision, governance, enhancement, constraint, restriction, bound, guidance, instruction, evaluation, assessment, reform, reconstruction, law, mechanism, ethic and morality	361
Scopus			355
JSTOR			1,030

Source: Authors’ elaboration

Based on the preliminary screening of literature, this study applied four inclusion criteria to identify relevant studies that meet the requirements for a systematic review, thereby forming the final literature collection. The four inclusion criteria are as follows: First, only studies that focus on administrative discretion in the public sector as their core subject are included, specifically those that examine the constraints and boundaries faced by state institutions, administrative agencies, and their staff when exercising administrative discretion. Second, literature must include empirical content or evidence supporting the possibility or intent of regulating the exercise of administrative discretion, such as laws and regulations, ethical norms, institutional mechanisms, or supervisory methods. Studies that are purely conceptual discussions are excluded, as are those that only partially address

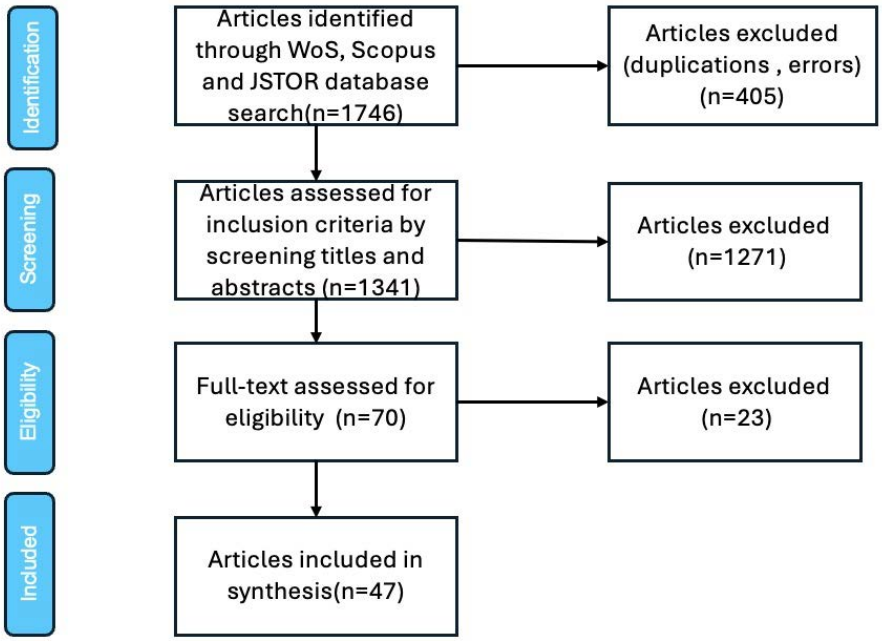
administrative discretion as one of several regulatory objects. Third, the literature must focus on specific regulatory measures aimed at refining the rules governing the exercise of administrative discretion and preventing its abuse. Fourth, there is no restriction on the starting year for the search in terms of time, but only academic publications in English are included, excluding theses, book chapters, and other literature reviews, to ensure that as many core research findings in this field as possible are covered.

2.3. Study Selection and Analysis

Through database searches, a total of 1,746 relevant literature records were initially identified. After data cleaning, 1,341 records were retained following the removal of errors and duplicates. Subsequently, based on predefined inclusion criteria, titles and abstracts were reviewed, resulting in the exclusion of 1,271 records, leaving 70 that initially met the inclusion criteria. As the full texts of all 70 records were available, an in-depth assessment was conducted to further confirm their eligibility. Through rigorous content analysis and full-text evaluation, 47 studies were ultimately determined to fully meet all inclusion criteria and were formally included in this systematic literature review. These studies are systematically presented in the text, focusing on the mechanisms and impacts of the exercise of administrative discretion, and offering valuable theoretical insights and practical references for future research directions.

To ensure the robustness and reliability of the screening process, two authors (authors 1 and 3) independently conducted the literature screening following thorough discussion and agreement on the inclusion criteria (Hoon, 2013; Linneberg and Korsgaard, 2019). In cases of disagreement or uncertainty, a third independent researcher was invited to intervene and help reach a consensus. The specific results of the entire screening process are detailed in the PRISMA flowchart below (Moher *et al.* 2009).

Figure 1 PRISMA flow diagram for literature review process, adapted from http://www.prisma-statement.org/



Source: Authors' elaboration

2.4. An Overview of Literature

This section provides an overview of the literature included in the systematic review, covering trends in the field of research, publication outlets, geographical distribution, methodologies, theoretical frameworks, and the evolutionary trajectory of research on administrative discretion (Agostino *et al.* 2020).

The 47 studies included in this review span a period of 42 years, with the earliest being Boyer (1983), published in Law and Policy, marking the first study on the regulation of administrative discretion. Among the selected studies, four papers were published in both 2019 and 2025, while five papers appeared in 2020. Notably, publications from the past five years account for nearly 30% of the total, indicating a sustained rise in research activity within this field in recent years. Research on this topic has persisted over time, with a gradual increase in studies conducted in recent years.

The 47 articles were sourced from 45 distinct journals, with Administration and Society and Studia Iuridica Lublinensia each publishing two articles, while all other journals contributed one article each. The majority of these journals fall within the fields of public administration and public policy.

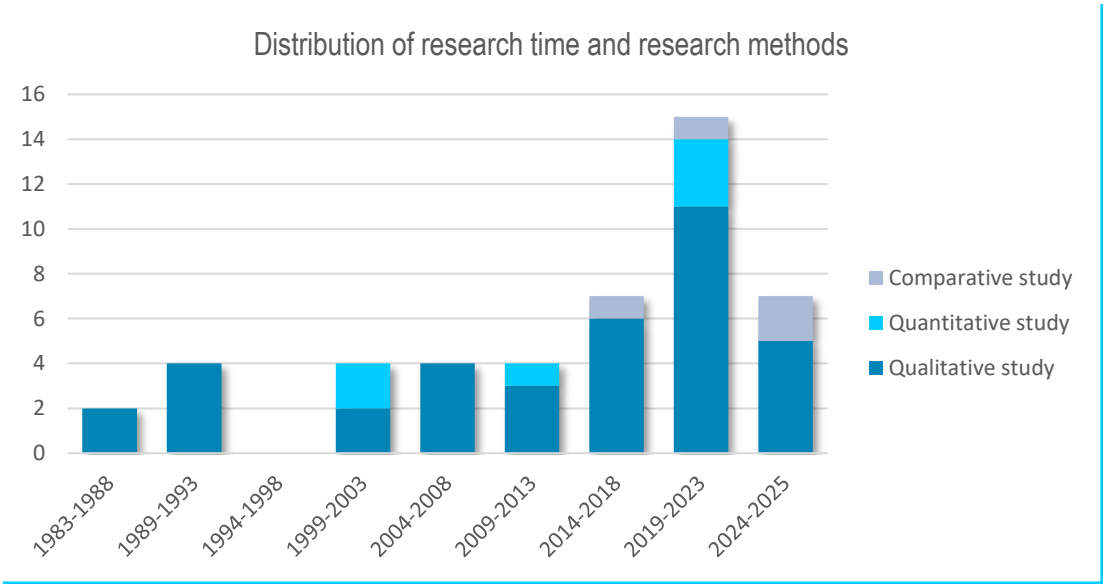
Among the 47 included studies, research subjects were primarily concentrated in the United States (30%) and European countries (43%). Earlier studies included relatively few documents on developing countries; however, in recent years, research focusing on these regions has gradually increased and is often closely linked to the development processes of specific countries. For example: Nigeria emphasizes human rights protection in the exercise of discretionary power; China's legislative, judicial, and administrative reforms concerning administrative discretionary power have drawn attention; Thailand and Egypt highlight the impact of e-government development on administrative discretionary power; Malaysia requires that the grounds for prohibiting publications ensure ministers' discretionary power aligns with legal and natural justice principles (Badamasiuy and Bello, 2013; Chan, 1992; Gao, 2019; Reddick *et al.* 2011; Varavithya and Esichaikul, 2006; Mohd Safri *et al.* 2025). Notably, comparative studies between continents and countries also constitute a portion of the sample, reflecting the broad applicability and research value of administrative discretion regulation across different national systems and governance contexts.

Of the 47 studies included in the literature, only about 13% employed quantitative research methods. These quantitative studies utilized tools such as questionnaires, data collection, statistical analysis, modeling, and joint experiments (Bolton and Thrower, 2019; Dietrich *et al.* 2023; Humphries and Songer, 1999; Reddick *et al.* 2011; Van Rompuy, 2022). In contrast, qualitative research methods dominate literature, incorporating a variety of approaches such as literature reviews, theoretical analysis, case studies, and interviews. Notably, one study adopted ethnographic research methods (Cinque, 2011). Additionally, comparative studies are also represented, including comparisons between developed countries and cross-country comparisons between developed and developing nations (Adinda *et al.* 2024; Bakhtina, 2023; Ip, 2014; Covilla, 2024).

Among the 47 included studies, most studies emphasized the critical role of the legal framework in regulating administrative discretion. Only a few discussions were grounded in theoretical frameworks, including proposals to establish management models and apply the principle of proportionality (Adinda *et al.* 2024; Margulies, 2023). Notably, one study highlights the urgent need for new theoretical and methodological support in current research but does not offer specific theoretical constructs or methodological approaches (Kravchuk, 1991).

The forms and exercise of administrative discretion discussed in the literature have evolved over time. Early studies primarily focused on transparency, procedural fairness, and accountability mechanisms in the exercise of administrative discretion by specific departments or local governments (Boyer, 1983; Crook, 1989; Box, 1992; Humphries and Songer, 1999; Franchino, 2000).

Figure 2. Number of Papers Published Per 5 Years



Source: Authors' elaboration

Table 2. Number of Papers by Geographical Area[1]

Geographical area	Percentages	N Papers
Developed countries		
Europe	4%	2
European Union (EU)	13%	7
German	6%	3
Netherlands	4%	2
Poland	2%	1
Spanish	4%	2
Sweden	2%	1
UK	8%	4
USA	28%	15
Canada	6%	3
Japan	2%	1
Australia	2%	1
Developing country		
Egypt	2%	1
Ukraine	2%	1
South Africa	2%	1
Nigeria	2%	1
Indonesia	2%	1
Thailand	2%	1
Iraqi	2%	1
China	4%	2
Malaysia	2%	1
Pakistan	2%	1
Brazil	2%	1

Source: Authors' elaboration

After 2000, research gradually introduced the individual freedom of citizens and public officials, treating "people" as a key variable influencing administrative discretion. Although most studies still take departments or governments as the unit of analysis, there has been a marked increase in attention to the behavior and subjective judgment of public officials (Sossin, 2005; Haraway and Kunselman, 2006; Alexander and Richmond, 2007; Bernick, 2019; Ignacio Criado *et al.* 2020; Bakhtina, 2023). With the rise of e-government, the exercise of administrative discretion has also undergone significant changes, with studies beginning to link it to organizational change, technological embeddedness, and the evolution of governance structures (Varavithya and Esichaikul,

1 Note: 4 articles exist that are comparative studies, so the final design of the Geographical area will be more than the number of papers studied in this dissertation. Due to rounding, the total percentage exceeds 100%.

2006; Reddick *et al.* 2011). In recent years, big data and AI have started to reshape how power is exercised, prompting a shift in focus from face-to-face discretion to issues of algorithmic transparency and checks and balances (Covilla, 2024).

3. Discussion

A review of the literature indicates that, with the passage of time, the forms and scope of administrative discretion have continuously evolved, and even the definition of administrative discretion itself has undergone certain changes. Correspondingly, the regulatory measures governing its exercise have also been consistently updated and expanded. The following section provides a systematic analysis of the process of standardizing the exercise of administrative discretion.

3.1. Macro, Meso and Micro Actor Norms: Hierarchical Differences in Practice

The discussion on the regulation of administrative discretionary power at different levels aims to explore how the hierarchical level of power holders influences regulatory mechanisms. Regulatory approaches at the national level and those at the individual level differ significantly in terms of objectives, methods, and implementation strategies. This analytical perspective also raises a critical question: As power holders become more specifically defined - from the national to the organizational to the individual level - should regulatory mechanisms be refined accordingly? Should regulatory measures be adjusted to align with these distinctions in order to achieve more targeted and effective oversight of administrative discretionary power?

The macro level refers to the state as the normative subject governing the exercise of administrative discretion. Comparative studies between countries (including within the EU) mainly emphasize the framework, complemented by the rule of law. By comparing the political and legal frameworks between different countries, discussions are made in terms of standards of review, judicial control and the construction of the rule of law (Adinda *et al.* 2024; Bakhtina, 2023; Eklund, 2024; Ip, 2014). Country-based studies, on the other hand, focus more on “law”, such as legal frameworks, legislation, law reform, and inclusion in the scope of charter review (Ali *et al.* 2022; Badamasiuy and Bello, 2013; Binder *et al.* 2018; Bovens and Zouridis, 2002; Chan, 1992; Kravchuk, 1991; Morgan, 1987; Sossin, 2002; Covilla, 2024) From this perspective, the macro-level regulation of the exercise of administrative discretion is more of a top-level structure, in the hope of constructing a sound legal framework, the exercise of administrative discretion into the framework, so as to constrain its exercise. Of course, these studies are not purely framework construction, but add various supplements on the basis of framework construction, such as judicial review, soft law (policy guidelines, training materials, and other non-legislative tools), ethics, etc. (Appleby and Reilly, 2017; Engster, 2020; Haraway and Kunselman, 2006; Sossin, 2002). These supplements to some extent can make up for the rigidity of the framework. These supplements can make up for the overly rigid characteristics of the framework, and to a certain extent, they have guided the direction for the refinement of the specific contents of the framework. Some scholars have also proposed new theoretical frameworks, such as administrative justice legislation, management models, legal mechanisms (Type A), external incentive mechanisms (Type B), and internal value mechanisms (Type C) (Morgan, 1987), as well as constructing the theory of "authorized discretion" - these are some of the more remarkable attempts (Bertelli *et al.* 2025).

The meso-level refers to the organization as the normative subject regulating the exercise of administrative discretion. Due to significant differences in political systems across countries, the identification of organizations varies widely. For the purposes of this study, the government, judiciary, and various departments are classified as meso-level organizations. Administrative discretion arises from the need for policy implementers to adapt policies to societal realities, making administrative organizations its primary bearers. In meso-level studies, the sources of regulatory power over administrative discretion can be categorized as internal and external. Internal regulation stems from within the administration itself. Research on internal regulation is relatively dispersed, covering areas such as organizational change and collaboration, improving procedural efficiency and transparency, respecting legal standards in administrative reviews, and integrating administrative decision-making with the experience and values of decision-makers (Boyer, 1983; Humphries and Songer, 1999; Konstant, 2016; Mendes, 2016; Reddick *et al.* 2011; Sossin, 2005; Van Rompuy, 2022). These studies approach internal regulation from the perspectives of organizational structure adjustments, process optimization, internal administrative review, and coordination among staff and departments. They draw heavily on public management principles, including planning, organizing, leading, coordinating, and controlling. External normative research primarily revolves around the law and is divided into three dimensions. In terms of legislation, the focus is on balancing legislative procedures with preference distributions and uncertainty factors, legislative and practical reforms, and the construction of the rule of law (Crook, 1989; Gao, 2019). In terms of law enforcement, the emphasis is on implementing legal constraints on administrative agencies, expanding the role of the law, and adjusting the effects of the law (Bornemann, 2019; Humphries and

Songer, 1999; Mendes, 2016; AllahRakha, 2025). In terms of the judiciary, the focus is on the use of judicial review tools, judicial control, and strengthening judicial intervention (Kaneko, 2020; Martinsen, 2011; McHarg, 2017; Winder, 2020). External norms at the meso level logically build upon norms at the macro level. The macro level focuses on top-level design, while the meso level refines specific institutional content. Additionally, some studies emphasize the synergistic effects of multiple normative mechanisms, such as the interaction between legal and political environments, transforming administrative discretionary power into mandatory functions through legislation, and combining the rule of law with performance management.

The micro level refers to the constraints faced by executors of administrative discretion when exercising such power. It is important to note that while both the macro and meso levels focus on normative subjects as the object of study, the micro level centers on the executors of power. This distinction arises because, although some of the reviewed articles discuss individual regulation in the exercise of administrative discretion, they treat individuals merely as components of the normative subject, limiting the potential for further exploration. As direct executors, individuals are mostly studied as subjects of norms, which means the discussion remains relatively constrained. Executors of administrative discretion are primarily administrative staff, including, in some cases, normative studies of the president as a unique government actor. Micro-level research does not focus on whether or how executive staff comply with laws and rules - an approach somewhat disconnected from macro- and meso-level analyses. Instead, it emphasizes morality and ethics, highlighting political constraints, the balancing of normative values, ethical leadership and reflection, the protection of personal freedoms of executors, and the cultivation of administrative ethics to enhance public employees' capacity for fair and balanced judgment in administrative dilemmas. These perspectives focus on how executors of administrative discretion can use ethics to guide their behavior and ultimately achieve normative compliance (Alexander and Richmond, 2007; Box, 1992; Cinque, 2011; Dietrich *et al.* 2023; Haraway and Kunselman, 2006; Ignacio Criado *et al.* 2020). It is also noteworthy that the study of the president's norms in exercising discretion is closely tied to ethics. Under the separation of powers, the president adheres to principles of faithful execution and respects the authority of Congress (Bernick, 2019; Bolton and Thrower, 2019; Price, 2014).

As a result, the regulation of administrative discretion spans the macro to micro levels, reflecting a systemic construction. The macro level establishes the framework and its supplements, the meso level refines its content both internally and externally within organizations, and the micro level externalizes ethics and morality to shape individual behavior.

3.2. Diversification of Normative Forms: Integration of Multiple Subjects and Multiple Means

A review of relevant literature reveals that the regulation of administrative discretionary power displays diverse characteristics, primarily reflected in the plurality of regulatory entities and the organic integration of regulatory measures.

In the context of pluralistic governance, the regulation of administrative discretion originates from a variety of actors, combining both "bottom-up" and "top-down" approaches. Congress, the President, and the High Court of Justice are involved in shaping the political and legal framework for administrative discretion (Chan, 1992; Bovens and Zouridis, 2002; Binder *et al.* 2018; Adinda *et al.* 2024; Ip, 2014; Eklund, 2024), defining legal concepts and roles (Mendes, 2016; Appleby and Reilly, 2017; Covilla, 2024), and establishing mechanisms for judicial control and review (Chan, 1992; Appleby and Reilly, 2017; Ali *et al.* 2022; Bakhtina, 2023; Covilla, 2024). Local governments, supervisory bodies, courts, and prosecutors contribute through the development of soft law (Sossin, 2002), procedural review (Boyer, 1983; Franchino, 2000; Leonelli, 2021; Van Rompuy, 2022), and judicial restraint (Kaneko, 2020; Winder, 2020; Leonelli, 2021). Public officials, street-level bureaucrats, politicians, and citizens engage in reflections on role differentiation (Box, 1992; Cinque, 2011), protection of individual freedoms (Ignacio Criado *et al.* 2020; Dietrich *et al.* 2023), and moral deliberation (Haraway and Kunselman, 2006; Alexander and Richmond, 2007; Cinque, 2011; Bornemann, 2019; Dietrich *et al.* 2023). These dynamics collectively result in a multiplicity of actors involved in regulating the exercise of administrative discretion.

In the previous section, analysis from the macro, meso, and micro perspectives revealed significant differences in regulatory forms at each level, yet law remains the common thread throughout. As the primary regulatory instrument, law operates both ex ante and ex post. Ex ante regulation involves developing a legal framework within the constitutional context and refining administrative discretion benchmarks aligned with practice, thereby enabling subsequent constraints and oversight. Ex post regulation includes procedural review, performance management enhancement, and the cultivation of judgment that promotes the externalization of administrative ethics during discretion execution. Post hoc norms manifest as judicial intervention, review, and regulation.

Regulatory approaches thus span legal, procedural, ethical, economic, judicial, and supervisory domains, reflecting a multifaceted blend of hard and soft mechanisms across economic, social governance, and scientific fields.

The methods by which multiple entities participate in the regulation of administrative discretionary power vary, with each entity focusing on different aspects and directions of regulation, thereby forming a clearly defined and well-structured distribution of responsibilities. To ensure effectiveness, regulatory measures must be implemented by entities equipped with the appropriate resources and mandates. As a result, multiple entities and diverse regulatory methods are organically integrated.

3.3. Evolution of Normative Logic: Transition from Multidimensional Integration to Center of Attention

The subjects of action and normative forms primarily represent the external manifestations of administrative discretion, yet these manifestations conceal an underlying logical evolution. A review of relevant research reveals that the normative trajectory of administrative discretion has followed a developmental path - shifting from multidimensional integration to the establishment of subject autonomy, and ultimately toward a focus on core mechanisms.

Multi-dimensional integration involves combining behavioral actors from various dimensions with diverse normative forms. Prior to 2000, scholars had already moved beyond reliance on a single approach, instead exploring multiple dimensions such as legislation, institutional design, environmental factors, and individual development. These studies reflect a trend toward divergent thinking centered on normative actors, emphasizing the interaction of multiple dimensions. They construct a comprehensive constraint system - like ropes extending from all directions - firmly binding the exercise of administrative discretion within normative frameworks and preventing it from arbitrarily straying from institutional tracks.

After 2000, with the advancement of information and communication technology and the rise of e-government, the impact of citizen participation gradually became more prominent, and the interaction between public officials and citizens emerged as a central research focus. Prior to this, “people” were merely one of many normative factors - and often overlooked. However, research during this period elevated the role of “people” to a core variable. How, then, do individuals influence the formation of discretionary norms? This involves the influence of factors such as the social context in which individuals are embedded, moral constraints, and value perceptions. As a result, the research logic of this stage places greater emphasis on rational reflection, value construction, and experiential accumulation, reflecting a shift from external institutional constraints to internal psychological construction. This signifies a normative trajectory in which intrinsic values drive external behavior.

Around 2018, research entered a new phase characterized by multi-dimensional integration, optimization, and restructuring. As the regulation of administrative discretion involves multiple forces, simple or random combinations proved ineffective in forming robust mechanisms. Consequently, studies began to adopt a “center-periphery” model to organize various elements. The hallmark of this phase was the integration of other factors around the core of the rule of law and legal systems. Research frameworks often took the form of a “rule of law/law + X” model, such as rule of law plus oversight and accountability, rule of law plus citizens’ rights, law plus practice, and law plus training. These models emphasized strengthening the core while refining peripheral elements. Compared to the previous phase, the key difference lay in the clarity and coherence of the logical structure. While the earlier stage featured loosely connected elements, this phase centered on the rule of law, highlighting its integrative and expansive capacity. Anchoring the framework in legal principles provided a solid foundation, while complementary components enriched and enhanced the overall structure, forming a cohesive whole.

The above discussion requires clarification on two points. First, the division of stages is neither absolute nor static; even after the year 2000, many studies continued to follow the logic of the first stage, which emphasized “multi-dimensional integration.” The three stages outlined in this paper aim to highlight the relatively mainstream or dominant research orientations within each period, rather than rigidly classifying all research. Second, within the integration logic centered on the rule of law or legal systems in the third stage, the emphasis on “rational thinking” proposed in the second stage remains a vital element. This concept is further absorbed and developed in the third stage, becoming a key intellectual resource that supports the integration of peripheral elements with the core.

Digital Discretion: Shifting Power to Create New Normative Systems

With the continuous development of ICT, e-government, and even AI, administrative enforcement methods have undergone profound changes, and traditional office models have been gradually replaced. Technological progress has driven the evolution of organizational forms, with street-level bureaucrats gradually giving way to system-level bureaucrats, and administrative discretionary power evolving into digital discretionary power (Bovens and Zouridis, 2002; Reddick *et al.* 2011; Varavithya and Esichaikul, 2006). A comparison reveals that the rise of digital discretionary power has led to a noticeable shift in authority. When administrative actions are based on

established e-government procedures or AI-generated analysis, the discretionary decision-making once held by public officials is partially or entirely transferred to the designers of these systems. This shift risks rendering traditional norms regulating administrative discretion ineffectively. Consequently, in recent years, how to regulate digital discretionary power has emerged as a new research hotspot. This paper focuses on the normative framework for the exercise of traditional administrative discretionary power, while digital discretionary power, by fundamentally separating decision-makers from executors, presents a distinct structure. Although final implementation remains in the hands of public officials, the decisions and guidance they follow originate from system designers. Thus, while digital discretionary power is relevant to this study, due to its fundamentally different power structure and regulatory logic, this paper offers only a brief discussion and summary of it. In the era of digital discretionary power, the legal-centered regulatory model remains intact. However, for emerging procedures and systems in the decision-making process, the relevant regulatory framework is still in its infancy and has yet to form a comprehensive and mature constraint mechanism.

According to the inclusion criteria, the literature meeting the requirements of this study primarily focuses on how institutions adapt to technological change through innovation. The core of institutional innovation lies in integrating the discretionary power of system designers into the regulatory framework to ensure procedural legitimacy and decision-making fairness (Bovens and Zouridis, 2002). Although the division of power and responsibility between those exercising discretionary authority and system designers remains unclear, research attention is increasingly shifting toward system designers. The introduction of systems helps reduce the abuse of administrative discretionary authority, with relevant regulations mainly emphasizing procedural transparency and public participation. Additionally, similar to the regulatory logic of traditional administrative discretion, such research also underscores the importance of supporting legal framework and supervision mechanisms for personnel behavior.

In the future, digital discretionary power represents an inevitable direction of development. Regarding its regulatory path, research will gradually differentiate the respective responsibilities of procedural makers and procedural users in the exercise of power, thereby achieving a clearer and more rational institutional arrangement. As a result, the regulation of administrative discretionary power will involve more regulatory entities, a transformation in regulatory forms, and even the establishment of mutual supervision mechanisms among different power holders. However, institutional change is not a leapfrogging process; the existing regulatory system will continue to play an important role in the transition and integration process.

4. Exploitation of Current Research

As administrative discretion plays an increasingly prominent role in public governance systems, academic attention to its regulation has steadily grown. Numerous studies have explored legal systems, ethical frameworks, procedural fairness, and related topics, producing a wealth of findings. However, a systematic review of 47 relevant studies reveals that current academic research still faces a disconnect between theoretical construction and practical guidance, reflected in fragmented regulatory tools, the absence of evaluation mechanisms, and limited adaptability to specific contexts. These issues urgently call for resolution and breakthroughs in future research.

4.1. Fragmentation of Standardization Tools

Current research on the regulation of administrative discretionary power tends to focus on specific aspects such as legal constraints, institutional design, or ethical norms. While each of these areas has its own value, the overall picture is one of “fragmented tools and fragmented theories.” There is often a lack of cross-disciplinary dialogue between different studies, leading to a lack of a unified theoretical framework and systematic logic for regulatory approaches. Although a legal-centric model has gradually emerged, some studies emphasize using legal frameworks to define the boundaries of discretion but fail to delve deeply into how legal norms are implemented in specific administrative practices. Other studies focus on the use of auxiliary tools but lack effective safeguards for their institutionalization. The resulting “center-periphery” model has failed to truly integrate and coordinate various tools, and different models operate independently, undermining the explanatory power of theory and the applicability of practice.

4.2. The Lack of An Evaluation Mechanism

Current research on the effectiveness of regulations governing administrative discretionary power remains significantly underdeveloped. Most literature focuses on “how regulations should be” or “how regulations may be,” but lacks systematic quantitative or qualitative assessments to verify the actual impact of existing regulatory pathways. There is a notable shortage of empirical studies addressing whether legal regulations effectively

constrain administrative abuse of power or whether ethical education genuinely enhances officials' awareness of discretionary responsibility. This absence of robust evaluation mechanisms not only weakens the scientific rigor of regulatory frameworks but also limits policymakers and practitioners in optimizing and refining policies based on empirical feedback.

4.3. Insufficient Situational Adaptability

Current research on the regulation of administrative discretion, governance theories and institutional frameworks from developed countries - particularly those in Europe and the United States - predominate. A systematic review of 47 English-language studies reveals that some research has yet to sufficiently consider the significant differences in political systems, administrative cultures, organizational structures, and public service practices across countries and regions in their normative designs.

Developed countries typically possess more comprehensive legal systems, stronger administrative accountability mechanisms, and higher levels of citizen participation. Their regulations on discretionary power primarily emphasize procedural fairness, transparency, and the establishment of accountability mechanisms. In contrast, administrative systems in developing countries often face challenges such as resource shortages, unclear delineation of responsibilities, and broader discretionary space at the grassroots level, resulting in more flexible and context-dependent discretionary practices. The allocation of discretionary authority among multi-level governments follows an “emotion-reason-law” interactive logic, presenting more complex challenges for normative design. Ignoring these differences in governance contexts and mechanically applying normative models across countries or regions can easily lead to “theoretical incompatibility.”

5. Future Research Directions: Integration, Deepening, and Transformation

In summary, future research on the regulation of administrative discretionary power can proceed from the following aspects:

First, theoretical integration. Bridging theories across disciplines to construct a multi-perspective analytical framework for regulating discretionary power enables the organic integration of legal norms, ethical guidance, and institutional design. By taking law as the core, and rationally incorporating other elements, the practical functions of various regulatory tools can be effectively realized.

Second, empirical deepening. The practical value of norms must be validated through research methods that combine qualitative and quantitative approaches. Comprehensive investigations and analyses of the logic, regulatory pathways, and actual outcomes of discretionary power can enhance the real-world explanatory power of theory. Norms should not only aim to solve problems but also depend on objective evaluation systems to provide feedback and enable optimization of their effectiveness and operability.

Finally, localization and transformation. Future studies should further strengthen contextual sensitivity by identifying the characteristics of different governance systems at the macro-institutional level while also examining the discretionary logic and behavioral patterns of frontline officials at the micro-operational level. This will facilitate situational adjustments and the localization of regulatory pathways, improving their applicability and practical value across diverse governance environments.

Concluding Thoughts and Ways Forward

Administrative discretion profoundly influences policy formulation, implementation, and oversight. While it is employed throughout the administrative process, it is also subject to regulatory pressures from various actors. Since the 1980s, a growing number of scholars have focused on how to regulate its use. This paper synthesizes that body of work, systematically reviewing 47 studies on the regulation of administrative discretion to provide a detailed overview of the field’s current state, highlight key regulatory challenges, and propose new directions for future research.

While acknowledging that administrative discretion is an inevitable aspect of government administration, this study aims first to summarize and outline the evolution of administrative discretion, and then to examine how different types of discretion have been regulated across different periods, highlighting that its exercise must always occur within constraints.

Previous studies on the regulation of administrative discretion have conducted varying degrees of analysis and summary. This study adopts a systematic literature review approach, differing from earlier works by not limiting its focus to a single department or specific aspect. Instead, it offers a comprehensive analysis from a global perspective, integrating macro, meso, and micro levels, and closely linking the evolution of administrative discretion with broader administrative reforms. It is a review that combines both breadth and focus.

This systematic review aims to encompass a broad range of topics, and as a result, certain details may be overlooked. Administrative discretion is continuously evolving, and its regulation will inevitably be further refined and innovated in the future. The underlying logic of regulating the exercise of administrative discretion should involve extending a center-focused model, enhancing the relationship between the core and other influencing factors, while also reinforcing the role of individuals in normative considerations.

This study breaks through the limitations of previous research, which often focused on a single dimension or disciplinary perspective of administrative discretionary power. For the first time, it systematically integrates multidimensional normative findings across micro, meso, and macro levels, constructing a holistic analytical framework for the normative exercise of administrative discretionary power on an interdisciplinary basis. By revealing the intrinsic connections and evolution of normative logics across different levels, this study not only enriches the theoretical foundation for the rational exercise of administrative discretionary power but also offers new interpretive pathways and operational insights for institutional design and practical improvements of discretionary power in the context of digital transformation. This literature review provides practical theoretical support and practical implications for optimizing the quality of administrative decision-making, enhancing governance capabilities, and addressing the complex ethical and normative challenges posed by digital administration. It is worth noting that administrative discretionary power represents only one form of administrative authority. Research on its exercise norms possesses distinct characteristics while also offering valuable reference points. Summarizing the norms governing the exercise of administrative discretionary power can provide support for future studies on the norms of power exercise.

Declarations

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Credit Authorship Contribution Statement:

Liang ChunMei: Conceptualization, Investigation, Methodology, Project administration, Software, Formal analysis, Writing – original draft, Data curation, Validation, Writing – review and editing, Visualization
Nadhrah A Kadir: Supervision, Data curation, Validation, Writing – review and editing
Zhang WenRui: Software, Formal analysis, Writing – original draft

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Analysis of Economic Factors in the Context of Healthcare Reform in Ukraine

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Abstract: The study aimed to assess the impact of economic factors on the healthcare system renewal in Ukraine. The study analysed key regulatory documents that affect healthcare financing and management and compares the Ukrainian model with those of other European countries, such as Poland, Germany, the Czech Republic and Switzerland. To obtain the results, data for 2019-2025, including official statistics on sector financing and access to healthcare services, were used. The main findings of the study indicate significant regional disparities in access to healthcare services in Ukraine, which appear to be associated with the uneven distribution of financial resources. The available data suggest that healthcare reform based on the principle of "money follows the patient" has improved funding for healthcare facilities in large cities, while rural facilities tend to remain comparatively underfunded. In addition, the study determined that higher incomes provide better access to healthcare services, while people with lower incomes face financial barriers and informal payments, which worsen access to healthcare. Comparisons with healthcare models in Poland, Germany and the Czech Republic demonstrated that systems with compulsory health insurance provide greater financial stability and equal access to healthcare services. The Ukrainian system requires significant reforms to address regional disparities and improve the efficiency of financing. The findings highlight the need to improve the mechanisms for allocating financial resources, particularly for rural areas, and to attract additional private investment to modernise healthcare facilities.

Keywords: budget financing; investment resources; healthcare governance; behavioural economics; health economics.

JEL Classification: I10; I11; I18; H51.

Introduction

The global economic challenges highlighted issues in many areas, including healthcare systems, which continue to face challenges related to limited financial resources and underdeveloped infrastructure. The healthcare system in Ukraine needs to be transformed, as the old model does not meet modern requirements, especially in the context of economic instability. One of the main tasks is to reform healthcare systems to increase their resilience and ability to respond effectively to future challenges. Changes in the economy have confirmed that the resilience of healthcare systems is a crucial factor in ensuring their effective operation in various crises. The research relevance is determined by the need to develop economic strategies that will help improve the efficiency of healthcare systems and their adaptation to new challenges. Investment in regional healthcare infrastructure and the introduction of innovative technologies were emphasised. This will not only improve the quality of medical services but also reduce regional inequalities in their provision, ensuring more equal access to medical resources across the country.

The World Health Organisation (WHO) (2024) synthesises post-2017 reform progress (single purchaser, explicit benefit package/Medical Guarantee Programme, and an increasingly mature eHealth backbone) while

documenting how these arrangements were stress-tested by the full-scale invasion and associated demographic, epidemiological, and fiscal shocks. The review argues that prior financing reforms materially supported continuity of service delivery, yet identifies persistent constraints, especially under wartime budget compression, around out-of-pocket burdens, equity of access across regions, and the need to further optimise purchasing and provider-payment design to improve allocative efficiency and protect vulnerable groups (Leshchenko and Leshchenko, 2023).

In peer-reviewed policy debate, Habicht *et al.* (2024) conceptualise Ukraine's progress toward universal health coverage as a function of institutional attributes that enabled rapid adaptation during wartime (including governance arrangements and financing instruments), but they also highlight that maintaining UHC trajectories during conflict requires deliberate fiscal and administrative choices, not merely emergency mobilisation. Complementing this, Murphy and Kovtoniuk (2025) present Ukraine as an illustrative case of health-system resilience after three years of full-scale invasion, emphasising the practical role of the Medical Guarantee Programme, primary-care financing, and service-package revision (including mental health and rehabilitation), while also underscoring the continuing pressures created by infrastructure damage, workforce disruption, and recurrent security risks.

Beztelesna *et al.* (2024) empirically associate provider behaviour and patient choice with increased competition and shifting utilisation patterns under reform – relevant to analyses of how incentives operate when resources are scarce and accountability requirements intensify. In parallel, Mudge *et al.* (2025) argue that Ukraine's reconstruction window makes digital health architecture a core enabling condition for recovery: the policy case for a future-facing digital system is advanced explicitly as a mechanism to scale access, sustain continuity amid displacement, and improve system-level coordination. Finally, recovery-oriented policy documentation, including the Government's health-care recovery planning and World Bank programme materials, situates health reform within broader reconstruction finance, emphasising targeted investments, strengthened purchasing capacity, and institutional performance improvements as prerequisites for equitable rebuilding (The National Council for the Recovery of Ukraine from the Consequences of the War, 2022).

Existing studies primarily address individual aspects such as governance adaptation, financing reforms, or system resilience under crisis, but lack an integrated economic and comparative perspective. In contrast, this study provides a comprehensive analysis that combines regulatory review, longitudinal financial data, regional equity assessment, and international comparison, thereby offering a more rigorous and policy-relevant understanding of how healthcare financing, incentives, and resource allocation shape access and sustainability under wartime conditions.

The novelty of this study lies in its comprehensive assessment of healthcare reform in Ukraine under concurrent pandemic and wartime conditions, integrating economic analysis, regulatory review, and international comparison. Unlike previous studies that examine individual aspects of healthcare financing or governance, this research focuses on the interaction between economic factors, regional disparities, behavioural incentives, and technological innovation. The significance of the study is determined by its policy-oriented approach, offering economically grounded recommendations to improve the efficiency, accessibility, and resilience of the healthcare system in conditions of prolonged economic and institutional instability.

The study aimed to analyse the impact of economic factors on the reform of the healthcare system in Ukraine in the context of current challenges. To achieve this goal, the existing problems of healthcare financing and management, which have become particularly evident during the COVID-19 pandemic, were analysed, and the possibilities of introducing innovative technologies and improving regional infrastructure to increase the efficiency of healthcare services were explored.

1. Materials and Methods

The study covered the period from 2019 to 2025, which is characterised by significant changes in the financing and functioning of the Ukrainian healthcare system under the influence of both internal economic factors and external challenges, including the COVID-19 pandemic and the war. For a comprehensive assessment of the reform processes, quantitative and qualitative data were used to analyse the dynamics and effectiveness of the implemented measures.

The first stage of the study was a detailed analysis of regulatory documents that affected the reform of the healthcare system in Ukraine. The Law of Ukraine No. 2168-VIII "On State Financial Guarantees of Medical Service to the Population" (2018) was central to this analysis. The Resolution of the Cabinet of Ministers of Ukraine No. 410 "On Approval of the Procedure for the Implementation of State Guarantees of Medical Care for the Population" (2018) was analysed. The Order of the Cabinet of Ministers of Ukraine No. 1013-p "On Approval of the Concept of

Reform of the Financing of the Healthcare System" (2016), which provides for significant changes in the mechanisms for financing medical institutions, was also examined. In addition, the National Strategy for Building a New Healthcare System in Ukraine for the Period 2015-2025 (2014) was analysed, which establishes the main strategic directions for the development of the sector, including the introduction of innovative technologies, telemedicine and infrastructure modernisation. The effect of these legal acts on the structure and functioning of medical services, access to medical care in different regions of the country, and the integration of new technologies such as telemedicine was emphasised. The stage aimed to identify the legal basis and main directions of reforms that had a direct impact on the financing and management of the healthcare system in Ukraine. The assessment of the impact of these documents determined how effectively they respond to current challenges, in particular, financial constraints and problems of medical resource management, identifying potential weaknesses that need to be further improved.

The second stage involved the use of statistical data provided by the Cabinet of Ministers of Ukraine, in particular: Ministry of Finance of Ukraine (2024) data on healthcare expenditures in 2023, data on state budget expenditures in 2021 (MinFin, 2025a), and information on healthcare expenditures in 2022 and 2019 (Ministry of Finance, 2023; MinFin, 2025b). This data included not only information on the dynamics of financing the sector, but also indicators on private investment in the healthcare sector and per capita expenditures. The statistical indicators were used to track trends in healthcare financing and assess their impact on the availability and quality of healthcare services, especially in remote regions.

The third stage of the study employed a structured international comparative analysis of healthcare governance models in Ukraine and selected European countries (Poland, Germany, the Czech Republic, and Switzerland). These countries were chosen based on the following criteria: (i) geographic and historical proximity to Ukraine (Poland and the Czech Republic), (ii) differing but well-established healthcare financing and insurance models (Germany and Switzerland), and (iii) availability of comparable and reliable statistical data from international databases (World Health Organisation (WHO) (2023), World Bank Group (2025a, 2025b)).

To ensure methodological comparability, the analysis was conducted using a uniform set of indicators grouped into four analytical dimensions: (1) healthcare financing structure, including public health expenditure as a percentage of GDP and per capita health expenditure; (2) insurance and governance model, distinguishing between tax-based, social health insurance, and mixed systems; (3) cost-containment and financial sustainability mechanisms, such as co-payments, pooled purchasing, and regulatory price controls; and (4) access and equity indicators, including population coverage, out-of-pocket expenditure share, and access to healthcare services across different socio-economic groups.

The comparative assessment focused on how each governance model responds to common systemic challenges, namely chronic underfunding, demographic ageing, and rising healthcare costs. Data were analysed using descriptive and comparative methods to identify structural advantages and limitations of each model. Particular attention was paid to policy instruments and governance practices that demonstrate effectiveness in maintaining financial sustainability while preserving equitable access to healthcare services. The results of this comparison were subsequently evaluated in terms of their potential adaptability to the institutional, economic, and social context of Ukraine.

2. Results

Given the internal economic problems and external threats such as war, the reorganisation of the healthcare system is one of the top priorities for Ukraine in the current environment. The healthcare system faces many challenges, including underfunding of the sector, outdated equipment, a shortage of qualified staff and insufficient access to healthcare services. Considering these circumstances, cost-effective reforms are of utmost importance.

As financing and optimisation of resources are fundamental to creating a sustainable and competitive healthcare system, economic factors are substantial in determining the feasibility and effectiveness of reforms. Innovative technologies are an important part of the reform as they can significantly improve the quality of healthcare services and reduce costs, but their implementation requires appropriate financial and economic plans (Panchenko *et al.* 2018; Ketners *et al.* 2024). In this situation, an analysis of economic factors is important to assess the success of current reforms and to develop plans.

The transformation of the healthcare system in Ukraine is based on several key regulatory documents that have significantly influenced the development of the sector. One of the central regulatory acts is the Law of Ukraine No. 2168-VIII "On State Financial Guarantees of Medical Service to the Population" (2018), which introduced a new model of financing medical institutions based on the principle of "money follows the patient" based on the 2018 Medical Reform (Zaporizhzhia City Council, 2025). This approach was designed to improve the efficiency of public

resource use and encourage medical institutions to improve the quality of services. According to the regulatory framework, patients are formally granted the right to choose their doctor and medical institution. There is evidence indicating that this mechanism may contribute to improvements in service quality, although its effects vary across regions.

Hospitals in large cities, where patient volumes are higher, tend to receive comparatively more funding, while healthcare facilities in remote regions face persistent resource constraints (Hasanov *et al.* 2025; Moskalenko *et al.* 2025). According to recent analyses by WHO/Europe and national recovery planning documents, these financial pressures have contributed to the consolidation and restructuring of healthcare networks, including the reduction or reorganisation of some rural facilities. Available evidence suggests that such changes may affect physical access to services in sparsely populated areas if compensatory measures (*e.g.*, strengthened primary care, mobile units, or telemedicine) are not adequately implemented (World Health Organisation (WHO), 2025; The National Council for the Recovery of Ukraine from the Consequences of the War, 2022). This distribution of resources has not only deepened regional disparities in the provision of healthcare services but also demonstrated the need for further improvements in the financing mechanism.

The next important stage of the reforms was the Order of the Cabinet of Ministers of Ukraine No. 1013-p "On Approval of the Concept of Reform of the Financing of the Healthcare System" (2016), which consolidated the transition to the state insurance model. This was intended to relieve the state budget by attracting additional insurance resources to finance healthcare services. In practice, the implementation of this model can optimise healthcare costs and use public funds more rationally. However, there were difficulties with the management of insurance funds, which led to insufficient financial support for some medical institutions. The lack of proper control over the use of funds in some regions has worsened the situation with access to quality healthcare services for socially vulnerable groups.

An additional impetus to healthcare reform was provided by the Resolution of the Cabinet of Ministers of Ukraine No. 410 "On Approval of the Procedure for the Implementation of State Guarantees of Medical Care for the Population" (2018), which defined the rules for implementing state guarantees for medical care for the population through the National Health Service of Ukraine. It introduced mechanisms for financing healthcare services, which contributed to increased transparency and predictability in the allocation of resources. It also improved the efficiency of planning of medical institutions and increased their financial stability. However, the problem of uneven distribution of financial resources between different types of institutions was also evident, which only contributes to the existing disparities.

"The National Strategy for Building a New Healthcare System in Ukraine for the Period 2015-2025" (2014) is one of the most important strategic documents. This document defines the main directions of the healthcare system's development. These areas include the introduction of innovative technologies, the development of telemedicine and the implementation of the latest solutions to improve the efficiency of healthcare services. Although the strategy has had many benefits, including the creation of an electronic healthcare system and the attraction of foreign investment, the lack of funding for healthcare facilities in the regions remains a problem (Yaremko and Dumych, 2025). Currently, one of the challenges for Ukraine's healthcare system is that the integration of new technologies requires not only financial resources, but also the training of personnel to operate them.

These reforms coincide with ongoing disparities between urban and rural healthcare facilities, underscoring the need for further improvements in healthcare financing and governance. Policy reviews by WHO/Europe emphasise that such disparities are influenced not only by reform design but also by wartime disruptions, demographic change, and fiscal constraints, which jointly shape access outcomes across regions (World Health Organisation (WHO), 2025; Murphy and Kovtoniuk, 2025).

An analysis of key economic indicators in the Ukrainian healthcare system assessed the dynamics of financing and identified the main trends in the development of the industry. The period from 2019 to 2025 has seen significant changes, in particular due to the impact of the COVID-19 pandemic and full-scale invasion, which have forced the government to increase healthcare spending. While public funding for healthcare has been steadily increasing, so needs to modernise infrastructure and ensure access to quality healthcare. At the same time, private investment remains insufficient to fully support the development of the system, especially in remote regions. Per capita healthcare expenditures show a downward trend in dollar terms, which likely reflects broader macroeconomic pressures and currency devaluation, limiting the state's capacity to fully cover the cost of medicines and medical equipment. Table 1 shows the main economic indicators in the healthcare sector of Ukraine for 2019-2025.

Table 1. Analysis of key economic indicators in the healthcare system

Year	Healthcare expenditures (billion UAH)	Public expenditures (billion UAH)	Private investment (billion UAH)	Expenses per capita (USD)
2019	131.7	95.1	-	104
2020	131.3	114.6	8.2	159
2021	170.5	132.7	9.4	144
2022	215.3	187.2	10.6	136
2023	217.4	181.8	11.2	116
2024	238.7	204.2	11.8	110
2025	253.7	217.0	12.5	105

Source: compiled by the author based on MinFin (2025a, 2025b, 2025c, 2025d, 2025e).

The analysis of key economic indicators in the Ukrainian healthcare system for 2019-2025 shows a significant increase in state funding, which is a prerequisite for supporting the industry, especially in the context of the pandemic and military operations. Despite the overall increase in expenditures, the main challenges remain: a decline in per capita expenditures in dollar terms, which reflects growing economic instability and hryvnia devaluation, as well as insufficient private investment. Public funding is mainly allocated to current expenditures, including wages and medicines, while investments in the modernisation of medical infrastructure are insufficient. This highlights the need for additional measures to attract private capital and to use public funds more efficiently to ensure that healthcare services are accessible and of a quality that meets European standards.

To analyse the percentage by which the annualised growth rate of per capita healthcare spending falls short of the annualised growth rate of per capita gross domestic product (GDP), the following formulas are proposed (1-3):

$$\mathrm{CAGR1} = (\mathrm{EV1}/\mathrm{BV1})\text{^}(1/\mathrm{n}) - 1, \quad (1)$$

$$\mathrm{CAGR2} = (\mathrm{EV2}/\mathrm{BV2})\text{^}(1/\mathrm{n}) - 1, \quad (2)$$

$$\mathrm{CAGR}\Delta = \mathrm{CAGR1} - \mathrm{CAGR2}, \quad (3)$$

where: CAGR1 – compound Annual Growth Rate of healthcare spending per capita; CAGR2 – compound Annual Growth Rate of GDP per capita; EV1 – ending value of healthcare spending per capita; EV2 – ending value of GDP per capita; BV1 – beginning value of healthcare spending per capita; BV2 – beginning value of GDP per capita; n – number of years.

The resulting -6% for Ukraine confirms the shortfall of Healthcare Spending CAGR during 2019-2025 relative to GDP CAGR for the same period (World Bank Group, 2025b).

In the process of changing the healthcare system, it is also necessary to account for elements of behavioural economics. Behavioural economics studies how psychological, social and emotional factors influence people's economic decisions (Shafa, 2021; Panteghini, 2000). Implementing reforms in the Ukrainian healthcare system can be more effective if it incorporates not only economic indicators and government strategies, but also the behaviour of healthcare professionals, patients and other system stakeholders. Behavioural economics can better influence healthcare decisions and programmes.

The use of incentives, or "nudges", to change behaviour is one of the core concepts of behavioural economics. In healthcare, this can include providing doctors and healthcare facilities with financial incentives to achieve certain outcomes or provide better medical services. Hospitals that improve patient survival rates or reduce infectious diseases may receive more funding (Leontyev and Ketners, 2023; Drobyazko *et al.* 2019). This improves efficiency and encourages healthcare professionals to adopt new treatments. Behavioural approaches can also motivate patients to adopt healthier lifestyles, which reduces the burden on the healthcare system in the long term. For example, offering discounts on health insurance to those who maintain a healthy lifestyle or undergo regular medical check-ups can have a positive impact on overall health (Peredalo *et al.* 2019).

The use of "nudges" for patients is an important tool. For instance, offering discounts on health insurance to patients who regularly undergo medical check-ups or follow a healthy lifestyle. This reduces the incidence of chronic diseases and, consequently, reduces the burden on the healthcare system in the future, as the number of expensive medical procedures and inpatient treatment is also reduced.

Another effective method is the creation of patient awareness platforms. E-reminder systems or personalised health plans can help patients control their health, which will facilitate timely visits to the doctor, reducing the number of serious illnesses and hospitalisations.

The literature and conceptual analysis suggest that the use of incentives for doctors and patients may have a broad economic impact, although the magnitude of this effect depends on institutional design and implementation conditions. Improving the health of the population by encouraging healthy habits reduces treatment costs, reducing the need for expensive medical procedures and hospitalisation. Investing in prevention is more effective in the long run, as it reduces the cost of treating diseases that could have been prevented (Aliyev, 2014; Vazova *et al.* 2025).

The integration of behavioural economics into the reform of the Ukrainian healthcare system will significantly improve the efficiency of healthcare services. The use of financial incentives for doctors and patients, as well as innovative approaches to health management, will reduce treatment costs, reduce morbidity and improve the quality of healthcare services in the country (Niyazbekova *et al.* 2023; Shtal *et al.* 2023).

Decision-making under uncertainty is another important element of behavioural economics. Medical decisions are often made under conditions of limited time and information, which can lead to erroneous or incomplete decisions by both doctors and patients. Behavioural economics approaches can help people make decisions by providing them with better tools to analyse treatment options, disease prognoses, or choose healthcare providers (Panteghini, 2006; Nitsenko *et al.* 2024). In particular, the quality of medical decisions can be significantly improved by introducing AI-based systems that offer the best treatment options based on the statistics and medical indicators of each patient.

Thus, in the process of reforming the healthcare system, the introduction of behavioural economics principles can contribute to a more rational use of resources, reduce costs and improve the quality of medical services. This can be used to develop a long-term healthcare model that considers not only technological and financial aspects, but also behavioural factors that influence medical decision-making and treatment outcomes. A comparison of economic models of healthcare management in different countries reveals several important examples that could be useful for reforming the Ukrainian system. In particular, Poland, which has a system of compulsory social health insurance, demonstrates both the advantages and disadvantages of this strategy. Despite the wide coverage of the population and access to basic healthcare services, the level of funding remains low compared to other countries. This limits the ability to modernise infrastructure, improve the quality of healthcare services and ensure a sufficient number of healthcare workers, especially in rural areas. In such circumstances, increased investment and improved financing are needed to ensure the sustainability of the healthcare system.

Accordingly, Germany and Switzerland have more stable healthcare financing models based on compulsory health insurance with high contribution rates, which improves the efficiency of management. Health insurance premiums in Germany account for a significant percentage of income, which guarantees stable funding for private and public healthcare systems. Switzerland has compulsory health insurance and a model where patients bear partial costs of medical services. This allocates resources more optimally. This guarantees a high level of medical services, access to modern technologies and continuous development of medical facilities (Durdykulyyeva, 2025).

The experience of these models provides evidence indicating that healthcare provision can be improved through mixed financing arrangements, private investment, and strengthened social insurance systems, subject to adaptation to national contexts such as Ukraine's. Germany and Switzerland show how well-developed insurance systems can ensure stable financing and high levels of healthcare services, while Poland's experience highlights the need to invest in infrastructure and expand access to healthcare services.

The Czech Republic is another country with which to compare, as its healthcare system is based on compulsory health insurance that covers all people and provides broad access to healthcare services. To maintain a high level of healthcare services, the Czech Republic has one of the highest shares of public funding for healthcare among European countries. Quality management systems are widely used in the Czech Republic, such as accreditation of healthcare facilities according to international standards (*e.g.*, International Organisation for Standardisation (ISO) 9000) (Czechia: Health..., 2023). This improves the structure and efficiency of healthcare facilities.

The Czech healthcare system is committed to maintaining high standards of care and continuously improving services. Increasing the number of accredited hospitals and implementing quality management systems in clinical practices are important components, as they improve patient safety and reduce medical errors. At the

same time, the Czech healthcare system still faces two challenges. These are rising healthcare costs due to the national economic difficulties and a shortage of medical staff, especially in rural areas.

Ukraine could employ the Czech model, in implementing accreditation standards and investing in improving the quality of healthcare services. The use of quality management and accreditation systems will help improve the efficiency of medical institutions and strengthen patients' trust in the services provided (Musayeva *et al.* 2025; Abbasova *et al.* 2023).

Another important example is Germany, which has the oldest health insurance system in the world, based on the Bismarck model. The system is based on compulsory insurance through numerous social insurance funds financed by contributions from employees and employers. The main goal of the German system is to ensure high-quality healthcare services while controlling costs. However, Germany has faced challenges related to changes in the demographic structure and an ageing population, which negatively affected the healthcare financing system (Breckenkamp *et al.* 2007).

Germany actively uses measures to manage the quality of healthcare services, such as external comparative hospital quality management. This ensures regular monitoring and evaluation of the quality of healthcare facilities, providing open data to assess their performance. The introduction of internal quality management systems in hospitals, which became mandatory in 2004, is also important. These steps improved the quality of healthcare services, but there have also been problems, including bureaucratic obstacles and problems with obtaining reliable data. Table 2 highlights a comparison of the healthcare models of the above countries.

Table 2. Comparison of healthcare models

Country	Healthcare model	Primary sources of funding	Issues
Poland	Compulsory health insurance through the National Health Fund		Low funding in rural areas, waiting lists for specialised care
Czech Republic	Universal health insurance, state funding	Social Contributions, government funding	Shortage of medical staff, rising costs of medical services
Germany	Multi-channel compulsory health insurance (Bismarck model)		Rising costs, ageing population
Switzerland	Mandatory health insurance with partial payment for services by patients	Contributions from the public, private insurance, and public funding	High costs of medical services, regional differences in access to services

Source: compiled by the author based on Smarżewska *et al.* (2022), Briš *et al.* (2018), Schusselé Filliettaz *et al.* (2021).

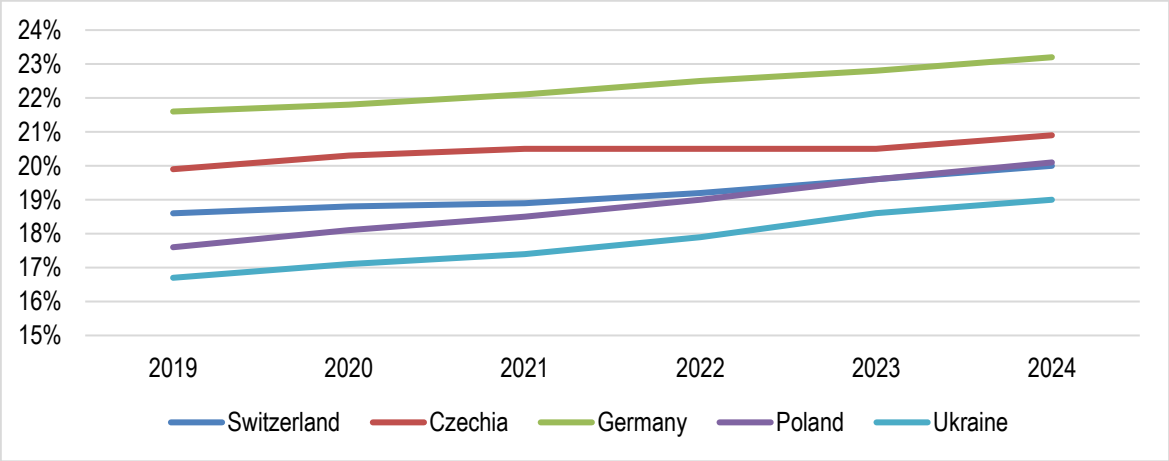
Although all four countries have compulsory health insurance systems, they face different challenges depending on the financing and structure of their systems. Poland, which relies on compulsory health insurance through the National Health Fund, needs additional funding to address problems with access to healthcare in rural areas and reduce waiting times for specialised treatment. This points to the need for infrastructure improvements and increased funding in certain regions. The Czech Republic, with a comprehensive compulsory health insurance system, continues to face a shortage of medical personnel and rising healthcare costs. To maintain an effective healthcare system, attention must be paid to attracting new staff and improving human resources, and strategies to optimise costs must be developed (Aliyeva *et al.* 2025; Fedotova *et al.* 2021). Germany, with its multi-channel insurance system, remains an example of a highly developed healthcare system, but rising healthcare costs and an ageing population pose challenges for long-term financial stability. This requires continuous monitoring and the development of new approaches to effective resource management.

Overall, these examples demonstrate that each system has advantages but also faces unique challenges that require adaptation and reform. Ukraine should incorporate the positive experience of these countries to improve the domestic healthcare system, especially in the areas of financing and optimising healthcare delivery.

Considering the overall trend of the ageing population in the world and in the mentioned countries, and as a result, higher demand for medical services, it is becoming more crucial to find new efficiencies in the Healthcare Systems financing (Figure 1).

The introduction of new technologies into the healthcare system is crucial for increasing cost-effectiveness and improving the quality of healthcare services. Each technology currently in widespread use has unique benefits that help optimise the operation of healthcare facilities and reduce healthcare costs. Modern healthcare has been transformed by the introduction of technologies such as electronic health records, telemedicine, robotic surgical systems and artificial intelligence (AI) (Hasanova and Najafova, 2025; Kovalchuk *et al.* 2024).

Figure 1. Aging populations in selected countries (2019-2024)



Note: percentage of population aged 65+.
Source: compiled by the author based on World Bank Group (2025a).

One of the most important technologies in the modern healthcare system is electronic health records (EHR), which provide a more efficient organisation of medical services. The old record-keeping system was inefficient and error prone. EHRs have greatly simplified access to medical information, providing quick results of examinations, treatment and patient history. This greatly reduces the likelihood of errors, such as incorrect prescriptions or repeated diagnostic procedures (Honavar, 2020). Electronic health records facilitate cooperation between medical institutions and ensure quick information exchange. Access to a single medical database guarantees continuity of care, for example, if a patient changes doctors or visits different doctors. Reduced administrative costs, shorter decision-making times, and reduced need for duplication of medical procedures are economic benefits of implementing EHRs (Dzhedzhula *et al.* 2024; Kussainova *et al.* 2018).

During the COVID-19 pandemic, telemedicine has become particularly relevant as it has become important to reduce physical contact between doctors and patients (Huriev, 2024; Nurusheva *et al.* 2024). Doctors can conduct remote consultations via video calls or special platforms. This greatly simplifies access to medical services for patients, especially those who live in remote areas or have limited mobility. Reduction of the burden on healthcare facilities and the cost of transporting patients can be achieved by reducing the need for personal visits to hospitals. Telemedicine can also provide professional advice, which contributes to faster diagnosis and treatment of diseases at early stages. Subsequently, this reduces the cost of treating chronic diseases, as regular health monitoring via telemedicine platforms provides timely intervention if necessary.

Robotic surgical systems, such as Da Vinci, have revolutionised surgery. Doctors can perform operations with greater precision than is possible with traditional surgery using these systems. The robot can perform complex surgical interventions with minimal incisions, which reduces the risk of complications, the length of time patients recovers and the length of hospital stays. Patients return to normal life faster after surgery, which reduces the cost of postoperative care for healthcare facilities. Robotic systems require significant initial investment, but their use significantly reduces the cost of treatment and rehabilitation after surgery. In addition, robots can perform surgeries with precision that is difficult to achieve with the human hand, which increases the probability of treatment success (Reddy *et al.* 2023).

AI is becoming increasingly important as an important tool in the medical field, especially in the management of large amounts of medical data and diagnostics (Lavrukhina *et al.* 2025; Andriushchenko and Panteghini, 2025). AI can help doctors diagnose diseases more accurately, detect previously unnoticed symptoms, and predict the development of diseases due to its ability to analyse large amounts of information. This provides for faster treatment and the avoidance of complex complications, which reduces the cost of lengthy and complex treatment. AI can also be used to optimise medication management, which can reduce the cost of procuring medicines and increase their effectiveness. AI algorithms can, for example, predict the need for specific medications and prevent overstocks or shortages.

Among other technologies, e-prescriptions are an important step towards automating procedures in the healthcare system. Doctors can issue prescriptions electronically through this technology, which facilitates processing and reduces the likelihood of prescription errors. Patients can get the medicines they need quickly thanks to e-prescriptions, which facilitate the work of pharmacies. To reduce logistics and procurement costs, the introduction of this technology improves control over the distribution and procurement of medicines.

Overall, the reviewed evidence suggests that the introduction of new technologies in the healthcare sector can increase economic efficiency, particularly through reductions in administrative costs and improved service coordination. Modern technologies not only improve the quality of medical services but also reduce overall healthcare costs by optimising medical and administrative processes and reducing treatment costs (Issayeva *et al.* 2024; Gulaliyev *et al.* 2023). Notably, the successful implementation of these technologies requires significant initial investments, but their long-term economic effect justifies these costs.

An analysis of environmental risks and obstacles that may affect the successful implementation of health system reforms is important to assess obstacles that may slow or even prevent the implementation of changes. Limited financial resources are the main risk. Compared to more developed countries, the healthcare system in Ukraine remains underfunded, as is the case in many transition countries such as Bulgaria, Romania and Moldova. Budgetary constraints are a major obstacle to introducing modern technologies, modernising infrastructure and ensuring access to high-quality healthcare services in all regions. In addition, due to problems with transparency and weak governance, resources are often allocated inefficiently, resulting in poor healthcare system performance.

Economic instability caused by conflicts and inflation, the devaluation of the hryvnia and the decline in the country's investment attractiveness are other significant obstacles. Opportunities for long-term planning and implementation of structural reforms in the healthcare sector are limited by constant economic fluctuations. For instance, due to unpredictable costs and the need to respond quickly to economic crises, the introduction of expensive technologies or infrastructure projects becomes problematic.

Inefficient resource management is another significant risk. The implementation of reforms is significantly hampered by weak planning, expenditure monitoring and insufficient coordination between different levels of government. In addition, corruption problems pose additional challenges, as funds may not be used for targeted programmes or may be misused.

In addition, the shortage of personnel and low salaries of healthcare workers are important obstacles that can lead to an outflow of healthcare workers from the country or their refusal to work in the public healthcare system. The shortage of doctors, nurses, and other staff reduces the overall efficiency of the system and makes it difficult to introduce new technologies and programmes. This problem is exacerbated by outdated equipment and a lack of modern technology in many healthcare facilities, as even qualified healthcare professionals cannot provide quality care without the right tools.

Economic risks also include the high costs associated with implementing reforms that require significant short-term investments. For instance, infrastructure upgrades, the transition to electronic medical records, and the purchase of modern medical equipment require significant financial investments that often exceed the capacity of the national budget. The upfront costs can pressure the national financial system, rendering it difficult to simultaneously address other pressing issues such as security and social support (Shahini and Shahini, 2025; Lakbaev *et al.* 2017).

Political instability and constant changes in legislation can also impede reforms. Frequent changes in governments or reform programmes can lead to a lack of public confidence and the cancellation or postponement of important initiatives. This, in turn, delays the process of change and reduces the effectiveness of what is already being done. The main risks that may impede the implementation of reforms are highlighted in Table 3.

Table 3. Key economic risks and their impact on the implementation of healthcare reforms

Economic risk	Impact on the implementation of reforms
Underfunding	Inability to modernise infrastructure, introduce new technologies and ensure access to quality services
Economic instability	High risks of unforeseen expenses, reduced opportunities for long-term planning
Resource management inefficiency	Non-transparent use of funds, loss of part of the budget due to corruption, and reduced productivity.
Staff shortage	Outflow of qualified healthcare workers, insufficient staff to implement reforms
High costs of implementation	The need for significant short-term investments, exceeding budget capacities
Political instability	Political instability can cause unpredictable changes in budgeting and the cancellation or postponement of important reforms, which can delay the implementation of systemic changes and reduce the efficiency of resource use.

Source: compiled by the author.

The successful implementation of healthcare reforms in Ukraine is largely dependent on overcoming numerous economic risks and barriers. Limited funding, economic and political instability, inefficient resource management, staff shortages and high costs of innovation remain key obstacles to modernising the system. To overcome them, strategic approaches are needed to attract investment, improve resource management and ensure stable financing, which will create a sustainable and efficient healthcare system. This will not only improve the quality of healthcare services but also reduce costs, contributing to a more sustainable, affordable and efficient healthcare system that meets European standards.

The establishment of mobile medical clinics and healthcare units is one of the key solutions in reforming the healthcare system in Ukraine, which will improve access to healthcare services in remote areas. Mobile clinics give patients living in rural or hard-to-reach areas the opportunity to receive medical care locally, without having to travel long distances, which is a new and original contribution to the reform. Such clinics will also improve overall access to healthcare services and reduce the burden on inpatient medical facilities.

In addition, an important aspect is the introduction of telemedicine in mobile clinics, which will provide remote consultation with doctors using electronic platforms, receive preliminary consultations and prescriptions using electronic prescriptions. The use of such technologies will significantly reduce administrative costs, increase the efficiency of healthcare services and improve their quality through the rapid exchange of information between healthcare professionals.

These changes will reduce the costs of medical care, transportation of patients and doctors, and administrative costs of record keeping. The introduction of such innovations in healthcare will reduce the cost of serving the population in remote areas, increase the efficiency of using medical resources and ensure more equitable access to healthcare services in the country. At the same time, the use of artificial intelligence to automate diagnostics, predict diseases and determine the best treatment methods is cost-effective, as it will significantly improve the accuracy and speed of decision-making by healthcare professionals.

However, the development of mobile clinics and technologies such as telemedicine and AI comes with certain obstacles. First, it requires significant investment in infrastructure and training for healthcare professionals on how to use the new technologies. Second, the rapid introduction of electronic prescriptions and telemedicine may be hindered by issues related to patient safety and data protection. In addition, there is a risk of uneven distribution of such clinics across regions, which could worsen access to services for part of the population, as well as difficulties in integrating new systems into existing healthcare systems. From an economic point of view, these innovations will help reduce healthcare costs, as most services will be provided directly at the patient's place of residence, reducing transportation and hospitalisation costs. At the same time, the use of electronic prescriptions and telemedicine will save healthcare workers time, increasing their productivity and efficiency. The implementation of such technologies will reduce the cost of manual record keeping, accelerate the process of providing medical services, and improve the accuracy of diagnoses using automated decision support systems. Solutions for improving medical services in Ukraine are presented in Table 4.

Table 4. Solutions to improve healthcare services in Ukraine through mobile clinics and innovative technologies

Problem	The proposed solution	Expected results
Unequal access to medical services between urban and rural areas	Establishment of mobile medical clinics and medical aid stations	Improvement of access to healthcare services in remote areas
Insufficient funding in rural areas	Implementation of public-private partnerships to finance mobile clinics	Attraction of additional financial resources, reducing the burden on the state budget
Lack of infrastructure in remote areas	Introduction of financial reserves to support healthcare facilities in rural areas	Modernisation of medical facilities, purchase of new technologies and equipment
Lack of medical staff in rural areas	Implementation of training and motivation programmes for healthcare professionals to work in rural areas	Increasing the skills and number of healthcare workers in remote regions
Insufficient efficiency in the management of healthcare services	Introduction of electronic prescriptions and telemedicine for remote consultations	Reduced administration costs and improved decision-making speed

Source: compiled by the author.

The proposed solutions, such as the creation of mobile medical clinics and the introduction of innovative technologies, can significantly improve the accessibility of healthcare services to the population, reduce healthcare

costs and ensure that all people in Ukraine, especially those in rural and remote areas, have equal access to healthcare services. They have great potential to improve the quality of healthcare services and the overall level of healthcare in the country.

3. Discussions

Fredriksson (2024) examined Sweden's healthcare policy and its impact on access to healthcare. The study demonstrated the importance of removing financial barriers to improve access. In Ukraine, reforms face challenges due to insufficient funding and a lack of governance coherence.

Bíró and Prinz (2019) determined that healthcare expenditures are correlated with income, which is also the case in Ukraine, where higher incomes provide better access. However, due to economic difficulties, these barriers may be more significant.

Sparkes *et al.* (2022) noted that political and economic factors influence the implementation of reforms. Their findings are consistent with the results of this study on the impact of social and political realities on reforms in Ukraine.

Husereau *et al*. (2022) addressed the development of standards for economic evaluation in health care, which is important for decision-making and resource management. The study emphasised the importance of standardising valuation methods to ensure transparency and comparability across countries, which is relevant for healthcare reform in Ukraine. They also emphasised the need to incorporate socio-economic conditions when interpreting the results of economic evaluations, which is important for Ukraine due to challenges such as underfunding and inequalities in access to services. The main differences between the study by Husereau *et al.* (2022) and this study are related to the maturity of economic valuation mechanisms, which are still in their infancy in Ukraine.

Clements *et al.* (2012) examine the economic aspects of health care reforms, in particular the financing and cost-effectiveness issues associated with rising health care costs due to demographic factors and technological advances. The findings of this study are consistent with the findings of Clements *et al.* (2012) that rising healthcare costs are a major challenge. The study also emphasised the need for a balance between quality of service and cost control, which is consistent with the findings of this study on the efficient use of public resources and the attraction of private capital for infrastructure modernisation.

Sorum *et al.* (2023) analysed the use of automation to improve access to healthcare services and reduce administrative costs. The results are consistent with the findings of the current study, which also confirms the importance of reducing administrative barriers to improve system efficiency. The study by Sorum *et al.* (2023) emphasised behavioural aspects, while in the presented context, the economic challenges are addressed, due to limited resources.

Denis *et al.* (2023) analysed reforms in Canada and the political challenges faced by the healthcare system. In Ukraine, there are also political and economic obstacles to reforms, due to insufficient funding. The difference is that in Canada, the problems were with policy coordination between governments, while in Ukraine, they were associated with economic stability.

Guo *et al.* (2022) demonstrated how reforms in China have improved access to healthcare services, but inequalities between urban and rural areas persist. This is also the case in Ukraine, where unequal access to healthcare services is a substantial issue, particularly in rural areas due to a lack of staff and funding.

Jarvis *et al.* (2023) highlight the impact of centralisation of resources in Canada on improving coordination, but also on limiting local responsiveness to needs. This is in line with the findings of the current study, which also mentions that centralisation can negatively affect the distribution of resources between urban and rural areas. Ikegami (2024) analysed the economic feasibility of healthcare reforms in terms of access to healthcare services, efficiency of healthcare delivery, and use of pharmaceutical products. The study highlighted that, even in developed countries, willing-to-pay patients have better access to specialised care. In addition, the study underlined the importance of standardising clinical procedures to improve efficiency, as well as the importance of assessing the value of medicines based on cost-benefit analysis.

Discussing the results of the study is important for understanding the economic factors that influence healthcare reform. The data confirm the need to adapt economic models to ensure accessibility and improve the quality of healthcare services. This correlates with the findings of Jakovljevic *et al.* (2023), emphasising the importance of financial inputs to achieve sustainable health development in low- and middle-income countries. The study also demonstrated that investments in infrastructure and new technologies have a significant impact on the efficiency of healthcare services. As noted by Jakovljevic *et al.* (2023), public funding and private investment should be balanced to ensure access to healthcare for all segments of the population.

Overall, the results of the study point to the need to integrate economic models of healthcare management that have proven effective in other countries to improve the Ukrainian system. The use of similar approaches as described by Jakovljevic *et al.* (2023) could be a key factor in improving health outcomes in Ukraine.

Habicht *et al.* (2023) analysed the impact of national health system reforms on economic sustainability and equitable access to health services. The study emphasised the importance of effective financial management, including balancing public investment and private financing, to ensure equal access to healthcare for all segments of the population.

The results of this study are consistent with the findings of Habicht *et al.* (2023) that proper financial management is critical for the successful implementation of healthcare reforms. Both studies emphasise the importance of securing stable funding to support the sustainability of health services in times of economic instability. However, this study addressed the challenges faced by the Ukrainian healthcare system as a result of the military operations and the economic crisis, while Habicht *et al.* (2023) addressed general aspects of financial management in different countries. The World Health Organization (WHO) (2025) emphasizes the centrality of equitable access to essential health services (including in underserved and remote communities), together with robust health financing, transparent priority-setting, and effective governance as prerequisites for health-system sustainability and universal health coverage. In the context of Ukraine, WHO/Europe's recent analyses additionally foreground system resilience under wartime shocks and the need to align public and partner resources with strategic priorities, including stronger governance of capital investment and health-care network transformation (*e.g.*, consolidation and strengthened primary/community care) to improve efficiency and population-level outcomes. These emphases are consistent with the present study's conclusions regarding access constraints in resource-limited settings and the importance of management efficiency and investment mobilisation; however, the study places comparatively greater weight on the economic consequences of hostilities for service continuity and financial sustainability, thereby extending and specifying the war-related macro- and meso-level pressures highlighted in WHO/Europe's recent reviews of Ukraine's health financing reform and recovery trajectory.

The analysis of the implementation of new economic models of healthcare management in Ukraine and comparison with the studies of other authors demonstrates that, despite some convergence in conclusions, there are significant differences. Studies confirm the importance of removing financial barriers, increasing access to healthcare services and improving financing mechanisms. However, Ukraine faces unique challenges, including underfunding, inequalities in access to healthcare services, and political and economic instability due to the war.

Implementing reforms in Ukraine requires adapting international experience to local conditions, especially given the limited resources and geographical inequalities. Comparisons with other countries show that attracting investment, introducing innovations, and optimising management models are key to the successful modernisation of the Ukrainian healthcare system.

Conclusions and Further Research

This study demonstrates that the transformation of Ukraine's healthcare system is not merely a managerial or technological challenge but a matter of urgent public policy that directly affects social stability, regional cohesion, and long-term economic resilience. The findings indicate that chronic underfunding, combined with the uneven territorial distribution of financial and human resources, has become a structural weakness of the healthcare system. In policy terms, this necessitates a revision of intergovernmental fiscal allocation mechanisms, particularly those linked to the "money follows the patient" principle, to ensure that rural and conflict-affected regions receive compensatory financing that reflects higher service delivery costs and lower population density.

A key policy implication of the study is the need to institutionalise targeted equalisation instruments within national healthcare financing. This includes the introduction of adjustment coefficients for rural and frontline regions, earmarked subventions for essential healthcare services, and minimum service availability standards enforced by the National Health Service of Ukraine. Without such regulatory corrections, existing financing rules may risk further deepening regional inequalities, particularly in rural and conflict-affected areas.

The results also provide strong evidence that digitalisation and technological innovation should be treated as core elements of state healthcare policy, rather than auxiliary modernisation tools. The implementation of electronic medical records, telemedicine, e-prescriptions, and automated management systems has direct fiscal implications: reducing administrative expenditure, limiting informal payments, improving expenditure transparency, and enabling real-time monitoring of service provision. From a public policy perspective, this requires the adoption of a national digital health investment programme, supported by medium-term budget planning and clearly defined performance indicators, rather than fragmented pilot initiatives.

Another important conclusion concerns healthcare investment policy. Given the limited fiscal capacity of the state under conditions of war and economic instability, the study confirms that public–private partnerships (PPPs) and regulated private investment must become a formal component of healthcare governance. Policymakers should prioritise the development of a predictable regulatory framework for private participation, including guarantees for investors, transparent procurement procedures, and safeguards to ensure that private capital complements rather than replaces public responsibility for essential services. Such an approach would allow the state to focus public resources on universal coverage while leveraging private investment for infrastructure modernisation and technological upgrading.

The findings further highlight that healthcare reform cannot succeed without human resource policy interventions. Persistent staff shortages, especially in rural areas, indicate the need for targeted public programmes that combine financial incentives, housing support, and career development opportunities for medical professionals. These measures should be embedded in national and regional healthcare strategies rather than implemented as temporary or ad hoc solutions.

At the same time, this study has several limitations that are relevant for policy interpretation. Ongoing military operations and economic disruptions limited comprehensive regional coverage, which constrains the generalisability of some conclusions. In addition, the lack of fully harmonised post-pandemic data restricts long-term evaluation of COVID-19-related policy effects. These limitations underline the need for continuous data collection and adaptive policy monitoring mechanisms within the healthcare system.

Future research should therefore focus on policy evaluation and impact assessment, particularly the cost-effectiveness of digital health technologies, public-private partnership models, and behavioural incentives for providers and patients. Further comparative studies at the regional level are also needed to assess how differentiated financing instruments and governance models perform under conditions of economic instability and demographic change. Such research would provide an empirical basis for refining healthcare policy instruments and ensuring the long-term sustainability, equity, and resilience of Ukraine's healthcare system.

Declarations

Declaration of Competing Interest: The author declares that he has no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Declaration of use of generative AI and AI-assisted technologies: The author declares that he has not used generative AI.

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Digital Transformation of MSMEs: Inclusion, Readiness, and Innovation Toward a Sustainable Economic Ecosystem

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Abstract: This study investigates the correlation between digital readiness, digital inclusion, and digital transformation with business model innovation and local economic sustainability among culinary MSMEs in Medan City. Using a quantitative approach grounded in the TOE Framework and DEIM model, data was collected from 250 respondents via structured questionnaires and analyzed using SEM-PLS. The findings reveal that digital readiness and digital inclusion significantly influence innovation in business models. Furthermore, the digital business ecosystem acts as a mediating variable impacting sustainable economic development. Practical implications include formulating community-based digital empowerment strategies and inclusive policy interventions.

Keywords: digital transformation; digital inclusion; digital readiness; business model innovation; digital business ecosystem; sustainable economy.

JEL Classification: G21; L26; M13; O17; R11.

Introduction

Digital transformation has become an imperative in the global business landscape, particularly after the COVID-19 pandemic accelerated the need for digitization - especially in the Micro, Small, and Medium Enterprises (MSMEs) sector. Drastic changes in consumption patterns, social mobility, and customer–business interactions have pushed all economic sectors to adapt. MSMEs, as the backbone of economies in developing countries including Indonesia, face major challenges in the digital adaptation process. In Medan City, MSMEs contribute more than 60% to the Gross Regional Domestic Product (GRDP) and employment (BPS Kota Medan, 2025). However, the reality shows that the level of digital adoption among Medan MSMEs remains relatively low. Recent data reveals that only 30.1% of culinary MSMEs actively use digital platforms, and most lack a clear digital strategy (Dinas Koperasi UKM Kota Medan, 2025; INDEF, 2024). Major challenges include low digital literacy, limited technological infrastructure, and minimal understanding of technology-based business model innovation (Mo *et al.* 2023; Wijaya and Eviyanti, 2024). This phenomenon highlights a gap between local economic potential and entrepreneurs' readiness to compete in the digital economy. Digital readiness and digital inclusion serve as the foundation for MSMEs' digital transformation. Digital readiness encompasses infrastructure, technological competence, organizational preparedness, and policy support enabling technology integration into business processes (Bughin *et al.* 2018; Lutfi *et al.* 2022). Meanwhile, digital inclusion emphasizes equitable access to digital technology regardless of gender, geography, or education level (UNDP Indonesia, 2012; Khasawneh, 2024).

Fulfilling both aspects is critical for MSMEs to innovate, expand markets, and sustain their businesses. In Medan, 41% of MSMEs are digitally unprepared, 31% are partially prepared, and only 28% are fully prepared. This disparity signals low digitalization efficiency and hinders the creation of a solid digital ecosystem. Globally,

digital ecosystems have proven capable of adding value through cross-sector collaboration and digital servitization, such as omnichannel integration, big data adoption, and supply chain automation (Lamperti *et al.* 2024; Jorzik *et al.* 2024). Another pressing issue is the lack of digital business model innovation among MSMEs. Many still rely on conventional methods for daily operations. Innovations such as e-commerce, digital payment, and AI-based technologies are yet to be widely optimized (Chesbrough, 2006; Sitorus, 2022; Yanti *et al.* 2024). This exacerbates the digital divide and increases the risk of digital economic exclusion, especially for small-scale and women entrepreneurs. In Medan's context, solutions must be contextualized, considering that local social, cultural, and economic characteristics significantly influence MSMEs' adaptation to technology. Previous studies emphasize the importance of multi-actor collaboration - government, educational institutions, digital platforms, and local communities - in strengthening MSME digital readiness (Berliandaldo *et al.* 2021; Gao, 2024). Community-based interventions such as collective digital training, women entrepreneur empowerment, and local tech incubation are strategic measures to promote digital equity and grassroots economic empowerment. The conceptual model proposed in this study is the Digital Ecosystem Innovation Model (DEIM), an extension of the TOE Framework (Technology–Organization–Environment) by Tornatzky and Fleischer. DEIM integrates dimensions of readiness, inclusion, and digital transformation within the context of business model innovation and local economic sustainability. The TOE Framework has been widely applied to study technology adoption in business sectors but has yet to explicitly incorporate sustainability and inclusion dimensions in the MSME context of developing countries (Dwivedi *et al.* 2021; Omrani *et al.* 2024). The aim of this research is to examine the relationships between digital readiness, digital inclusion, and digital transformation on business model innovation and local economic sustainability. Specifically, it seeks to determine whether the digital business ecosystem serves as a mediating variable in strengthening these relationships. Using a quantitative approach via Structural Equation Modeling (SEM-PLS), the study tests hypotheses based on empirical data from culinary MSMEs in Medan City. Strategically, the study supports technology-based regional economic development, particularly in the informal sector, which is vulnerable to being left behind in digitalization. The findings are expected to serve as a reference for local governments, business communities, and technology providers in designing adaptive and sustainable intervention strategies. Academically, the DEIM model enriches literature on digital innovation in the MSME sector and offers an integrative approach to bridge the digital gap and promote inclusive economic growth. This study advances the discourse on digital transformation among micro, small, and medium-sized enterprises (MSMEs) by proposing the Digital Ecosystem Innovation Model (DEIM) - a conceptual extension of the traditional Technology-Organization-Environment (TOE) framework. DEIM uniquely integrates dimensions of sustainability and digital inclusion, two critical yet often marginalized aspects within prevailing MSME literature, particularly in contexts situated in the Global South. Unlike prior studies that predominantly adopt techno-economic perspectives, this research empirically validates a multidimensional framework and situates it within the socio-economic landscape of post-pandemic recovery. Focusing on the culinary MSME sector in Medan, Indonesia, the study not only addresses structural and contextual particularities but also generates policy-relevant implications. The findings hold the potential to inform urban development strategies and guide digital ecosystem stakeholders - including governments, NGOs, and platform providers - in crafting inclusive digital innovation pathways that are both sustainable and locally adaptive.

1. Research Background

TOE Framework and Its Development

Digital transformation in the MSME context requires a multidimensional approach capable of systematically explaining influencing factors. One of the most relevant theoretical frameworks is the TOE Framework (Technology–Organization–Environment) introduced by Tornatzky and Fleischer (1990). The TOE has been widely used to explain technology adoption phenomena at the organizational scale, including MSMEs in developing countries. This framework emphasizes that adoption decisions are influenced by three contexts: technological conditions, organizational characteristics, and external environmental factors. In this study, the TOE is developed into the Digital Ecosystem Innovation Model (DEIM) by adding sustainability and digital inclusion perspectives as key elements in building a digital economic ecosystem. This model considers that business model innovation cannot occur without strong digital readiness, inclusive access to technology, and strategic environmental support (Sitorus *et al.* 2024).

Technology: Infrastructure, Relevance, and Digital Readiness

The technological component is a key aspect in MSME digital transformation. Technological infrastructure such as broadband internet, software, hardware, and digital security is a prerequisite for digitization (Díaz-Arancibia *et al.* 2024). Lutfi *et al.* (2022) found that the availability of adequate technological infrastructure is directly proportional to entrepreneurs' readiness to adopt digital systems. Technological relevance is equally important - technology misaligned with entrepreneurs' capacities risks inefficiency. Abdullah *et al.* (2021) developed a "six-gear roadmap" to help MSMEs align technology choices with internal capacities and business objectives. Without such needs mapping, technology adoption may become a burden rather than an asset. Digital readiness goes beyond the mere availability of devices. Baihaqy and Subriadi (2023) explain that readiness includes human resource digital competence, an organizational culture of innovation, and policy support facilitating change. Gurzhii *et al.* (2022) highlight that digital readiness is a prerequisite for adopting disruptive technologies such as blockchain.

Organization: Structure, Human Resources, and Digital Strategy

Organizational structure can either drive or hinder digital transformation. MSMEs with flexible structures are more easily able to integrate technology-based changes. Rachinger *et al.* (2021) note that lean and collaborative structures support innovation and cross-functional adoption because decisions can be made faster and more adaptively. Human resources play a central role. Gfrerer *et al.* (2023) emphasize that continuous digital training is key to improving entrepreneurs' technological literacy. Competence in operating applications, analyzing data, and understanding digital market trends is crucial for transformation. A digital strategy is the driver of the entire digitalization process. Li *et al.* (2022) found that MSMEs with a written and directed digital strategy integrate technology more effectively. This strategy must include a long-term vision, HR training, inter-unit integration, and regular evaluation. Transformational leadership open to technological change can inspire teams to innovate (Hanelt *et al.* 2021), while an adaptive organizational culture that tolerates experimentation and failure accelerates digitalization (Vial, 2021).

Environment: Government Support, Inclusive Ecosystem, and Digital Markets

The external environment plays a major role in supporting or hindering technological adoption. Government policies - training, digital incubation, and fiscal incentives - are vital stimuli for MSMEs (Nair *et al.* 2023). These policies must adapt to local characteristics to be effective. An inclusive ecosystem enables collaboration among entrepreneurs, digital platforms, communities, and financial institutions. Autio *et al.* (2022) note that open ecosystems supporting diversity enhance resilience against disruption. Links between MSMEs and digital communities like coworking spaces and incubators are strategic (Spigel and Harrison, 2020). The digital market offers MSMEs new arenas for expanding consumer access. Turki *et al.* (2023) report that MSMEs active on digital channels increased revenues by up to 30%. Shifts in consumer behavior toward platform-based services push MSMEs to adopt e-commerce, digital customer service, and cloud-based supply chain management (Nambisan *et al.* 2021). Partners such as fintech, marketplaces, and technology service providers facilitate growth. Yet Elia *et al.* (2020) warn that inconsistent regulations can hinder adoption - making flexible regulation, data protection, and accommodative digital taxation essential.

Business Model Innovation and Economic Sustainability

Digital transformation not only changes tools but also redefines value processes in business. Weill and Woerner (2021) argue that digital business model innovation requires MSMEs to create new value through more efficient, scalable, and technology-driven methods. These include subscription models, e-commerce, freemium models, and AI-powered product personalization. Economic sustainability is a core focus in MSME development in the digital era. Torres *et al.* (2023) show that MSMEs with high readiness indexes are more resilient to crises and disruptions. Gallego and Gutierrez (2020) add that digital inclusion helps underdeveloped regions participate in the digital economy and reduces structural inequality. Kraus *et al.* (2022) propose green digital business models as a simultaneous strategy for transformation and sustainability. In local contexts such as Medan, combining digital innovation with local cultural identity creates market differentiation opportunities.

2. Research Methodology

This study employs quantitative research design with a survey methodology to explore the interconnections among variables articulated within the Digital Ecosystem Innovation Model (DEIM) framework. Its primary

objective is to produce a rigorously structured, empirically verifiable, and quantitatively measurable account of digital readiness, digital inclusion, and digital transformation shape business model innovation and the economic resilience of local micro, small, and medium-sized enterprises (MSMEs). The quantitative approach is well-suited to this purpose, as it allows for the investigation of causal mechanisms through standardized instruments and the application of advanced statistical modeling. The focus is placed on the culinary MSME sector in Medan City, a segment that has been disproportionately affected by the COVID-19 pandemic yet possesses considerable potential for digitalization, particularly in the domains of online food delivery, cashless payment systems, and social media–driven marketing strategies. Based on data from the Medan City Office of Cooperatives and MSMEs (2024), there are over 7,000 culinary businesses operating both formally and informally. Participants were recruited through accidental sampling, a non-probability technique relying on respondent accessibility. While this limits generalizability, it was deemed methodologically appropriate under pandemic-related mobility constraints. The final sample comprised 250 respondents from 21 districts, all meeting three inclusion criteria: (1) a minimum of one year in business operations, (2) prior engagement with at least one digital platform such as GoFood, Tokopedia, or ShopeeFood, and (3) voluntary agreement to complete the survey. Data were collected using a closed-ended questionnaire on a five-point Likert scale ranging from “Strongly Disagree” to “Strongly Agree.” The instrument, adapted from previously validated studies, assessed six principal constructs: Digital Readiness (DR), which includes infrastructure, internet connectivity, digital skills, and internal preparedness (Lutfi *et al.* 2022); Digital Inclusion (DI), encompassing technology access, digital literacy, and community participation (UNDP, 2012; Mo *et al.* 2023); Digital Transformation (DT), referring to shifts toward digitized processes, platform adoption, and automation (Bughin *et al.* 2018); Innovation Business Model (IBM), covering sales diversification, value chain digitization, and technology-based customer service (Chesbrough, 2006); Digital Business Ecosystem (DBE), which addresses platform engagement, collaboration, and policy support (Spigel and Harrison, 2020); and Sustainable Economic Local (SEL), representing business resilience, local economic contribution, and technology-driven revenue growth (Torres *et al.* 2023). The survey was distributed online via Google Forms and through MSME networks such as SAKA and Medan Go-Digital between February and March 2025. Validity testing using outer loading and Average Variance Extracted (AVE) in SmartPLS 3.5 confirmed that all indicators exceeded the thresholds (outer loading > 0.7; AVE > 0.5) (Hair *et al.* 2021).

Reliability was established with Cronbach’s Alpha and Composite Reliability values surpassing 0.7. Data analysis was conducted using Structural Equation Modeling–Partial Least Squares (SEM-PLS) in SmartPLS 3.5, selected for its capacity to manage complex models with multiple latent constructs and indicators, and its robustness to non-normal data distributions. The analysis involved two phases: outer model evaluation for indicator reliability, convergent validity (AVE), and discriminant validity (Fornell–Larcker and HTMT criteria); and inner model evaluation to determine predictive accuracy (R^2) and path significance via bootstrapping with 5,000 sub-samples. The following twelve hypotheses are proposed based on the DEIM framework, which integrates the TOE model with digital inclusion and sustainability aspects:

H1: Digital Readiness affects Business Model Innovation

H2: Digital Readiness affects Digital Business Ecosystem

H3: Digital Inclusion affects Business Model Innovation

H4: Digital Inclusion affects Digital Business Ecosystem

H5: Digital Transformation affects Business Model Innovation

H6: Digital Transformation affects Digital Business Ecosystem

H7: Business Model Innovation affects Sustainable Local Economy

H8: Digital Business Ecosystem affects Sustainable Local Economy

H9: Digital Readiness affects Business Model Innovation affects Sustainable Local Economy

H10: Digital Inclusion affects Business Model Innovation affects Sustainable Local Economy

H11: Digital Readiness affects Digital Business Ecosystem affects Sustainable Local Economy

H12: Digital Inclusion affects Digital Business Ecosystem affects Sustainable Local Economy

The DEIM model extends the TOE Framework by incorporating sustainability and digital inclusion. SEM-PLS is adopted due to its robustness in analyzing complex models, suitability for small to medium-sized samples,

and ability to test both direct and mediating effects.

3. Research Results

Respondent Characteristics

From the 250 MSME respondents, 62% were women and 38% men. Most (54%) were aged 31–45, 29% under 30, and the rest above 45. Educationally, 78% had completed high school, and only 10% had higher education. In terms of business duration, 63% had operated for over three years, while 12% were new (in under one year). Digitally, 42% used more than one platform (e.g., Shopee, Tokopedia, GoFood, GrabFood, Instagram, Facebook), but only 28% had a structured digital strategy.

Outer Model Evaluation

All indicators met the outer loading threshold (> 0.7) and AVE (> 0.5). Composite Reliability values ranged from 0.867 to 0.945, Cronbach's Alpha values exceeded 0.8, and Fornell-Larcker criteria confirmed discriminant validity.

Inner Model Evaluation

R^2 for IBM was 0.841, meaning 84.1% of its variance is explained by DR, DI, and DT. R^2 for SEL was 0.870, indicating 87% explanatory power. Variance Inflation Factor (VIF) values were below 5, confirming no multicollinearity.

Direct Hypothesis Testing

All direct paths were significant ($p < 0.05$):

Hypothesis	Path	Koefisien β	t-statistik	p-value	Keterangan
H1	DR affects IBM	0.301	4.987	0.000	Significant
H2	DR affects DBE	0.267	3.812	0.000	Significant
H3	DI affects IBM	0.425	6.723	0.000	Significant
H4	DI affects DBE	0.308	4.209	0.000	Significant
H5	DT affects IBM	0.376	5.589	0.000	Significant
H6	DT affects DBE	0.249	3.721	0.000	Significant
H7	IBM affects SEL	0.442	7.412	0.000	Significant
H8	DBE affects SEL	0.387	6.129	0.000	Significant

All paths had p-values < 0.05, which means that they statistically supported the research hypothesis.

Indirect Effects and Mediation Statistical analysis.

Mediation tests were conducted to see whether the IBM and DBE constructs mediated the influence of DR, DI, and DT on SEL. Bootstrapping results showed that all mediation effects were significant:

- DR affects IBM mediated the influence of SEL (β = 0.133; p = 0.000)
- DI affects IBM mediated the influence of SEL (β = 0.188; p = 0.000)
- DT affects IBM mediated the influence of SEL (β = 0.166; p = 0.000)
- DR affects DBE mediated the influence of SEL (β = 0.103; p = 0.001)
- DI affects DBE mediated the influence of (β = 0.119; p = 0.002)
- DT affects DBE mediated the influence of SEL (β = 0.096; p = 0.003)

These results indicate that business model innovation and the digital ecosystem play an important role as mediating variables in the digital transformation of MSMEs towards economic sustainability

Goodness-of-Fit dan Predictive Relevance

Q^2 values were 0.521 (SEL) and 0.462 (IBM), indicating strong predictive relevance. GoF was 0.689, exceeding

the 0.36 threshold for large models (Tenenhaus *et al.* 2005).

Based on the test results, it was found that: Digital readiness and digital inclusion significantly encourage technology-based business model innovation. The digital business ecosystem acts as a connecting channel between digital transformation and local economic sustainability. The DEIM model has proven to have strong theoretical and empirical validity in explaining the dynamics of MSME digitalization in urban areas.

4. Discussions

Digital Readiness as the Foundation for Transformation

The results of the study indicate that digital readiness (DR) has a significant impact on business model innovation (IBM) and the formation of a digital business ecosystem (DBE). This underscores that technological readiness and internal competencies are the primary prerequisites for the success of digital transformation in SMEs. These findings align with the research by Lutfi *et al.* (2022) and Abdullah *et al.* (2021), which emphasize the importance of infrastructure readiness, human resource training, and technology risk management as the foundation for effective digital adoption. In Medan, many culinary SMEs still use manual methods for financial record-keeping, inventory management, and marketing strategies. The lack of digital tools and insufficient technological literacy are the main barriers to innovation implementation. Therefore, digital readiness must be developed systematically through regular training, technology adoption incentives, and community-based digital transformation programs.

Digital Inclusion and Equal Access

Digital inclusion (DI) has also proven to play an important role in driving innovation and building an inclusive digital ecosystem. Access to technology, stable internet networks, and the availability of digital devices influence the extent to which businesses can participate in the digital economy ecosystem. These findings reinforce the studies by Mo *et al.* (2023) and UNDP (2012), which state that digital exclusion poses a real threat to micro-businesses in developing countries. Although digital platforms such as Shopee, Tokopedia, and GoFood have opened up new opportunities, technology penetration among SMEs is not evenly distributed. MSMEs located in suburban areas and lacking digital community networks tend to be left behind. Therefore, policy interventions should focus on providing equitable access to technology, as well as institutional support such as digital learning communities and technology facilitators.

Digital Transformation and Innovative Business Models

The impact of digital transformation (DT) on business model innovation is significant. The digitization of business processes drives operational efficiency, market expansion, and increased customer satisfaction. SMEs that have transformed their ordering, delivery, and payment processes have seen increases in revenue and customer loyalty. These findings support the views of Vial (2021) and Bughin *et al.* (2018) that digital transformation is multidimensional and requires changes in business mindset. The adoption of technologies such as digital point-of-sale systems, QRIS, and content-based marketing has transformed how SMEs operate their businesses. However, technology adoption is not always linear. Businesses face challenges such as subscription costs for applications, the complexity of new systems, and a lack of technical understanding. This indicates that digital transformation is not just about tools but also about the social and cultural readiness of the organization.

The Role of Ecosystem Mediation and Innovation

The role of business model innovation and digital business ecosystems as mediators strengthens the relationship between digital readiness and inclusion and local economic sustainability (LES). Innovation is key to adapting to the dynamics of the digital market. SMEs that can develop subscription-based business models, community partnerships, or supply chain digitalization have better economic resilience (Chesbrough, 2006; Rachinger *et al.* 2021). The digital business ecosystem involves cross-actor interactions: local governments, e-commerce platforms, digital financial institutions (fintech), and user communities. This study found that SMEs' involvement in such ecosystems accelerates innovation and opens up collaborative opportunities. Studies by Autio *et al.* (2022) and Spigel and Harrison (2020) confirm that inclusive ecosystems accelerate the diffusion of innovation and strengthen local economic structures.

Implications for Local Economic Sustainability

The finding that IBM and DBE directly and significantly influence local economic sustainability (LES) reinforces the argument that digital transformation must be linked to the sustainable development agenda. Sustainability

does not only mean surviving in the long term, but also being able to adapt to market changes, create jobs, and strengthen the socio-economic capacity of local communities (Torres *et al.* 2023). MSMEs that utilize digital technology show greater resilience during the pandemic, recover more quickly, and are more flexible in response to fluctuations in demand. This underscores that technology adoption is not merely a business strategy but a fundamental necessity in addressing economic crises. Conceptually, these findings reinforce the validity of the Digital Ecosystem Innovation Model (DEIM) as an extension of the TOE Framework. This model not only emphasizes the three core aspects - technology, organization, and environment - but also highlights the importance of the digital ecosystem and sustainability dimensions. This approach aligns with recent literature from Kraus *et al.* (2022) and Gallego and Gutiérrez (2020), who propose integrating sustainability dimensions into the digital transformation of the micro and small sector. Using the SEM-PLS approach, this model has proven capable of explaining up to 87% of the variation in the economic sustainability construction. The predictive value and goodness-of-fit are also high, indicating that the DEIM model is relevant for application in developing urban areas like Medan City. As a metropolitan city outside Java Island, Medan has unique SME characteristics - a dominant informal sector, low digital literacy, and few active digital incubators. However, the growth potential is enormous. With a high youth population, increased internet access, and the growth of the digital logistics sector, Medan could become a hub for community-based SME innovation. Policy intervention opportunities are wide open: establishing digital training centers in each sub-district, subsidizing digital platform subscriptions, and integrating SMEs into smart city programs. Another opportunity is to strengthen collaboration between universities, city governments, and the SME community to encourage the adoption of evidence-based technology.

Conclusions and Further Research

This research offers significant theoretical enrichment to the discourse on digital transformation by embedding the constructs of digital inclusion and local economic sustainability within the extended TOE-based Digital Ecosystem Innovation Model (DEIM). Such integration facilitates a more nuanced and context-sensitive analytical lens through which the dynamics of MSME digitalization, particularly within informal urban economies - can be more comprehensively understood. By reconciling structural, technological, and socio-economic dimensions often treated in isolation, the study contributes to the evolution of the TOE framework into a more integrative paradigm that is attuned to the realities of the Global South.

From a practical standpoint, the research generates empirically grounded insights that serve as a strategic foundation for formulating inclusive digital transformation policies. It responds directly to the persistent asymmetries in digital capability, infrastructure access, and institutional outreach that characterize many urban informal sectors in Indonesia. The model proposed herein not only underscores the imperative of tailoring digitalization strategies to local socio-economic configurations but also highlights the centrality of community - embedded support mechanisms in ensuring the sustainability and equity of digital innovation processes. Digital transformation is no longer just an option, but a necessity for the survival and growth of MSMEs in the era of technology-based economy. This study confirms that digital readiness, digital inclusion, and digital transformation play a key role in shaping innovative business models and strengthening the economic sustainability of MSMEs, particularly in the culinary sector of Medan City. Through testing on 250 SME actors using the SEM-PLS approach, it was found that these variables interact significantly within the Digital Ecosystem Innovation Model (DEIM) framework. The DEIM model developed in this study was proven to explain up to 87% of the variation in the economic sustainability of local SMEs, demonstrating strong structural and predictive validity. These findings support the expansion of the TOE Framework by adding the dimensions of digital ecosystem and sustainability as significant mediating factors. Digital readiness has a positive and significant influence on business model innovation and the digital ecosystem of SMEs. Without adequate readiness in terms of infrastructure, skills, and organizational readiness, the digitalization process tends to be hindered. Digital inclusion also has a direct influence on innovation and the digital ecosystem. Fair access to technology, digital literacy, and engagement in digital communities are important drivers for SMEs' active participation in the digital economy. Digital transformation contributes to driving changes in business models and shaping more adaptive, efficient, and connected collaboration patterns within the digital ecosystem. Business model innovation serves as an important mediator between digital readiness and inclusion in relation to the sustainability of the local economy. SMEs that are able to develop technology-based business models experience improvements in efficiency, market expansion, and business resilience. The digital business ecosystem (Digital Business Ecosystem) serves as a strategic connector between businesses, technology, government, and communities, fostering cross-sector collaboration and innovation integration. Local economic sustainability (Sustainable Economic Local) is directly influenced by innovation capabilities and engagement within the digital ecosystem. SMEs connected to the digital

ecosystem demonstrate higher adaptability and growth potential.

Declarations

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Credit Authorship Contribution Statement:

Sunday Ade Sitorus: Conceptualization, Methodology, Data Collection, Formal Analysis, Writing – Software, Data Curation, Visualization, Formal Analysis - Original Draft. Sunday Ade Sitorus led the formulation of the research questions, constructed the conceptual framework, designed the data collection instruments, and carried out the fieldwork. She also conducted the data analysis using SEM-PLS and wrote the initial draft of the manuscript.
Nalom Siagian: Supervision, Validation, Writing – Review and Editing, Funding Acquisition. Nalom Siagian provided overall supervision of research design and analytical strategy. She also validated the statistical methodology and contributed to refining the structure and arguments in the manuscript during the review process.
Orlando Steven: Resources, Investigation, Project Administration, Writing – Review and Editing. Dr. Orlando Steven coordinated access to MSME respondents in the Nias Islands and managed the field team. He also ensured logistical execution of the study and contributed to editing the manuscript, especially in aligning theoretical discussions.

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Oliver Williamson's Opportunism

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Abstract: In his study of the modern firm Oliver Williamson proposes the concept of opportunism as the reason for vertical integration. Williamson divides opportunism conditionally into ex ante and ex post opportunism by analogy with his classification of transaction costs as ex ante transaction costs incurred prior to concluding the deal and ex post transaction costs, which arise after that. Ex ante screening can prevent ex post opportunism. Opportunism is a synonym of fraud in the market game. It is the practice of cheating, lying or stealing in business relations. It is very common in some cultures and societies which hampers prosperity and economic progress.

Keywords: opportunism; transaction costs; Oliver Williamson; new institutional economics.

JEL Classification: D23; D82; O10.

Introduction

Oliver Williamson makes operational Ronald Coase's theory of the firm. Williamson defines types of transaction costs and relates the different levels of those costs to different governance structures, i.e. organizational forms, using a discriminating approach. Like Coase Williamson supports that transaction costs are the reason for the existence of firms. An essential source of transaction costs to Williamson is opportunism, a demonstration of the transactional and behavioral failures of the market and a result of human behavior. Williamson formulates opportunism as a concept broader than moral hazard, adverse selection, asymmetric information, misrepresented quality or other types of market failure. Opportunism includes all these forms of market failure (Williamson, 1993a). Transaction costs are at the root of all types of market failure.

We study the different aspects of opportunism, as seen by Williamson in his theory of the firm. Williamson's opportunism is essential for economic organization. It is a condition for vertical integration between successive firms along the distribution channel but, more importantly, it leads to complete market failure when due to fraud certain markets disappear. We analyze critically Williamson's concept and its significance for economic theory particularly with relevance to economic development. Using a descriptive approach, we pose the question to what extent opportunism, as defined by Williamson, explains differences in development among economies with varying levels of institutional trust. Section 1 of the paper is a brief introduction. Section 2 reveals the different forms and effects of opportunism, as introduced by Williamson. The paper ends with conclusions.

Opportunism and Its Role in the Market Game

Williamson (1983) borrows the term 'opportunism' from Niccolo Machiavelli and the field of political science. Machiavelli advised the prince that:

> 'a prudent ruler ought not to keep faith when by so doing it would be against his interest, and when the reasons which made him bind himself no longer exist' (Machiavelli 1952, 92).

The ruler can and ought to violate agreements when it is in his interest to do so without fearing a penalty. This is because the other parties to the agreement would also violate the agreement in order to achieve their goals. Williamson (1983, 3) claims that opportunism 'has broad and recognizable significance to social and economic organization.' Human agents are not fully trustworthy in economic dealings (Williamson 1993a).

According to Williamson (1985) there are three levels of selfishness in economic behavior: 1) obedience or lack of self-interest seeking, 2) simple self-interest seeking which is a normal level of selfishness in search of profits, and 3) opportunism as a strong form of self-interest seeking. Obedience is the lack of human selfishness in economic behavior. An example of that is voluntary slavery when someone agrees to be someone's slave or be unlimitedly exploited by another person (Coase 1937). Coase (1937) reminds that such a contract of enslavement would be legally invalid and unenforceable. Williamson provides as an example of obedience the socialist economy when individuals give up their own goals and adopt the macroeconomic goals of the central plan. Thus, individuals in socialist societies sacrifice their own interests for the sake of the state or the central plan.

Simple self-interest seeking is a normal level of selfishness in market transactions. Classical authors like Adam Smith and David Riccardo assumed that economic agents are only normally selfish in pursuit of profits. When they wrote their theories, they did not presume excessive human selfishness in market exchange:

> 'It is not from the benevolence of the butcher, the brewer, or the baker that we expect our dinner, but from their regard to their own self-interest. We address ourselves not to their humanity but to their self-love, and never talk to them of our own necessities, but of their advantages' (Smith, 1776, Book I, chapter II. Of the Principle Which Gives Occasion to the Division of Labour, p. 56).

And when discussing foreign trade, Smith refers to the invisible hand that drives individuals. By 'invisible hand' he means nothing but people's selfishness in pursuit of profits.

> '… every individual… generally, indeed, neither intends to promote the public interest, nor knows how much he is promoting it. By preferring the support of domestic to that of foreign industry, he intends only his own security; and by directing that industry in such a manner as its produce may be of the greatest value, he intends only his own gain, and he is in this, as in many other cases, led by an invisible hand to promote an end which was no part of his intention… By pursuing his own interest he frequently promotes that of the society more effectually than when he really intends to promote it' (Smith, 1776, Book IV, II. Of Restraints Upon the Importation from Foreign Countries of Such Goods as Can Be Produced at Home, p. 160).

There is a need for some selfishness in the market game. Individuals who are normally selfish and normally greedy create value and deliver products to the market which brings them profit. But this search of profit is moderate, individuals are not presumed to lie in market dealings, they do not deliver products of lower quality, they deliver the product on time and in the right amount. Thus, classical writers assumed that individuals are relatively well-intended, and that competition is honest.

Such a limited view of human behavior renders classical economics unrealistic. Once opportunism is introduced in market dealings, there is a provision of the transactional and behavioral failures of the market. Economics becomes a realistic subject – individuals are no longer only reasonably selfish and boundedly rational but excessively greedy in their pursuit of profits. They rob or lie to their commercial partner, they mislead, cheat, obfuscate information, they refuse to pay or procrastinate payment, they deliver products of lower than claimed quality, and are generally dishonest. New institutional economics in general and Oliver Williamson's concept of opportunism in particular introduce an element of realism in economic theory. By introducing extreme selfishness in the market game Williamson reveals the darkest aspects of human nature, the worst features of homo economicus. In relation to this is Coase's observation that new institutional economics is economics as it ought to be:

> 'Modern institutional economics should study man as he is, acting within the constraints imposed by real institutions. Modern institutional economics is economics as it ought to be' (Coase 1984, 231).

Opportunism, as defined by Williamson, is extreme selfishness in market dealings. It is a strong form of self-interest seeking, very different from obedience as non-self-interest seeking or simple self-interest seeking as a semi-strong form. Williamson (1985, 47) defines opportunism as:

> 'self-interest seeking with guile. This includes but is scarcely limited to more blatant forms, such as lying, stealing, and cheating. Opportunism more often involves subtle forms of deceit. Both active and passive forms and both *ex ante* and *ex post* types are included.'

Power may not be symmetrically shared between the parties to a contract. The more powerful side may try to appropriate some or all quasi-rents of the other party. The stronger party in effect changes the *ex ante* quasi-rent negotiated before the conclusion of the deal by obtaining *ex post* the economic rent of the other party or what was agreed on as its value added. The stronger party thus changes the rules of the contract *ex post* following a strategic behavior which benefits it but deprives the other party of its value added.

Opportunism is inherently related to contracts. The possibility for opportunism arises with the conclusion of a contract where each of the parties would like to protect itself against the risks associated with the behavior of the other party. Every party to a contract would like to incorporate clauses or safeguards to protect itself against the risky behavior of the other party. Opportunism thus is an indispensable part of the study of contract. It is highly relevant to economic reality since economic activity is based on contracts and all economic agents are susceptible to contractual risks. Furthermore, contracts should not be based on mere promise but should be supported by credible commitments (Williamson 1996).

There is no presumption of opportunism in Coase's theory of the firm. Coase makes no reference to opportunism which is why Williamson (1985, 78, footnote) criticizes him:

> 'Coase (implicitly) acknowledges bounded rationality but makes no reference to opportunism. Indeed, to contend, as he does, that… '[w]e can imagine a system where all advice or knowledge was bought as required', is essentially to deny that markets for information are beset by opportunism. Coase is… silent on the contracting hazards and maladaptations on which I rely to explain nonstandard contracting...'

While Coase does not mention opportunistic behavior explicitly, he presumes it because he refers to Knight (1933) who discusses human nature in the context of uncertainty. Knight views human nature as the unpredictability of human actions and the uncertainty it brings when human knowledge about the future is limited. To Williamson 'human nature as we know it' is a synonym of selfishness, greed, unpredictability and lack of trust. Williamson's contractual man is unpredictable, he is lured by the full economic profit, he wishes to appropriate the full rent of his contractual partner and is unlimitedly greedy. Williamson expands Knight's concept of human nature and introduces an element of realism in economic theory. Knight (1933, 260) studies 'human nature' and moral hazard in the context of risk and uncertainty but his work is a basis for Williamson to introduce opportunism as 'a subtle and pervasive condition of human nature with which the study of economic organization must be actively concerned' (Williamson 1985, 6).

Coase discussed transaction costs generally. These are 'some marketing costs' or what it costs to use the market mechanism. He did not specify all the sources of transaction costs. There may be different sources of transaction costs, both objective and subjective. Transaction costs which arise objectively stem from the technical difficulties in leading prolonged negotiations between multiple parties, the technological time it takes to draft a contract, the objective differences between the parties and the time and effort it takes to overcome these differences. To Williamson there is a substantial subjective source of transaction costs where a party to a transaction may intentionally try to take advantage of the other party. Opportunism represents this essential type of subjective transaction costs which arise of the intentional, ill-intended human behavior. One of the parties to a transaction realizes that his commercial partner is trapped in a contractual relationship and purposefully wishes to appropriate his quasi-rents. Hodgson (2004) is critical of this view. He believes that individuals are far more cooperative in business dealings and different misunderstandings can occur due to the cognitive and perceptional differences among them. Hodgson, however, discusses objective obstacles such as human cognition and perception within the firm where individuals may unwillingly face communication problems because they differ in their cognitive processes when involved in mutual work. Hodgson does not discuss interfirm problems of cognition during the negotiation process, that is, across different technologically separable stages of the market interface when one phase of the exchange process ends, and another phase starts.

Some believe that there has always been opportunism and that it existed prior to Williamson. He argues opposite:

> 'I seriously dispute that opportunism has been the operative behavioral assumption. Public goods, insurance, and oligopoly aside, there was little or no provision for opportunism in most textual or other treatments of economic organization as recently as 1970… Simple self-interest-seeking, rather than opportunism, was plainly the ruling view.' (Williamson 1985, 65)

There was no reference to opportunism in the literature or its practical significance was not recognized. In describing the situation with firm studies before 1970 Williamson (1985, 65) mentions that there was no reference to efficient

governance and the attenuation of opportunism in relation to labor union organization. Regulatory prescriptions regarding contractual complications stemming from opportunism were dismissed. The theory of contracts relied on the concept of differential risk aversion, while concerns over the hazards of opportunism were suppressed. In support of Williamson that there was no theoretical provision of fraud in the market game Peter Diamond (1971, 31) remarks:

> 'Economic models [treat] individuals as playing a game with fixed rules which they obey. They do not buy more than they know they can pay for, they do not embezzle funds, they do not rob banks.'

Except Knight there were other economists who hinted at opportunism back in time. As an organizational theorist Herbert Simon studied the quantitative dimensions of organizational design. Simon (1957) hints at organizational opportunism in that individuals in organizations may pursue their own goals or identify with local goals which contradict the global goals of the organization.

Arrow also believes that people can be opportunistic. Arrow (1969, 506) claims that 'mutually advantageous agreements are not arrived at because each party is seeking to engross as much as possible of the common gain for itself.' There is severe asymmetry and opportunism in the markets for information. An example is the 'knowledge paradox' when the buyer of some knowledge is unwilling to pay for it before he obtains it but once he obtains it, he is no longer willing to pay for it.

Williamson emphasizes market opportunism more than internal organizational opportunism. He refers to organizational opportunism only on two accounts: 1) organizational form for the firm as a governance structure and 2) conflict and conflict resolution within the firm.

The firm should not be seen as a production function but as a governance structure. Organizational form, therefore, matters with different types of forms economizing on transaction costs differently. The multidivisional form to Williamson is optimal for the large corporation not only because it relocates transaction costs and informational load optimally between: 1) the strategic management which takes the long-term decisions of the corporation related to its mission, vision, etc. and 2) the operational, day-to-day management of the separate unit, division or subsidiary charged with the task to organize its smooth operation. The multidivisional form has advantages over other firm forms such as the holding or the conglomerate in that it subjects the different units, divisions or subsidiaries to the organizational goals. They no longer follow their own goals or maximize their own profit at the expense of the company profit but pursue the organizational goals and maximize the cumulative firm profit. Thus, in Williamson's view the multidivisional form overcomes local opportunism within the organization. This conclusion is fully consistent with Herbert Simon's view of organizational goals. Simon's influence over Williamson, who was his student in organizational theory at Carnegie Melon, is obvious.

Williamson also refers to internal opportunism in the context of conflict resolution. The firm has its inbuilt mechanism of solving conflicts, something which is missing in conflicts between parties across the market interface. In interfirm, market disputes it is the judge who solves the conflict between the parties. To Williamson, the manager assumes the role of the judge in solving disputes within the firm. Williamson calls this process 'fiat,' by which conflicts get more easily resolved within the firm. It takes less time following the internal rules of the organization; the parties and the manager as a mediator are more competent and familiar with the circumstances and may come up with a better solution, compared to an external figure such as the judge. The judge may need more time to understand the conflict and take the right decision. Also, the firm may not want to disclose the nature and details of the conflict. It may be too costly to use the court system to resolve conflicts (Williamson 1993c).

Williamson pays a lot of attention to external opportunism which occurs across the market interface. It arises between two independent firms involved in a contractual relationship and results from the dishonesty of one of the firms. This interfirm or market opportunism is not common:

> '[This] does not imply that I believe that most economic agents are engaged in opportunistic practices most of the time. Rather, most economic agents are engaged in business-as-usual, with little or no thought to opportunism, most of the time. That opportunism does not continuously intrude is partly because many economic agents are well-socialized' (Williamson 1993a, 98).

Therefore, a major reason why some economic agents act opportunistically is the lack of socialization in Williamson's view. Opportunism arises with specific assets[1] which can hardly be replaced with universal or general-purpose assets in a specific deal. Specific assets on their own cannot be a source of transaction costs. Because opportunism causes asymmetric information and transactional and behavioral uncertainty, it is potentially risky for specific assets. What is initially a general-purpose asset turns into a specific asset once the contract is signed.

[1] Specific assets include: 1) dedicated assets, 2) human asset specificity, 3) site specificity, 4) physical asset specificity, 5) brand name capital.

What is a large number of bidders at the outset, turns into a single provider of the good or service upon conclusion of the contract. This very much resembles a marriage contract. When a person is single, he or she may have many suiters. But once the person gets married, out of the many suiters remains only one. The party is then trapped in a contractual relationship where the other party may or may not be faithful.

Williamson stresses the risks associated with commercial contracts. There could be opportunistic behavior with spot markets, but it does not have long-term consequences because it is a one-time deal. With prolonged market contracting where specific assets are involved and parties are boundedly rational, the consistent opportunism by one of the parties results in a merger of the two firms. Transactional and behavioral failures such as consistent opportunism by one firm lead to the vertical integration of the two firms along the distribution channel. The merger could be between the producer and an opportunistic supplier or between the producer and an opportunistic distributor. An opportunistic supplier may fail to deliver the right parts to the producer, or may deliver parts of lower quality, or fail to deliver them on time. An opportunistic producer may refuse to pay for the parts ordered or may not pay the full amount to the supplier or may delay the payment substantially. The hazard of opportunism by a contractual partner may result in significant underinvestment in specific assets. Their application in alternative uses is limited which results in losses for the investing party. An opportunistic distributor may fail to distribute, promote or exhibit the product of the producer, as contracted or agreed on. If this behavior persists, the producer may be forced to acquire the opportunistic distributor. Opportunism can be observed at any level of the distribution channel. Both *ex ante* and *ex post* opportunism are present. To prevent *ex post* opportunism e*x ante* safeguards can be designed at the stage of contract formulation or a careful *ex ante* screening of potential commercial partners may be necessary. Higher *ex ante* transaction costs incurred prior to signing the deal may reduce the risk of *ex post* opportunism.

Interfirm opportunism is a factor for vertical integration when combined with asset specificity, bounded rationality, uncertainty and continuous market exchange. Therefore, the conditions for vertical integration are: 1) specific assets, 2) contractual opportunism by one of the parties, 3) bounded rationality, 4) uncertainty, and 5) long-term contracting. Bounded rationality and opportunism weaken market contracting as a form of economic organization. This gives advantage to nonmarket forms of governance such as nonstandard forms of contracting (franchising and joint ventures), specialized mediation (arbitration), and complex hierarchical structures (administrative organization) (Williamson 1983).

Williamson (1993a) draws a direct parallel between opportunism and some specific forms of transactional behavior. He considers opportunism less technical than adverse selection and moral hazard. Adverse selection is an example of *ex ante* opportunism when a party to a contract fails to reveal its true attributes to the other party. A typical case is the employment contract when a job candidate does not reveal his adverse features to the employer prior to signing the contract. The employer finds out about the true potential of the employee only after the contract is signed and the employee starts working. With human asset specificity the employee develops a set of skills and knowledge strictly relevant to the particular company. This creates the possibility for the employer to act dishonestly. As time goes by and the employee develops more firm-specific knowledge, it becomes harder for him to find alternative employment increasing thus the opportunity cost of his leaving the firm. Such firm-specific knowledge and talents turn into sunk costs for the worker. This creates an opportunity for the manager to extract more of the employee's rents stipulated in or implied by the employment contract. Likewise, employees would try to extract as much of the quasi-rent of the firm attributable to human capital. Employees could go as far as expropriating the full rent of the employer, unless the labor contract is terminated prematurely. Asset specificity which arises with labor can be the cause of transaction costs on both sides of the employment contract.

Moral hazard is a case of *ex post* opportunism where once the contract is signed, one of the parties becomes negligent and fails to perform its contractual obligations. A common example provided in the economic literature is the insurance business where once a person gets insured, he becomes more irresponsible when it comes to his health or property. He fails to abide by the insurance contract.

Shirking within the firm is another example of *ex-post* opportunism. It could be an illustration of the principal-agent problem from agency theory where the manager is not the owner of the firm and fails to manage the firm in a way that is profit-maximizing for the owner. Shirking can also occur at a very low level when workers simply underperform and do not provide the maximum of their marginal product. Workers may provide lower quality than what is desired or expected. They shirk on the effort of other team members. Shirking can also take the form of absenteeism and procrastination. The most extreme form of shirking on the part of both workers and managers is stealing from the firm or the workplace. All three categories, adverse selection, moral hazard and shirking, fit ideally within the concept of opportunism.

Asymmetric information and quality misrepresentation are forms of external opportunism which take place over the market interface. Buyers may not be perfectly informed about the features or functions of a product. The seller may not present the information about the product accurately. More specifically, he may sell a product of lower quality as one of superior quality thus appropriating the rents of the buyer. Since buyers expect the seller to cheat on quality, they refuse to buy at any given price level. Demand becomes so low that it can no longer meet supply. The market thus falls into a low-quality equilibrium which is essentially a lack of equilibrium. Mutually advantageous transactions are lost due to the loss of trust caused by potential or real opportunism. Transaction costs stemming from contractual opportunism cause deadweight social loss where sizable total social surplus is being lost. This effect of informational asymmetry which stems from behavioral opportunism is well described by Akerlof (1970) in the 'lemon market' example of second-hand car markets. Akerlof's conclusion is that mostly 'lemon' cars are traded in second-hand car dealers, and they are presented as 'peaches.' Because customers know that mostly lemons are offered in second-hand markets, they refuse to buy at any price level. Akerlof also discusses the behavior of cheating with lending and credit markets in underdeveloped countries. Indian housewives must carefully clean the rice from 'stones of the same color and shape which have been intentionally added to the rice' (Akerlof 1970, 496). 'Any comparison of the heterogeneity of quality… suggests that quality variation is a greater problem in the East than in the West' (Akerlof 1970, 496). It seems that opportunism is a bigger problem in less developed and transitional countries without solid traditions and customs in the operation of markets.

Williamson does not make a direct reference to the underdeveloped world. In his theory opportunism is a condition for the vertically integrated firm. Williamson does not discuss opportunism in the context of the low-end equilibrium trap when cheating by one market participant can destroy the entire market. Because opportunism is more prevalent in some countries, cultures or societies, such cultures are more susceptible to complete market failure and economic underdevelopment than others. The presence of individuals who are more likely to cheat in the market game is an obstacle to development in such societies. This is beyond what Williamson observes. He admits that transaction costs are at the root of market failure but does not relate opportunism to economic backwardness. Williamson does refer to Akerlof (1970) and Banfield (1958) on how cheating can be a cultural trait. Japan is a culture of high trust in business relations (Dore 1983), while there is a very low degree of trust outside the family in villages in Southern Italy (Banfield 1958). Fraud is very common in less developed countries. In Williamson's view the propensity for opportunism varies among individuals and between cultures (Williamson 1996).

Economic agents should not be contractually naive and allow 'user-friendly' terms like promise and trust disguise the objective features of the deal (Williamson 1993a, 105). The parties which foresee the potential contractual risks and include preventive clauses *ex ante* have a clear advantage over those shortsighted which risk blindly and knock on wood. If one contract turns out to be riskier than another, this should be accounted for in the value of the deal. Between two contracts the parties should choose the one with less potential for opportunism. If the risks are prohibitive, then the deal is not worthwhile (Williamson 1993a, 105). The hazards of opportunism should be addressed openly rather than suppressed. Williamson seriously objects to Bradach and Eccles (1989) that the growing interdependence between two commercial partners who bargain continuously strengthens trust between them. Just the opposite, transaction cost economics posits that a stronger interdependence that develops with time is a prerequisite for opportunistic behavior. As time passes, the parties to a contractual relationship may become less and less alert and, hence, more vulnerable to the opportunistic behavior of the other party. Williamson (1993b) considers trust an elusive notion. It is inevitably related to risk. Trust is the reaction of an individual when he takes on certain risks which depend on the behavior of another individual.

Because it is unlikely that opportunistic agents will stick to their own promises, it is necessary to design credible threats or commitments that guarantee contract compliance. Credible commitments serve as incentives for contract observance. Williamson thinks that trust undermines the continuous contractual relationship between two parties and confuses economic analysis.

> 'Transactions that are subject to *ex post* opportunism will benefit if cost-effective safeguards can be devised *ex ante*. Rather than reply to opportunism in kind, the wise prince is one who seeks to both give and receive credible commitments. That is a much deeper and more important contractual response, but it requires that the hazards of opportunism be faced candidly rather than suppressed (Williamson 1993a, 105).'

Inside the organization the most opportunistic and dishonest individuals take advantage of the honest, non-opportunistic individuals. Opportunistic individuals easily invade, and exploit organizations built on high trust and cooperation. Solid organizations, therefore, are those which have mechanisms for detecting and preventing internal opportunism.

> 'One of the implications of opportunism is that 'ideal' cooperative modes of economic organization, by which I mean those where trust and good intentions are generously imputed to the membership, are very fragile. Such organizations are easily invaded and exploited by agents who do not possess those qualities. 'High-minded' organizational forms – those which presume trustworthiness, hence are based on nonopportunistic principles – are thus rendered nonviable by the intrusion of unscreened and unpenalized opportunists. Accordingly, those who would have cooperatives succeed must, of necessity, make organizational concessions to the debilitating effects of opportunism. Viable cooperatives will attempt to screen against, socially recondition, and otherwise penalize opportunistic invaders (Williamson 1985, 64).'

Williamson does not give the rationale for opportunism in contractual relationships. He only detects it and its effect on contracts, markets and organizations. He does not study the motivation for opportunistic behavior and admits that reputation effects are no contracting panacea (Williamson 1985, 396). Opportunism is still not widely accepted among economists. Its different forms are studied separately and outside its context. One reason is that some economists have developed their own models of certain types of market failure. For instance, Stiglitz (1975; 1985; 2000) introduces a model of information, information costs and information asymmetry. Arrow (1985) studies the principal-agent problem. Some economists (Hodgson 2004) question that opportunism is the reason for the existence of the firm. To deny opportunism is to deny standard concepts like moral hazard and adverse selection in economic theory.

More recent studies reveal the role of opportunism in various contexts. Zardkoohi, Harrison and Josefy (2017) and Wagner (2019) study opportunism in the context of agency theory. To Wagner (2019) the problem is one of reciprocal nature. While economic analysis is preoccupied with the opportunistic behavior of the agent, there is reverse opportunism, that of the principal, which originates from power and dominance, rather than information asymmetries. The principal can humiliate, harass, undermine, overrule or overload the agent.[2] Hennart and Verbeke (2022) discuss opportunism in international markets and reveal transaction cost theory as a framework for finding optimal governance structures in the process of value creation in international business. Stephen (2017) relates institutional and economic underdevelopment to culture. More specifically, economic reform and the attempts of the Chinese government at building the new normal economy depend on law enforcement which has its roots in legal tradition and culture. Pejovich (2003) traces the high transaction costs and mishaps of development in Eastern Europe to culture.

The concept of opportunism is important not just in the context of the vertically integrated firm but also in the general context of economic development. Opportunism is a behavioral source of transaction costs and as such is the reason for market failure. It could be seen as a regional, ethnic or cultural trait. Societies dominated by opportunistic individuals where opportunism is a national characteristic are more prone to market failure than non-opportunistic populations. Such opportunistic societies enjoy high transaction costs of market exchange, where due to behavioral failures it is more costly to use the market mechanism. Economic development is significantly hampered by ethnic or culturally embedded opportunism.

Conclusion

Opportunism is an extreme form of selfishness in economic activity. It arises in the process of market contracting and is inevitably related to contracts. Williamson proposes opportunism as a comprehensive category which incorporates all types of behavioral failures in the process of transacting. According to Williamson all types of behavioral failures fit very well within the concept of opportunism – adverse selection, moral hazard, shirking, the principal-agent problem, asymmetric information, quality misrepresentation, etc. Opportunism is generally any kind of cheating in the market game when one of the parties to a contract attempts to acquire the quasi-rent of the other party with as little effort as possible on its part. It includes lying, cheating, distorting, hiding information, stealing and other forms of deceit. Opportunism is a major subjective source of transaction costs in economic exchange. Once the concept of opportunism is introduced in economic theory, the economic system becomes realistic. Opportunism has two essential effects on the economy. It is the reason for vertical integration when two firms along the distribution channel merge to form a bigger firm. This increases market concentration and monopoly power but reduces the transaction costs faced by the firms in the industry. This outcome is also more favorable since no productive value or welfare is lost. Market transactions are internalized within the firm. A second effect of contractual

[2] Of course, while the manager is a principal of the worker who is an agent in the employment contract, the former is an agent of the owner(s) of the company whose interests he represents in managing it. A misbehaving principal may turn out to be an underperforming agent or a principal may be underperforming just because he is an opportunistic agent. We should stress here the relative nature of the problem.

opportunism is complete market failure when commercial fraud drives the market into disequilibrium. Since some societies and cultures are more opportunistic than others, this prevents economic development. As a behavioral, subjective source of transaction costs opportunism causes market failures of different types and economic backwardness. Opportunism is an essential obstacle to economic development in third world and transitional countries.

Declarations

Declaration of Competing Interest: The author declares that she has no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Declaration of Use of Generative AI and AI-assisted Technologies: The author declares that she has not used generative AI and AI-assisted technologies during the preparation of this work.

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Human Resource Management as a Factor Fostering Companies' Economic Growth

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Abstract: The Effective human resource management plays a pivotal role in optimizing labor organization, thereby stimulating productivity growth and ensuring the companies' sustainable economic advancement, which underscores the significance of research in this domain. The purpose of this study was to evaluate the influence of working conditions and labor process organization on productivity, while considering both global and national contexts. The study used regression, correlation, and comparative analysis methods. Employing regression, correlation, and comparative analysis methodologies, the findings elucidate how human resource management through working hours organization, remuneration, and the implementation of training and innovative technologies affects corporate productivity as a determinant of economic growth.

Regression analysis revealed that employee income exerts the most substantial influence on productivity, whereas the number of hours worked affects productivity only when considered in conjunction with income. The corresponding standardized Beta coefficients for these variables are 0.9207 for income and 0.1926 for hours worked. Among intangible factors, the most significant impact stems from the companies' adoption of digital technologies, reflected in a coefficient of 0.7437. Against this backdrop, the proportion of firms offering formal training did not demonstrate a statistically significant effect on productivity according to the regression analysis. However, correlation analysis indicated a positive association between productivity and the implementation of training (0.4568), suggesting that this factor may also play a potentially critical role in corporate growth.

The case study of China illustrated that the influence of the examined indicators may vary across different nations, shaped by unique cultural and traditional contexts. Consequently, this research affirms the existence of a substantial impact of human resource management on organizational efficiency and economic growth. A novel contribution of this work lies in the proposed methodology for constructing a sample of indicators and conducting an analysis of the effects of working conditions and labor process organization on productivity. The outcomes of this study may serve as a valuable resource for developing human resource management strategies that account for the identified predictors of productivity enhancement. Future research prospects may involve examining the studied indicators at the organizational level, which, although narrower in scope, could yield more indicative results.

Keywords: human resource management, economic growth, productivity, income, number of hours worked, digital technologies, personnel training, sustainable development.

JEL Classification: J24; M12; O15; L25.

Introduction

Human resource management constitutes a pivotal element in companies' economic growth, as effective personnel management fosters the attraction, integration, development, enhancing motivation, and retention of exceptional talent (Furman *et al.*, 2023; Kadirov *et al.*, 2024). This objective is accomplished through the formulation of effective human resources policies that guarantee effective training, rational use of time, equitable remuneration, and organizational considerations, including the implementation of digital technologies (Zayed *et al.*, 2022). At the same time, evaluating the tangible impact of these metrics on corporate growth presents a challenge, as not all organizations transparently disclose the data for comprehensive analysis. Furthermore, assessing intangible metrics, such as employee motivation and engagement, complicates this evaluation. An additional critical undertaking in this context is the selection of a judicious approach to appraising the companies' economic growth. The selection of an effective evaluative strategy becomes particularly salient within the sustainable development framework (Raza *et al.*, 2022), facilitating the identification of the principal factors influencing company's economic, social, and environmental sustainability (Madero-Gómez *et al.*, 2023).

This paper proposes a groundbreaking approach to quantifying the impact of human resource management on corporate economic growth through the utilization of quantitative indicators and advanced economic and mathematical modeling. It is proposed to evaluate the personnel management effectiveness via indicators related to working conditions and the organization of labor processes, encompassing metrics such as hours worked, remuneration, training implementation, and digitalization initiatives. The assessment of economic growth is inherently complex due to its multifactorial nature. With that in mind, this paper suggests employing productivity as a comprehensive indicator of resource efficiency. Furthermore, it underscores that the influence of these indicators may vary significantly across different national contexts, highlighting the necessity of considering local circumstances. For instance, the example of China reveals that specific indicators pertaining to working conditions and labor process organization exert varying degrees of influence compared to the global sample.

The proposed methodology addresses the persistent issue of the disjunction between the theoretical frameworks and practical applications of human resource management (Cooke *et al.*, 2021), thereby facilitating the enhancement of personnel policies in light of the identified predictors of effectiveness. The central hypothesis of this study posits that the parameters of working conditions and the organization of labor processes exert a substantial influence on the organizational productivity increase. The novelty of the study lies in developing an approach to analyzing the impact of working conditions and work process organization on productivity with the integration of digitalization factors into the evaluation model. Consequently, the primary objective of this study was to evaluate the impact of working conditions and labor process organization on productivity, taking into consideration both global and national contexts.

Research objectives include:

- conducting a correlation analysis between indicators of working conditions, labor process organization, and productivity across a global sample of nations;
- performing a regression analysis to ascertain the influence of working conditions and labor process organization on productivity within a global context;
- comparing the analytical outcomes of the indicators for the global sample of countries with those specific to China.

1. Literature Review

Human resource management is frequently regarded in numerous scholarly works as a key factor in enhancing productivity, competitiveness, and the sustainability of enterprises in contemporary contexts. According to Šebestová & Popescu (2022), investments in human resources are of paramount importance for the success of organizations, increasing their overall effectiveness. Furthermore, Siswanto *et al.* (2022) established a correlation between human resource development and economic growth. Next, Ojochona *et al.* (2022) showed the connection between human resource management practices and organizational effectiveness. Phiri & Phiri (2022) further demonstrated the presence of a relationship encompassing all human resource management practices and organizational effectiveness. Nonetheless, the conclusions drawn from the above studies do not exclude the potential impact of subjective and regional factors, as they are predicated on the findings of local surveys.

Garengo *et al.* (2022) underscored the pivotal role of human resource management in enhancing organizational performance. For instance, Rustiawan *et al.* (2023) and Gomes *et al.* (2025) described the significance of human resource management in achieving corporate objectives, particularly within the framework

of sustainable development. Moreover, Susantinah and Krishernawan (2022) alongside Easa and Orra (2021) demonstrated that proficient human resource management can serve as a catalyst for an organization's innovative advancement. Nevertheless, it is noteworthy that these studies are bibliometric reviews and lack empirical substantiation of the relationships they delineate.

Hernita *et al.* (2021) utilized multiple regression analysis and demonstrated that enhancing human resource capacity significantly elevates business productivity. Similarly, Althawadi (2025) asserted that fostering human capital development through proficient human resource management enhances business competitiveness. However, these studies predominantly focused on small and medium-sized enterprises, which may render the researchers' conclusions less applicable to organizations of varying sizes. While Anwar & Abdullah (2021) explored the influence of human resource management on organizational performance, yet their investigation was confined to government institutions.

A number of studies have shown the positive impact of technology implementation on human resource management, which is expressed through increased productivity. Diawati *et al.* (2023) consider information technology to be a key factor in increasing the efficiency and effectiveness of human resources in the workplace. However, the study does not provide empirical evidence for the conclusions drawn. In contrast, in the works of AlDhaheri *et al.* (2023) and Mohlala *et al.* (2024), the positive impact of technologies is confirmed using economic and mathematical modeling, allowing theoretical conclusions to be reinforced in practice.

This study extends the existing literature on HRM and economic growth, primarily by moving from theoretical generalizations and survey results to empirical analysis based on real data. Unlike most previous studies, which have established the relationship between HRM and productivity or economic efficiency of enterprises on the basis of local or subjective observations, this study uses correlation and regression analysis to assess the impact of specific indicators of work organization and employment conditions on productivity in a sample of 46 countries. In addition, the work complements the scientific discussion by introducing a comparative approach - combining a general global model with a national case study on pickled Chinese. This approach allows us to show that the role of HRM in ensuring productivity is heterogeneous and depends on cultural, social and managerial contexts.

2. Methodology

2.1. Research Procedure

The first stage of the study entailed the formulation of a sample comprising various countries and relevant indicators that reflect working conditions, the organization of labor process, and productivity. This sample incorporated both developed and developing nations, thereby ensuring a wide data variability. Furthermore, during this phase, the criteria for the selection of indicators and countries were substantiated. Authoritative sources of statistical information and analytical research were employed to gather data: CEIC Data (n.d.-a; n.d.-b), FM Global (n.d.), Ritchie *et al.* (n.d.), Trading Economics (n.d.), WorldData.info (n.d.), World Bank (n.d.). Data cleaning procedure: countries with missing data on key variables were removed; outliers and outliers were checked, which could have biased the results.

The second stage involved the application of correlation and regression analysis methodologies to elucidate the relationships between the selected indicators of working conditions, labor process organization, as well as productivity. Correlation analysis facilitated the identification of the degree of dependence among variables, particularly highlighting which facets of working conditions exhibit the most significant correlation with productivity. On the other hand, regression analysis enabled an assessment of the strength and direction of influence exerted by individual factors, which in turn made it possible to formulate analytical hypotheses.

The third stage involved a comparative analysis of the obtained results against existing studies within the scientific literature. This process not only facilitated the validation of the consistency of the results with established scientific paradigms but also enabled the identification of unique characteristics inherent to the studied sample. Special emphasis was placed on the analytical outcomes pertaining to China, which provided insights into specific national attributes regarding the impact of working conditions on productivity.

2.2. Sample

The sample of indicators for the study comprised a productivity metric alongside indicators pertaining to working conditions and labor process organization across various countries (latest available data, mostly 2019–2023). In terms of GDP per hour, productivity is expressed as a comprehensive measure of corporate economic efficiency. This metric elucidates the efficacy with which labor resources are utilized in conjunction with other production factors, serving as a pivotal predictor of corporate economic advancement. The indicators related to working conditions and labor process organization encompass as follows: the DAI Business Sub-index, the percentage of

companies offering formal training, average annual hours worked, as well as annual income. These indicators reflect the effectiveness of human resource management, as they delineate the extent of business digitalization, the availability of learning opportunities, work-life equilibrium, and the financial remuneration of employees. Such factors are instrumental in attracting, developing, and retaining skilled personnel and are prevalent across most nations worldwide.

DAI Business Sub-index – characterizes business digitalization (index 0–100) (CEIC Data, n.d.). An increase in the index is expected to have a positive impact on productivity, as digitalization contributes to process automation and more efficient use of resources.

Firms offering formal training (% of firms) – percentage of companies offering formal training (WorldData.info, n.d.). Theoretically, an increase in the percentage of companies offering training should increase productivity, as employees acquire new skills and improve their qualifications.

Average hours worked per year – average number of hours worked per year (hours/year) (World Bank, n.d.). The effect is expected to be mixed: excessive hours can reduce productivity due to fatigue, while moderate workload can have a positive impact on work results.

Annual income – average annual income of an employee (USD/year) (Trading Economics, n.d.). Theoretically, income growth should have a positive impact on productivity, as better material motivation and employee well-being stimulate more efficient work.

The initial sample included all countries globally in the world for which productivity data were accessible (122 countries). However, during the process of incorporating data on additional indicators, the list of countries was markedly diminished due to the unavailability of data for specific indicators. Ultimately, the final sample comprised 46 countries, including: Argentina, Austria, Bangladesh, Belgium, Brazil, Bulgaria, Cambodia, Chile, China, Colombia, Costa Rica, Croatia, Cyprus, Denmark, Ecuador, Estonia, Finland, France, Georgia, Germany, Greece, Hungary, India, Ireland, Israel, Italy, Kyrgyzstan, Latvia, Lithuania, Luxembourg, Malaysia, Malta, Mexico, New Zealand, Philippines, Poland, Portugal, Romania, Singapore, Slovenia, South Africa, Spain, Sri Lanka, Sweden, Thailand, Ukraine. Thus, total number of observations: 46 countries × 4 core indicators of working conditions and work organization + productivity indicator.

The initial sample encompassed all nations for which productivity data were (122 countries). However, given the sample size, the conclusions derived from this analysis can be regarded as generalized: they elucidate the influence of only the most fundamental indicators prevalent across numerous nations. Consequently, an additional phase of analysis was undertaken, focusing on China as a nation significantly shaped by its national traditions. Owing to its distinctive amalgamation of rapid economic advancement and an exceptional model of labor organization, China was selected for comprehensive examination. This model is predicated on centralized planning, cultural characteristics, and contemporary management practices, rendering the country an exemplary case study. It should be mentioned that data was gathered from authoritative sources of statistical information and analytical research, including CEIC Data, CEIC Data, FM Global, Ritchie *et al.*, Trading Economics, WorldData.info, and the World Bank.

2.3. Methods

The methodology of correlation analysis, as delineated by the Pearson criterion, employed to examine the linear interrelationships between variables, made it possible to postulate the existence of either a direct or inverse association among these variables. The presence of medium to strong correlations among the examined indicators underscored the feasibility of retaining all variables for further analysis employing alternative methodologies. To assess the impact of several factors on productivity at the same time, multiple linear regression was used, since the indicators of working conditions and labor process organization are numerical, cross-sectional, and measured at the same time interval. Regression analysis was instrumental in elucidating the degree to which indicators of working conditions and labor process organization account for variations in productivity.

Description of model variables:

Dependent variable: Productivity – GDP per hour worked, USD/hour, expected positive impact from improving working conditions.

Independent variables: DAI Business Sub-index, Firms offering formal training, Average hours worked per year, Annual income; all indicators are numerical, measured in the appropriate units, the expected impact is positive for all, except Average hours worked, where the reverse effect is possible.

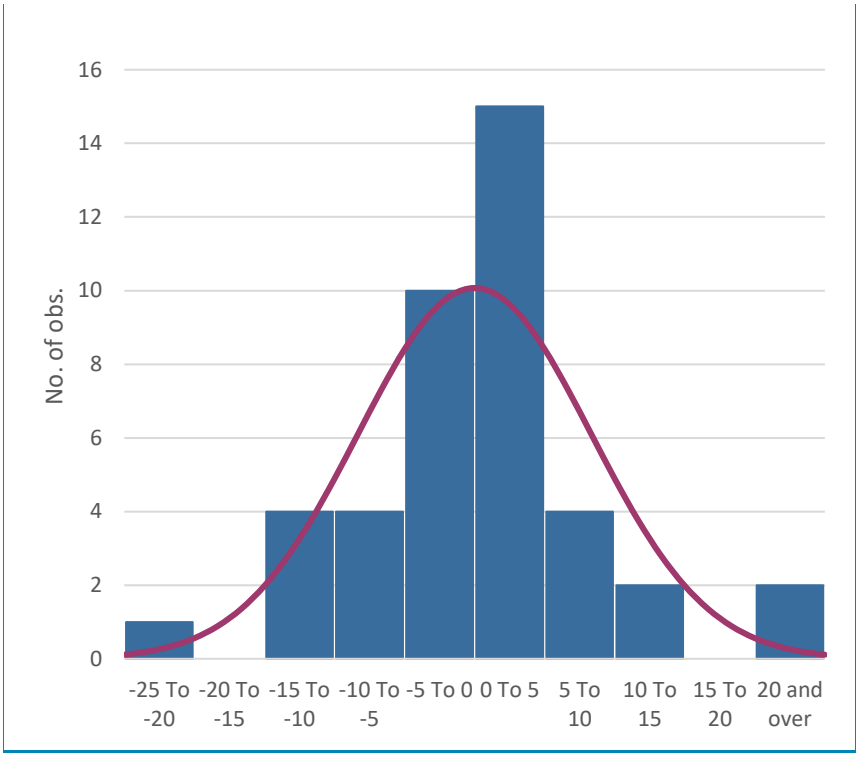
The integrity of the regression models was examined through tests for multicollinearity, heteroscedasticity, autocorrelation, as well as the residuals normality. Regression statistics and graphs to test the normality of the distribution are presented in Tables 1-2 and Figures 1-6.

Table 1. Regression statistics for model 1

Regression Statistics						
R	0,9261	*R-Squared*	0,8577	*Adjusted R-Squared*		0,8423
MSE	76,6745	*S*	8,7564	*MAPE*		25,3397
Durbin-Watson (DW)	1,8049	*Log likelihood*	-148,0646			
Akaike inf. criterion (AIC)	7,2888	*AICc*	7,3145			
Schwarz criterion (BIC)	7,4957	*Hannan-Quinn criterion (HQC)*	7,3646			
PRESS	4 179,5102	*PRESS RMSE*	9,9756	*Predicted R-Squared*		0,7903

Source: built by the author based on data from (WorldData.info, n.d.; Ritchie et al., n.d.; World Bank, n.d.; FM Global, n.d.).

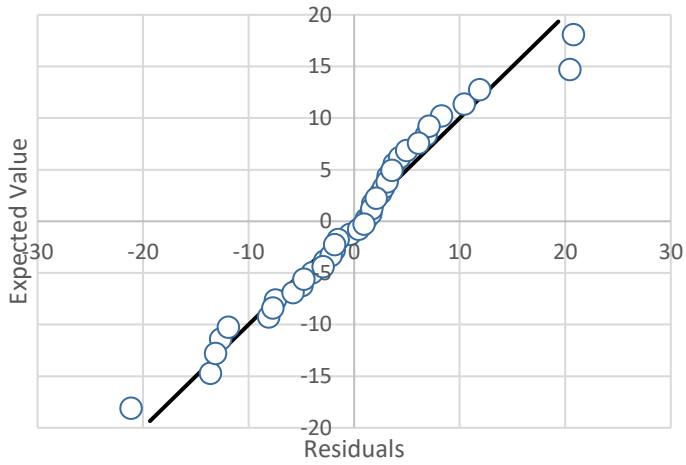
Figure 1. Histogram for "Residuals" for model 1



Source: built by the author based on data from (WorldData.info, n.d.; Ritchie et al., n.d.; World Bank, n.d.; FM Global, n.d.).

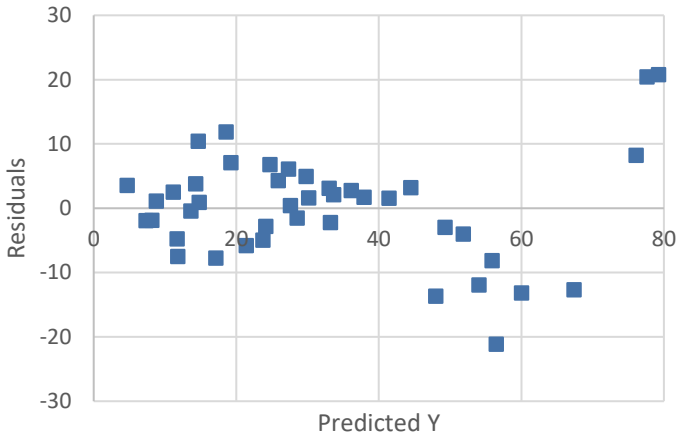
The first model is statistically reliable, explains the dependence well, and meets the basic assumptions of regression. The second model is acceptable for general analysis but is less accurate and has weak predictive power. A comparative analysis was conducted to delineate the disparities in regional strategies pertaining to human resource management, particularly illustrated through the case of China.

Figure 2. Normal Q-Q Plot - Residuals for model 1



Source: built by the author based on data from (WorldData.info, n.d.; Ritchie et al., n.d.; World Bank, n.d.; FM Global, n.d.).

Figure 3. Residuals vs Predicted Y for model 1



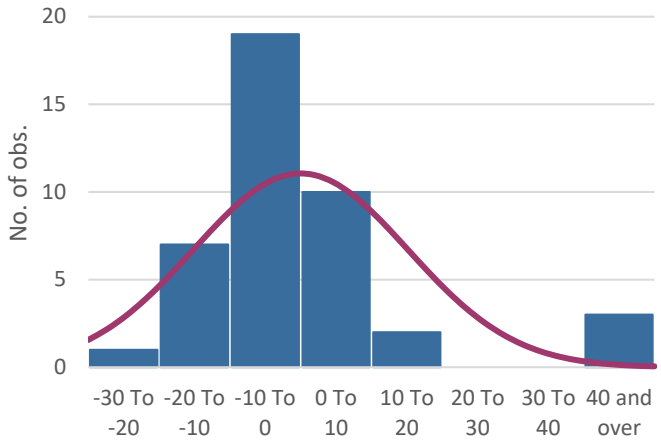
Source: built by the author based on data from (WorldData.info, n.d.; Ritchie et al., n.d.; World Bank, n.d.; FM Global, n.d.).

Table 2. Regression statistics for model 2

Regression Statistics					
R	0,7264	*R-Squared*	0,5277	*Adjusted R-Squared*	0,4904
MSE	247,7756	*S*	15,7409	*MAPE*	48,3763
Durbin-Watson (DW)	1,7958	*Log likelihood*	-173,2567		
Akaike inf. criterion (AIC)	8,4408	*AICc*	8,4558		
Schwarz criterion (BIC)	8,6063	*Hannan-Quinn criterion (HQC)*	8,5015		
PRESS	12 441,1802	*PRESS RMSE*	17,2110	*Predicted R-Squared*	0,3759

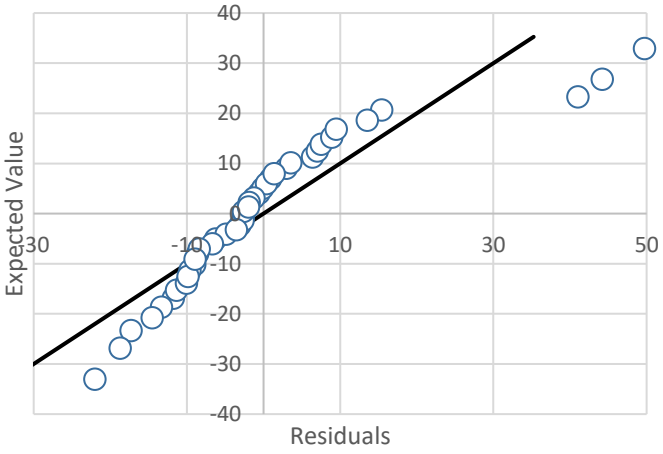
Source: built by the author based on data from (WorldData.info, n.d.; Ritchie et al., n.d.; World Bank, n.d.; FM Global, n.d.).

Figure 4. Histogram for "Residuals" for model 2



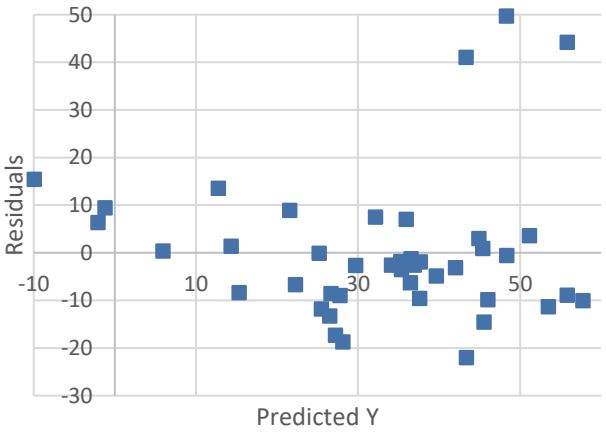
Source: built by the author based on data from (WorldData.info, n.d.; Ritchie et al., n.d.; World Bank, n.d.; FM Global, n.d.).

Figure 5. Normal Q-Q Plot - Residuals for model 2



Source: built by the author based on data from (WorldData.info, n.d.; Ritchie et al., n.d.; World Bank, n.d.; FM Global, n.d.).

Figure 6. Residuals vs Predicted Y for model 2



Source: built by the author based on data from (WorldData.info, n.d.; Ritchie et al., n.d.; World Bank, n.d.; FM Global, n.d.).

3. Research Results

The first stage of the research involved conducting a correlation analysis between the indicators under study. Although correlation between indicators is not yet definitive confirmation of a causal relationship, it can show the presence of a statistical relationship between variables. What is more, correlation analysis determines the direction and strength of such a relationship and can show which hypotheses are appropriate to test using other analysis methods. The results of the correlation analysis between productivity and indicators of working conditions and labor process organization are presented in Table 3.

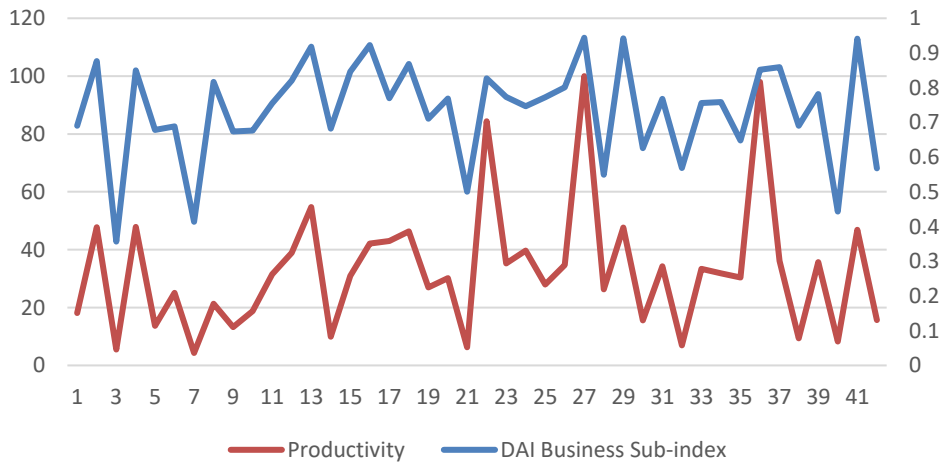
Table 3. Results of the correlation analysis between productivity and indicators of working conditions and labor process organization

	DAI Business Sub-index	Firms offering formal training (% of firms)	Average hours worked per year	Annual income	Productivity
DAI Business Sub-index	1				
Firms offering formal training (% of firms)	0,612911	1			
Average hours worked per year	-0,63839	-0,53523	1		
Annual income	0,772431	0,516794	-0,58165	1	
Productivity	0,724676	0,456879	-0,43016	0,914116	1

Source: calculated by the author based on data from (WorldData.info, n.d.; Ritchie et al., n.d.; World Bank, n.d.; FM Global, n.d.).

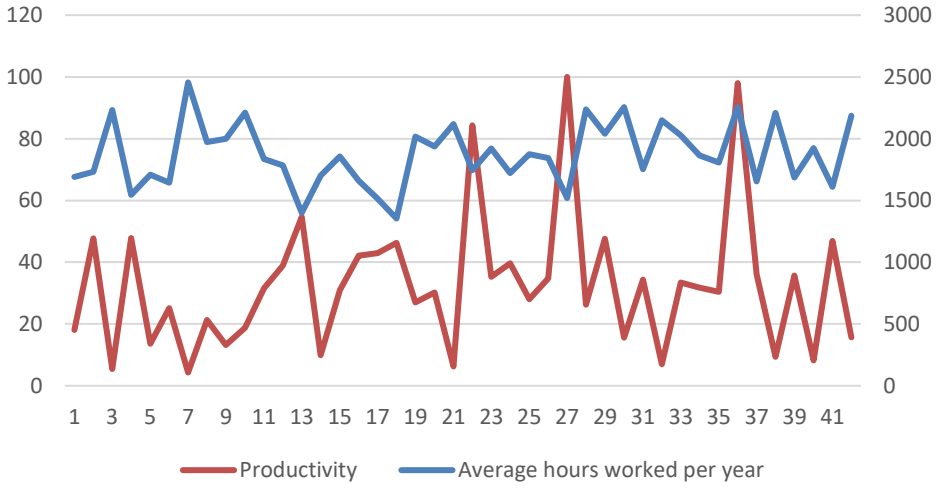
As evidenced by the results of the correlation analysis, productivity exhibits a strong correlation with the average annual income across nations, as well as the index of the firms adopting digital technology. The direct nature of this association indicates that productivity escalates concurrently with income growth and the assimilation of digital technologies within organizations. Furthermore, a direct and positive correlation of moderate strength is observed between productivity metrics and the proportion of firms offering formal training. Consequently, the implementation of employee training initiatives can significantly enhance productivity. On the other hand, an inverse moderate relationship is noted between productivity and the total number of hours worked annually. This may suggest that an increase in working hours does not necessarily correlate with heightened productivity and could even detrimentally impact labor efficiency. Below are graphs that clearly illustrate the relationships between the studied indicators (Figures 7-10).

Figure 7. Interdependence of productivity and DAI Business Sub-index



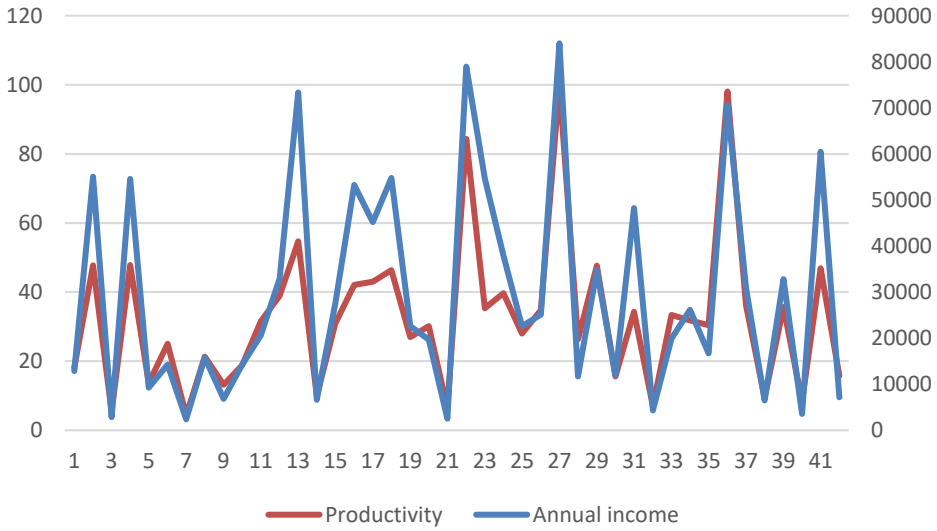
Source: built by the author based on data from (WorldData.info, n.d.; Ritchie et al., n.d.; World Bank, n.d.; FM Global, n.d.).

Figure 8. Interdependence of productivity and hours worked per year



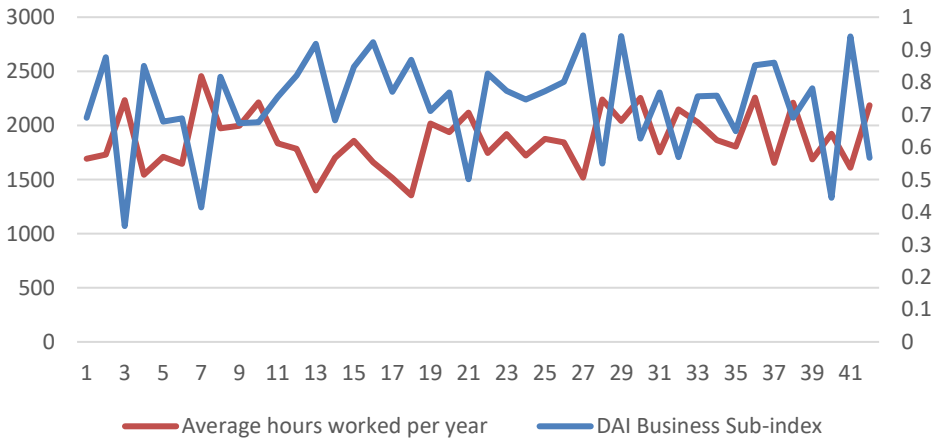
Source: built by the author based on data from (WorldData.info, n.d.; Ritchie et al., n.d.; World Bank, n.d.; FM Global, n.d.).

Figure 9. Interdependence of productivity and average employee income



Source: built by the author based on data from (WorldData.info, n.d.; Ritchie et al., n.d.; World Bank, n.d.; FM Global, n.d.).

Figure 10. Interdependence of hours worked and DAI Business Sub-index



Source: built by the author based on data from (WorldData.info, n.d.; Ritchie et al., n.d.; World Bank, n.d.; FM Global, n.d.).

Figure 7 shows a direct correlation between productivity and DAI Business Sub-index. This clearly demonstrates that business digitalization contributes to productivity growth. At the same time, Figure 8 illustrates the inverse relationship between productivity and hours worked. Interestingly, in the regression model, in combination with other factors, in particular, the amount of employee income, the number of hours worked has a direct impact on productivity. Accordingly, it can be assumed that an increase in the number of working hours increases productivity only simultaneously with an increase in financial remuneration. There is the closest direct correlation between productivity and employee income (Figure 10). At the same time, there is an inverse correlation between the DAI Business Sub-index and the number of hours worked (Figure 10). From this we can conclude that digitalization allows you to reduce working hours, while positively contributing to productivity.

Regression analysis was used to expand the conclusions obtained regarding the relationship between the studied indicators. The dependent variable was productivity, which enabled assessing the impact of indicators of working conditions and the organization of the labor process on its level. The first stage of the regression analysis covered all indicators included in the correlation analysis. The results are presented in Table 4.

Table 4. Results of the regression analysis of the impact of indicators of working conditions and labor process organization on productivity

	Coefficients	Std Err	LCL	UCL	t Stat	p-value	H0 (5%)	VIF	TOL	Beta
Intercept	-39,2740	20,3158	-80,4377	1,8896	-1,9332	0,0609	*Accepted*			
DAI Business Sub-index	20,9076	16,9640	-13,4647	55,2800	1,2325	0,2255	*Accepted*	3,1626	0,3162	0,1359
Firms offering formal training (% of firms)	0,0010	0,0954	-0,1922	0,1942	0,0103	0,9918	*Accepted*	1,7003	0,5881	0,0008
Average hours worked per year	0,0164	0,0072	0,0019	0,0309	2,2902	0,0278	*Rejected*	1,8387	0,5439	0,1926
Annual income	0,0009	9.4856E-5	0,0007	0,0011	9,2627	3.5463E-11	*Rejected*	2,5687	0,3893	0,9207
T (5%)	2,0262									
LCL - Lower limit of the 95% confidence interval										
UCL - Upper limit of the 95% confidence interval										

Source: calculated by the author based on data from (WorldData.info; Ritchie et al., 2022; World Bank; FM Global).

The resulting model allows explaining up to 84.23% of the variation in the dependent variable by the coefficient of determination, and there is a close correlation between the variables in the model at the level of 0.9261. The model looks as follows:

*Productivity = - 39.2740 + 20.9076 * DAI Business Sub-index + 0.0010 * Firms offering formal training (% of firms) + 0.0164 * Average hours worked per year + 0.0009 * Annual income*

Looking at the regression results in detail, it is worth noting that the indicators Average hours worked per year and Annual income have the greatest impact on the dependent variable. This means that these variables largely determine productivity, with the influence of both variables being direct. It should be noted that, when looking at the standardized Beta coefficient, the impact of income is much stronger. Unlike the results of correlation analysis, the results of regression analysis show that the number of hours worked is directly related to productivity. These differences can be explained by considering the influence of several factors simultaneously, which allows for the assessment of regression analysis. Therefore, in combination with other factors (in particular, income growth), the number of hours worked can have a positive impact on productivity, whereas business adoption of digital technologies and implementation of training did not show a significant impact on productivity in this context.

The significant impact of income on productivity has a logical explanation, as it determines the level of employees' well-being and stimulates effective work. However, it is worth examining whether other variables will affect productivity when income is excluded as the most influential variable. Given the above, this will allow us to

assess how productivity is affected by the intangible factors of working conditions and the organization of the labor process (Table 5).

The results of the regression analysis of the indicators after excluding the income variable showed some deterioration in the model quality. The correlation coefficient was measured at 0.7264, and the explanatory power, as indicated by the coefficient of determination, was 49.04%. The model looks as follows:

*Productivity = - 63.0528 + 114.3794 * DAI Business Sub-index + 0.0412 * Firms offering formal training (% of firms) + 0.0054 * Average hours worked per year*

Table 5. Results of the regression analysis concerning the impact of working conditions and labor process organization indicators on productivity (excluding the income indicator)

	Coefficients	Std Err	LCL	UCL	t Stat	p-value	H0 (5%)	VIF	TOL	Beta
Intercept	-63,0528	36,2278	-136,3921	10,2865	-1,7405	0,0899	Accepted			
DAI Business Sub-index	114,3794	24,5130	64,7554	164,0035	4,6661	3.7463E-5	Rejected	2,0435	0,4894	0,7437
Firms offering formal training (% of firms)	0,0412	0,1712	-0,3054	0,3879	0,2408	0,8110	Accepted	1,6968	0,5894	0,0350
Average hours worked per year	0,0054	0,0127	-0,0203	0,0311	0,4246	0,6735	Accepted	1,7881	0,5593	0,0633
T (5%)	2,0244									
LCL - Lower limit of the 95% confidence interval										
UCL - Upper limit of the 95% confidence interval										

Source: calculated by the author based on data from (Ritchie et al., 2022; World Bank; FM Global).

In this light, it is imperative to examine the variations in the strength of the influence exerted by the studied variables on productivity. The only variable of significance within this model was the DAI Business Sub-index. Consequently, taking into account the effects of income, the firm's integration of digital technologies emerges as the foremost factor influencing labor productivity. Thus, it can be argued that the integration of digital technologies within the company, particularly in human resource management, constitutes an important factor of productivity. Furthermore, it is noteworthy that, independent of income considerations, the number of hours worked ceased to exert an influence on productivity. Accordingly, the hours worked in itself do not dictate productivity; in this scenario, income serves as a mediating variable. Offering training programs by the firms did not yield a statistically significant impact in either model. Nevertheless, the moderate and direct correlation between productivity and this indicator may suggest the relevance of training within specific contexts.

The analysis encompassed indicators from numerous countries across the globe, each exhibiting a variety of characteristics – including methodologies and organizational frameworks pertaining to personnel management. Consequently, the findings can be regarded as generalized; they reflect the impact of only the most general indicators prevalent in the majority of nations. These indicators characterize the fundamental facets of labor organization, irrespective of the unique attributes of national human resources management paradigms. Therefore, the adaptation of the proposed models to a specific country's practices necessitates the incorporation of supplementary variables that consider the local context.

Next, it is proposed to elucidate the characteristics of personnel management organization through the lens of China, a nation profoundly influenced by its national traditions. The impact of elements such as traditions and cultural characteristics is inherently challenging to assess, as they frequently lack explicit metrics. Nonetheless, these factors may exert an equally significant influence on human resource management as the aforementioned indicators.

Specifically, the following attributes can be discerned within Chinese culture that enhance employee motivation and productivity:

- the importance of building relationships based on trust;
- concern for the reputation and dignity of a person, expressed in respect, public recognition and reciprocity;

- motivation through career advancement opportunities, the potential for professional growth, and training to attain status is more compelling than motivation stemming from financial incentives; however, equitable compensation remains a crucial factor;
- significance of leveraging digital technologies, particularly for the facilitation of remote or hybrid work environments.

Below are the results of the correlation analysis between productivity and individual indicators of working conditions and labor process organization in China.

Table 6. Results of the correlation analysis between productivity and indicators of working conditions and labor process organization in China

	Productivity	China Average Annual Wages, K CNY/year	Average number of hours worked
Productivity	1		
China Average Annual Wages, K CNY/year	0,549793	1	
Average number of hours worked	0,706367	0,568759	1

Source: calculated by the author based on data (Trading Economics, n.d.; CEIC Data, n.d.-a; CEIC Data, n.d.-b).

As can be seen from Table 6, productivity in China is most intricately linked to the number of hours worked: this metric exhibits a significant and direct correlation with productivity levels. Conversely, while wages are indeed associated with productivity, they demonstrate the lowest degree of correlation among the examined indicators. These findings highlight the substantial disparities that may arise between global analyses and those that consider localized characteristics. Furthermore, they may corroborate the notion that in China, financial incentives exert a relatively smaller impact on performance, with factors such as respect and recognition taking precedence. Thus, local characteristics must be considered in human resource management strategies. The most advantageous approach entails synergy of exemplary global practices with the distinctive attributes of national human resource management models.

4. Discussions

The findings of the author's research align closely with the conclusions drawn by prominent scholars regarding the profound influence of human resource management on organizational efficiency and economic advancement. Specifically, Šebestová & Popescu (2022) and Siswanto *et al.* (2022) emphasized a strong correlation between human resource management practices and economic growth, as well as enhanced economic efficacy of enterprises. Hernita *et al.* (2021) identified a connection between the increasing human resource potential and the adoption of technology, which subsequently elevates business productivity. These insights are consistent with the author's findings, which revealed that the integration of digital technologies alongside effective human resource management significantly enhances productivity.

Ojochona *et al.* (2022) demonstrated that human resource management practices encompassing skill enhancement, motivation, and empowerment exert a substantial influence on corporate performance. Phiri & Phiri (2022) established that performance management, rewards, training, development, and employee well-being significantly affect organizational efficacy. Like the author of the study, AlDhaheri *et al.* (2023) found empirical evidence of the positive impact of salary, training and development, and innovation on labor productivity using the example of government employees in the UAE. The results of Damayanti *et al.* (2025) also showed that vocational training positively contributes to increasing employee productivity as well as work discipline. Nevertheless, not all scholarly inquiries unequivocally evaluate the impact of training and development on organizational effectiveness. According to Anwar & Abdullah (2021), among the various HR management instruments, only decentralization, defined as the delegation of authority to employees and teams, was identified as a statistically significant factor affecting organizational effectiveness. The researchers dismissed the hypothesis suggesting a statistically significant effect of training and employee incentives on efficiency. Furthermore, their study revealed no statistically significant impact of corporate training initiatives on productivity. However, a positive correlation between these variables was substantiated, which may imply the latent influence of training on performance.

Susantinah and Krishernawan (2022) demonstrated that the cultivation of employee skills, increasing competencies, as well as the promotion of engagement can significantly bolster organizational innovation. Nedumaran and Rani (2021) asserted that human resource management is intricately linked to increasing the firms' competitive advantage. This article places a particular emphasis on the integration of technology within human resources management, notably in processes such as e-recruitment and e-learning. The perspectives articulated

by scholars are corroborated by the findings of the current study, which showed a positive correlation between staff training and the organization's embrace of digital technologies.

Similar to the assertions posited by the study's author, Zhao *et al.* (2021) and Lai & Zeng (2014) emphasized the imperative of acknowledging the regional idiosyncrasies inherent in human resource management, particularly in the context of China. Special emphasis is placed on the significance of traditional cultural values. Malik *et al.* (2022) corroborated these perspectives through an analysis encompassing several Asian nations, including China. Knies *et al.* (2024) remarked that the preeminent Western practices in human resource management may prove ineffectual in China, primarily due to the subtly divergent national values. The results of the study have practical significance for various groups of stakeholders – managers, government agencies and investors – as they allow to understand which aspects of human resource management directly affect labor productivity and economic efficiency. For managers, the results confirm that the digitalization of HRM processes and fair remuneration are key factors in increasing productivity. Managers should invest in digital HR management tools and form balanced motivation systems. For governments: the study emphasizes the importance of supporting policies aimed at developing digital competencies, improving the quality of jobs and encouraging employee training. For investors: a high level of digitalization and effective HRM can serve as an indicator of sustainable economic growth and be a criterion when assessing the investment attractiveness of companies or countries.

4.1. Limitations

The limitations of the study relate primarily to the lack of particular data on working conditions and labor process organization in China, which constrained the ability to juxtapose the findings of the global sample analysis with those of the national results. Moreover, the sample coverage does not include all countries with comparable economic structures, which may limit the generalizability of the results. Another important limitation is the lack of microeconomic (firm-level) data, preventing a deeper exploration of intra-organizational factors affecting labor productivity. Additionally, the potential influence of organizational culture on employee behavior and performance was not directly captured, which could moderate or mediate some of the observed relationships.

4.2. Recommendations

Improving human resource management strategies necessitates a consideration of both global trends and the local context. The models proposed in this study can be used in the practices of individual countries, with adaptations that incorporate additional indicators that may exert an influence at the national level. The key predictors of productivity enhancements through human resources are employee income and hours worked. However, in the absence of adequate income, the significance of hours worked diminishes. Consequently, human resource strategies should strive to harmonize these indicators, ensuring equitable remuneration for time invested while fostering a balance between personal and professional life.

Digital adoption emerges as a key intangible predictor of productivity advancements. Thus, the integration of cutting-edge technologies into human resource management practices and the broader organizational framework is imperative for securing companies' sustainable economic growth. Although no statistically significant correlation between formal training and productivity was identified, the positive association between these variables may suggest the latent importance of training.

Conclusions and Further Research

Human resource management significantly influences the companies' economic growth by enhancing their productivity through the strategic organization of work. The analysis revealed that income serves as the most pivotal determinant of productivity, while the number of hours worked impacts productivity only in conjunction with income. Consequently, modern firms should devote substantial attention to the planning of working hours and the promotion of a harmonious balance between personal life and professional obligations. A critical intangible factor influencing productivity is the firms' adopting digital technologies. This underscores the paramount importance of leveraging innovative technologies to enhance firm's productivity, thereby fostering sustainable economic growth.

Interestingly, the proportion of firms offering formal training did not exhibit a significant effect on productivity. However, this outcome may be attributed to the limited data available regarding this indicator, as accurately determining the precise number of companies implementing formal (and, even more challenging, informal) training is inherently complex. The moderate correlation observed between the proportion of firms offering formal training and productivity further suggests a positive relationship between formal training initiatives and productivity enhancement.

In addition to the aforementioned general predictors of productivity growth, which hold significance across the global spectrum of indicators, it is expedient to highlight the national characteristics that influence the efficacy of human resource management. For instance, the case of China demonstrates that the correlation between income and productivity is markedly weaker than that observed in the global sample, indicating that non-material motivation may assume a more substantial role.

The main hypotheses of the study were partially confirmed: income and digitalization have a positive impact on labor productivity, while formal education demonstrates only an indirect effect. This indicates that economic incentives remain the leading factor in productivity growth, but digital transformation is becoming a critical condition for improving the efficiency of human resources management. The practical implications for companies are the need to invest in digital HR tools, develop flexible motivation systems and optimize working hours. For government agencies, the results can be used to shape wage policies, regulate working hours and stimulate the digitalization of enterprises. From the perspective of employment and education policy, it is advisable to increase the effectiveness of vocational training programs by integrating them with digital platforms and skills assessment systems. This will contribute to the creation of a more productive and innovative work environment. Future research endeavors could focus on a granular analysis of the examined indicators at the company level; while such an analysis will have a smaller scope, its findings could yield more illustrative insights.

Declarations

Credit Authorship Contribution Statement:

Chinara Alamanova: Conceptualization, Investigation, Methodology, Project administration, Software, Formal analysis, Writing – original draft, Supervision, Data curation, Validation, Writing – review and editing, Visualization, Funding acquisition;
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Assessment and Economic Factors for Improving the Quality of Life: Theoretical Foundations, Methodological Approaches, Strategic Priorities

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Abstract: Purpose: The purpose of this study was to identify the key aspects of assessing and improving the quality of life, as well as to use foreign practices to develop more effective strategies. Methodology: The study employed the methods of analysing models, statistical indices, and comparative data analysis, which enabled a greater understanding of the aspects of quality of life and its interrelationships in the context of Kyrgyzstan and other countries such as Kazakhstan, Turkmenistan, Azerbaijan, Uzbekistan, Tajikistan, Armenia. Findings: The study identified key factors affecting the quality of life of the population of Kyrgyzstan, among which the critical factors are economic development, social policy, environmental sustainability, and citizen engagement. The study was found that the creation of new jobs in sectors such as agriculture and tourism substantially increase the level of income and well-being of the population. Access to quality education and healthcare was also found to be critical to improving living conditions, especially in remote and rural areas. The study confirmed that environmental sustainability is a critical aspect, with modernisation of wastewater treatment systems and adoption of environmentally friendly technologies playing a significant role in ensuring the health of the population. Originality: As a result of the analysis, the study concluded that an integrated approach is required, which would consider the interaction of the above factors to improve the quality of life at all levels, thus necessitating the active engagement of both the state and society in joint initiatives.

Keywords: resource management; economic factors of quality of life; social aspects; environmental sustainability; citizen engagement.

JEL Classification: I31; O15; Q56; H53.

Introduction

Quality of life is a multifaceted concept that encompasses a wide range of aspects such as health, education, income, social ties, and environmental conditions. These elements are interrelated and influence each other, creating a holistic picture of the well-being of individuals and society as a whole. For example, a person's health may depend not only on health services, but also on living standards, nutrition, and environmental factors such as clean air and water.

In the modern context, where society faces a variety of challenges such as economic crises, social inequalities and environmental problems, the need to assess and improve quality of life becomes particularly relevant. Economic crises can lead to higher unemployment rates and lower incomes, which can negatively affect the overall standard of living (Bashtannyk *et al.,* 2020; Makhazhanova *et al.,* 2024). Social inequalities create gaps between different population groups, limiting access to education, healthcare, and other necessary resources. Environmental issues such as pollution and climate change also seriously affect the quality of life. Recent cross-

national evidence links perceived economic inequality to lower well-being via status anxiety and lower social trust, reinforcing the centrality of social factors in quality-of-life policy (García-Sánchez *et al.*, 2024).

The health of the population depends on the state of the environment, and therefore sustainable development and environmental protection become major priorities for improving the quality of life (Buribayev *et al.,* 2020; Hari *et al.,* 2024). Research in this area aims to identify factors that substantially influence perceptions of quality of life and to develop effective strategies to help improve it. This may include not only economic initiatives, but also social programmes aimed at improving access to education and health care, as well as environmental measures that contribute to a sustainable environment for future generations.

The relevance of quality-of-life assessment is related to many issues such as social inequality, access to education and healthcare, and environmental challenges. López-Ruiz *et al.* (2021) noted the relationship between economic growth and quality of life, noting that an increase in personal income did not always lead to an improvement in the overall perception of life. The researchers also emphasised that it is essential to account for the distribution of income in the population to better assess its impact on well-being. Khan, Krishnan, and Arayankalam (2022) emphasised the significance of social factors such as access to education and healthcare in improving the well-being of citizens. The researchers noted that quality educational services and affordable healthcare can greatly improve the lives of the population. Omri *et al.* (2022) argued that environmental sustainability is critical to quality of life because environmental degradation can adversely affect the health and well-being of the population. The researchers also considered the effects of pollution on the mental health of citizens. Bell and Reed (2022) investigated the role of active citizen engagement, arguing that involving citizens in the decision-making process facilitated a better response to their needs and demands. The researchers emphasised that such initiatives increased the level of trust between the public and government agencies.

Birkmann *et al.* (2022) were engaged in comparative analyses of international quality of life indices, which allowed identifying best practices and adapting them in different regions. The researchers also emphasised the need to consider cultural and social contexts when using these indices. Karuppiah *et al.* (2021) stressed the significance of an integrated approach that combines economic, social, and environmental aspects, highlighting the need to integrate different strategies to achieve sustainable development. The researchers believed that without such an approach it is impossible to solve the current problems related to quality of life. Costa *et al.* (2021) also emphasised that quality of life is not a static variable and requires continuous monitoring and adaptation of approaches in response to changing conditions. The researchers noted that regular updating of data and strategies enabled a better response to the challenges of the times. Giannico *et al.* (2021) identified the role of cultural aspects in the perception of quality of life, demonstrating that culture and identity can considerably influence citizens' satisfaction levels. Their findings revealed that cultural activities and access to the arts positively affected the well-being of the community. Ferreira *et al*. (2021) emphasised the need to analyse the psychological factors affecting quality of life, noting that emotional well-being and social ties played a key role in shaping overall levels of happiness. The researchers argued that community support and psychological support could greatly enhance life satisfaction.

Despite existing research, gaps in understanding the interaction between economic, social and environmental factors remain and require further study. In particular, the relationship between human resource management and economic growth remains under-researched in the context of developing countries and countries with economies in transition. Previous studies have focused primarily on resource management at the organisational level, analysing its impact on employee productivity, motivation and innovation. However, there is still limited evidence on how resource management mechanisms, such as workforce development, education and equal access to employment, affect overall economic performance and quality of life at the national level. This study fills this gap by demonstrating how investments in human capital and sectoral employment policies contribute not only to economic growth but also to the overall well-being of the population. Thus, this study expands the existing literature on human resource management by integrating it with macroeconomic and social development perspectives, showing that human capital is a fundamental driver of sustainable growth.

The purpose of the present study was to identify the more significant aspects of quality of life and find ways to optimise them.

The objectives of this study were as follows:

1. To investigate the relationship between economic and social factors affecting the quality of life.
2. To analyse various approaches to assessing the quality of life, including methods of quantitative and qualitative analysis.
3. To assess the role of environmental sustainability in the development of the general level of well-being of the population.

4. To develop practical recommendations for improving the quality of life of the population based on the findings obtained.

1. Materials and Methods

The methodological framework of this study combines theoretical modelling with quantitative and comparative analysis. It integrates the concept of the triple balance and the Human Development Index (HDI) as analytical bases for assessing the quality of life, while also incorporating digital and sustainability dimensions. This approach makes it possible to examine the interaction of economic, social, and environmental indicators in the context of Kyrgyzstan's national development strategy.

The empirical material of the study was derived from official and publicly accessible sources to ensure transparency and comparability of results. Data were obtained from the United Nations Development Programme (2025), which provided information on the Human Development Index and its core components such as life expectancy, education indicators, and income per capita. Complementary information was drawn from the OECD Papers on Well-Being and Inequalities (Fleischer and Stokenberga, 2023), which were used for regional comparison and contextual validation. The Decree No. 221 "On the National Strategy of Development of the Kyrgyz Republic on 2018-2040" (2018) served as the key policy reference for identifying national priorities and sustainability benchmarks. Additionally, the empirical study of Sharipova and Kudebayeva (2023) was used as a comparative reference to reflect well-being trends in Central Asia. The analysis covered the period 2018-2025 and included seven countries: Kyrgyzstan, Kazakhstan, Turkmenistan, Azerbaijan, Uzbekistan, Tajikistan and Armenia. The compiled dataset comprised approximately 210 country-year entries across the principal indicators. All data were verified for consistency, checked for duplicates, and adjusted for unit uniformity; minor gaps (less than 5 percent) were resolved by interpolation using adjacent-year averages. The study employed six principal indicators representing the economic, social, and environmental dimensions of the quality of life (Table 1).

Table 1. Key Indicators Representing the Dimensions of Quality of Life

Variable	Definition	Unit of measurement	Theoretical expectation
Income	Average monthly income per capita	Kyrgyz som (KGS)	Higher income improves living standards
Employment rate	Share of employed population aged 15-64	%	Greater employment increases welfare
Education access	Percentage of children enrolled in education	%	Higher access enhances social well-being
Health access	Number of healthcare facilities per 10 000 inhabitants	count	Better access improves well-being
Air pollution	Concentration of pollutants in ambient air	mg/m³	Higher pollution lowers life quality
Digital access	Internet users per 100 inhabitants	%	Digital inclusion raises social participation

Source: compiled by the authors.

Given the nature of the data, the study employed descriptive and comparative analysis. The analytical procedure included the compilation of national and regional indicators into unified datasets, the calculation of average annual values, and normalisation according to international standards. Comparative evaluation across countries was performed to identify proportional imbalances and development asymmetries. Contextual interpretation of observed disparities was based on official strategic documents and prior empirical research in the field of human development.

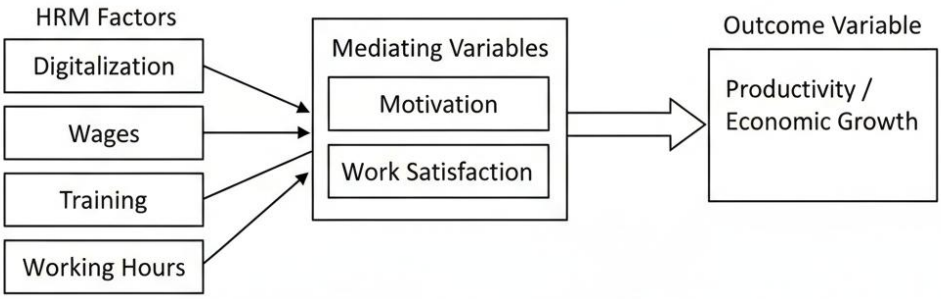
To ensure the reliability of results, sensitivity analysis was carried out by comparing indicators across multiple consecutive years from 2018 to 2025. This allowed testing the stability of the findings and minimising the effect of short-term fluctuations. Where possible, data from different sources such as the United Nations Development Programme (2025) were cross-checked to ensure consistency and credibility.

This study integrates digitisation into the productivity and quality-of-life assessment paradigm, a methodological innovation. This research incorporates digital data flows and technology-driven variables like access to digital infrastructure, ICT penetration, and population digital competencies into the analytical framework, unlike conventional approaches that use only statistical and comparative indicators. This integration allows a holistic assessment of economic productivity, social, and environmental dimensions through digital transformation. Digital measurements in the productivity model allow the study to assess how technological advancement influences

economic growth, environmental sustainability, and human well-being. This technique extends quality-of-life analysis models and provides a foundation for other developing economies undergoing digital transition.

To illustrate the theoretical logic underpinning the study, a conceptual framework was developed (Figure 1).

Figure 1. Conceptual Framework Linking HRM Factors to Productivity and Economic Growth



Source: compiled by the authors.

Figure 1 reflects the assumed relationships between key HRM factors, digitalization, wages, training, and working hours, and the mediating mechanisms of motivation and work satisfaction, which in turn determine productivity and economic growth. This model provides the analytical basis for the empirical assessment presented in the subsequent section.

2. Results

Quality of life is a complex category that includes many aspects of human activity and conditions of existence. Its study requires the integration of multiple approaches, as the term covers both objective and subjective parameters of well-being. An essential approach to assessing the quality of life is the triple-balance model, which includes three core elements: economic, social, and environmental aspects (Decree No. 221, 2018). The economic component is related to income, employment, access to material goods and opportunities. In countries with a high standard of living, such as Sweden, Norway, and Canada, this aspect is fundamental to the well-being of the population, but economic growth alone is not sufficient to improve the quality of life comprehensively (Tvaronavičienė *et al.*, 2022). The social dimension includes parameters such as access to education, healthcare, equality of opportunity, and social justice. It emphasises the need to create conditions that foster better social connections and opportunities for every citizen, regardless of their position in society.

The environmental aspect is equally significant as the state of the environment directly affects the health and well-being of people (Fleischer and Stokenberga, 2023). Recent global burden estimates attribute ~6.5 million deaths annually to air-pollution-related exposures, with $PM_{2.5}$ the dominant driver (Pozzer *et al.*, 2024). Clean air, access to clean water, absence of pollution, and conservation of natural resources are factors that are crucial in shaping a high quality of life in the long term. Environmental sustainability is becoming an increasingly critical element in the modern world, where global environmental issues such as climate change can adversely affect the well-being of entire nations (Işık *et al.,* 2025b; Bilan *et al.,* 2017). The triple-balance model proposes that quality of life should be considered as the outcome of the interaction of economic, social, and environmental factors, providing a comprehensive assessment of the state of society. The model also emphasises that development in one of these areas should not come at the expense of the others. For example, economic growth cannot be sustainable without preserving social justice and environmental protection. On the contrary, environmental degradation or lack of access to important social services can undermine economic gains.

Table 2 presents the key indicators characterising the quality of life in Kyrgyzstan. These factors are key indicators of the socio-economic condition of the population and reflect their well-being. The level of income, employment, access to education and health services, and the level of air pollution are essential components that influence the overall perception of the quality of life of citizens. Average monthly income and employment rate are directly related to the financial status and opportunities of citizens, while access to education and healthcare determines the level of social protection and public health. The level of air pollution also plays a critical role as it affects the health and well-being of citizens. By analysing the data from the table, it is possible to identify existing problems and outline solutions to improve the overall standard of living in the country (Akunova and Soyuzova, 2024).

Table 2. Fundamentals of Quality of Life in Kyrgyzstan

Factor	Measured parameter	Value
Income level	Average monthly income (KGS)	15,000
Employment rate	Employment rate (%)	56%
Access to education	Percentage of children enrolled in education (%)	90%
Access to health services	Number of healthcare facilities per 10,000 inhabitants	4
Air pollution level	Level of pollutants (mg/m^3)	0.05

Source: compiled by the authors of this study based on Sharipova and Kudebayeva (2023).

Since quality of life encompasses both objective and subjective aspects, both qualitative and quantitative methods are used to investigate it, as well as mixed approaches that combine elements of both approaches (Table 3). Each of these methodologies has its advantages and limitations, and therefore it is vital to combine them properly to obtain a comprehensive and reliable assessment. Table 3 presents key quantitative indicators reflecting the level of quality of life in Kyrgyzstan. These data allow assessing the socio-economic situation in the country and identifying the major problems that require attention. The Human Development Index serves as an essential indicator of the overall well-being of citizens and reflects the balance between economic, social, and environmental factors (Giannias and Sfakianaki, 2024). Poverty levels, access to education and healthcare, and air pollution levels are critical indicators that affect the lives of the population. Analysing these indicators helps to understand which areas need improvement and where efforts should be focused to improve the quality of life. Thus, this table provides a basis for developing strategies to improve the social and economic situation in Kyrgyzstan.

Table 3. Data on Quality of Life in Kyrgyzstan

Indicator	Value	Year
Human Development Index (HDI)	0.638	2021
Poverty rate (%)	20.1%	2021
Access to education (%)	94%	2021
Access to healthcare (%)	75%	2021
Air pollution level (μg/m^3)	45	2021

Source: compiled by the authors of this study based on Decree No. 221 "On the National Strategy of Development of the Kyrgyz Republic on 2018-2040" (2018).

For a better understanding of this issue, Table 4, which presents the basics of quality of life in different countries, is provided.

Table 4. Basics of Quality of Life in Different Countries

Country	Income level (average monthly income, USD)	Employment rate (%)	Access to education (% of children enrolled)	Access to health services (number of facilities per 10,000 inhabitants)	Air pollution level (mg/m^3)
Kazakhstan	550	65%	97%	5	0.07
Turkmenistan	450	62%	94%	3	0.08
Azerbaijan	500	58%	95%	4	0.06
Uzbekistan	400	60%	96%	3	0.09
Tajikistan	350	57%	91%	2	0.10
Armenia	480	63%	96%	4	0.05

Source: compiled by the authors of this study based on United Nations Development Programme (2025).

After analysing the data presented in Table 4, several conclusions can be drawn regarding the state of the quality of life in the Central Asian countries. Kazakhstan, Azerbaijan, and Armenia have the highest average incomes among the countries of the region, which may reflect a greater level of economic development in these countries than in the others. Uzbekistan and Tajikistan, albeit with somewhat lower incomes, show positive trends in economic growth, especially in recent years. Employment rates are relatively high in all countries of the region, but Kazakhstan and Armenia have the strongest rates, which may be indicative of more jobs and more effective labour policies. Tajikistan and Uzbekistan have lower employment rates, which may be related to a lack of economic diversification. In terms of access to education, all countries show high enrolment rates, suggesting a positive trend in the availability and quality of education. Kazakhstan and Azerbaijan are in the lead due to the development of education systems and significant investment in the sector. In the healthcare sector, Kazakhstan, Azerbaijan, and Armenia have the greatest number of medical centres per capita, which may indicate better accessibility and quality of medical services. In contrast, Turkmenistan, Uzbekistan, and Tajikistan require more efforts to improve the healthcare infrastructure, especially in remote areas. The environmental situation in these countries varies: air pollution levels are greater in Turkmenistan and Tajikistan due to industrial and agricultural pressures, as well as weaker regulation of environmental standards. Kazakhstan and Armenia have lower levels of air pollution, suggesting stricter environmental measures and availability of infrastructure for air purification. Thus, while there are common trends in Central Asian countries to improve the quality of life, there is considerable variation in certain indicators, requiring country-specific strategies to improve these aspects.

Qualitative methods form an integral part of research aimed at exploring people's subjective perceptions of quality of life (Larsen *et al.*, 2021). These methods include interviews, focus groups, and observations that enable researchers to develop a deeper understanding of individual experiences and perceptions of well-being. The significance of these methods lies in their ability to identify subjective aspects of life that are not easily quantified, such as personal feelings of happiness, life satisfaction, or the impact of social relationships on well-being. Interviews, for instance, allow people to describe how they evaluate their lives, what factors are meaningful to them, and what they think improves or worsens their quality of life. Focus groups, on the other hand, allow discussing key topics in a group setting, which helps researchers to understand collective perceptions and identify shared problems that may be specific to certain communities or social groups. However, qualitative methods also have their limitations. Since they focus on individual experiences, the results of such studies can be challenging to compare or generalise. Each person perceives their life uniquely, and while interviews and focus groups provide in-depth insights into individual cases, they do not always allow for the assessment of general trends and dynamics in large populations. Furthermore, these methods are often time- and resource-intensive, making them less suitable for use in large studies.

Quantitative methods, in contrast, provide objective data that can be easily measured, analysed, and compared across different groups or regions. One of the most popular tools in this area is the HDI developed by the United Nations (UN), which includes indicators such as life expectancy, educational attainment, and per capita income (Homayuni *et al.*, 2021). This index provides an overall picture of the level of well-being in various countries and regions, revealing inequalities and progress towards achieving a high quality of life. In addition to the HDI, there are other quantitative indicators such as gross domestic product (GDP) per capita, unemployment rates, access to basic social services (education, healthcare) and even indicators such as crime rates or pollution levels. These data enable large-scale studies and models to predict changes in quality of life based on economic and social indicators.

The principal advantage of quantitative methods is their objectivity and reproducibility. Data from these studies can be analysed using statistical methods and compared between various countries or regions, making them indispensable for global and national development reports. However, quantitative methods also have their limitations. They often do not reflect individual feelings and perceptions, which is particularly significant when assessing subjective well-being. For example, two people with the same level of income may have differing perceptions of their lives, which is not always captured when using statistical data alone. Therefore, quantitative methods, while essential for understanding objective living conditions, cannot fully capture the complexity of human experience and perception. Mixed methods, which combine qualitative and quantitative approaches, compensate for the shortcomings of each of these approaches and provide a more complete picture of quality of life (Manullang *et al.*, 2024). This methodological approach involves the use of both statistical data to identify general trends and interviews or focus groups to analyse people's perceptions of their well-being in greater depth. For instance, a study may start by analysing quantitative data, such as income levels or life expectancy, and then be complemented by qualitative methods to understand how people actually assess their living conditions. This allows not only to assess

objective indicators but also to incorporate subjective feelings such as life satisfaction, psychological well-being, and social ties.

Mixed methods are becoming increasingly popular in quality-of-life research as they allow for more comprehensive results. One example might be using quantitative data to assess the level of access to healthcare in various regions and then interviewing local residents to ascertain their perceptions of the accessibility and quality of healthcare services. This leads to a better understanding of what aspects of healthcare are actually valuable to people and how they assess their ability to receive the care they need. Improving the quality of life in Kyrgyzstan requires a comprehensive and strategic approach. With the country facing various economic, social, and environmental challenges, it is necessary to focus on key strategies that can create conditions for sustainable development. Key priorities include economic development, social policy, environmental sustainability, and active citizen engagement. Each of these strategies plays a unique role in improving the living conditions of the population and requires coordinated efforts by all stakeholders.

Economic development is the most significant factor affecting the quality of life of the population (Tleubayev *et al.,* 2024; Shahini and Shahini, 2025). In Kyrgyzstan, this area requires special attention, as the creation of new jobs can substantially affect the level of income and well-being of citizens. The level of employment in the country is directly linked to economic indicators, and effective economic development strategies can greatly improve living conditions (Hamelin and Bhatti, 2023). One of the most promising areas is agriculture, which historically has been at the centre of the country's economy. Agriculture provides not only food security, but also employment for a large part of the population, especially in rural areas. It is therefore crucial to modernise this sector by introducing the latest technologies that will help increase productivity and resilience to climate change. For example, the use of new seed varieties, drip irrigation systems, and organic fertilisers can greatly increase yields. This will enable farmers to earn more income and improve the quality of their produce. It is also necessary to train farmers in modern farming methods, which will enable them to adapt to new conditions and increase their competitiveness in the market. Furthermore, the development of tourism can become a powerful engine of economic growth. Kyrgyzstan has unique natural and cultural resources that attract tourists from all over the world. The country has picturesque mountain landscapes, historical monuments, and a rich culture, which creates tremendous opportunities for the development of the tourism industry.

This requires the development of infrastructure such as roads, hotels, and tourist routes. Improved transport links, comfortable accommodation, and safe travelling routes contribute to the influx of tourists (Li *et al.,* 2025; Işık *et al.,* 2025a). In addition, training the local population in service and tourism industries can create new jobs and attract foreign investment. The next key priority is social policy, which aims to ensure equal access to quality education and healthcare. Social conditions in Kyrgyzstan require special attention, especially in the context of remote and rural areas where access to vital services is often limited. This creates major difficulties for the local population, leading to inequalities in opportunities and a deterioration in the quality of life. Improving the quality of education requires a comprehensive modernisation of educational institutions. This includes not only upgrading infrastructure and facilities but also ensuring access to modern learning materials and technologies. It is vital to develop teacher training programmes so that teachers can use new educational methods effectively. The creation of distance education programmes is becoming a relevant solution to expand access to quality education for all segments of the population, especially those living in remote parts of the country.

Furthermore, it is necessary to introduce innovative approaches to learning, such as the use of multimedia technologies and interactive platforms that make the learning process more engaging and effective. Educational initiatives aimed at developing critical thinking and practical skills help to prepare young people for the demands of the modern labour market, which in the long term positively affects the country's economic development (Abduvalieva *et al.,* 2024; Kozub *et al.,* 2025). In terms of healthcare, there is a need to focus on improving access to health services, which is also critical to ensuring the health of the population. The establishment of mobile medical teams can be one of the key solutions to serve remote regions, where local residents often face a shortage of medical facilities and qualified personnel. Mobile teams can provide basic medical services, including preventive check-ups and vaccinations. Furthermore, the introduction of telemedicine is becoming a valuable tool that enables medical consultations to be conducted remotely. This not only increases access to health services but also enables patients to receive qualified care without having to travel long distances. Such technologies are particularly relevant in environments where access to conventional healthcare facilities is limited. Providing quality treatment and prevention programmes is a major step towards improving the overall health of the population. Disease prevention, education campaigns about healthy lifestyles, and access to health services can significantly reduce morbidity and increase life expectancy (GBD 2021 Risk Factors Collaborators, 2024). This improves the quality of life and creates a healthy society.

Environmental sustainability is an essential aspect in the context of improving quality of life (Table 5). In Kyrgyzstan, where natural resources play a key role in the economy and well-being of the population, combating air and water pollution is critical for the health of citizens and the future development of the country. Environmental problems, such as water pollution in rivers and lakes, as well as deteriorating air quality in cities, require a comprehensive approach and urgent measures.

Table 5. Role of Environmental Sustainability in Shaping the Welfare of the Population in Kyrgyzstan

Indicator	Description	Value
Air purity	Atmospheric pollution level	0.05 mg/m^3 (2023)
Water resource quality	Accessibility and cleanliness of water bodies	74% (access to clean water)
Natural resource conservation	Sustainable use of forests and lands	24% forest land
Biological diversity	Presence of diverse types of flora and fauna	4,500 plant species, 530 animal species

Source: compiled by the authors of this study based on Suprapto, Sumaryoto, and Saleh (2022).

Measures are necessary to reduce pollutant emissions and protect water resources, which play a vital role in ensuring food security and public health. This includes modernising wastewater treatment systems, which will help prevent pollution of natural water bodies and improve the quality of drinking water. Controlling emissions from industrial plants is also an essential area that requires the implementation of strict environmental regulations and standards. To achieve sustainable development, it is also necessary to adopt environmentally friendly technologies that reduce the effects on the environment (Bulatov *et al.,* 2024; Bulatov, 2025). This may include switching to renewable energy sources such as solar and wind power, which will not only reduce carbon emissions but also reduce the country's dependence on fossil fuels. The application of the latest technologies in agriculture, such as precision farming and the use of organic fertilisers, can also greatly enhance environmental sustainability and improve product quality (Liu, Jay, and Chen, 2021). Environmental education programmes can play a key role in raising public awareness of the significance of nature protection and sustainable resource use. Education helps to develop citizens' responsible attitude towards the environment and awareness of their role in its preservation. For instance, programmes to recycle waste, clean water bodies, and protect natural areas can bring local communities together and increase their responsibility for the environment.

Joint initiatives aimed at restoring ecosystems and protecting biodiversity can considerably improve the environmental situation in the country (Dankevych *et al.,* 2024; Apasov and Karabaev, 2022). The establishment of nature reserves and protected areas will contribute to the preservation of unique ecosystems and the sustainability of natural resources. It is also significant to involve young people in environmental initiatives, which will help to raise a new generation that recognises the value of sustainable development. Active engagement of citizens in decision-making processes is becoming a key element for improving the quality of life in Kyrgyzstan. When the population is engaged in resource management and participation in public discussions, it allows considering the interests of citizens and making governance more transparent and effective. It is necessary for citizens to feel their significance in the decision-making process, which contributes to strengthening democracy and increasing trust in public institutions.

Creating platforms for dialogue between the state and citizens, such as local councils and community initiatives, helps the population to be more involved in the processes affecting their lives (Dziundziuk *et al.,* 2024; Adamkulova *et al.,* 2025). These platforms enable citizens to discuss current problems and propose solutions that can lead to an improved quality of life. For example, through such initiatives, residents can share their ideas for improving infrastructure, education, healthcare, and the environment, making governance more inclusive. Furthermore, citizens who are actively involved in policy making can make suggestions to improve living conditions and monitor the implementation of social programmes. This engagement not only increases the government's accountability to citizens but also strengthens the public's confidence that their voice matters. In this way, public participation serves as an effective mechanism for monitoring the performance of the authorities, which helps to identify and address weaknesses in governance.

Citizen engagement creates a sense of responsibility and belonging to the community, which contributes to social stability and trust in public institutions. When citizens see that their opinions are respected and their proposals are implemented, it bolsters their commitment to society and increases engagement in public life. Furthermore, public engagement can reduce corruption and increase the effectiveness of public programmes, as citizens will be

more interested in controlling the use of public resources. It is also vital to develop programmes to train citizens in skills necessary for active political participation, such as public debate, legal education, and project management. This will not only help to increase public engagement but also strengthen critical thinking and active citizenship skills. Thus, to improve the quality of life in Kyrgyzstan, it is necessary to focus on four key strategic priorities: economic development, social policy, environmental sustainability, and citizen engagement. These strategies are interrelated and can considerably affect the overall well-being of the population. An integrated approach to implementing these priorities will create a sustainable and equitable system that meets the needs of all segments of society. Successful implementation of these strategies requires concerted action on the part of government, business and civil society, which will lead to long-term positive results and improved quality of life for all citizens of Kyrgyzstan.

3. Discussions

The study analysed the dependence of the level of quality of life in Kyrgyzstan on various factors. Economic development, particularly job creation and income growth, was found to significantly affect the overall well-being of citizens. Improving employment conditions in sectors such as agriculture and tourism was found to be one of the key drivers of improved living standards. These findings emphasise the significance of supporting these areas of the economy for long-term improvements in living conditions. Studies with comparable findings by various researchers confirm the link between economic development and quality of life. For example, Walker, Druckman, and Jackson (2021) found that economic development is directly related to the improvement of living standards as economic growth leads to an increase in the income and wealth of citizens. At the same time, the cited study emphasised the positive aspects of economic growth, while the present study pointed to the need for a comprehensive approach that addresses the specifics of individual sectors, such as agriculture and tourism. This is particularly relevant for Kyrgyzstan, where these sectors play a significant role in economic development.

Aman *et al.* (2022) also emphasised the significance of job creation as a key factor in improving the quality of life. New jobs reduce unemployment and provide stable sources of income, which improves the welfare of the population. In contrast to the current study, Aman *et al.* focused on working conditions and safety at workplaces, emphasising their significance for sustainable economic growth and quality of life. Therewith, economic development can lead to unequal distribution of benefits, which negatively affects the quality of life of certain social groups and regions. In a growing economy, social and economic gaps emerge, with some regions or segments of the population benefiting more than others. Fitrianto *et al.* (2023) confirmed that without adequate social policy measures, economic growth can increase inequality. These findings are consistent with current research that emphasises the significance of designing policies to distribute economic benefits evenly.

Social policies aimed at increasing access to basic services such as healthcare and education play a key role in generating a high standard of living. It was found that access to quality education and health services in remote areas is severely limited, which creates further hardship for the population. These findings emphasise the need to modernise educational institutions and introduce modern technologies in the healthcare system to ensure equal opportunities for citizens regardless of geographical location (Le *et al.*, 2024). Fitrianto *et al.* (2023) highlighted the necessity of effective social programmes to support vulnerable groups, which helps to reduce inequalities and meet the basic needs of citizens. These findings are consistent with the results of the current study, however, Fitrianto *et al.* focused on the programmes already in place, while the current analysis focused on the identified gaps and the need for social policy reform.

Yao *et al.* (2021) showed that modernisation of the education and healthcare system is a vital element of social policy aimed at improving the overall standard of living. Unlike the current study, which focused on problems in Kyrgyzstan, S. Yao et al. emphasised the introduction of innovative practices that can be a valuable complement to existing policies, especially in healthcare and education services. Environmental sustainability is an essential aspect of analysing factors affecting quality of life (Hussain *et al.,* 2022; Hadasik *et al.,* 2025). The findings of the present study revealed that environmental pollution negatively affects the health of the population, which reduces the quality of life. These findings are supported by the studies of Zhang and Dong (2023), who emphasised the relationship between environmental protection and the level of population health. However, their study did not address the specific regional features, which is of significant relevance for Kyrgyzstan, considering the climatic and environmental conditions. Sheehy and Farneti (2021) emphasised the need to introduce environmentally friendly technologies and develop sustainable strategies that address global challenges such as climate change. This aspect coincides with the current findings, however the cited study emphasised international aspects while the present study focused on national green initiatives.

These findings are consistent with the findings outlined in the previous section, emphasising that environmental sustainability is an integral part of public policy and is necessary not only to protect the environment but also to preserve public health. Active engagement of citizens in the decision-making process is a major factor contributing to the improvement of the quality of life. New international case study by Nguyen, Drejer, and Marques (2024) show that co-designing services and structured citizen panels measurably improve innovation outcomes and legitimacy. The study found that citizen involvement in resource management and participation in public discussions contributes to more transparent and efficient management. This helps to recognise the interests of diverse populations and develop more inclusive initiatives. Tran and La (2022) confirmed that active citizen engagement in governance is key to ensuring transparency and accountability of public institutions. Unlike the findings of the current study, which focused on the problems of lack of citizen engagement, Tran and La focused on positive examples of effective civic engagement in advanced democracies. Casero-Ripollés (2021) also pointed out the significance of creating platforms for dialogue between public authorities and citizens, which enable the exchange of opinions and collaborative problem-solving. The researcher highlighted the need for such platforms for active citizen engagement and social justice, which confirmed the findings of the current study on the need to create conditions for dialogue.

Based on the analysis of the study findings, an integrated approach involving the coordinated interaction of all aspects of governance is necessary to improve the living standards of citizens. It is essential to consider the interrelationship between economic, social, and environmental factors as they influence each other. The development of integrated strategies aimed at sustainable development of all areas can greatly improve the quality of life of the population. Brinkhof *et al*. (2021) argued that an integrated approach to problem solving involves recognising the interrelationship of the various factors that influence quality of life. Their study highlighted the necessity of analysing the interrelationship of economic, social, and environmental aspects, which is essential for sustainable development. However, their study did not address the cultural factors, which is a prominent aspect for Kyrgyzstan. Zhang *et al.* (2022) found that integrated strategies for sustainable development become a necessary tool for achieving harmony between economic growth and environmental conservation. Such strategies provide synergies between distinct sectors, enabling the implementation of joint projects that accommodate the interests of all stakeholders. As a result, an integrated approach promotes more holistic and balanced development, which ultimately improves the quality of life and creates a sustainable society.

Thus, the findings of the present study provided valuable data on the state of the quality of life in Kyrgyzstan and identified the principal areas requiring attention. The need to further study the influence of cultural and historical factors on the perception of quality of life stays relevant. It is necessary to continue to improve the living conditions of citizens by focusing on economic development, social policy, environmental sustainability, and active engagement of the population in governance. This will create conditions for sustainable and comprehensive growth of welfare and improvement of the quality of life in the country.

Conclusions

The study found that the quality of life in Kyrgyzstan depends on various theoretical frameworks and methodological approaches that should be considered when developing strategies to improve it. Theoretical models, such as the triple balance model, emphasise the significance of the interaction of economic, social, and environmental factors. Analyses of these components revealed that increasing income levels and job creation are paramount to improving the overall well-being of citizens. This is because a stable income enables basic needs such as food, shelter, and healthcare to be met, which then affects the overall perception of quality of life.

Methodological approaches, incorporating both qualitative and quantitative methods, provided a comprehensive picture of the current state of quality of life. This data is critical for the formulation of effective social policies aimed at eliminating existing disparities.

The results suggest that governments and policymakers should prioritise inclusive economic initiatives that promote employment in important industries, particularly tourism and agriculture, while maintaining regional equity. The Human Development Index can be considerably raised by making wise investments in renewable energy, infrastructure, and education. In order to increase social trust and accountability, governments should also provide procedures for citizen participation in decision-making. The report provides managers and company executives with advice on how to match corporate plans with social and environmental goals. By implementing sustainable manufacturing methods, making investments in worker welfare, and assisting with community development projects, businesses operating in Kyrgyzstan and comparable environments can increase their competitiveness. In addition to enhancing public perception, corporate social responsibility initiatives and the prudent management of natural resources support long-term economic stability. The report draws attention to the expanding prospects in

industries associated with sustainable development for investors. Modern agricultural systems, ecotourism, clean technology, and renewable energy investments are anticipated to produce both financial gains and favourable social effects. In line with ESG principles, promoting green innovations and socially conscious businesses would also aid in luring in foreign investment.

Thus, an integrated approach that incorporates all these aspects is a prerequisite for sustainable development and improved quality of life in the country. Public involvement, transparency of processes, and cooperation between the state and citizens can lead to a more favourable social environment and long-term changes for the better.

Limitations and Future Research

Because it only includes Kyrgyzstan and a few surrounding Central Asian nations, leaving out other pertinent economies with comparable socioeconomic patterns, the study's sample makeup is one of its limitations. Accordingly, future studies should broaden their geographic focus by incorporating more nations from other regions in order to facilitate more comprehensive comparison analyses and to find more broadly applicable trends in the factors that influence quality of life. Another drawback is the lack of comprehensive microeconomic data, which might offer more profound understandings of economic inequality and welfare dynamics within the populace. Examples of such data include consumption patterns, household-level income distribution, and individual labour market indicators. Such data would enable a more sophisticated understanding of the relationship between economic growth and personal well-being in future research. Additionally, not enough research has been done on how organisational culture may affect how people perceive their quality of life. The impact of organisational ideals, managerial styles, and institutional norms on employee satisfaction, productivity, and general quality of life should be the focus of future research, especially in the public sector. A more thorough and multifaceted model of quality-of-life assessment in the framework of sustainable socioeconomic development would result from future research that addresses these issues.

Declarations

Credit Authorship Contribution Statement:

Asmat Oruntaeva: Conceptualization, Investigation, Methodology, Formal analysis, Writing – original draft, Data curation, Writing – review and editing;
Elmira Djumalieva: Conceptualization, Investigation, Methodology, Project administration, Formal analysis, Writing – original draft, Writing – review and editing.

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A Digital Innovation-Based Creative Economy Model for MSMEs Growth: Theoretical Integration and Practical Insights from an Emerging Economy

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Abstract: The acceleration of economic growth in the digital era requires a strategic transformation of the small and medium enterprises (SMEs) sector, particularly through the adoption of creative economy frameworks underpinned by digital innovation. This study investigates the influence of digital innovation integration on SME growth by employing a quantitative approach using Partial Least Squares-based Structural Equation Modeling (PLS-SEM). A total of 250 SME actors in Medan City were selected through purposive sampling to participate in the study. The results indicate that digital literacy, digital infrastructure, stakeholder engagement, and creative collaboration exert a significant influence on digital innovation, which subsequently drives SME growth. Moreover, the Medan Go Creative model - comprising the dimensions of Go Digital, Go Global, and Go Green - emerges as an effective strategy for enhancing SME sustainability and competitiveness. The model demonstrates strong predictive relevance, with an R^2 value of 0.782 and a Q^2 value of 0.652. These findings contribute to the theoretical advancement of integrative models within the creative economy paradigm and provide practical insights for policymakers seeking to accelerate the digital transformation of SMEs at the local level.

Keywords: small and medium enterprises; digital innovation; digital literacy; creative economy; digital transformation.

JEL Classification: H57; L26; O17; O33; O35; R11; M15; Q56.

Introduction

The dynamics of economic growth in the digital era necessitate the rapid transformation of micro, small, and medium enterprises (MSMEs) to remain adaptive within an increasingly globalized environment. In this context, the creative economy emerges as a key driver, offering avenues for inclusive growth through the development of ideas, innovation, and digital technologies. The Government of Indonesia has affirmed this commitment through Government Regulation No. 24 of 2022 on the Creative Economy, as well as the Presidential Asta Cita (Eight Goals), particularly Point 2, which designates the creative economy as a cornerstone of the new economic development paradigm. However, the implementation of these policies has not been fully realized at the regional level, particularly in the city of Medan - an area with significant creative economic potential. With over 300,000 MSMEs operating in the city, many still lack the capacity to harness digital technologies optimally. Low levels of digital literacy, inadequate infrastructure access, and financing constraints present major obstacles (Hastalona *et al.* 2024).

Consequently, the digital transformation of MSMEs has progressed slowly, leaving Medan at risk of falling behind other major urban centers such as Jakarta and Surabaya. A study by Tokopedia (2023) reveals that digitalization can boost MSME revenues by up to 147%, yet such outcomes are not evenly distributed. A systematic approach is thus required to design a digital-based creative economy model that is responsive to local needs and

strategically accelerates MSME growth. The Medan Go Creative Economy (GCE) initiative seeks to address these challenges through an innovative and collaborative framework. The creative economy is conceived not merely as an industrial sector but as an ecosystem encompassing creativity, technology, culture, and entrepreneurship. In the global digital landscape, digital innovations such as e-commerce, digital marketing, big data, and fintech play a pivotal role in enhancing MSME competitiveness (Jun *et al.* 2022). These innovations extend market reach and reshape business models to be more adaptive and efficient. Medan, as a major urban center in North Sumatra, faces both challenges and opportunities in building such an ecosystem. However, disparities in technological access and limited digital readiness result in uneven innovation adoption (Qi & Chu, 2022). This underscores the need for structured, measurable, and sustainable policy- and technology-based interventions. The GCE model addresses these gaps by incorporating three integrated dimensions - Go Digital, Go Global, and Go Green - to holistically empower MSMEs. These dimensions promote not only technological transformation but also sustainability and global expansion, aligning with the principles of green and inclusive economic development as advocated by the Sustainable Development Goals (SDGs). As such, Medan GCE constitutes a strategic narrative for redesigning the future of MSMEs through creativity and digital innovation.

From an academic standpoint, integrative models such as GCE remain underexplored within localized contexts. A bibliometric analysis conducted in this study reveals that over the past five years, no research has explicitly developed a digital-based creative economy model aimed at driving MSME growth in Medan. This points to a significant research gap and underscores the high degree of novelty in this project. While earlier studies have emphasized the importance of synergy between digital technology and creative capacities in boosting MSME productivity (Khattak *et al.* 2022), few have attempted to formulate a specific model that simultaneously integrates the three GCE dimensions - digitalization, global orientation, and environmental sustainability. Abdelwahed and Bano (2024) argue that digital transformation is a key driver of creative economic development in emerging economies. Accordingly, this study responds to both theoretical gaps and practical needs by proposing a contextual, measurable, and applicable digital creative economy framework. Importantly, the urgency of this research is not merely theoretical, but also highly practical. MSMEs in Medan are confronting increasingly complex market competition, both domestically and internationally. Digital transformation is no longer optional; it is imperative for survival and growth. However, piecemeal interventions - such as technical training without infrastructural or policy support - are unlikely to produce significant outcomes (Cockshut *et al.* 2020).

Therefore, a systemic approach such as GCE, involving synergistic collaboration among government actors, creative communities, digital industry players, and educational institutions, becomes crucial to success. Medan GCE is not merely an economic model; it is a strategic development approach based on innovation and collaboration. Within this framework, the article argues that integrating digital technologies into the creative ecosystem can significantly increase revenue, expand market access, and reinforce MSME sustainability.

Thus, the study seeks not only to develop a model but also to offer a data- and policy-informed approach for implementing such transformation effectively. Despite being a focal point of both local and national government policies, the digital transformation of MSMEs continues to be marred by persistent implementation gaps. Many digitalization programs remain ceremonial, lacking sustainability and relevance to the actual needs of entrepreneurs. For instance, digital training programs are frequently conducted without appropriate follow-up measures such as mentoring, market access facilitation, or adequate infrastructure support (Hossain *et al.* 2024). In Medan, these challenges are particularly pronounced, as a majority of MSME owners possess only lower secondary education and lack regular access to technology (Harahap *et al.* 2022). Digital literacy is thus a critical but often overlooked factor in intervention design. Research by Dutta and Sarma (2023) demonstrates that mastering basic digital skills has a direct impact on technology adoption and MSME performance. Strengthening digital literacy enables entrepreneurs to enhance their innovative capacities, expand business networks, and maximize digital platform utilization.

Accordingly, digital literacy emerges as a foundational pillar within the Medan GCE model. It is not sufficient to merely provide access; a systematic and contextualized capacity-building process is essential. Thus, the inclusion of digital literacy as a key variable in this study is both academically relevant and strategically significant. In addition to human capacity, digital infrastructure constitutes another critical variable influencing MSME transformation. Fast, affordable, and equitable internet access is a prerequisite for integrating MSMEs into the digital ecosystem. Without adequate infrastructure, digitalization remains a superficial concept. Medan faces serious challenges in this regard, particularly in its suburban and peri-urban areas, which host many MSMEs. A study by Qi and Chu (2022) affirms that the success of digital economic development is highly dependent on the quality of fundamental infrastructure such as broadband networks and data centers. One of this article's key contributions, therefore, is to emphasize the need for equitable and distributed digital infrastructure investment.

Local governments, telecommunications providers, and donor institutions must take active roles in delivering inclusive infrastructure. This dimension is embedded within the GCE model as a holistic approach to digital economic development. The integration of human capital and technological infrastructure is expected to generate an innovative ecosystem that fosters sustainable growth. Accordingly, this study contributes to the ongoing discourse on the relationship between technological readiness and local MSME economic performance. The imperative to promote integrative models like GCE also stems from global pressures related to sustainability and international market orientation. MSMEs in Indonesia - including those in Medan - are increasingly expected not only to cater to local markets but also to compete globally and adopt environmentally responsible practices. The "Go Global" dimension in the GCE model guides MSMEs to leverage digital export platforms and strengthen branding based on local culture. Lingfu *et al.* (2024) found that digital innovation bridges geographical limitations and expands market reach for MSMEs in developing countries. Meanwhile, the "Go Green" dimension incorporates sustainability principles in production and distribution, including the use of eco-friendly materials, waste reduction, and energy efficiency. Al Halbusi *et al.* (2024) note that environmentally responsible MSMEs have greater opportunities to access green markets and receive incentives. By combining these three dimensions, the GCE framework offers a model that emphasizes not only economic growth but also social and ecological sustainability.

This study provides both a conceptual map and an operational model for realizing MSME transformation that is global, green, and digital. Government policies are often developed based on assumptions or short-term political agendas, lacking comprehensive empirical data support. This study presents data, analysis, and models that can serve as evidence-based foundations for more targeted MSME transformation policies. Moreover, the involvement of stakeholders such as academia, creative communities, and the private sector in building the GCE ecosystem offers a collaborative model potentially replicable in other regions. This aligns with findings by Cockshut *et al.* (2020), who highlight the importance of cross-sector interventions in advancing micro creative economies. In this regard, the article serves as a bridge between academic inquiry and public policy. The formulation of performance indicators, intervention designs, and evaluation mechanisms within the model can be adopted by policymakers to accelerate MSME digitalization in a structured and inclusive manner. The primary objective of this study is to construct and test a digital innovation-based creative economy integration model that significantly drives MSME growth. This model is not only a theoretical framework but also a practical roadmap for stakeholders seeking to transform MSMEs. In the short term, the model is expected to guide strategic policy formulation to support MSME digitalization in Medan. In the long run, it holds potential for national replication to accelerate a creativity- and technology-based economic transformation. By designing a systemic, inclusive, and evidence-based approach, this study aims to address the gap between the potential and the current reality of regional MSME sectors. As such, GCE is not merely an economic model, but a development strategy rooted in innovation, collaboration, and sustainability.

The scholarly contribution of this article lies in the formulation of a new theoretical model that integrates literature on the creative economy, digital innovation, and MSME development strategies into a unified framework. It further strengthens the importance of cross-disciplinary approaches in addressing the complexity of local economic development. By combining theories of innovation, public policy, entrepreneurship, and digital transformation, this article expands academic discourse on regional economic development models. This research is expected to enrich the literature and serve as a valuable reference for future studies on the creative economy and MSME development. Additionally, the GCE model can serve as a decision-making tool for governments, donor agencies, and industry actors in designing sustainable MSME empowerment strategies. Ultimately, this study offers a concrete contribution to local economic development driven by data, technology, and creativity. In the face of globalization, climate crisis, and technological disruption, approaches like GCE are increasingly relevant and urgent. Medan - with its vast potential - can serve as a living laboratory for the development of a digital creative economy in Indonesia. This study suggests that MSME transformation must begin with a deep understanding of local contexts, while adopting a global vision and technology-driven strategy. Through the synergy of policies, communities, and technologies, MSMEs can not only survive but also thrive and become key drivers of the future economy. Therefore, this article adds not only to academic knowledge but also provides a strategic direction for real action in innovation- and collaboration-based economic development.

1. Literature Review

The transformation of the creative economy through digital innovation has emerged as a strategic foundation for MSME development, particularly in metropolitan areas such as Medan. In this context, the construction of a robust theoretical framework is essential to understand the interrelationships among variables within a complex system. This study adopts Open Systems Theory as its foundational perspective, positioning MSMEs as dynamic entities

that interact with their surrounding environment - including technology, markets, policies, and communities (Johannessen, 2020). This framework is further enriched by the incorporation of digital innovation theory and creative economy concepts, which explain how the adoption of information technology can enhance performance and competitiveness in creativity-based enterprises (Jun *et al.* 2022; Zaldívar, 2022). Within this approach, digital literacy is a critical precondition for fostering innovation capabilities, while digital infrastructure, stakeholder support, and access to global markets constitute environmental factors that shape the success of MSMEs. This study identifies six key variables that influence MSME growth within the digital creative economy ecosystem: (1) Digital Literacy, (2) Digital Infrastructure, (3) Stakeholder Support, (4) Digital Innovation, (5) Creative Collaboration, and (6) MSME Growth. The digital literacy variable reflects the extent of knowledge and skills among MSME actors in effectively utilizing information technologies.

A study by Dutta and Sarma (2023), published in Vilakshan – XIMB Journal of Management, reveals that digital literacy has a direct impact on the adoption of digital innovation in developing countries. Meanwhile, digital infrastructure encompasses the availability and accessibility of internet connectivity, hardware, and adequate technical support. Qi and Chu (2022), in China Political Economy, argue that strong digital infrastructure accelerates the transition from informal to formal economies through technological integration. The third variable, stakeholder support, involves the collaborative roles of government, academia, industry actors, and creative communities in fostering an enabling ecosystem for MSME development. Research by Cockshut *et al.* (2020) emphasizes the importance of community-based digital policy development through collaborative approaches. Such support plays a pivotal role in accelerating MSME digital transformation through policy incentives, training programs, and facilitation of digital market access. The fourth variable, digital innovation, refers to the application of technology to create new products, services, or processes that enhance business efficiency and value creation. Jun *et al.* (2022) underscore that digital improvisation, or the capacity to flexibly utilize emerging technologies, is a key determinant of innovation within small and medium-sized enterprises. This capacity is closely linked to the adaptability of MSMEs in responding to market disruptions. Creative collaboration, as the fifth variable, pertains to cross-sector partnerships - both among MSME actors and with other institutions - to share ideas, resources, and technologies. Al Halbusi *et al.* (2024), in the European Journal of Innovation Management, found that integrating sustainability values into cross-sector collaborations enhances innovation performance and business competitiveness. This study positions collaboration as a crucial element in reinforcing synergy within a sustainable creative ecosystem. Lastly, MSME growth is utilized as the dependent variable, measured through indicators such as revenue increases, customer base expansion, and market outreach. A study by Jibril *et al.* (2024), published in the International Journal of Organizational Analysis, demonstrates that MSMEs adopting digital strategies have experienced accelerated post-pandemic growth.

While numerous studies have examined the relationship between digital technology and MSME growth, there remains a theoretical and empirical gap in understanding the integration of these variables within a unified model, particularly in local contexts such as Medan. Most prior research has focused on one or two variables in isolation, without developing a systemic framework that reflects interdependent relationships. To date, no model has explicitly integrated digital literacy, stakeholder support, infrastructure, innovation, and creative collaboration into a comprehensive framework linked to holistic MSME growth. Furthermore, few studies have explored how local dynamics and regional policy influence the success or failure of digital innovation adoption within the MSME sector. As a scholarly contribution, this article proposes a conceptual model grounded in empirical findings that examines the interrelations among six variables using a Structural Equation Modeling - Partial Least Squares (SEM-PLS) approach, with the MSME landscape in Medan as the contextual case. This model addresses the theoretical void by incorporating multiple variables within an integrative framework, while also offering practical guidance for local governments and stakeholders in designing digitally driven creative economy transformation strategies. Through this approach, the article aims to serve as a key reference in developing innovative MSME ecosystems and inform policy formulation with evidence-based and locally relevant insights. The literature indicates that digital literacy, digital infrastructure, and stakeholder support are critical enablers of digital transformation in the MSME sector. These factors are believed to influence the level of digital innovation, which in turn contributes to business growth. In addition, creative collaboration plays a significant role in fostering synergy among entrepreneurs, thereby supporting the sustainable development of the creative economy. To empirically explore the relationships among these variables, a conceptual framework was developed by identifying six core constructs: digital literacy (X1), digital infrastructure (X2), stakeholder support (X3), digital innovation (X4) as a mediating variable, creative collaboration (X5), and MSME growth (Y) as the dependent variable. Based on this conceptual foundation, the research hypotheses proposed are as follows:

H1: The integration of a creative economy model based on digital innovation has a significant effect on MSME growth in the City of Medan.

H2: The utilization of digital technologies has a significant impact on revenue growth and the sustainability of MSMEs.

H3: Access to international markets through digitalization positively influences MSME growth.

H4: Sustainable and eco-friendly innovation practices enhance the competitiveness and business continuity of MSMEs.

H5: The availability of digital infrastructure positively affects the effectiveness of creative economy model integration.

H6: The availability of digital infrastructure positively affects the effectiveness of creative economy model integration.

H7: The digital literacy level of MSME actors contributes significantly to the successful adoption of digital innovation.

2. Research Methodology

This study adopts a quantitative approach with an explanatory design to examine the causal relationships among variables within the conceptual model of digital-based creative economy development. The choice of this design is grounded in its capability to assess both direct and indirect effects among latent constructs and to empirically evaluate the significance of inter-variable relationships. The research was conducted in the city of Medan, selected due to its status as one of Indonesia's key hubs for MSME growth and the development of the digital creative economy sector. Data collection took place in December 2025, with consideration given to the readiness of MSME actors in navigating the post-pandemic digital transformation. The population of this study includes all MSME actors operating in the creative economy sector in Medan. A total of 250 MSME respondents were selected through purposive sampling. The selection criteria comprised: (1) the enterprise has been in operation for a minimum of two years, (2) digital technology is utilized in its business processes, and (3) the enterprise is officially registered in the database of the Department of Cooperatives and MSMEs. This sampling technique was employed to ensure that the sample accurately represents the characteristics relevant to the research objectives. The research instrument was a structured questionnaire developed based on indicators derived from established theoretical constructs used in prior studies. The questionnaire underwent content validation by academic experts. Data were analyzed using Structural Equation Modeling with Partial Least Squares (SEM-PLS), supported by the SmartPLS 4 software. This analytical method was chosen for its ability to handle non-normal data, its suitability for complex models involving multiple latent variables, and its effectiveness with moderate sample sizes (Hair *et al.* 2020). The analysis process involved two key stages: testing the measurement model (outer model) to assess the validity and reliability of the constructs and evaluating the structural model (inner model) to examine the strength and significance of the hypothesized relationships among variables.

3. Research Results

3.1. Results

The demographic characteristics of the respondents are summarized in the table 1 below:

Table 1. The demographic characteristics of the respondents

Characteristic	Category
Gender	Male (60%), Female (40%)
Age	21–30 years (25%), 31–40 years (40%), 41–50 years (25%), over 50 years (10%)
Educational Attainment	Senior High School (30%), Diploma (25%), Bachelor's Degree (35%), Master's Degree (10%)
Business Duration	Less than 1 year (10%), 1–3 years (30%), 4–6 years (35%), more than 6 years (25%)
Business Type	Culinary (30%), Fashion (25%), Handicrafts (20%), Digital Services (15%), Others (10%)

Source: The Result Data, 2025

The distribution indicates that the majority of MSME actors in this study are male, aged between 31–40 years, with a bachelor's degree as the most common educational background. Most businesses have been in operation for 4–6 years, with culinary and fashion being the dominant sectors. This profile provides a representative foundation for analysing digital innovation within the creative economy sector in Medan. The demographic characteristics of respondents in this study offer a representative overview of the MSME population in the city of Medan.

In terms of gender distribution, the majority of business actors are male (60%), while female participants account for 40%, indicating that the MSME sector in Medan remains predominantly male-driven. Regarding age, the largest proportion falls within the 31–40 age group (40%), followed by those aged 21–30 (25%), 41–50 (25%), and above 50 (10%). This pattern suggests that MSME actors are largely within the productive age range, which presents strong potential for digital transformation. The educational background of respondents is notably diverse, with the majority holding a bachelor's degree (35%), reflecting an intellectual readiness to embrace technological change.

Other educational levels include senior high school (30%), diploma (25%), and master's degree (10%), further highlighting a range of academic experiences that may shape perceptions and adoption of digital innovation. In terms of business experience, the majority of respondents have been operating their enterprises for 4–6 years (35%), followed by those with 1–3 years (30%) and more than 6 years (25%) of experience. Only 10% of participants reported having run their businesses for less than a year. These figures indicate that most MSME actors are in the growth or stabilization phase - critical stages for strengthening innovation and expanding market reach. Business types also show a compelling variation: the culinary sector represents the largest share (30%), followed by fashion (25%), handicrafts (20%), digital services (15%), and others (10%). This composition affirms that sectors with high creative value are integral to the broader creative economy ecosystem in Medan. This respondent profile is highly relevant to the aim of the present study, which focuses on developing a digital-based creative economy model. The diversity in demographics and business characteristics underscores the need for an inclusive and adaptive model that aligns with the local context.

Furthermore, this information serves as a crucial foundation for assessing the relevance of empirical test results and the external validity of the SEM-PLS model employed in the study. The balance across age, education level, and business type suggests that the selected sample is sufficiently representative of the overall MSME population in Medan. Overall, the respondent description reinforces confidence in the application of the Medan Go Creative model to this dataset. The diversity in business backgrounds also allows for more precise testing of the effects of variables such as digital innovation, Go Digital, Go Green, and other key dimensions. In the context of public policy, these findings can inform more targeted interventions based on the distinct characteristics of MSMEs. Therefore, the respondent profile presented here serves as a foundational element that strengthens the quality of subsequent analysis.

Table 2. Testing of Uji Validity and Reliability (Outer Model)

Variable	AVE	Composite Reliability (CR)	Cronbach Alpha
Go Digital	0.620	0.872	0.812
Go Global	0.655	0.885	0.825
Go Green	0.610	0.860	0.790
Digital Infrastructure	0.680	0.892	0.840
Digital Literacy	0.640	0.876	0.818
Stakeholder Support	0.670	0.890	0.835
Digital Innovation	0.695	0.900	0.850
UMKM Growth	0.705	0.915	0.870

Source: The Result Data, 2025

The outer model assessment was conducted to evaluate the reliability and validity of the indicators that form each latent construct within the SEM-PLS model. The analysis results indicate that the Average Variance Extracted (AVE) values for all variables exceed the threshold of 0.60, signifying that convergent validity is adequately met.

The highest AVE values were observed in the constructs of MSME Growth (0.705) and Digital Innovation (0.695), suggesting that the indicators for these constructs are capable of explaining more than 70% of the variance. The Go Green construct yielded an AVE of 0.610, which, while approaching the lower acceptable limit, is still considered adequate within SEM literature. These findings confirm that each indicator demonstrates a strong ability to reflect its corresponding construct. From a reliability perspective, the results for Composite Reliability (CR) also reveal highly satisfactory values, with all constructs scoring above 0.860. The highest CR values were recorded for MSME Growth (0.915) and Digital Innovation (0.900), indicating a high level of internal consistency among the indicators of these constructs. The Cronbach's Alpha values for all constructs ranged from 0.790 to 0.870, where a score above 0.70 is generally considered acceptable in social science research. These findings affirm that the research instrument possesses robust reliability and is suitable for further empirical testing. Discriminant validity was assessed using the Heterotrait-Monotrait Ratio (HTMT), and the results show that all HTMT values fall below the conservative threshold of 0.85. For instance, the HTMT value between *Go Digital* and *Go Global* is 0.56, while the value between *Digital Innovation* and *UMKM Growth* is 0.55. These results indicate strong discriminant validity between constructs. The low HTMT values confirm that each construct measures a conceptually distinct dimension, eliminating concerns of conceptual overlap or redundancy among variables. With convergent validity, composite reliability, and discriminant validity all satisfactorily met, it can be concluded that the constructs used in this model are both valid and reliable. This ensures that the measurement instrument is sufficiently robust to capture the concepts under investigation. Validity and reliability serve as critical foundations before advancing to the inner model analysis, which examines the causal relationships among constructs. Hence, the outer model testing process has met all methodological requirements, strengthening the overall integrity of the study.

Table 3. Structural Model Assessment (Inner Model)

Endogenous Variable	R-Square (R^2)	Q-Square (Q^2)
MSME Growth	0.782	0.652

Source: The Result Data, 2025

The inner model analysis represents a crucial step in SEM-PLS to evaluate causal relationships between latent constructs. In this study, the primary endogenous variable, *UMKM Growth*, recorded an R-Square value of 0.782, indicating that 78.2% of the variance in MSME growth can be explained by the exogenous variables within the model. This figure is considered high within social research contexts, suggesting that the *Medan Go Creative* model possesses strong predictive capability. All exogenous constructs - *Go Digital*, *Go Global*, *Go Green*, *Digital Infrastructure*, *Digital Literacy*, *Stakeholder Support*, and *Digital Innovation* - significantly contribute to explaining the variation in MSME growth. In addition to R-Square, the Q-Square value (predictive relevance) stands at 0.652.

Table 4. Hypothesis Testing

Hypothesis	Path Coefficient	t-Statistic	p-Value	Significance
H1	0.54	9.21	0.000	Significant
H2	0.48	8.45	0.000	Significant
H3	0.40	7.80	0.000	Significant
H4	0.32	6.50	0.000	Significant
H5	0.37	6.95	0.000	Significant
H6	0.45	7.90	0.000	Significant
H7	0.50	8.60	0.000	Significant

Source: The Result Data, 2025

As this value exceeds the 0.35 threshold proposed by Hair *et al.* it indicates a high degree of predictive relevance. This high Q-Square value implies that the model is not only statistically robust in explaining variance but

also possesses strong predictive utility for new data. This is especially relevant in policy implementation contexts, where models should offer forward-looking insights in addition to describing current conditions. Therefore, the model presents strong applicability for guiding local digital economic transformation. The inner model results also reinforce the findings from the outer model, confirming that all exogenous constructs are valid and significant.

These outcomes affirm the robustness of the *Medan Go Creative* framework as a replicable model. In policy terms, the high R^2 and Q^2 values suggest that targeted interventions in dimensions such as *Digital Innovation* and *Stakeholder Support* can yield substantial impact. With this data-driven approach, policymakers are better equipped to design strategies that are accurate, effective, and responsive to MSME needs. Overall, the inner model findings confirm that the SEM-PLS–based approach reliably explains the dynamics of MSME growth. This model is not merely theoretical - it is operational and well-positioned as a basis for strategic policy formulation. As such, the inner model demonstrates both scientific integrity and high practical relevance.

Hypothesis testing in this study was conducted to examine the significant influence of seven exogenous constructs on MSME growth in Medan. The results indicate that all hypotheses are statistically accepted, as evidenced by p-values < 0.001 and t-statistics above the 1.96 threshold for significance.

The primary hypothesis (H1), which investigates the impact of integrating a digital innovation–based creative economy model on MSME growth, yields a path coefficient of 0.54 with a t-statistic of 9.21, confirming a strong and significant influence. This finding supports the proposition that the *Medan Go Creative* framework serves as an effective integrative approach for advancing digital and creative transformation in the MSME sector.Hypothesis H2 (*Go Digital*) shows a significant influence (0.48, t = 8.45), suggesting that the adoption of digital tools such as e-commerce, digital marketing, and fintech enhances business sustainability and revenue. Similarly, H3 (*Go Global*) yields a coefficient of 0.40 (t = 7.80), indicating that international market orientation supported by digitalization contributes meaningfully to growth. This highlights the competitive advantage of MSMEs that extend their reach through global digital platforms.H4 (*Go Green*) also demonstrates a positive effect (0.32, t = 6.50), affirming that eco-friendly innovations can improve long-term sustainability. Systemic support variables such as *Digital Infrastructure* (H5: 0.37, t = 6.95) and *Digital Literacy* (H6: 0.45, t = 7.90) are also shown to significantly enhance the effective implementation of digital innovation in MSMEs. Without sufficient infrastructure and digital skills, transformative outcomes remain elusive.The final construct, *Stakeholder Support* (H7), demonstrates a strong effect (0.50, t = 8.60), emphasizing the vital role of collaboration among government, creative communities, and industry in establishing an innovative ecosystem. Accordingly, all tested hypotheses are significant, reinforcing the structural soundness of the *Medan Go Creative* model. The hypothesis testing provides strong empirical support for the SEM model structure. With high path coefficients and significant t-values, each dimension is shown to contribute substantively to MSME growth. These findings offer robust arguments for formulating evidence-based policies to advance sustainable and digital MSME development. The integration of all seven constructs forms a collaborative strategy that not only accelerates growth but also enhances local economic competitiveness. This contribution also enriches the academic discourse on technology-driven creative economy models.

Table 5. Model Fit Index (PLS Goodness-of-Fit)

Index	Value	Interpretation
SRMR	0.059	Good Fit
NFI	0.912	Good Fit
GoF	0.742	Large Fit

Source: The Result Data, 2025

Model fit in SEM-PLS is a critical indicator for evaluating how well the theoretical model aligns with the empirical data. In this study, three key indices were used to assess model fit: SRMR (Standardized Root Mean Square Residual), NFI (Normed Fit Index), and GoF (Goodness of Fit). The SRMR value was recorded at 0.059 - well below the recommended maximum of 0.08 - indicating an excellent fit. A low SRMR implies minimal discrepancy between the observed and predicted matrices, reflecting minimal model error. The NFI score, used to compare the structural model with a null model, was 0.912. This exceeds the recommended minimum of 0.90, signifying that the proposed SEM model explains the data significantly better than a baseline model with no relationships among variables. The high NFI further supports the model's strong representational capacity for capturing empirical realities within the MSME population of Medan. The final index, GoF, yielded a value of 0.742,

classified as a “large fit” based on Wetzels *et al.* (2009). GoF is calculated from the square root of the product of average AVE and R^2 values, and it reflects the overall quality of the measurement and structural components of the model. A score of 0.742 indicates that the model has a very high ability to explain the overall variance in the data. Taken together, the three fit indices confirm that the *Medan Go Creative* model meets statistical adequacy criteria. These results reinforce the interpretation that the SEM model is reliable and suitable for both further academic investigation and practical policy implementation. Therefore, the model is not only theoretically and empirically sound, but also a feasible tool for formulating city-level digital creative economy strategies

4. Discussions

The results of the first hypothesis test (H1) indicate that the integration of a creative economy model based on digital innovation has a significant influence on MSME growth in the city of Medan, with a path coefficient of 0.54 and a t-statistic of 9.21 ($p < 0.000$). These findings affirm that an integrative approach - combining technology, collaboration, and creativity - can drive overall MSME performance. The active involvement of various actors within the digital ecosystem has further accelerated the adoption of innovation among small business players. Digital transformation is no longer optional; it has become a strategic necessity for business sustainability. In the context of Medan, this model is articulated through the “Go Creative” strategy, which integrates the Go Digital, Go Green, and Go Global approaches as a development framework. Government programs and positive responses from local business communities have further strengthened the model’s practical implementation. These findings align with Hair *et al.* (2020), who assert that digital-based business models offer competitive advantages for MSMEs in the innovation-driven economy. Improvements in business performance can be observed through increased revenue, product diversification, and market expansion. Thus, this integrated model may be considered a strategic framework for strengthening regional creative MSME sectors. The second hypothesis (H2) confirms that the use of digital technology significantly influences MSME revenue growth and sustainability, with a path coefficient of 0.48 and a t-statistic of 8.45 ($p < 0.000$). The use of e-commerce, digital marketing, and financial technology (fintech) has demonstrably enhanced financial performance. MSMEs that actively engage with digital platforms report improved efficiency in business processes and broader market reach. Prasetyo & Lestari (2021) highlight that digitalization not only accelerates transactions but also strengthens consumer trust through service transparency. Strengthened digital capacity in internal management improves accountability and long-term business planning.

Respondents noted that using platforms such as Tokopedia, Shopee, and Instagram significantly boosted demand. Digital technology also facilitates real-time sales reporting, inventory management, and market analysis. Therefore, integrating technology into daily MSME operations can be seen as a primary engine of sustainable growth. For the third hypothesis (H3), results show that international market access through digitalization positively impacts MSME growth, with a path coefficient of 0.40 and a t-statistic of 7.80 ($p < 0.000$). In the era of digital globalization, geographic boundaries are no longer a barrier to reaching international consumers. MSMEs using digital export platforms such as Alibaba, Amazon, or cross-border B2B channels are significantly expanding their scale. This finding is consistent with research by Wijayanti *et al.* (2021), which noted that digitalization enables a more inclusive pathway to international trade for MSMEs. In Medan, MSMEs in the food and craft sectors have penetrated export markets through digital catalogs and international social media platforms. Global market access also accelerates adaptation to quality standards and international certifications that were previously out of reach. Government support through digital export facilitation programs is key to enhancing the export capacity of regional MSMEs.

Thus, digitalization not only broadens market access but also improves competitiveness and global presence. The fourth hypothesis (H4) demonstrates that sustainable and environmentally friendly innovation practices enhance MSME competitiveness and business continuity, with a path coefficient of 0.32 and a t-statistic of 6.50 ($p < 0.000$). Environmentally oriented innovation is now a global trend that cannot be ignored. Modern consumers prefer products that are ethically made, eco-friendly, and sustainable. In this context, MSMEs that integrate green business principles into their production and distribution processes earn greater market trust. Research by Handayani *et al.* (2022) shows that green innovation directly impacts customer loyalty and brand perception. In Medan, an increasing number of MSMEs are producing recycled bags, organic goods, and eco-friendly packaging in response to growing ecological awareness. Green innovation also reduces long-term production costs and enhances energy efficiency. These sustainable practices ultimately contribute to business longevity and open up partnership opportunities with institutions that prioritize social and environmental responsibility. The fifth hypothesis (H5) confirms that the availability of digital infrastructure positively influences the effectiveness of creative economy model integration, with a path coefficient of 0.37 and a t-statistic of 6.95 ($p < 0.000$). Digital infrastructure includes internet connectivity, hardware, and supporting digital systems that enable

digital business processes. Without adequate infrastructure, technological adoption remains slow and uneven. This finding supports the study by Siregar *et al.* (2022), which identifies infrastructure gaps as a major barrier to equitable MSME digitalization. In Medan, respondents with stable internet access and sufficient digital tools demonstrated higher engagement in digital business activities. The city government has facilitated public Wi-Fi access points and community-based digital literacy training. Equitable access to technology promotes economic inclusion across both urban and semi-urban areas. Therefore, developing digital infrastructure is a fundamental prerequisite for the effective implementation of the creative economy model. The sixth hypothesis (H6) reveals that digital literacy among MSME actors significantly contributes to the success of digital innovation adoption, with a path coefficient of 0.45 and a t-statistic of 7.90 ($p < 0.000$). Digital literacy extends beyond basic technology use; it includes strategic understanding of how digital tools support business decision-making. MSME actors with stronger comprehension of digital platforms adapt more quickly to changing trends and market demands. A study by Putri & Nugroho (2021) emphasizes that digital transformation success depends on the human resource capacity to understand and manage technology effectively. In this study, most respondents had middle to high educational attainment, making them receptive to advanced technology training. Improved digital literacy results in better platform usage, more effective online promotion, and increased data security.

Therefore, enhancing digital capacity should be a priority program in accelerating technology-based creative economic transformation. The seventh hypothesis (H7) shows that collaboration among government, industry, and creative communities significantly influences the development of a digital creative ecosystem, with a path coefficient of 0.50 and a t-statistic of 8.60 ($p < 0.000$). Cross-sector collaboration fosters synergy that accelerates innovation. Governments provide policy and regulatory support; industry contributes networks and capital; and creative communities serve as sources of ideas and innovation energy. Research by Ardiansyah *et al.* (2021) underscores the importance of collaborative approaches in building regional innovation ecosystems. In Medan, initiatives such as the Medan Creative Hub and integrated training programs have successfully fostered collaborative spaces. These partnerships also accelerate business incubation, technology dissemination, and local product promotion at national and international levels. Hence, an inclusive and collaborative ecosystem model forms the foundation of a sustainable digital creative economy at the local level.

Conclusions and Further Research

This study empirically confirms that integrating a creative economy model based on digital innovation significantly impacts MSME growth in Medan. The Medan Go Creative (GCE) model - structured around Go Digital, Go Global, and Go Green - has proven effective in systematically enhancing the competitiveness and sustainability of small and medium enterprises. All hypotheses within the conceptual framework were found to be statistically significant, demonstrating that digital technology utilization, international market access, sustainable innovation practices, digital literacy, infrastructure readiness, and multi-stakeholder collaboration all contribute meaningfully to revenue growth, market expansion, and business resilience. SEM-PLS analysis indicates that the GCE model possesses strong predictive power ($R^2 = 0.782$; $Q^2 = 0.652$) and meets all criteria for construct validity and reliability. With high model fit indices (GoF = 0.742; SRMR = 0.059; NFI = 0.912), the model is suitable for policy formulation and replication in other regions. These findings provide scientific justification that digital transformation cannot succeed in isolation but requires adequate infrastructure and human capacity. Therefore, cross-sector collaboration is essential to building an inclusive and sustainable digital creative ecosystem. The academic contribution of this study lies in the development of an integrative model based on six key variables - digital literacy, digital infrastructure, stakeholder support, digital innovation, creative collaboration, and MSME growth - which have been underexplored in local contexts such as Medan. The practical contribution lies in its potential to serve as a data-driven, context-sensitive, and implementable roadmap for digital MSME transformation. The results affirm that digitalization in the creative economy is not merely technical, but also strategic and multidimensional. Thus, Medan Go Creative may be adopted as a local economic development strategy grounded in technology, creativity, and inter-actor collaboration. Strengthening digital literacy and expanding infrastructure access must be pursued simultaneously and continuously to ensure that digitalization benefits reach all MSME actors, particularly in resource-limited areas. This study also confirms that global market orientation and eco-friendly practices are no longer optional trends but strategic necessities in facing global economic dynamics. Therefore, GCE offers a role model for accelerating MSME digital inclusion on a national scale. This study provides a strategic policy direction for digital-based MSME development at the regional level. Local governments should enhance digital literacy through practical and sustained training tailored to MSME needs. Equitable development of digital infrastructure is a primary condition for ensuring access and effectiveness in transformation. Additionally, stakeholder collaboration - including government, industry, and creative communities - should be institutionalized through innovation and incubation

centers such as Creative Hubs. Sustainable innovation practices should also be encouraged through incentives for MSMEs that adopt environmentally responsible approaches. Overall, policies should focus on building a digital creative economy ecosystem that is inclusive, competitive, and responsive to the challenges of the digital transformation era.

Declarations

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Credit Authorship Contribution Statement:

Dina Hastalona: Conceptualization, Methodology, Data Collection, Formal Analysis, Writing – Original Draft. Dina Hastalona led the formulation of the research questions, constructed the conceptual framework, designed the data collection instruments, and carried out the fieldwork. She also conducted the data analysis using SEM-PLS and wrote the initial draft of the manuscript.

Eka Hayana Hasibuan: Supervision, Validation, Writing – Review & Editing, Funding Acquisition**,** Software, Data Curation, Visualization, Formal Analysis. Eka Hayana Hasibuan provided overall supervision of the research design and analytical strategy. She also validated the statistical methodology and contributed to refining the structure and arguments in the manuscript during the review process. **H**andled data preprocessing, performed SmartPLS 4 modeling, and produced tables and diagrams. He was responsible for ensuring data integrity and supported the statistical robustness of the findings.

Dedy Lazuardi: Resources, Investigation, Project Administration, Writing – Review & Editing. Dedy Lazuardi coordinated access to MSME respondents in the Nias Islands and managed the field team. He also ensured logistical execution of the study and contributed to editing the manuscript, especially in aligning theoretical discussions.

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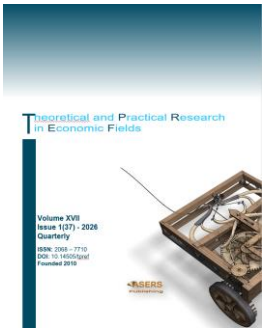
Are Crypto-Assets More Resilient to Financial Shocks than Conventional Assets?



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Abstract: This article examines the resilience of crypto-assets and that of conventional assets to financial shocks. It uses GARCH models to analyze the volatility of daily returns of crypto-assets (*i.e.*, BTC, ETH, BNB, XRP, ADA) and conventional assets (*i.e.*, AAPL, MSFT, GOOG, AMZN, NVDA), with their respective benchmarks (*i.e.*, CRIX and S&P500). The total study period runs from March 16, 2018, to June 30, 2023, divided into three sub-periods: the pre-COVID-19 period (March 16, 2018, to November 29, 2019), the post-COVID-19 period (December 02, 2019, to February 09, 2022), and the Russo-Ukrainian war period (February 10, 2022, to June 30, 2023). The results indicate that crypto-assets are more volatile than conventional assets over the full study period, confirming their status as risky assets. Furthermore, all assets experienced a significant increase in volatility during the COVID-19 pandemic, with particularly high levels for crypto-assets compared to conventional assets. During the Russo-Ukrainian war period, crypto-assets experienced high levels of volatility, which were slightly lower than those observed during the post-COVID-19 period. Compared to crypto-assets, conventional assets are more resilient to financial shocks. Our research could help investors build their portfolios while also allowing them to understand the role of digital assets in risk management.

Keywords: crypto-assets; conventional assets; GARCH models; COVID-19; Russo-Ukrainian war; volatility; resilience.

JEL Classification: G15; C22; C58.

Introduction

Over the past decade, cryptocurrencies have rapidly emerged on the global financial landscape. Many hedge funds and asset managers have begun to incorporate cryptocurrency-related assets into their investment portfolios (Fang *et al.* 2022). Bitcoin has distinguished itself as the market leader among these assets. It is considered a kind of digital currency and payment mechanism, operating online via decentralized, distributed networks (Hayes, 2017). Its value is not based on the economy of any country and relies instead on the security of the algorithm and the traceability of transactions (Platanakis and Urquhart, 2020). Although created as a digital currency, Bitcoin is also used as an asset (Baur *et al.* 2018). As such, several authors have examined Bitcoin in relation to other conventional financial instruments, including its utility as a safe-haven asset, hedging tool, or means of diversification (Abdelmalek, 2023; Bouri *et al.* 2017; Rashid *et al.* 2023; Stensås *et al.* 2019).

Designed to function as a cryptographically secure means of exchange (Nakamoto, 2008), cryptocurrencies have revolutionized the financial world by offering a decentralized alternative to traditional financial assets. Their growing adoption has been fuelled by their potential for direct peer-to-peer transactions, eliminating the need for financial intermediaries (Peters *et al.* 2015; Steli and Ouchen, 2024; Swartz, 2014). With the explosive rise of

cryptocurrencies and their growing integration into investment strategies, it is essential to assess their ability to offer resilience against financial shocks compared to conventional assets.

The COVID-19 pandemic and the Russo-Ukrainian war have exacerbated the volatility of global financial markets and raised concerns about the stability of conventional assets and crypto-assets (Chen and Yu, 2025; Mgadmi *et al.* 2023; Ouchen, 2022; Özdemir, 2022; Shaik *et al.* 2023). During periods of intense uncertainty, characterized by high volatility in financial asset prices, some investors view crypto-assets as a safe-haven (Corbet *et al.* 2020; Dwita Mariana *et al.* 2021; Tarchella *et al.* 2024; Yatie, 2022). Corbet *et al.* (2020) find that bitcoin offers diversification benefits and plays a similar role to gold as a safe-haven during the COVID-19 crisis. Indeed, Dwita Mariana *et al.* (2021) analyze the safe-haven properties of crypto-assets (*i.e.*, Bitcoin and Ethereum) for equities during the COVID-19 pandemic. The results indicate that Bitcoin and Ethereum can serve as short-term safe havens. In addition, Tarchella *et al.* (2024) examine the safe-haven, hedging, and diversification properties of oil, gold, and two cryptocurrencies (*i.e.*, Bitcoin and Ethereum) for G7 stock markets. The results show that cryptocurrencies have safe-haven potential during the COVID-19 crisis. Finally, Yatie (2022) analyzes the safe-haven properties of crypto-assets and gold for European assets during the COVID-19 crisis. The results show that crypto-assets such as Tether, Cardano, and Dogecoin exhibited safe-haven characteristics, proving to outperform gold. While Bitcoin, Ethereum, Litecoin, and Ripple performed particularly well as diversification tools for European indices.

However, some researchers put forward arguments against the idea that crypto-assets can be considered safe-havens during periods of financial crisis (Ballis *et al.* 2025; Conlon *et al.* 2020; Conlon and McGee, 2020; Karamti and Belhassine, 2022; Li and Miu, 2023; Yuyama *et al.* 2023). Ballis *et al.* (2025) show that cryptocurrencies cannot serve as safe-havens in times of crisis and may begin to behave similarly to traditional assets during difficult times. Conlon *et al.* (2020) indicate that Bitcoin and Ethereum do not fulfill this safe-haven function for global stock market indices during the COVID-19 crisis. Conlon and McGee (2020), Karamti and Belhassine (2022) state that Bitcoin cannot be considered a safe-haven since its price varies closely with the S&P500. Li and Miu (2023) find that cryptocurrencies are not a safe-haven for equity investors, since they fail to play their risk-mitigating role during market downturns. Yuyama *et al.* (2023) conclude that crypto-assets do not fulfill the role of “digital gold” or safe-haven in times of crisis. They demonstrate that the correlation between Bitcoin and the S&P500 increased significantly during COVID-19, the Russo-Ukrainian invasion, and the crypto winter.

This debate surrounding the status of crypto-assets as safe-havens, due to their resilience to shocks, leads us to the following question: Are crypto-assets more volatile than conventional assets? What about their respective resilience during the COVID-19 crisis and the Russo-Ukrainian war?

To provide some answers to this research question, we apply GARCH models to the daily returns of five crypto-assets, *i.e.*, Bitcoin (BTC), Ethereum (ETH), Binance Coin (BNB), Ripple (XRP), and Cardano (ADA); five US equities, *i.e.*, Apple (AAPL), Microsoft (MSFT), Google (GOOG), Amazon (AMZN), and Nvidia (NVDA); and their respective benchmark indices, *i.e.*, CRIX and S&P500. The study period runs from March 16, 2018, to June 30, 2023, divided into three sub-periods: the pre-COVID-19 period (March 16, 2018, to November 29, 2019), the post-COVID-19 period (December 02, 2019, to February 09, 2022), and the Russo-Ukrainian war period (February 10, 2022, to June 30, 2023).

This study contributes to the literature on the resilience of crypto-assets and conventional assets to financial shocks. It proposes a framework for examining the responsiveness of both asset classes during periods of crisis. The research highlights that crypto-assets are more volatile and therefore less resilient to financial shocks than conventional assets. This perspective will provide investors with valuable recommendations for managing the risks of their portfolios and exploiting opportunities for diversification in digital assets.

The remainder of this paper is structured as follows. The first section is devoted to a literature review on the resilience of crypto-assets relative to conventional assets during crisis periods. The second section presents the GARCH model and its extensions, suitable for modeling the volatility of the daily return series of the financial assets studied. The final section focuses on the analysis and discussion of the results.

1. Literature Review: Resilience of Crypto-Assets versus Traditional Assets During Crisis Periods

The COVID-19 pandemic and the Russo-Ukrainian war caused major fluctuations in financial assets, highlighting their resilience in the face of crises. Against this backdrop, the literature falls into three broad categories. The first category of research shows the resilience of crypto-assets during periods of crisis. The second concludes, on the

contrary, that conventional assets are more resilient. On the other hand, the third highlights a significant absence of resilience for both asset classes.

1.1 Resilience of Crypto-Assets Compared to Conventional Assets

Numerous studies have analyzed the issue of the comparative volatility of digital assets compared to their conventional counterparts during periods of crisis (Maghyereh and Abdoh, 2022; Ullah, 2025; Terraza *et al.* 2024). Some have demonstrated the resilience of crypto-assets, highlighting their role as a safe-haven. Melki and Nefzi (2022) examined the hedging and safe-haven characteristics of the three main cryptocurrencies (*i.e*., Bitcoin, Ripple, and Ethereum) against three traditional indices (*i.e*., MSCI World, Gold Bullion LBM, and EUR/USD) during the COVID-19 pandemic. The results show that cryptocurrencies, in particular Bitcoin and Ethereum, exhibit strong safe-haven characteristics due to their resilience to external shocks. Nguyen (2022) analyzes the relationship between the stock market and Bitcoin during periods of uncertainty, notably during the COVID-19 pandemic. The results indicate that Bitcoin could function as a safe-haven due to the high correlation between traditional assets and cryptocurrencies in times of crisis. This shows its resilience to economic shocks and its potential to diversify portfolios. Taera *et al.* (2023) examined the volatility of traditional assets, the Fintech index, and cryptocurrencies during the COVID-19 pandemic and the Russo-Ukrainian war. They demonstrate that all financial and alternative market assets retained in this study experienced significant volatility, except for Bitcoin, over the total study period. Mejri *et al.* (2025) examined the impact of geopolitical risk on Bitcoin, gold, and green bonds using quantile wavelet analysis. The results show Bitcoin's resilience to stress conditions, highlighting its hedging capacity within diversified portfolios. Marobhe (2022) examines the sensitivity of cryptocurrencies to the COVID-19 crisis, comparing them to the main stock market indices. His study reveals that cryptocurrencies showed greater resilience in these difficult times, managing to recover rapidly as early as April 2020, shortly after the onset of the pandemic. In contrast, indices such as the S&P500, FTSE 100, and SSE Composite continued to be affected by the COVID-19-related panic until June 2021.

1.2 Resilience of Conventional Assets Against Crypto-Assets

Conversely, other research challenges the perception of crypto-assets as resilient during turbulent times. Lahmiri and Bekiros (2020) compare the behavior of 45 cryptocurrencies with global stock markets during the COVID-19 crisis. The results show that cryptocurrency markets are more impacted by the pandemic than global stock markets. Certainly, there is greater instability in the cryptocurrency market compared to the equity market. Yarovaya *et al.* (2022) also analyzed the financial market response and recovery of four financial asset classes (*i.e*., stock market, precious metals, bonds, and cryptocurrencies) during the COVID-19 pandemic. The results show that stock markets are more predictable and therefore less risky, while cryptocurrencies are considered the riskiest asset class in the long term. Kayani *et al.* (2024) examined quantile connectivity in digital and traditional asset markets with the renewable energy price index. The study period from January 2, 2018, to December 4, 2023, covered various economic crises. The results show that the volatility of digital assets is higher than that of traditional and energy assets. Bampinas and Panagiotidis (2024) studied the links between six international stock markets and the two main cryptocurrency markets during the COVID-19 pandemic and the Russo-Ukrainian war. The results show that Bitcoin and Ethereum possess diversification and limited safe-haven properties during COVID-19, which further diminish during the war. In their research into the resilience of cryptocurrencies during the Russo-Ukrainian war, Khalfaoui *et al.* (2023) show that cryptocurrencies, particularly Bitcoin, were affected by the war and are not entirely resilient to geopolitical crises.

1.3 Absence of Significant Resilience of Crypto and Traditional Assets

However, some studies highlight the fact that the volatility of both asset classes was particularly affected during periods of crisis. Jeribi and Kammoun Masmoudi (2021) studied the relationship between the volatility of traditional and digital assets before and during the COVID-19 pandemic. They show that stock markets reacted to the COVID-19 pandemic as did the cryptocurrency market, with worrying volatility. Zhu *et al.* (2025) provided an econometric modeling of volatility and estimation of extreme risk for Bitcoin, stock indices, gold, and crude oil. The results show that extreme risk levels for all asset classes increased significantly during the COVID-19 pandemic, confirming the disruptive effect of crises on financial stability. Hamouda *et al.* (2024) show that cryptocurrency markets became more closely linked to equity markets after February 2022. Gaies and Chkili (2023) studied the dynamic relationship between Bitcoin volatility and stock market volatility during the Russo-Ukrainian war. They also show that the correlation between the two markets increased during the war, and, consequently, Bitcoin was not a safe-haven

during this period. However, in a portfolio context, their findings indicate that integrating Bitcoin into an equity portfolio can reduce risk without compromising expected returns.

2. Methodological Framework

2.1 Variables and Study Period

This study takes the daily return series of five crypto-assets, *i.e.*, Bitcoin (BTC), Ethereum (ETH), Binance Coin (BNB), Ripple (XRP), and Cardano (ADA); five U.S. market stocks, *i.e.*, Apple (AAPL), Microsoft (MSFT), Google (GOOG), Amazon (AMZN), and Nvidia (NVDA); as well as their respective benchmark indices, *i.e.*, CRIX and S&P500, during the period from March 16, 2018, to June 30, 2023. The selection criteria for these assets are market capitalization and data availability. The daily return of an asset i on date t is calculated using the following formula:

$$R_{it} = \ln\left(\frac{P_{it}}{P_{i,t-1}}\right) \quad (1)$$

2.2 Volatility Analysis

2.2.1 GARCH Models

In 1986, Bollerslev (1986) developed Engle's ARCH model into the GARCH (Generalized AutoRegressive Conditional Heteroskedasticity) model. We have used the well-known GARCH (1,1) econometric model to model risk and volatility in our study. This model is frequently used to analyze time series data with volatility clusters, meaning that large changes in the time series tend to be followed by other significant changes. The GARCH (1,1) model also provides a more accurate representation of volatility clustering than simpler models such as the constant variance model or the ARCH (n) model (Bollerslev, 1986; Chou, 1988).

2.2.1.1 ARCH Models

The ARCH (AutoRegressive Conditional Heteroskedasticity) model introduced by Engle (1982) can be used to model chronicles (mainly financial) that have an instantaneous variability that depends on the past. This makes it possible to develop a dynamic forecast of the chronicle in terms of mean and variance.

The ARCH (1) model equation is then written as follows:

$$\begin{aligned} r_t &= \delta + \varepsilon_t = \delta + n_t\sqrt{h_t} \\ h_t &= \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 \end{aligned} \quad (2)$$

With $\alpha_0 > 0$ and $\alpha_1 \geq 0$; $\varepsilon_t = n_t\sqrt{h_t}$ (where $n_t \sim N(0,-1)$) as the error term of the AR (1) model: $r_t = \emptyset_1 y_{t-1}$ of our study variable; and h_t as the conditional variance.

2.2.1.2 GARCH Model

The GARCH (1, 1) model equation is written as:

$$r_t = \delta + \varepsilon_t = \delta + n_t\sqrt{h_t}$$

The residual conditional variance equation is defined as:

$$h_t = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 h_{t-1} \quad (3)$$

Where: $\alpha_0 > 0$, $\sim \alpha_1 \geq 0$, and $\sim \beta_1 \geq 0$.

2.2.1.3 EGARCH Model

The EGARCH model introduced by Nelson (1991) was developed to incorporate the impact of asymmetry between positive and negative shocks on the conditional variance of future observations. The model also takes into account the leverage effect, whereby negative shocks have a greater impact on conditional variance than positive shocks of the same magnitude.

The equation of the EGARCH (1,1) model is written as follows:

$$\log(h_t) = \alpha_0 + \alpha_1 \left|\frac{\varepsilon_{t-1}}{h_{t-1}}\right| + \alpha_2 \frac{\varepsilon_{t-1}}{h_{t-1}} + \beta_1 \log(h_{t-1}) \quad (4)$$

Where α_1 denotes the ARCH effect, estimating the response to any market shock or news;
α_2 represents the coefficient identifying the presence of the asymmetric effect;
β_1 represents the GARCH effect, identifying the persistence of volatility.

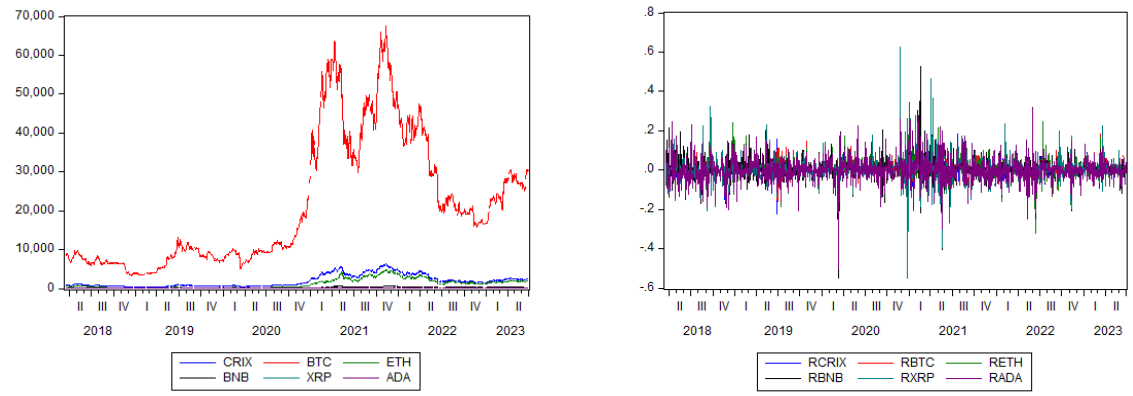
3. Results

3.1 Graphical and Statistical Examination of the Series of Daily Returns on the Assets of Our Interest

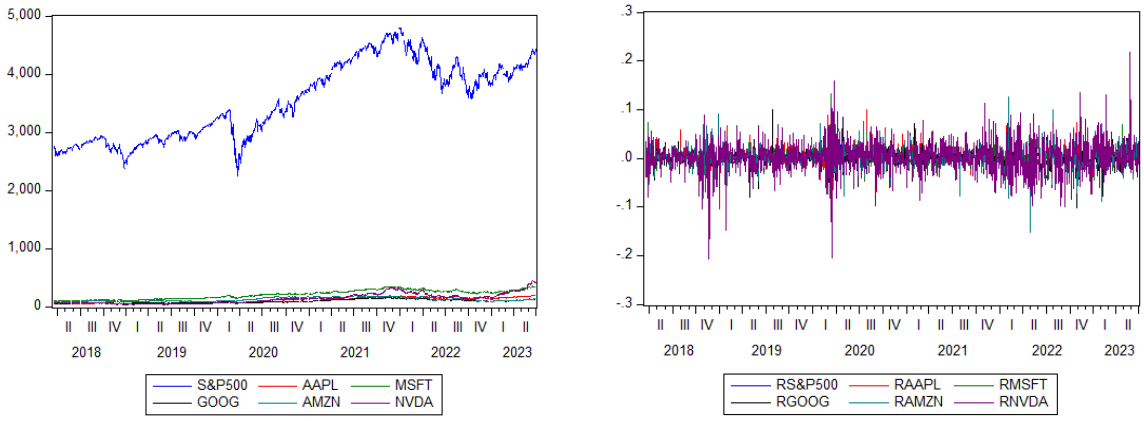
Figure 1 below shows the graphical evolution of the series of prices and daily returns on the assets of our study over the full study period from March 16, 2018, to June 30, 2023.

Figure 1. Daily asset prices and returns

(a) Crypto-assets



(b) Conventional assets



Source: Eviews software, Authors

Graphical analysis of the variables in our study and unit root tests, namely the increased Dickey–Fuller, Phillips–Perron, and KPSS (Kwiatkovski, Phillips, Schmidt and Shin), show that the daily prices of the five crypto-assets, *i.e.*, Bitcoin (BTC), Ethereum (ETH), Binance Coin (BNB), Ripple (XRP), and Cardano (ADA); the five U.S. market stocks, *i.e.*, Apple (AAPL), Microsoft (MSFT), Google (GOOG), Amazon (AMZN), and Nvidia (NVDA); as well as their respective benchmark indices, *i.e.*, CRIX and S&P500, are not stationary I(1). In contrast, the daily return series for the same assets: RBTC, RETH, RBNB, RXRP, RADA, RAAPL, RMSFT, RGOOG, RAMZN, RNVDA, RCRIX, and RS&P500, are stationary and therefore I(0), throughout the full study period (Figure 1). This stationary characteristic is also verified over the three distinct sub-periods (pre-COVID-19, post-COVID-19, and the Russo-Ukrainian war period). Tables 1, 2, 3, and 4 below present the statistical indicators of the daily return series of our interest assets for the full study period (between March 16, 2018 and June 30, 2023) as well as its three sub-periods, namely, the pre-COVID-19 sub-period (between March 16, 2018 and November 29, 2019), the post-COVID-19 sub-period (between December 2, 2019 and February 9, 2022), and the Russo-Ukrainian war sub-period (between February 10, 2022 and June 30, 2023).

Table 1. Statistical indicators of daily asset return series for the full study period

	RCRIX	RBTC	RETH	RBNB	RXRP	RADA
Mean	0.000691	0.000976	0.000879	0.002464	-0.000282	0.000356
Median	0.001639	0.000973	0.000881	0.001722	-0.000361	-6.66E-05
Maximum	0.189390	0.203046	0.343523	0.529218	0.626741	0.316747
Minimum	-0.272552	-0.464730	-0.550732	-0.543084	-0.550503	-0.503638
Std. Dev.	0.045015	0.044203	0.058590	0.060253	0.066097	0.065918
Skewness	-0.431010	-0.983517	-0.765685	-0.222714	0.449244	-0.050890
Kurtosis	6.728078	14.81685	12.23142	15.73495	18.42266	7.713621
Jarque-Bera (Probability)	810.1709 (0.000000)	7940.730 (0.000000)	4845.217 (0.000000)	8984.885 (0.000000)	13206.18 (0.000000)	1229.982 (0.000000)
Observations	1328	1328	1328	1328	1328	1328
	RS&P500	RAAPL	RMSFT	RGOOG	RAMZN	RNVDA
Mean	0.000362	0.001109	0.000965	0.000569	0.000381	0.001439
Median	0.000819	0.001243	0.001005	0.000862	0.001080	0.002385
Maximum	0.089683	0.113157	0.132929	0.099380	0.126949	0.218088
Minimum	-0.127652	-0.137708	-0.159453	-0.117667	-0.151398	-0.207712
Std. Dev.	0.013571	0.020760	0.019564	0.019981	0.022760	0.033321
Skewness	-0.762157	-0.235582	-0.210616	-0.154119	-0.146223	-0.199795
Kurtosis	16.20253	7.738534	9.768400	6.639625	6.895875	7.601898
Jarque-Bera (Probability)	9773.551 (0.000000)	1254.722 (0.000000)	2544.707 (0.000000)	738.2508 (0.000000)	844.5728 (0.000000)	1180.655 (0.000000)
Observations	1328	1328	1328	1328	1328	1328

Source: Eviews software, Authors

Table 2. Statistical indicators of daily asset return series for the pre-COVID-19 sub-period

	RCRIX	RBTC	RETH	RBNB	RXRP	RADA
Mean	-0.001272	-0.000167	-0.003150	0.001349	-0.002550	-0.003402
Median	-0.000930	0.000910	-0.001829	0.001068	-0.003625	-0.005175
Maximum	0.189390	0.203046	0.247451	0.213333	0.322005	0.246724
Minimum	-0.224789	-0.159026	-0.206860	-0.192859	-0.188028	-0.208078
Std. Dev.	0.048122	0.043194	0.056754	0.056547	0.056560	0.064245
Skewness	-0.077698	0.100427	-0.095643	0.167175	0.771679	0.156437
Kurtosis	5.753549	5.959420	5.329934	4.440054	7.274881	4.639329
Jarque-Bera (Probability)	136.2774 (0.000000)	157.6400 (0.000000)	97.91788 (0.000000)	39.15771 (0.000000)	370.0968 (0.000000)	49.90313 (0.000000)
Observations	430	430	430	430	430	430

	RS&P500	RAAPL	RMSFT	RGOOG	RAMZN	RNVDA
Mean	0.000307	0.000945	0.001093	0.000323	0.000316	-0.000336
Median	0.000762	0.001647	0.001552	0.000416	0.001343	0.000851
Maximum	0.048403	0.068053	0.072977	0.099380	0.090254	0.089504
Minimum	-0.033416	-0.104924	-0.055870	-0.080089	-0.081423	-0.207712
Std. Dev.	0.009321	0.017876	0.015543	0.016625	0.019546	0.029682
Skewness	-0.372962	-0.609645	-0.021953	-0.018403	-0.202877	-1.337071
Kurtosis	6.254113	7.328999	5.539545	8.007192	6.000290	10.38571
Jarque-Bera (Probability)	199.6930 (0.000000)	362.3986 (0.000000)	115.5843 (0.000000)	449.2304 (0.000000)	164.2309 (0.000000)	1105.453 (0.000000)
Observations	430	430	430	430	430	430

Source: Eviews software, Authors

Table 3. Statistical indicators of daily asset return series for the post-COVID-19 sub-period

	RCRIX	RBTC	RETH	RBNB	RXRP	RADA
Mean	0.003729	0.003275	0.005598	0.006046	0.002505	0.006267
Median	0.005829	0.002410	0.004788	0.006054	0.001601	0.004732
Maximum	0.185811	0.191527	0.343523	0.529218	0.626741	0.279436
Minimum	-0.272552	-0.464730	-0.550732	-0.543084	-0.550503	-0.503638
Std. Dev.	0.045642	0.047903	0.064715	0.071707	0.081119	0.073712
Skewness	-0.627328	-1.664714	-1.175558	-0.283132	0.354816	-0.268015
Kurtosis	6.715640	20.16415	15.32755	16.82391	17.63128	8.395706
Jarque-Bera (Probability)	352.4616 (0.000000)	7005.471 (0.000000)	3609.288 (0.000000)	4386.737 (0.000000)	4917.408 (0.000000)	673.7724 (0.000000)
Observations	550	550	550	550	550	550
	RS&P500	RAAPL	RMSFT	RGOOG	RAMZN	RNVDA
Mean	0.000704	0.001785	0.001332	0.001428	0.001078	0.002964
Median	0.001534	0.001332	0.001230	0.002325	0.001171	0.003340
Maximum	0.089683	0.113157	0.132929	0.089856	0.126949	0.158340
Minimum	-0.127652	-0.137708	-0.159453	-0.117667	-0.082535	-0.203979
Std. Dev.	0.016090	0.023138	0.021341	0.020004	0.021088	0.032314
Skewness	-1.033940	-0.225911	-0.453384	-0.274476	0.226487	-0.353969
Kurtosis	18.12024	8.608635	13.08276	7.966613	7.039588	7.438995
Jarque-Bera (Probability)	5337.239 (0.000000)	725.5630 (0.000000)	2348.596 (0.000000)	572.1968 (0.000000)	378.6626 (0.000000)	463.0507 (0.000000)
Observations	550	550	550	550	550	550

Source: Eviews software, Authors

Table 4. Statistical indicators of daily asset return series for the Russo-Ukrainian war sub-period

	RCRIX	RBTC	RETH	RBNB	RXRP	RADA
Mean	-0.001444	-0.001033	-0.001344	-0.001579	-0.001619	-0.004018
Median	0.000745	-0.001311	-0.000125	0.001087	0.000706	-0.000913
Maximum	0.177088	0.181200	0.247058	0.130593	0.226182	0.316747
Minimum	-0.244354	-0.257227	-0.323717	-0.251202	-0.217138	-0.249988
Std. Dev.	0.039536	0.038971	0.049602	0.041849	0.048180	0.053079
Skewness	-0.780904	-0.900139	-0.761879	-1.519334	-0.235551	0.042550
Kurtosis	9.006690	10.92154	10.82752	11.14029	8.162436	8.870215
Jarque-Bera (Probability)	555.3238 (0.000000)	951.3819 (0.000000)	916.7837 (0.000000)	1088.428 (0.000000)	387.4145 (0.000000)	496.8945 (0.000000)
Observations	346	346	346	346	346	346
	RS&P500	RAAPL	RMSFT	RGOOG	RAMZN	RNVDA
Mean	-3.47E-05	0.000345	0.000343	-0.000393	-0.000574	0.001426
Median	-0.000712	0.000697	-0.000997	-0.000884	0.000253	0.001178
Maximum	0.053953	0.085236	0.079059	0.074606	0.114915	0.218088
Minimum	-0.044199	-0.060472	-0.080295	-0.101313	-0.151398	-0.099518
Std. Dev.	0.013668	0.020118	0.021057	0.023481	0.028411	0.038710
Skewness	-0.103686	0.014043	0.111267	-0.068926	-0.313831	0.561886
Kurtosis	3.814657	4.169291	4.069672	4.238169	5.804046	5.757680
Jarque-Bera (Probability)	10.18780 (0.006134)	19.72244 (0.000052)	17.20945 (0.000183)	22.37560 (0.000014)	119.0331 (0.000000)	127.8421 (0.000000)
Observations	346	346	346	346	346	346

Source: Eviews software, Authors

During the total study period from March 16, 2018, to June 30, 2023, containing both crisis and stability phases, crypto-assets show higher volatility compared to conventional assets. The standard deviations of the daily returns of crypto-assets, ranging between 0.04 and 0.06, are significantly higher than those of conventional assets, which vary between 0.01 and 0.03. Furthermore, the average daily returns of both asset classes are generally positive and very close to 0.

During the pre-COVID-19 sub-period, most crypto-assets showed negative average returns and were very close to 0. In contrast, conventional assets presented positive average returns. The standard deviations of crypto-asset daily returns, ranging from 0.04 to 0.06, recorded higher volatility than conventional assets, whose standard deviations were generally lower, varying from 0.009 to 0.02.

During the post-COVID-19 sub-period, both crypto-assets and conventional assets recorded a significant increase in their volatilities compared to the pre-COVID-19 sub-period. However, crypto-assets, such as Ethereum, Binance Coin, Ripple, and Cardano, recorded higher levels of volatility and higher average returns compared to conventional assets during this post-COVID-19 sub-period. On the other hand, conventional assets recorded an increase in their positive average returns compared to the pre-COVID-19 sub-period.

During the Russo-Ukrainian war sub-period, the average returns of both crypto-assets and conventional assets were generally negative. Standard deviations of daily returns on conventional assets ranged from 0.01 to 0.03, demonstrating a degree of stability compared with crypto-assets. The latter showed higher volatility, with standard deviations ranging from 0.03 to 0.05. This observation highlights the increased sensitivity of crypto-assets to geopolitical crises compared with conventional assets.

Furthermore, over the full study period, it is remarkable that these series show leptokurtic distributions, with kurtosis coefficients exceeding 3, indicating a high probability of extreme points occurring. This characteristic is more pronounced in the post-COVID-19 period than in the pre-COVID-19 period, underlining an increase in volatility and uncertainty in financial markets following the pandemic. There is also non-linearity in these series. Except for the RXRP returns series, the distributions of the daily asset return series of our interest have skewness coefficients below 0, are asymmetric, and spread to the left. This asymmetry is consistent with lower volatility after an increase in returns than after a decrease. In other words, yields react more to a negative shock than to a positive one. What's more, the Jarque-Bera test shows that yield distributions do not follow a normal distribution. These results underline the complexity and dynamics of financial markets, with important implications for risk management and investor decision-making.

3.2 Results of the GARCH (1,1) Model Estimation

Tables 5, 6, 7, and 8 below show the results of the GARCH (1, 1) model estimation for the daily return series of crypto-assets and conventional assets during the total study period from March 16, 2018, to June 30, 2023; the pre-COVID-19 sub-period (March 16, 2018, to November 29, 2019); the post-COVID-19 sub-period (December 2, 2019, to February 9, 2022); and the Russo-Ukrainian War sub-period (February 10, 2022, to June 30, 2023), respectively.

Table 5. Results of the GARCH (1,1) model estimation over the full study period

	Equation for the conditional variance of the GARCH (1, 1) model residuals: $h_t = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 h_{t-1}$ Where: $\alpha_0 > 0$, $\alpha_1 \geq 0$, and $\beta_1 \geq 0$.					
	RCRIX	**RBTC**	**RETH**	**RBNB**	**RXRP**	**RADA**
α_0	0.000305*** (0.0000)	0.000254*** (0.0000)	0.000255*** (0.0000)	0.000187*** (0.0000)	0.000336*** (0.0000)	0.000296*** (0.0000)
α_1	0.096393*** (0.0000)	0.128882*** (0.0000)	0.110642*** (0.0000)	0.161979*** (0.0000)	0.245520*** (0.0000)	0.134873*** (0.0000)
β_1	0.752924*** (0.0000)	0.752053*** (0.0000)	0.822585*** (0.0000)	0.796947*** (0.0000)	0.729875*** (0.0000)	0.803650*** (0.0000)
$\alpha_1 + \beta_1$	0.849317	0.880935	0.933227	0.958926	0.975395	0.938523
LL	2271.135	2303.770	1941.699	2005.146	1860.132	1806.606
AIC	-3.413919	-3.463105	-2.917407	-3.013030	-2.794472	-2.713800
BIC	-3.390450	-3.439636	-2.893937	-2.989561	-2.771002	-2.690331
	Equation for the conditional variance of the GARCH (1, 1) model residuals: $h_t = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 h_{t-1}$ Where: $\alpha_0 > 0$, $\alpha_1 \geq 0$, and $\beta_1 \geq 0$.					
	RS&P500	**RAAPL**	**RMSFT**	**RGOOG**	**RAMZN**	**RNVDA**
α_0	4.65E-06*** (0.0000)	1.39E-05*** (0.0000)	9.13E-06*** (0.0000)	1.43E-05*** (0.0000)	1.65E-05*** (0.0000)	4.08E-05*** (0.0000)
α_1	0.200210*** (0.0000)	0.123827*** (0.0000)	0.126808*** (0.0000)	0.067754*** (0.0000)	0.136766*** (0.0000)	0.108468*** (0.0000)
β_1	0.778835*** (0.0000)	0.846054*** (0.0000)	0.850880*** (0.0000)	0.894726*** (0.0000)	0.837007*** (0.0000)	0.859392*** (0.0000)
$\alpha_1 + \beta_1$	0.979045	0.969881	0.977688	0.96248	0.973773	0.96786
LL	4188.245	3408.188	3533.861	3403.716	3274.641	2727.989
AIC	-6.303308	-5.127638	-5.317048	-5.120898	-4.926362	-4.102470
BIC	-6.279838	-5.104168	-5.293578	-5.097428	-4.902892	-4.079000

Source: Eviews software, Authors

Note: *** indicates coefficient significance at the 1% threshold; ** indicates coefficient significance at the 5% threshold; and * indicates coefficient significance at the 10% threshold.

α_1: the ARCH effect, which estimates the response to any shock or news in the market; β_1 : the GARCH effect, which identifies the persistence of volatility; $\alpha_1 + \beta_1$: the persistence of the shock within the market; LL: Log Likelihood; AIC: Akaike Information Criterion; and BIC: Bayesian Information Criterion.

Table 6. Results of the GARCH (1,1) model estimation during the pre-COVID-19 sub-period

	Equation for the conditional variance of the GARCH (1, 1) model residuals: $h_t = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 h_{t-1}$ Where: $\alpha_0 > 0$, $\alpha_1 \geq 0$, and $\beta_1 \geq 0$.					
	RCRIX	**RBTC**	**RETH**	**RBNB**	**RXRP**	**RADA**
α_0	0.000860*** (0.0074)	0.000329*** (0.0008)	0.000492** (0.0266)	0.000355** (0.0181)	0.000914*** (0.0000)	0.000485** (0.0246)
α_1	0.125194*** (0.0011)	0.128992*** (0.0023)	0.066214*** (0.0084)	0.109909*** (0.0005)	0.217863*** (0.0000)	0.099980*** (0.0024)
β_1	0.494399*** (0.0043)	0.694373*** (0.0000)	0.778604*** (0.0000)	0.776955*** (0.0000)	0.500247*** (0.0000)	0.783475*** (0.0000)
$\alpha_1 + \beta_1$	0.619593	0.823365	0.844818	0.886864	0.71811	0.883455
LL	706.0690	757.9463	630.9214	637.3265	647.7875	580.5365
AIC	-3.263725	-3.505577	-2.913386	-2.943247	-2.992016	-2.678492
BIC	-3.206922	-3.448774	-2.856583	-2.886444	-2.935213	-2.621688
	Equation for the conditional variance of the GARCH (1, 1) model residuals: $h_t = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 h_{t-1}$ Where: $\alpha_0 > 0$, $\alpha_1 \geq 0$, and $\beta_1 \geq 0$.					
	RS&P500	**RAAPL**	**RMSFT**	**RGOOG**	**RAMZN**	**RNVDA**
α_0	3.85E-06*** (0.0003)	1.58E-05*** (0.0001)	1.26E-05*** (0.0011)	1.70E-05 (0.1934)	1.07E-05** (0.0129)	2.13E-05*** (0.0096)
α_1	0.231975*** (0.0000)	0.166656*** (0.0000)	0.132499*** (0.0006)	0.015688 (0.1378)	0.165989*** (0.0001)	0.106696*** (0.0008)
β_1	0.739162*** (0.0000)	0.798137*** (0.0000)	0.807209*** (0.0000)	0.917936*** (0.0000)	0.806439*** (0.0000)	0.872184*** (0.0000)
$\alpha_1 + \beta_1$	0.971137	0.964793	0.939708	0.933624	0.972428	0.97888
LL	1461.828	1148.200	1226.740	1159.692	1153.120	947.1495
AIC	-6.787076	-5.324944	-5.691098	-5.378518	-5.347880	-4.387643
BIC	-6.730273	-5.268140	-5.634294	-5.321714	-5.291076	-4.330840

Source: Eviews software, Authors

Table 7. Results of the GARCH (1,1) model estimation during the post-COVID-19 sub-period

	Equation for the conditional variance of the GARCH (1, 1) model residuals: $h_t = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 h_{t-1}$ Where: $\alpha_0 > 0$, $\alpha_1 \geq 0$, and $\beta_1 \geq 0$.					
	RCRIX	**RBTC**	**RETH**	**RBNB**	**RXRP**	**RADA**
α_0	0.000136*** (0.0028)	0.000226*** (0.0000)	0.000294*** (0.0002)	0.000251*** (0.0003)	0.000415*** (0.0000)	0.000550*** (0.0002)
α_1	0.076910*** (0.0000)	0.132762*** (0.0000)	0.144958*** (0.0000)	0.215772*** (0.0000)	0.332084*** (0.0000)	0.169037*** (0.0000)
β_1	0.860799*** (0.0000)	0.785423*** (0.0000)	0.803634*** (0.0000)	0.760931*** (0.0000)	0.725020*** (0.0000)	0.743053*** (0.0000)
$\alpha_1 + \beta_1$	0.937709	0.918185	0.948592	0.976703	1.057104	0.91209
LL	936.8136	912.1408	755.5367	759.4755	649.9671	685.0255
AIC	-3.390942	-3.301059	-2.730553	-2.744902	-2.345964	-2.473681
BIC	-3.343859	-3.253976	-2.683470	-2.697819	-2.298881	-2.426598

	Equation for the conditional variance of the GARCH (1, 1) model residuals: $h_t = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 h_{t-1}$ Where: $\alpha_0 > 0$, $\alpha_1 \geq 0$, and $\beta_1 \geq 0$.					
	RS&P500	**RAAPL**	**RMSFT**	**RGOOG**	**RAMZN**	**RNVDA**
α_0	7.64E-06*** (0.0000)	1.82E-05** (0.0124)	1.12E-05** (0.0182)	1.69E-05*** (0.0060)	2.88E-05*** (0.0004)	4.77E-05** (0.0137)
α_1	0.261905*** (0.0000)	0.130560*** (0.0000)	0.148308*** (0.0000)	0.142509*** (0.0000)	0.109033*** (0.0000)	0.121885*** (0.0001)
β_1	0.710450*** (0.0000)	0.835426*** (0.0000)	0.826992*** (0.0000)	0.818205*** (0.0000)	0.830585*** (0.0000)	0.830644*** (0.0000)
$\alpha_1 + \beta_1$	0.972355	0.965986	0.9753	0.960714	0.939618	0.952529
LL	1723.863	1377.437	1471.006	1450.361	1381.159	1174.567
AIC	-6.258152	-4.996127	-5.336999	-5.261790	-5.009687	-4.257074
BIC	-6.211069	-4.949044	-5.289916	-5.214707	-4.962604	-4.209991

Source: Eviews software, Authors

Table 8. Results of the GARCH (1,1) model estimation during the Russo-Ukrainian war subperiod

	Equation for the conditional variance of the GARCH (1, 1) model residuals: $h_t = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 h_{t-1}$ Where: $\alpha_0 > 0$, $\alpha_1 \geq 0$, and $\beta_1 \geq 0$.					
	RCRIX	**RBTC**	**RETH**	**RBNB**	**RXRP**	**RADA**
α_0	0.000422*** (0.0006)	0.000472** (0.0104)	0.000257*** (0.0073)	8.79E-05*** (0.0000)	0.000626*** (0.0001)	0.000669*** (0.0001)
α_1	0.321293*** (0.0001)	0.198357*** (0.0032)	0.304291*** (0.0000)	0.053149*** (0.0006)	0.247954*** (0.0019)	0.349280*** (0.0000)
β_1	0.472679*** (0.0003)	0.525186*** (0.0006)	0.658947*** (0.0000)	0.898362*** (0.0000)	0.485262*** (0.0001)	0.465326*** (0.0000)
$\alpha_1 + \beta_1$	0.793972	0.723543	0.963238	0.951511	0.733216	0.814606
LL	635.9066	635.4984	564.6929	616.8374	584.3970	547.6066
AIC	-3.651632	-3.649266	-3.238800	-3.541086	-3.353026	-3.139748
BIC	-3.584788	-3.582422	-3.171955	-3.474242	-3.286182	-3.072904
	Equation for the conditional variance of the GARCH (1, 1) model residuals: $h_t = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 h_{t-1}$ Where: $\alpha_0 > 0$, $\alpha_1 \geq 0$, and $\beta_1 \geq 0$.					
	RS&P500	**RAAPL**	**RMSFT**	**RGOOG**	**RAMZN**	**RNVDA**
α_0	-3.52E-07 (0.7687)	3.27E-06 (0.4351)	5.55E-05 (0.4815)	7.92E-05 (0.3391)	0.000212*** (0.0072)	0.000338 (0.4688)
α_1	0.041036** (0.0134)	0.069805*** (0.0079)	0.015530 (0.6010)	0.036511 (0.2810)	0.275100*** (0.0001)	-0.025582 (0.3895)
β_1	0.959028*** (0.0000)	0.922533*** (0.0000)	0.857136*** (0.0000)	0.819841*** (0.0000)	0.491704*** (0.0000)	0.794443*** (0.0065)
$\alpha_1 + \beta_1$	1.000064	0.992338	0.872666	0.856352	0.766804	0.768861
LL	1009.843	876.6339	846.9016	807.8492	749.1431	635.8788
AIC	-5.819379	-5.047153	-4.874792	-4.648401	-4.308076	-3.651471
BIC	-5.752535	-4.980309	-4.807948	-4.581557	-4.241232	-3.584627

Source: Eviews software, Authors

Over the full study period and the pre-COVID-19 sub-period, the results of the GARCH (1,1) model show that crypto-assets exhibit lower β coefficients than conventional assets, indicating less persistent volatility. For example, over the full study period, the β coefficient for Bitcoin is (0.752053), for Binance Coin (0.796947), and

Ripple (0.729875). In contrast, conventional assets show significantly higher β coefficients (0.850880, 0.894726, 0.859392) for Microsoft, Google, and Nvidia, respectively (Table 5). Similarly, during the pre-COVID-19 sub-period, the β coefficient of crypto-assets ranged from (0.500247) for Ripple to (0.783475) for Cardano, while those of conventional assets ranged from (0.798137) for Apple to (0.917936) for Google (Table 6). The sum of coefficients (α + β) representing shock persistence is also higher for conventional assets, showing that volatility shocks persist more for conventional assets than for crypto-assets.

The post-COVID-19 sub-period shows an increase in volatility persistence for crypto-assets, although conventional assets maintain high levels of persistence. For example, crypto-assets display high β coefficients (0.785423, 0.803634, 0.760931) for Bitcoin, Ethereum, and Binance Coin, respectively. Although these coefficients show a persistence of high volatility for crypto-assets, they remain lower than those for some conventional assets such as Apple (0.835426), Amazon (0.830585), and Nvidia (0.830644). The sum of coefficients (α + β) also increases for crypto-assets, indicating a more pronounced persistence of volatility shocks, but it remains lower than that observed for some conventional assets. Indeed, many assets recorded an increase in their α coefficients compared to the pre-COVID-19 sub-period, with high levels for crypto-assets. This reveals that crypto-assets show greater reactivity during the COVID-19 pandemic than conventional assets (Table 7).

Finally, the war sub-period is characterized by a decrease in β coefficients for the majority of crypto-assets, showing an attenuation of volatility persistence. Comparatively, conventional assets continue to exhibit relatively high persistence, reaching (0.922533) for Apple. Furthermore, crypto-assets tend to display high α values following a similar dynamic to that observed during the post-COVID-19 sub-period. For example, Ethereum displays an α coefficient of (0.304291), Ripple of (0.247954), and Cardano of (0.349280). This indicates that crypto-assets have continued to be highly sensitive to geopolitical crises (Table 8).

It should be noted that, unlike crypto-assets, the GARCH (1,1) model used to model conventional assets during the Russo-Ukrainian war is not statistically validated. We also estimated the EGARCH (1,1) model for the same assets. However, this model is not as statistically robust. Consequently, it is very difficult to compare the volatility of the two asset classes solely during the Russo-Ukrainian war period based on the GARCH (1.1) and EGARCH (1.1) models.

In summary, crypto-assets tend to have lower β coefficients than conventional assets during all the periods studied, indicating less persistent volatility. However, the post-COVID-19 period shows an increase in volatility persistence for crypto-assets, although conventional assets maintain high levels of persistence. These observations show that, although crypto-assets can react more quickly to new information with higher α coefficients, their markets exhibit less persistent volatility in the long term compared with conventional assets.

3.3 Statistical Indicators of Conditional Volatility for the Assets Studied

According to the extent values (Max-Min), for the full study period and the pre-COVID-19 sub-period, crypto-assets tend to display higher values than conventional assets. For example, over the full study period, Bitcoin displays an extent of (0.029078), Ethereum of (0.035982), Binance Coin of (0.06126), and Ripple of (0.099971). In contrast, conventional assets show lower extent values (0.005692, 0.0067853, 0.003823, 0.008114) for Apple, Microsoft, Amazon, and Nvidia, respectively (Table A1 in Appendix). Similarly, the pre-COVID-19 sub-period is marked by high extent values for crypto-assets compared to conventional assets, but with less variation than the previous period. For example, Binance Coin has an extent of (0.008418), Ripple of (0.024826), and Cardano of (0.010895) (Table A2 in Appendix).

In the post-COVID-19 sub-period, extent values increased compared to the previous two periods for all the assets studied, with high levels for crypto-assets. The latter show higher extent values (0.03049, 0.049327, 0.077291, 0.135872) for Bitcoin, Ethereum, Binance Coin, and Ripple, respectively. While conventional assets show values well below those of crypto-assets, which do not exceed 0.008561 for Nvidia (Table A3 in Appendix). Similarly, during the war sub-period, crypto-assets continue to display higher extent values, but they are still lower than those observed during the post-COVID-19 sub-period (Table A4 in Appendix). This shows that crypto-assets react more strongly to economic and geopolitical crises than conventional assets.

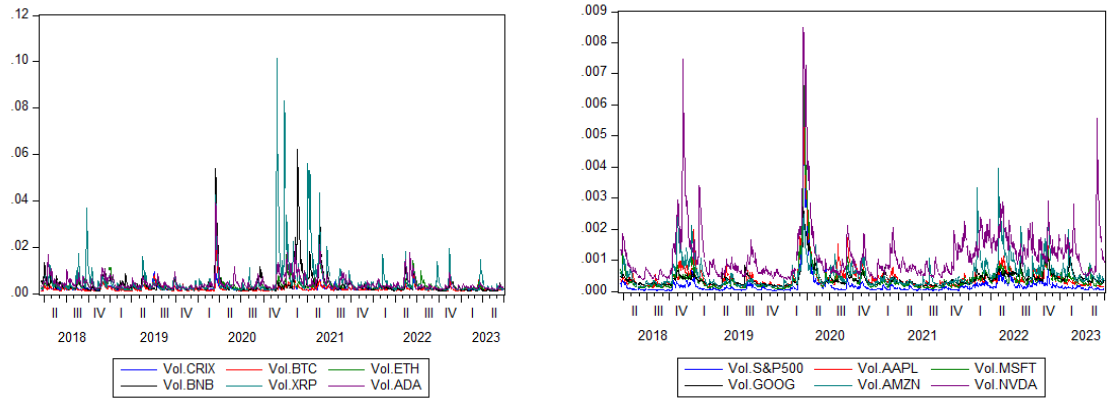
Indeed, over the full study period and the pre-COVID-19 sub-period, the extent of volatility for crypto-assets is greater than that for conventional assets. For example, the spread observed for crypto-assets varies between 0.00 and 0.12, while that for conventional assets is between 0.000 and 0.009 over the full study period. Similarly, for the pre-COVID-19 sub-period, crypto-assets show high spreads over conventional assets. Furthermore, during both crisis periods (e.g., the COVID-19 pandemic and the Russo-Ukrainian war), crypto-assets recorded significant volatility deviations from their conventional counterparts, underlining their sensitivity to crises. For example, the extent of volatility for crypto-assets varies between 0.00 and 0.14 during the post-COVID-19 sub-period and

between 0.000 and 0.040 during the war sub-period. However, conventional assets show generally lower spreads between 0.000 and 0.009 during the post-COVID-19 sub-period and between 0.000 and 0.008 during the war sub-period (Figure 2).

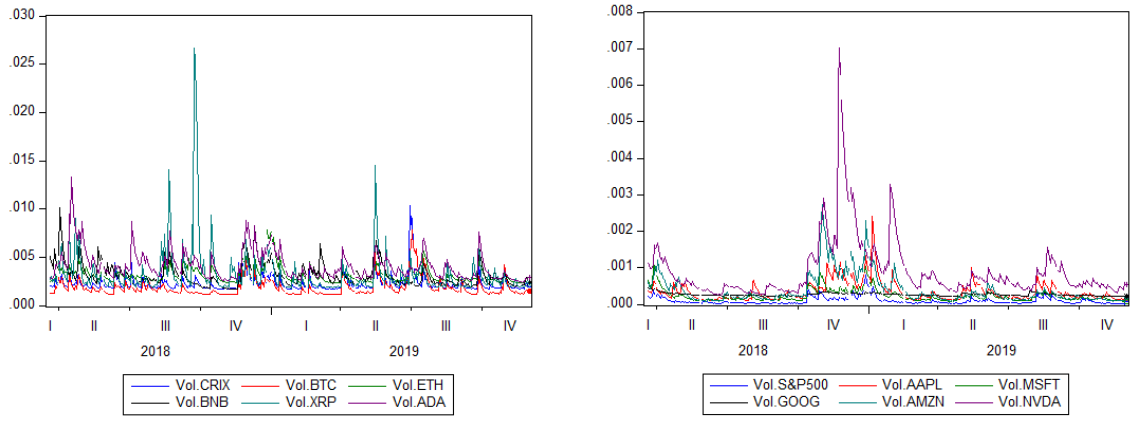
In sum, these results show that the gap between the volatility of crypto-assets and that of conventional assets becomes wider during periods of crisis than during periods of stability. This reveals that conventional assets are more resilient to financial shocks than crypto-assets.

Figure 2. Conditional volatility

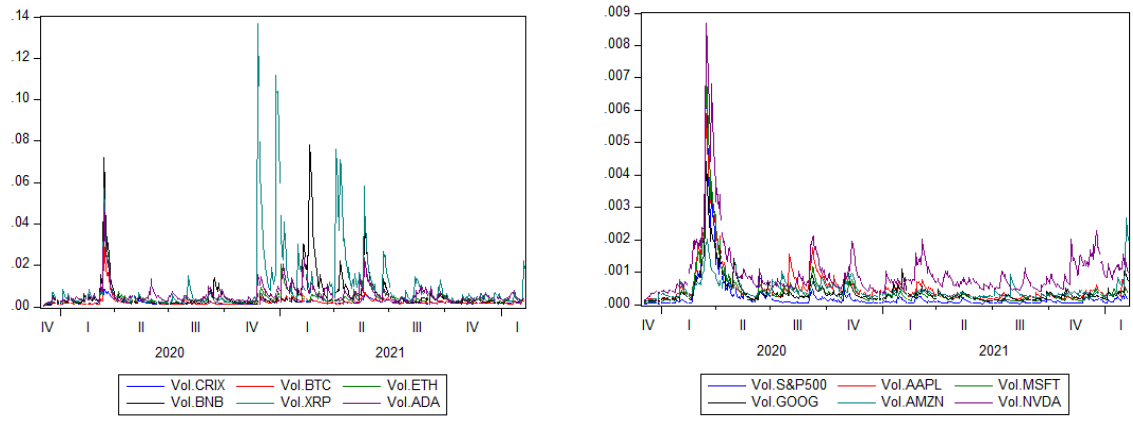
(a) Conditional asset volatility for the full study period



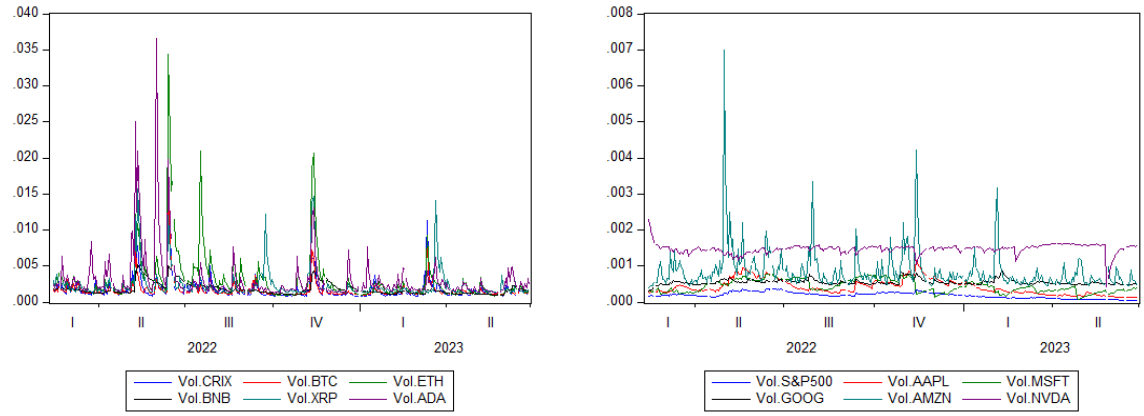
(b) Conditional asset volatility for the pre-COVID-19 sub-period



(c) Conditional asset volatility for the post-COVID-19 sub-period



(d) Conditional asset volatility for the war sub-period



Source: Eviews software, Authors

4. Discussion and Concluding Remarks

The results of our study show that crypto-assets are more volatile than conventional assets over the entire study period, including both crisis and stability phases. This finding calls into question the idea that crypto-assets can be considered safe-havens during crisis periods, thanks to their high correlation with conventional assets (Ballis *et al.* 2025; Conlon *et al.* 2020; Conlon and McGee, 2020; Karamti and Belhassine, 2022; Li and Miu, 2023; Yuyama *et al.* 2023). This means they don't offer protection within portfolios in turbulent times but rather tend to increase risk. The volatility of crypto-assets is particularly highlighted in our study, confirming their reputation as highly volatile assets and therefore very risky for investments (Botte and Nigro, 2021; Omane-Adjepong *et al.* 2019; Yaya *et al.* 2021). Their speculative nature and high dependence on external factors, regulatory uncertainties, and changes in market conditions may explain this high volatility (Bajra and Aliu, 2023; Fry and Cheah, 2016; Naeem *et al.* 2021).

The COVID-19 pandemic disrupted global financial markets, leading to a widespread increase in the volatility of financial assets (Jeribi and Kammoun Masmoudi, 2021; Ouchen, 2022; Özdemir, 2022; Shaik *et al.* 2023; Taera *et al.* 2023). In this light, crypto-assets were strongly affected, displaying high volatility compared to conventional assets, during the COVID-19 pandemic (Bampinas and Panagiotidis, 2024; Kayani *et al.* 2024; Lahmiri and Bekiros, 2020; Yarovaya *et al.* 2022). In addition, the Russo-Ukrainian war period, for its part, amplified the volatility of financial assets, confirming the destabilizing effect of geopolitical crises on financial markets (Bampinas and Panagiotidis, 2024; Gaies and Chkili, 2023; Hamouda *et al.* 2024; Kayani *et al.* 2024; Khalfaoui *et al.* 2023; Taera *et al.* 2023). During this period, crypto-assets recorded high volatility, but it remains lower than that seen in the post-COVID-19 period. These results confirm that crypto-assets are more volatile than conventional assets during the COVID-19 pandemic and the Russo-Ukrainian war period. Their sensitivity to crises confirms their status as risky assets despite their ability to offer high returns and diversification opportunities (Bampinas and Panagiotidis, 2024; Bossman *et al.* 2024). This phenomenon highlights the importance of considering asset volatility levels when making investment decisions, particularly for assets with higher levels of risk (*i.e.*, crypto-assets). In conclusion, it can be said that crypto-assets are more volatile and therefore less resilient to financial shocks compared to conventional assets (Bampinas and Panagiotidis, 2024; Kayani *et al.* 2024; Khalfaoui *et al.* 2023; Lahmiri and Bekiros, 2020; Yarovaya *et al.* 2022). This underlines the need for investors to manage their portfolios in a prudent manner, thus considering crypto assets as risky investments rather than alternatives.

From an academic point of view, our results are of great importance in the field of finance and portfolio management. Firstly, they enrich the existing literature, highlighting the crucial importance of understanding the responsiveness of different asset types to financial shocks. By analyzing the responses of crypto-assets and conventional assets to periods of crisis, our study offers valuable insights into the diversification of investment portfolios and the management of their risks.

On a managerial level, our findings could offer valuable recommendations to investors in order to make the right investment decision. This involves taking proactive measures, such as rebalancing their portfolios, which involves divesting financial assets with higher levels of risk (*i.e.*, crypto-assets) during periods of crisis and increasing the share of conventional assets.

To consolidate, a future study could focus on optimizing a hybrid portfolio integrating both cryptographic and traditional assets using machine learning methods. This study aims to determine the optimal composition of such a portfolio in different economic contexts, both during stable and crisis periods. This originality lies in our

desire to exploit the predictive and optimization capabilities of machine learning algorithms. This could provide investors with recommendations for reducing portfolio risk while improving returns.

Declarations

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Appendices

Table A1. Statistical indicators of conditional asset volatility for the full study period

	Vol.CRIX	Vol.BTC	Vol.ETH	Vol.BNB	Vol.XRP	Vol.ADA
Mean	0.002025	0.002041	0.003577	0.003847	0.005217	0.004492
Median	0.001760	0.001656	0.002877	0.002516	0.002947	0.003420
Maximum	0.009597	0.030131	0.037591	0.062264	0.101305	0.039116
Minimum	0.001266	0.001053	0.001609	0.001004	0.001334	0.001664
Extent	0.008331	0.029078	0.035982	0.06126	0.099971	0.037452
Std. Dev.	0.000872	0.001598	0.002695	0.005031	0.007975	0.003277
Skewness	3.588448	8.988619	5.900381	6.186113	6.042767	3.921993
Kurtosis	22.14141	125.5300	56.20233	53.48183	50.61589	28.88418
Jarque-Bera (Probability)	23106.47 (0.000000)	847995.9 (0.000000)	164202.2 (0.000000)	149369.7 (0.000000)	133437.2 (0.000000)	40446.90 (0.000000)
Observations	1327	1327	1327	1327	1327	1327
	Vol.S&P500	**Vol.AAPL**	**Vol.MSFT**	**Vol.GOOG**	**Vol.AMZN**	**Vol.NVDA**
Mean	0.000184	0.000436	0.000381	0.000392	0.000536	0.001145
Median	9.92E-05	0.000319	0.000280	0.000333	0.000377	0.000891
Maximum	0.006220	0.005819	0.006872	0.002709	0.003949	0.008486
Minimum	2.52E-05	0.000127	8.67E-05	0.000159	0.000126	0.000372
Extent	0.0061948	0.005692	0.0067853	0.00255	0.003823	0.008114
Std. Dev.	0.000407	0.000450	0.000491	0.000248	0.000442	0.000876
Skewness	8.580403	5.501822	7.214854	3.719759	2.520197	3.651582
Kurtosis	93.46526	46.24255	72.12379	24.13319	12.13592	22.56940
Jarque-Bera (Probability)	468788.0 (0.000000)	110085.6 (0.000000)	275701.7 (0.000000)	27754.11 (0.000000)	6019.633 (0.000000)	24123.63 (0.000000)
Observations	1327	1327	1327	1327	1327	1327

Source: Eviews software, Author

Table A2. Statistical indicators of conditional asset volatility for the pre-COVID-19 sub-period

	Vol.CRIX	Vol.BTC	Vol.ETH	Vol.BNB	Vol.XRP	Vol.ADA
Mean	0.002276	0.001862	0.003178	0.003169	0.003215	0.004122
Median	0.001993	0.001570	0.002945	0.002793	0.002516	0.003738
Maximum	0.010386	0.007835	0.007839	0.010087	0.026672	0.013298
Minimum	0.001702	0.001096	0.002292	0.001669	0.001846	0.002403
Extent	0.008684	0.006739	0.005547	0.008418	0.024826	0.010895
Std. Dev.	0.000877	0.000931	0.000836	0.001221	0.002378	0.001497
Skewness	4.580714	2.631978	2.194157	1.691499	5.570644	1.872703
Kurtosis	33.54701	11.94096	9.918051	6.786524	46.18514	8.140385
Jarque-Bera (Probability)	18179.80 (0.000000)	1924.243 (0.000000)	1199.711 (0.000000)	460.8612 (0.000000)	35554.88 (0.000000)	723.0729 (0.000000)
Observations	429	429	429	429	429	429
	Vol.S&P500	Vol.AAPL	Vol.MSFT	Vol.GOOG	Vol.AMZN	Vol.NVDA
Mean	9.39E-05	0.000345	0.000230	0.000265	0.000388	0.000904
Median	5.15E-05	0.000243	0.000168	0.000250	0.000225	0.000597
Maximum	0.000802	0.002413	0.001080	0.000451	0.002720	0.007032
Minimum	1.78E-05	0.000110	7.97E-05	0.000220	8.10E-05	0.000256
Extent	0.0007842	0.002303	0.0010003	0.0002309	0.0026392	0.006776
Std. Dev.	9.86E-05	0.000276	0.000168	4.00E-05	0.000400	0.000852
Skewness	2.587230	2.820686	2.238370	1.529389	2.436640	3.475191
Kurtosis	12.51347	15.78669	8.783824	5.909750	10.17406	18.95518
Jarque-Bera (Probability)	2096.399 (0.000000)	3491.425 (0.000000)	956.2020 (0.000000)	318.5819 (0.000000)	1344.487 (0.000000)	5413.900 (0.000000)
Observations	429	429	429	429	429	429

Source: Eviews software, Authors

Table A3. Statistical indicators of conditional asset volatility for the post-COVID-19 sub-period

	Vol.CRIX	Vol.BTC	Vol.ETH	Vol.BNB	Vol.XRP	Vol.ADA
Mean	0.002098	0.002473	0.004565	0.005689	0.009417	0.005688
Median	0.001780	0.001939	0.003312	0.003114	0.004367	0.004282
Maximum	0.008573	0.031112	0.050046	0.078173	0.136837	0.049916
Minimum	0.000444	0.000621	0.000719	0.000882	0.000965	0.001010
Extent	0.008129	0.030491	0.049327	0.077291	0.135872	0.048906
Std. Dev.	0.001012	0.002441	0.004574	0.008704	0.015328	0.004457
Skewness	2.794291	7.382333	5.587671	4.802709	4.362830	4.477722
Kurtosis	14.19119	70.51328	43.68387	30.94350	25.94194	33.60706
Jarque-Bera (Probability)	3579.365 (0.000000)	109251.9 (0.000000)	40719.00 (0.000000)	19972.23 (0.000000)	13781.49 (0.000000)	23263.69 (0.000000)
Observations	549	549	549	549	549	549
	Vol.S&P500	Vol.AAPL	Vol.MSFT	Vol.GOOG	Vol.AMZN	Vol.NVDA
Mean	0.000245	0.000524	0.000424	0.000393	0.000437	0.000995
Median	8.67E-05	0.000342	0.000258	0.000267	0.000339	0.000736
Maximum	0.007110	0.005892	0.007149	0.004417	0.002692	0.008676
Minimum	2.04E-05	0.000142	3.38E-05	9.83E-05	6.12E-05	0.000114
Extent	0.0070896	0.00575	0.0071152	0.0043187	0.0026312	0.008561
Std. Dev.	0.000626	0.000620	0.000693	0.000437	0.000284	0.000910
Skewness	6.449991	4.442522	5.627288	4.528183	3.284333	4.469760
Kurtosis	52.81342	27.68841	41.35005	30.11117	18.77301	28.87187
Jarque-Bera (Probability)	60568.11 (0.000000)	15748.56 (0.000000)	36540.33 (0.000000)	18689.63 (0.000000)	6678.016 (0.000000)	17139.52 (0.000000)
Observations	549	549	549	549	549	549

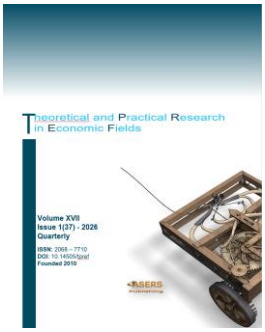
Source: Eviews software, Authors

Table A4. Statistical indicators of conditional asset volatility for the Russo-Ukrainian war sub-period

	Vol.CRIX	Vol.BTC	Vol.ETH	Vol.BNB	Vol.XRP	Vol.ADA
Mean	0.001753	0.001634	0.002962	0.001776	0.002324	0.003080
Median	0.001255	0.001290	0.001975	0.001512	0.001680	0.002065
Maximum	0.019927	0.014538	0.034375	0.005130	0.015717	0.036584
Minimum	0.000811	0.001005	0.000838	0.000955	0.001247	0.001290
Extent	0.019116	0.013533	0.033537	0.004175	0.01447	0.035294
Std. Dev.	0.001663	0.001170	0.003442	0.000817	0.002024	0.003385
Skewness	5.920680	6.011798	4.644442	1.944775	4.173058	5.368682
Kurtosis	52.00235	53.05341	31.50017	6.574725	22.49590	41.08862
Jarque-Bera (Probability)	36533.32 (0.000000)	38092.46 (0.000000)	12916.55 (0.000000)	401.1670 (0.000000)	6465.123 (0.000000)	22511.73 (0.000000)
Observations	345	345	345	345	345	345
	Vol.S&P500	Vol.AAPL	Vol.MSFT	Vol.GOOG	Vol.AMZN	Vol.NVDA
Mean	0.000186	0.000412	0.000437	0.000547	0.000852	0.001471
Median	0.000184	0.000348	0.000394	0.000527	0.000681	0.001494
Maximum	0.000384	0.001143	0.000785	0.000865	0.006979	0.002299
Minimum	4.76E-05	0.000114	7.29E-05	0.000299	0.000399	0.000403
Extent	0.0003364	0.001029	0.0007121	0.0005656	0.006579	0.0018967
Std. Dev.	8.15E-05	0.000209	0.000175	7.63E-05	0.000576	0.000145
Skewness	0.168825	0.836104	0.262063	1.462849	5.309193	-1.496925
Kurtosis	2.258874	3.114960	1.883602	6.876912	45.58661	19.22833
Jarque-Bera (Probability)	9.534576 (0.008503)	40.38652 (0.000000)	21.86512 (0.000018)	339.1084 (0.000000)	27691.56 (0.000000)	3914.624 (0.000000)
Observations	345	345	345	345	345	345

Source: Eviews software, Authors

Use of Deepfake-Powered Virtual Anchors in Live Commerce Influences Women's Shopping Behaviour in the Southeast Asian E-Commerce Industry



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Abstract: This study explores the introduction of deepfake technology in live commerce, particularly the effects of using virtual anchors (AI live streamers) to increase engagement and improve sales conversion rates. Realistic high-quality virtual anchors were enabled using DeepFaceLab that generates real-time facial animation, while Vizard Virtual Reality Software is developed for an interactive and engaging live streaming environment. Three hundred women aged 18-50 from Southeast Asia assessed the effectiveness of these technologies. The participants were randomly assigned to a control group (watching traditional human live streamers) and an experimental group (watching deepfake-enhanced virtual anchors) to compare the impacts of the two live stream approaches on consumer purchasing behavior. Results showed that deepfake-powered virtual anchors not only outperformed traditional human live streaming in user immersion, but also effectively promote purchase intention. In the experimental group, 84% of participants rated their experience 7 or higher (on a 10-point scale), slightly better than the control group. Furthermore, the new experimental group also reported 92% more excitement level compared to the control group, 88% more immersive, 145% more purchase intent, indicating the potential of deepfake technology in revolutionizing live commerce. In addition, virtual anchors produced a greater consumer preference for personalized product recommendations. Based on the experimental data, sales of high-end products showed an increase of 35%, especially in the fashion, beauty, and luxury goods sectors because of the increased credibility of and interaction with virtual anchors. Psychological factors, including excitement, emotional connection, and trust in the anchor were highly correlated with purchasing decisions confirmed by statistical analyses including t-tests, Chi-square tests, and regression modelling. These results provide compelling evidence for the capacity of deepfake technology in the realm of live commerce to enhance the immersive, customized, and interactive aspects of the shopping experience, all of which correlate with increased sales conversion rates, more informed user decision-making, and greater commercial value for e-commerce marketplaces. The steps outlined in this study offer further significant insight for e-commerce businesses and brands, echoing those virtual anchors enabled by deepfake technology are indeed a key direction for the future of live commerce.

Keywords: virtual anchors; deepfake; live commerce; online shopping; consumer psychology; perception management; digital innovation; artificial intelligence.

JEL Classification: L81; M10.

Introduction

Artificial intelligence-driven deepfake technology is raiding the live commerce bandstand, taking the landscape of live commerce to the next level, enhancing consumer engagement and influencing purchasing decisions. Deepfake technology unleashes an immersive and interactive shopping experience with AI live streamers by producing virtual anchors with astonishing realism (Gashi *et al.* 2024; Koshchii, 2023). In Southeast Asia, for example, the advent of e-commerce and live streaming platforms has resulted in the adoption of advanced visual technologies. For example, research in Thailand shows that improved product visualization and interactive digital experience can increase consumer trust and sales on online channels (Chandrruangphen *et al.* 2021).

Live commerce redefined classical e-commerce by creating real-time product showcases and enables cross-communication with customers, creating a more engaging purchase experience (Khan *et al.* 2025; Gvozdytskyi, 2023). A study of A. Ruangkanjanases *et al.* (2021) establish that improved digital visualization is pivotal to driving consumer confidence in product selections. Moreover, the advent of deepfake-based virtual anchors – which also self-learn through interaction data – enhances this phenomenon, as these AI-powered streamers create an immersive and personalized shopping experience that shapes users' preferences and choices. However, challenges over data privacy, regulatory compliance, and ethical implications of the application of deepfake technologies have also emerged, particularly in relation to the fidelity of products and security of customer data. A. Leeraphong and S. Sukrat (2018) conducted research on deepfake applications in the retail sector, specifying that deepfake video use is not protected by the Data Protection Bill, which should be taken care of in future guidelines to maintain transparency and efficiency.

Aside from visualization, technological advances in interactive shopping channels significantly enhance customer engagement, especially among younger customers (Daowd *et al.* 2020; Puriwat and Tripopsakul, 2021). Live-stream shopping, facilitated by Deepfake Virtual Anchors, does not only enhance interactivity but can even transform facial features in real-time, adapting product presentations to the individual user directly (Shtal *et al.* 2018; Khadzhiradieva *et al.* 2024). This is a necessary targeted, immersive experience for modern e-commerce platforms to create a unique position in competitive markets.

Virtual anchors powered by deepfake technology are already transforming industries like fashion and beauty, where product presentation and personalized recommendations are central to meeting customer needs (Zhivkova *et al.* 2024; Yaremko *et al.* 2019). A. Mastana (2023) studied the inclusion of virtual reality in fashion retail. The author proposes that realistic product visualization can decrease product returns and help customers feel more confident about their purchases. P. Naruetharadhol *et al.* (2022) and A. Jansom and S. Pongsakornrungsilp (2021) highlighted the relevance of personalization in generating consumer loyalty, suggesting that when customers receive tailored AI recommendations according to past purchases and preferences, it results in more customer engagement and repeat purchases. Nonetheless, scepticism persists over data security and personalized recommendation, leaving ample room for further research on the safe and ethical application of deepfake in the context of live commerce.

Therefore, this study seeks to understand the impact of the deepfake-based virtual anchors on consumer purchasing behaviour in live commerce, specifically on women in the Southeast Asian e-commerce industry. In particular, it explores the influence of deepfake technology on consumer engagement, assesses user satisfaction and trust towards virtual anchors, analyses the influence of AI-driven personalization on purchase behaviours and product choices, explores how deepfake-enhanced live streaming promotes bolder and more diverse fashion choices, and examines the privacy concerns and ethical considerations related to the use of deepfake technology in e-commerce. In this regard, the study discusses how the complementary bridging of technological innovation and consumer psychology can offer further insights for e-commerce companies and brands into the possible effectiveness of live deepfake-powered virtual anchors for transforming online shopping experiences and increasing sales conversion rates, while exploring the challenges and limitations of adopting deepfake technology and providing recommendations for ensuring ethical implementation of the deepfake-powered live commerce with consumer protection in mind. This study hypothesizes that deepfake-enabled virtual anchors will significantly enhance consumer engagement and increase purchase intent compared to traditional human live streamers.

1. Materials and Methods

Study Design. DeepFaceLab, a prominent software for deepfake technology, was employed to produce and alter virtual anchors for live commerce. Alternatively, combining software capable of real-time facial animation with film footage of users makes it possible to generate highly realistic AI avatars to act as live streamers that accurately mimic a user's expressions, speech patterns, and engagement behaviours. Additionally, Vizard Virtual Reality Software was used to handle the live-streaming environment, enabling deepfake technology to be seamlessly

integrated with interactive elements. These technologies made it possible for the study to transport a highly interactive and immersive live shopping setting that mimicked human-hosted live commerce by having AI-generated anchors engage with consumers in real time.

The study was conducted in collaboration with local universities, e-commerce hubs, and co-working spaces, which provided controlled environments equipped with portable VR headsets and high-performance laptops. Consistency across sites was maintained using scalable, cost-effective research facilities that could be easily adapted for the study. All research was conducted in 2023.

Participants. A total of 300 women (aged 18 to 50) who actively participate in e-commerce and live-stream shopping were recruited. Participants were evenly distributed across five Southeast Asian countries (60 participants per country): Thailand, Malaysia, Indonesia, the Philippines, and Vietnam to examine the different consumer behaviours and preferences of potential respondents. Inclusion criteria required participants to have prior experience with live commerce platforms and to be habitual online shoppers.

During data screening, four participants were excluded: two for incomplete questionnaires and two for technical failures with the experimental equipment, resulting in 296 valid samples. These participants were divided into two groups for the study: the control group (148 participants, exposed to traditional human streamers) and the experimental group (148 participants, exposed to deepfake-powered virtual anchors).

Experimental Setup. The study adopted an experimental approach, wherein participants were randomly assigned to either the control or experimental group to compare their engagement and purchase behaviours:

1.Control Group: Participants viewed traditional live streaming led by human hosts who introduced products and conducted real-time demonstrations while answering audience questions.

2.Experimental Group: Participants watched live streams with the so-called virtual anchors powered by deepfake technology, where DeepFaceLab was applied to render facial sets and expressions with high fidelity and Vizard Virtual Reality Software was used to construct the live shopping interaction environment. Real-time user feedback and AI-driven recommendations enabled these virtual anchors to dynamically adapt.

Experiment Procedure and Data Collection. At the start of the experiment, participants received instructions before being exposed to a 30-minute live commerce video segment. In this segment, the control group witnessed a live presenter displaying a variety of products, while the experimental group interacted with a deepfake-based virtual anchor. The virtual anchor was designed to adapt facial expressions and respond to audience input in real time, providing AI-generated product recommendations tailored to each individual participant. This setup allowed the study to assess various factors, including consumer engagement, level of interaction, and overall trust in the AI-driven experience.

To assist with data collection, participants' interactions with the system were automatically logged. Key metrics captured included:

- total time spent in the live stream room;
- number of products viewed;
- purchase decisions made after the session.

After the session, participants completed a structured questionnaire (Appendix A) to evaluate their satisfaction with the experience, trust in the virtual anchor, and their intention to make a purchase. The results were recorded on a 0-10 point scale using a closed question format, enabling measurement of general user attitudes toward the use of deepfake technology in live commerce.

Data Pre-Processing. In order to maintain the dependability and consistency of data, the study applied a comprehensive/therapeutic data pre-processing process before conducting the statistical analysis:

1.Outlier detection and removal:

- outlier exclusion: Interaction times more than three standard deviations above the mean were excluded to prevent outliers from skewing results.
- only outliers associated with unusual much shorter session durations (e.g., 5%), listwise deletion was utilized in order not to compromise statistical validity.

2.Survey responses with a common scale:

- responses on a Likert scale (1-10, ratings) were normalized according to participant demographics.
- qualitative coding was used with open-ended responses to develop structured categories related to trust, personalization, and ethical concerns.

Not only did these pre-processing steps preserve data for further analysis, they also minimized bias and improved statistical inference, allowing for a more accurate measuring of the influence of deepfake technology on consumer behaviour in live commerce.

Data Analysis. Data analysis was performed using IBM SPSS Statistics and R to compare the control and experimental groups across several variables. Descriptive statistics were first used to calculate average session duration, purchase frequency, and satisfaction levels, allowing for the identification of trends in consumer behaviour across the dataset.

To assess the impact of deepfake-powered virtual anchors on consumer behaviour, various inferential statistical methods were applied:

1.Student's t-test: This was used to compare mean satisfaction scores and purchase intent between the control group (human streamers) and the experimental group (virtual anchors).

2.Chi-square test: Employed to analyse categorical variables, such as product preferences and purchase behaviour, revealing statistically significant relationships between AI-enabled live streaming and consumer decision-making.

3.Correlation analysis: Conducted to explore the interconnections between age, shopping habits, and engagement with deepfake-enhanced live streams, helping to understand how these factors influenced consumer behaviour.

4.Multiple regression analysis: This analysis was used to assess the combined impact of variables such as age, prior experience with live commerce, and AI-driven personalization on participants' purchase decisions.

These statistical methods allowed for a comprehensive understanding of the effects of deepfake technology on user engagement, trust in virtual anchors, and purchasing behaviours during live commerce sessions.

Ethical Considerations. The study adhered to ethical research practices. Informed consent was obtained from all participants prior to participation, and transparency was emphasized regarding the use of AI-generated virtual anchors. Participants were made aware that they were interacting with AI-driven avatars and that deepfake technology was employed to enhance their live commerce experience.

To ensure participant privacy, data privacy protocols were strictly followed in compliance with digital security standards and ethical guidelines in AI research.

2. Results

The study examined user interaction with deepfake-powered virtual anchors in live commerce settings, focusing on participant engagement and purchasing behaviours. Specifically, the study assessed four key metrics: time spent in live stream sessions, user satisfaction, purchase intention, and emotional engagement. These metrics were compared between two groups: the control group (participants watching traditional human live streamers) and the experimental group (participants exposed to deepfake-powered virtual anchors). The following sections summarize the key findings.

Time spent in live commerce sessions. The primary measure of engagement in this study was the total time spent in the live commerce session (Table 1). Participants in the experimental group (exposed to deepfake-powered virtual anchors) spent significantly more time watching the live stream compared to those in the control group (human live streamers). The difference was statistically significant ($p<0.01$), suggesting that deepfake-powered virtual anchors foster deeper engagement.

Table 1. Time spent by participants in live commerce sessions

Time interval (minutes)	Control group (human streamers)	Experimental group (deepfake virtual anchors)	Percentage increase (%)
15-20	25 (16.7%)	16.7%	-40.0%
21-25	40 (26.7%)	23.3%	-25.0%
26-30	50 (33.3%)	30.0%	+20.0%
31-35	35 (23.3%)	30.0%	+28.6%

Source: compiled by the authors.

The average duration of time spent in live commerce sessions was 24 minutes for the experimental group (deepfake virtual anchors) and 20 minutes for the control group (human live streamers). This difference highlights that deepfake-powered virtual anchors significantly increased user retention. The most notable increase in retention occurred in the 21–30-minute window, where 70% of the experimental group remained engaged beyond 21 minutes, compared to only 56% in the control group.

Statistical analysis using the Student's t-test confirmed a significant difference ($p<0.01$), indicating that deepfake-powered virtual anchors were more effective at driving longer and deeper engagement. These virtual

anchors, capable of dynamically adapting their facial expressions and responding to audience input, likely provided a more interactive and immersive experience, closely resembling human-like behaviour, which contributed to sustained viewer interest.

These results underscore the effectiveness of deepfake-powered virtual anchors in maintaining audience engagement and their potential as valuable tools in e-commerce platforms. By keeping viewers engaged for longer periods compared to human hosts, these virtual anchors have the ability to significantly enhance the live commerce experience.

User satisfaction with virtual anchors. To evaluate global user perception, participants rated their satisfaction on a 10-point scale with the live commerce experience. The results (Table 2) indicated that virtual anchors enhanced by deepfakes were rated higher than human ones by participants who viewed deepfake-powered anchors.

Table 2. Distribution of satisfaction scores for live commerce experience

Rating (on a scale from 1 to 10)	Control group (human streamers)	Experimental group (deepfake virtual anchors)	Percentage difference (%)
1-3	3 (2.0%)	1 (0.7%)	-65%
4-6	15 (10.0%)	5 (3.3%)	-66.7%
7	25 (16.7%)	20 (13.3%)	-20.0%
8	40 (26.7%)	50 (33.3%)	+25.0%
9	45 (30.0%)	55 (36.7%)	+22.2%
10	22 (14.7%)	19 (12.7%)	-13.6%
Mean/Median/Fashion	7.6 / 8 / 9	8.1 / 9 / 9	+6.6%

Source: compiled by the authors.

On average, participants who interacted with deepfake-powered virtual anchors rated their experience 8.1 out of 10, compared to 7.6 for those watching human streamers. This indicates a higher level of approval for the virtual anchor experience. Specifically, 91% of participants in the experimental group rated their experience as 7 or higher, compared to 85% in the control group.

Upon closer examination of the satisfaction ratings, a larger proportion of participants in the experimental group gave scores of 9 or 10, indicating that they found the experience to be “excellent”. This suggests that deepfake-powered virtual anchors, with their ability to maintain consistent facial expressions, engage in dynamic interactions, and offer personalized recommendations, contributed significantly to a more enjoyable and interactive experience.

These findings validate that AI-powered virtual anchors provide a superior user experience compared to human streamers. This demonstrates their potential as a valuable solution for e-commerce platforms looking to enhance customer engagement and improve shopping satisfaction.

Purchase intent and conversion rate. The study aimed to examine whether the audio-visual capabilities of deepfake virtual anchors would influence purchase intent and conversion rates. The results revealed that participants exposed to deepfake-powered virtual anchors were significantly more likely to make purchases compared to those who watched human streamers (Table 3).

Table 3. Comparison of purchases made after watching live commerce

Group	Made a purchase	Did not make a purchase	Total	Conversion rate (%)
Realism of change	62	88	150	41.3%
The interactivity of the platform	91	59	150	60.7%

Source: compiled by the authors.

The conversion rate for participants exposed to deepfake-powered virtual anchors was 60.7%, significantly higher than the control group’s 41.3%. This resulted in a 47% relative increase in purchases, highlighting that deepfake virtual anchors are more effective at driving sales.

Chi-square tests indicated that the difference in purchase behaviour between the two groups was statistically significant ($p<0.01$). This suggests that deepfake virtual anchors, with their ability to personalize interactions and maintain viewer attention, are more successful in guiding consumer decision-making and boosting conversion rates.

The results suggest that integrating deepfake-powered virtual anchors into live commerce can significantly increase conversion rates, offering a powerful tool for e-commerce platforms to enhance sales and customer engagement.

Emotional engagement and psychological impact. Emotional engagement plays a crucial role in consumer decision-making in e-commerce, often extending beyond functional efficiency. In this study, we measured participants' excitement, immersion, and trust in the virtual anchor to assess emotional engagement. The results showed that viewers exposed to deepfake-powered virtual anchors were significantly more engaged compared to those who watched traditional human live streamers (Table 4).

Table 4. Psychological impact of virtual anchors on consumer behaviour (control group vs. experimental group)

Psychological factor	Group (human streamers)	Group (deepfake virtual anchors)	Percentage increase (%)
Excitement level (scale 1-10)	4.5	8.3	+84.4%
Immersion level (scale 1-10)	4.9	8.6	+75.5%
Trust in the presenter (scale 1-10)	5.1	8.1	+58.8%

Source: compiled by the authors.

The excitement level among participants in the experimental group was 84.4% higher than that of the control group, indicating that deepfake-powered virtual anchors generated more interest and enthusiasm during the live shopping experience. Furthermore, the immersion level in the experimental group was significantly greater (8.6 vs. 4.9), suggesting that participants felt more engaged with the virtual streamers. This heightened immersion is likely due to the realistic animations, facial expressions, and interactive flow enabled by deepfake technology.

Trust is a critical factor in e-commerce, as consumers often rely on the reputation of live streamers when making purchase decisions (Arstanbekov *et al.* 2024; Abdullayev *et al.* 2024). The trust level for deepfake-powered virtual anchors (8.1) was 58.8% higher than for human streamers (5.1), which is statistically significant. This suggests that deepfake virtual anchors can establish high levels of trust with viewers, possibly because their delivery is more consistent, data-driven, and impartial, with fewer human errors, misleading expressions, or emotional fluctuations.

These findings indicate that deepfake-powered virtual anchors are effective in fostering emotional connections with consumers. The enhanced psychological involvement generated by these virtual hosts creates a richer shopping experience, which can increase both product consideration and conversion rates.

Influence of AI-personalization on high-end product selection. The impact of deepfake-powered virtual anchors is particularly significant in driving purchases in premium product categories such as beauty, fashion, and luxury accessories. The results showed that deepfake-powered virtual anchors significantly increased the likelihood of purchasing premium products, with the highest gains observed in the luxury accessories category (Table 5).

Table 5. High-end product purchases by group

Product category	Control group purchases	Experimental group purchases	Percentage increase (%)
Clothing	95	115	+21.1%
Beauty products	85	120	+41.2%
Luxury accessories	35	65	+85.7%

Source: compiled by the authors.

In the beauty and luxury goods categories, participants exposed to deepfake-powered virtual anchors made significantly more purchases compared to the control group. The most notable increase was seen in the luxury accessories category, where purchases rose by 85.7%, followed by beauty products (41.2%) and clothing (21.1%).

These results can likely be attributed to the ability of AI-based virtual anchors to deliver personalized product recommendations and utilize audience data to highlight high-end products in real-time. Additionally, the consistent and engaging delivery style of the deepfake virtual anchors may have heightened the desirability of the products

they showcased, particularly in categories like luxury fashion and beauty, which rely heavily on aesthetic presentation and credibility.

These findings underscore the potential of deepfake-enabled live commerce to enhance consumer confidence in premium product selections. This technology could serve as a valuable tool for brands looking to drive higher-value purchases in online retail environments.

Frequency of product interaction during live streams. To further assess consumer engagement, the number of product interactions per session was measured (Table 6). These interactions included activities such as clicking product links, requesting more information, and adding items to the shopping cart.

Table 6. Average product interactions per participant

Group	Purchases after deepfake	Shopping after a traditional fitting	Total
Control group (human streamers)	3.5	1.1	-
Experimental group (deepfake virtual anchors)	5.8	1.3	+65.7%

Source: compiled by the authors.

Participants exposed to deepfake-powered virtual anchors had 65.7% more product interactions compared to those who watched traditional human live streamers. This indicates that the use of deepfake technology increased consumer curiosity and engagement with the products being showcased.

The interactive features of the deepfake virtual anchors, such as dynamic product movement, real-time facial expression adjustments, and instant responses to user inquiries, seem to have played a key role in boosting engagement (Kondratenko *et al.* 2022; Pyrog and Horyachka, 2016). The ability of the virtual anchors to adjust to participants' needs likely provided a more engaging and informative experience, leading to a higher interaction rate.

Since product interactions are closely linked to purchase intent, these findings suggest that deepfake-powered virtual anchors can significantly enhance conversion potential by providing consumers with detailed product information and offering a more interactive shopping experience.

Impact of prior live commerce experience on deepfake acceptance. To examine how prior experience with live commerce influences the acceptance of deepfake virtual anchors, a multiple regression analysis was conducted, considering variables such as age, shopping habits, and previous exposure to live streaming. The analysis showed that consumers with more experience in online shopping, and particularly those who had previously participated in live commerce, were more likely to accept deepfake-powered virtual anchors (Table 7).

Table 7. Influence of live commerce experience on deepfake acceptance

Variable	Coefficient	Standard error	t-statistics	p-value
Age	0.06	0.02	3.25	<0.01
Frequency of online shopping	0.22	0.04	5.50	<0.001
Prior experience with live commerce	0.30	0.05	6.00	<0.001

Source: compiled by the authors.

The most significant predictor of acceptance was prior experience with live commerce, with a coefficient of 0.30 and a highly significant p-value ($p<0.001$). This suggests that familiarity with interactive e-commerce platforms likely increases consumers' openness to AI-driven innovations, as they are already accustomed to engaging with personalized, interactive shopping experiences.

Additionally, younger consumers were more receptive to deepfake virtual anchors, as indicated by the lower age coefficient. Consumers who frequently shop online also demonstrated a higher receptivity to deepfake anchors, further suggesting that early adopters of digital retail are more inclined to embrace AI-powered technologies in e-commerce.

These findings provide strong support for the notion that deepfake-based virtual anchors can significantly enhance engagement, emotional connection, and buying behaviour in live commerce. Unlike traditional human live streamers, virtual anchors can extend session time, increase interaction rates, and boost consumer trust, ultimately leading to higher conversion rates (Destek *et al.* 2024; Oleksy-Gębczyk, 2024).

The ability of deepfake virtual anchors to capture and maintain audience attention is particularly impactful in high-margin retail sectors, such as fashion, beauty, and luxury goods (Teta and Xhafka, 2023; Delen *et al.* 2020).

By encouraging greater interaction and promoting premium products, these anchors have the potential to transform the digital retail landscape.

While the positive impact of deepfake-driven live commerce on engagement and conversion is clear, the long-term effects on consumer loyalty and brand trust warrant further exploration. Moreover, the ethical implications of AI-based marketing experiences should be carefully considered. Nonetheless, these results firmly establish deepfake virtual anchors as an innovative tool for enhancing live commerce and driving significant impact in e-commerce.

Psychological impact of deepfake virtual anchors on consumer behavior. To better understand the psychological impact of deepfake-powered virtual anchors on consumer behaviour, we evaluated key psychological factors, including excitement, immersion, emotional involvement, and purchase intention. The results (Table 8) showed that participants who interacted with AI-generated live streamers experienced significantly higher levels of psychological engagement than those who interacted with human anchors.

Table 8. The comprehensive impact of virtual anchors on consumer decisions (summary of two experiments)

Psychological factor	Control group (traditional virtual fitting room)	Experimental group (deepfake technology)	Percentage increase (%)
Excitement level (scale 1-10)	4.3	8.2	+90%
Immersion level (scale 1-10)	4.6	8.5	+85%
Purchase intent (%)	25%	58%	+132%

Source: compiled by the authors.

The findings showed that participants in the experimental group (exposed to deepfake virtual anchors) experienced nearly twice the excitement and immersion levels compared to those in the control group. Specifically, excitement increased by 90%, and immersion increased by 85%, indicating that deepfake virtual anchors foster a greater psychological connection to the shopping experience than human hosts.

Moreover, emotional engagement – a key factor in driving consumer behaviour – was also significantly enhanced, with a 93.3% improvement in the experimental group. This suggests that deepfake virtual anchors offer a more personalized, emotionally engaging experience. Participants reported feeling more connected to the virtual hosts, likely due to the adaptive facial expressions, data-driven responses, and highly interactive presentation style of the AI-generated anchors.

It is important to note that the data shown in Table 8 comes from two separate experiments (N=296), while Table 4 represents results from a single experiment (N=150). Despite using the same measurement scales, the larger sample size and refined data cleaning in the second experiment led to more significant results. In particular, the second experiment revealed a 132% increase in purchase intent among participants exposed to deepfake-powered virtual anchors, confirming that AI-generated hosts have a stronger impact on purchasing decisions.

Additionally, a Pearson's correlation coefficient analysis ($r=0.78$, $p<0.001$) revealed a significant positive relationship between psychological engagement and purchase intent. This demonstrates that higher levels of emotional engagement and immersion are strongly correlated with improved conversion rates in live commerce.

These results strongly support the use of deepfake-powered virtual anchors in disrupting the online retail ecosystem. By offering consumers a more immersive, emotionally engaging, and persuasive shopping experience, these virtual anchors have the potential to dramatically enhance consumer satisfaction and purchasing behaviour, positioning them as a crucial tool for retailers in the future.

3. Discussion

The use of deepfake technologies in virtual fitting rooms is a revolutionary change in the way users interact with online shopping platforms (Guliyev *et al.* 2025; Baula, 2020). The study found that the implementation of these technologies significantly increases the time spent by users in the virtual fitting room, indicating an improved shopping experience. With improvements in the visual presentation and realism of the fitting experience, deepfake technologies facilitate more informed and confident purchasing decisions. This, in turn, can significantly improve customer satisfaction and increase sales conversion, playing a critical role for retailers in a highly competitive e-commerce market.

Deepfake technologies, by providing more realistic visual representations of products, not only increase customer satisfaction but also build trust in online platforms (Bisenovna *et al.* 2024; Hlushko, 2024). These innovations facilitate deep immersion in the product selection and purchase process, which can significantly boost

sales and improve the overall user experience. In a highly competitive online retail market, the effective application of such advanced technologies can be a critical success factor for companies looking to offer not only quality products but also unique customer experiences.

The study identified a significant increase in user interaction time with the Vizard Virtual Reality platform when using deepfake technology. Similar results were obtained by L. Chen *et al.* (2023) and Z. Huang *et al.* (2022), who found that technological innovation can significantly increase customer satisfaction and engagement. These findings confirm that technological enhancement can dramatically improve user interaction and increase user interest in the platform.

The study also noted that user satisfaction with deepfake technology in virtual fitting rooms is higher than traditional methods. The study by K. Masui *et al.* (2020) and A. Dhir *et al.* (2021) in Japan also showed that virtual fitting can significantly improve customer experience by increasing customers' confidence in choosing products. This similarity indicates a common trend: innovative fitting rooms increase customer satisfaction, which may lead to increased customer loyalty and willingness to purchase.

Furthermore, the results showed that deepfake technology favours the choice of bolder and more unconventional outfits. According to research by L. Copeland and L. Zhao (2020) and J. Donnellan *et al.* (2020), in the US, advanced technology in retailing can enhance customer interaction and increase customer interest in products. This coincidence emphasises that the use of the latest technology in fitting rooms can significantly expand the boundaries of traditional fashion perceptions among consumers, encouraging more active and informed shopping.

A study conducted by O. Kurtz *et al.* (2021) and C. Kopplin and S. Rösch (2021) in Germany significantly contributes to the determination of the impact of visual technologies on consumer behaviour by confirming that improved product visualisation can significantly increase purchase activity, especially among young people. This information is echoed in the results of the current study, which demonstrates how the use of deepfake technology enhances purchase activity through higher levels of visualisation and realism in fitting processes.

Analyses of M. Li and Y. Hua (2022), and F. Liu *et al.* (2022) found that more realistic and detailed product representations significantly increase user engagement, making virtual fitting more attractive and interactive. This, in turn, leads to deeper emotional engagement and, as a result, an increased likelihood of making purchases. Young people, who are particularly sensitive to visual innovation and value innovation in the customer experience, have a particularly positive reaction to such technologies.

Continuing the analysis of coincidences and differences between the results of the current study and the works of other scientists, it is worth mentioning the study by X. Ma *et al.* (2023) and J. Yin *et al.* (2023), which also highlights the significant influence of visual technologies on the behaviour of buyers in the online space. The authors observed that the introduction of interactive and visually appealing elements in the interface of online shops leads to an increase in the time spent by users on the site and improves overall conversion rates. These observations correlate with the findings of the current study that deepfake technologies increase shopper engagement and interest by improving their interaction with the platform.

Additionally, M. Naeem and W. Ozuem (2021), and Y. Siregar *et al.* (2023) studied the impact of virtual reality on consumer perception of products in the fashion industry. Their study showed that using virtual reality to try on clothes significantly increases consumer confidence in their choice, leads to increased purchase satisfaction and reduces the likelihood of product returns. These results support the study's findings that virtual fitting technologies can significantly improve the consumer experience.

Also worth noting are the studies of S. Ibáñez-Sánchez *et al.* (2022) and J. Romero *et al.* (2021), who found that personalisation of the user experience in online shopping contributes to increasing customer loyalty. The authors found that platforms offering high levels of personalisation, including adaptive recommendations and personalised offers, achieve higher satisfaction and repeat purchases. These findings are in line with the current research emphasising the importance of adapting technology to individual user preferences and needs to improve engagement.

Although many aspects of the current study are supported by the work of other researchers, some differences may indicate the unique properties of the technologies used or the context of the experiment.

The current study found that the use of deepfake technology resulted in a significant increase in the amount of time participants spent in the virtual fitting room. This contrasts with the results of M. Kanwal *et al.* (2022) and M. Shukla *et al.* (2022), who found no significant effect of virtual fitting rooms on purchase decision time. The authors also suggested that this could have been due to insufficient implementation of the interface and visual design, which did not achieve full user immersion. This suggests that the effectiveness of virtual fitting rooms may be highly dependent on the quality of the technology implementation.

In the context of the current study, deepfake technologies received high ratings from participants who expressed significant satisfaction with their experience of using these innovations in the virtual fitting room. However, analyses of comparable studies in different geographical and cultural contexts reveal a diversity of perceptions and acceptability of such technologies. For example, the study conducted by R. Štefko *et al.* (2022) and E. Dias *et al.* (2022), showed that despite technological admiration, consumers may have mixed opinions about the use of virtual technologies due to concerns about data privacy and the accuracy of product visualisation. These differences in perceptions may be caused by several factors, including cultural differences, differences in the degree of familiarity and trust in digital technologies, and the variety of regulatory and statutory frameworks governing the use of these technologies.

It is also worth noting that in some cases the results of the current study disagree with the findings of M. Alshehri *et al.* (2022), and S. Tobon and J. García-Madariaga (2021), who pointed out a potential decrease in trust in online shops when using overly advanced visualisation technologies due to fear of possible manipulation. In the current study, such fears were not expressed, which may be due to more transparent and open communication to users about the operation and capabilities of deepfake technologies.

Analysing the current findings in the context of existing research reveals both similarities and significant differences in the perceptions and effectiveness of using deepfake technology and virtual fitting rooms. The current study contributes important data to the existing academic debate on the impact of technology on retailing, highlighting both the potential benefits and challenges associated with its adoption. The results point to the potential to improve customer engagement and increase sales by integrating personalised and interactive solutions but also highlight the importance of tailoring approaches to the specific market and needs of the target audience. This confirms the need for further research to optimise the application of deepfake and other advanced technologies in different settings and contexts.

Conclusions and Further Research

This study provides empirical evidence that deepfake-generated virtual anchors can significantly enhance consumer purchase intentions and emotional engagement in live commerce, highlighting their potential as valuable tools for e-commerce platforms. The results demonstrate that AI-based virtual anchors outperform human counterparts in terms of personalization and interactivity, ultimately leading to higher sales.

The key contributions of this study are rooted in quantitative evidence that underscores the positive impact of deepfake technology on e-commerce engagement and sales, especially for premium products. The research also offers insightful and counter-intuitive findings, revealing the psychological mechanisms driving consumer choices. It shows a strong correlation between media immersion, excitement, and purchase decisions.

However, several caveats should be considered. First, the analysis was conducted within the Southeast Asian market, meaning the findings may not be fully applicable to other regions with different patterns of digital adoption and varying cultural attitudes toward AI. It is an important consideration, as user perceptions of AI-powered technologies, including deepfake-generated content, may evolve. Only time will tell if these technologies can gain widespread consumer trust. Future research could explore the long-term effects of AI interaction on consumer loyalty and trust.

To ensure the ethical adoption of AI in live commerce, e-commerce platforms should adopt best practices, such as implementing clear policies on AI disclosures and the ethical use of AI-driven recommender systems. Such measures will help prevent misleading consumers. Additionally, e-commerce firms must develop adaptive AI strategies that cater to different age groups to foster a positive user experience.

While deepfake technology presents exciting opportunities for the live commerce industry, it is crucial to strike a balance between innovation and ethics in its implementation. Transparency is key to fostering consumer trust. Long-term acceptance of AI, cross-cultural perspectives, and regulatory frameworks for the use of deepfake-powered virtual anchors in online retail should be explored in future studies.

Declarations

Credit Authorship Contribution Statement:

Lifen Jiang: Conceptualization, Methodology, Project administration, Writing – review and editing;
Piang-or Loahavilai: Investigation, Software, Formal analysis, Writing – original draft;
Piyachat Udomwong: Investigation, Formal analysis, Writing – original draft, Visualization.

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Declaration of Use of Generative AI and AI-assisted Technologies: The authors declare that they have used/not used generative AI and AI-assisted technologies during the preparation of this work.

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Appendix

Questionnaire: Deepfake-powered virtual anchors in live commerce

Dear participant,
Please take a few minutes to complete this questionnaire about your experience using the deepfake-enabled virtual fitting room. Your responses will help us improve the platform and its features.

Section 1: Participant information

1. Age:

☐ 18-25 years ☐ 26-35 years ☐ 36-45 years ☐ 46-50 years

2. How often do you shop online?

☐ Several times a week ☐ Several times a month ☐ Once a month ☐ Less often

3. Have you previously watched live commerce broadcasts?

☐ Never used ☐ Used several times ☐ Frequently used ☐ Regularly used

4. Have you ever watched a deepfake-powered virtual anchor in a live stream before this study?

☐ Yes ☐ No

5. Which type of live commerce hosts do you prefer?

☐ Human live streamers ☐ AI virtual anchors ☐ No preference

Section 2: User perception of AI virtual anchors

6. How realistic do you find the deepfake virtual anchor's appearance? (1 – very uncomfortable, 10 – very comfortable)

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10

7. How natural were the virtual anchor's facial expressions and speech? (1 – not realistic at all, 10 – very realistic)

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10

8. Did the virtual anchor feel engaging and interactive? (1 – completely useless, 10 – very useful)

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10

9. How comfortable were you interacting with the AI virtual anchor? (1 – extremely uncomfortable, 10 – extremely convenient)

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10

10. Do you feel that AI-powered virtual anchors can replace human live streamers in e-commerce?

☐ Yes, completely ☐ Partially ☐ No, human hosts are still better

Section 3: Trust and emotional engagement

11. Did you feel emotionally connected to the virtual anchor while watching the live stream? (1=Not at all, 10=Very emotionally connected)

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10

12. How much do you trust the AI virtual anchor's product recommendations? (1 – Not at all, 10 – Completely trust it)

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10

13. Compared to human anchors, how persuasive is the AI virtual anchor?

☐ More persuasive ☐ Equally persuasive ☐ Less persuasive

14. Would you follow the AI virtual anchor for future shopping advice?

☐ Yes, definitely ☐ Maybe ☐ No

Section 4: Purchase intent and behaviour

15. How likely are you to purchase a product recommended by a deepfake virtual anchor? (1 – Not likely at all, 10 – Very likely)

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10

16. Did you purchase a product after watching the AI virtual anchor live stream?

☐ Yes ☐ No

17. Which product category did you purchase or consider purchasing?

☐ Fashion and Apparel ☐ Beauty and Cosmetics ☐ Electronics ☐ Luxury Goods ☐ Other

18. Compared to human live streamers, do AI virtual anchors make you more confident in purchasing?

☐ Yes, much more confident ☐ Somewhat more confident ☐ No difference ☐ Less confident

19. Would you watch another AI-powered live commerce stream in the future?

☐ Definitely yes ☐ Probably yes ☐ Not sure ☐ Probably no ☐ Definitely no

Section 5: Ethical concerns and privacy awareness

20. Do you think deepfake-powered virtual anchors raise ethical concerns in e-commerce? ☐ Yes, significant concerns ☐ Some concerns ☐ No concerns

21. What is your biggest concern about AI virtual anchors? (Select all that apply)

☐ Lack of authenticity ☐ Data privacy issues ☐ Potential for misinformation ☐ Replacing human jobs ☐ No concerns

22. Do you believe deepfake technology in live commerce should be regulated?

☐ Yes, strictly ☐ Some regulation is needed ☐ No regulation is necessary

How Well Has the Romanian Higher Education Prepared Graduates for the Labor Market Changes in the Last Decade? A PRISMA-Guided Systematic Review of Outcomes and Demand Trends

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Abstract: Persistent skills mismatches and overqualification among Romanian graduates highlight a gap between higher education outcomes and labor market needs. Technological transitions have amplified the demand for transversal, digital, and green competences, yet Romanian universities remain largely theoretical and slow to adapt. Objective: This systematic review aimed to synthetize evidence on the evolution of employability skills in Romania (2015-2025) and assess the alignment between higher education and labor market requirements. Eligibility criteria: Peer-reviewed empirical and theoretical studies from 2015 to 2025, addressing employability, skills mismatch, higher education, and digital competencies in Romania were included. Information sources: Data were retrieved from Scopus, Web of Science, and relevant EU institutional repositories. Methods: Following PRISMA 2020 guidelines, 36 studies were selected through a multi-stage screening (identification, eligibility, inclusion). Quantitative, qualitative, and mixed-method studies were synthetized thematically. Results: The findings show persistent skill mismatches, limited internship opportunities, and weak university – industry collaboration. Limitations: The review excludes non-English and grey literature and relies on cross-sectional data, limiting generalization and longitudinal insight. Conclusions: Romania's higher education system shows gradual progress toward skill alignment, but needs structural reform to meet technological, digital, and sustainability challenges.

Keywords: employability; skills mismatch; higher education; Romania; competences for labor market.

JEL Classification: I23; J24; O15; O33; A12.

Introduction

With the emergence of technological progress and generative artificial intelligence, the forces of labor demand and supply began to face disruptions which pushed labor markets to re-orientate and rewrite the rules of employability. The immersion of AI and sustainability spurred ongoing debates revolving around what skills remain competitive and relevant in an ever-changing world and how graduates might adapt to the new trends to easily enter the labor market based on the competences they acquire during education years. Higher education institutions are responsible for shaping curricula to fit the requirements of the labor market, because misalignments often lead to poor employability outcomes for graduates. In the case of young people who also happen to be fresh graduates, the very first years in the labor market could be critical (Arellano-Bover, 2022).

At the European Union level, employability is a policy priority, as it has the ability to enhance people's lives and improve the socio-economic context. In 2024, the EU employment rate for recent graduates, no matter the attained level, varied across countries: the highest employment rates were recorded in Germany (90.5%) and the

Netherlands (91.6%) and the lowest percentages in Romania (75%), Greece (73.2%) and Italy (69.6%) (Eurostat, 2025). As Eurostat statistics prove, recent graduates' employment rates are highest among those who have completed tertiary education. The employment rate of recent tertiary graduates overcame 90% in Lithuania, Malta, Poland, Slovakia, Germany, the Netherlands, Hungary, Bulgaria and Estonia, while in Italy and Greece the indicator was below 80% in 2024 (Eurostat, 2025).

The main objective of this paper is to synthetize the existing knowledge on the theme of graduates' employment in Romania and to explain how the higher education system may facilitate the school-to-work transition by adapting curricula to new skills and competences requirements in the labor market, and to propose practical and policy implications to minimize educational and employability mismatches. Therefore, this systematic literature review explores the following research questions:

(RQ1): What is the recent performance of Romanian higher education in graduate labor-market outcomes?

(RQ2): How have labor-market demands for competences and qualifications evolved in key Romanian sectors since 2015?

(RQ3): Which skill gaps or mismatches are consistently reported, and where are higher education curricula misaligned with employer needs?

(RQ4): What interventions are associated with better employment outcomes?

This systematic review holds importance in the research field of education and labor economics as it adds to the existent literature views on Romania's higher education system's adaptability to the demands of the labor market over the last decade. Because of the lack of PRISMA-based systematic reviews on the topic of higher education and graduates in Romania, hence the originality of our paper. This systematic literature review lays the foundation for potential future research on the Romanian higher education system and employability of graduates in the context of a dynamic labor market which redefines the market demands and trends. Regarding the collecting of data and its analysis following the PRISMA checklist, the research steps are explained in detail in the Research Methodology section.

1. Literature Review

As the macroeconomic situation of a country can highly influence the state of the labor market and employability, it is essential to monitor how each disruption affects graduates' entering the workforce. Skills transitions have a major impact on the evolution of workforce, in terms of digitalization and sustainability (green transition). On the one hand, the digital disruption started to gain shape during the COVID-19 pandemic, a period which surged in unemployed workers, and when re-employment strategies targeted the development of digital and social skills (Dartanto *et al.* 2023). Then, with the emergence of generative AI and the release of Chat GPT in November 2022 (Marr, 2023), previous skills were called into question: what will be replaced by technology and what will remain relevant? Digital literacy is surely one of the most important skills that HEIs should integrate in curricula, so as to mitigate the market shocks induced by technological transformations (Pastore & Choudhry, 2022). The 2024 Digital Decade report shows that there is a basic digital skills coverage of 27.7% in Romania, compared to the EU's average of 55.6% (European Commission, 2024), despite the country's efforts to find strategies to improve this indicator, like the "The Skills4IT Coalition", established in 2015, and the "SMART-Edu 2021-2027" strategic initiative for digitalization of education, established in 2020 (Kralj, 2024).One the other hand, the circular economy transition encourages educational programs to align training programs with the vital skills needed for developing circular systems (Trevisan *et al.* 2025). The study by Trevisan *et al.* (2025) discloses that existent courses on sustainability in higher education focus on "resilience cross-cutting skills" and "specialized or technical skills", while there is a need for skills like "environmental and social awareness", and "reverse logistics and operational management skills", meaning that HEIs should combine both green and digital skills for better graduates' outcomes (Trevisan *et al.* 2025). Moreover, if too many changes happen at the same time, and because it takes time to develop and implement curricula, educational programs should continue to focus on foundational knowledge and, when it comes to sustainability, these programs must deliver generic skills that enable students to adapt easily and to master more domains than the one they specialize in (Allais, 2024). The shifts towards learner-centered teaching means ensuring both professors and students adapt to technology-supported learning environments and that an effective design of classes is based on virtual mobility, interdisciplinary teamwork, and online project tools, which makes e-learning a strong driver of sustainability competences (Barth & Burandt, 2013).

2. Research Methodology

This paper is a PRISMA-based systematic literature review, following a checklist of objectives, source of information, eligibility criteria, search methods, process of data collection and main findings. The review and its protocol were not registered publicly.

2.1. Database Search Strategy

Papers in our database were collected from two reputable scientific databases: Scopus by Elsevier and Web of Science (WoS) during October 2025. Detailed search strings for advanced search queries were used in the two databases, as follows:

1) *In Scopus*: (TITLE-ABS-KEY (Romania OR Romanian*) AND TITLE-ABS-KEY ("higher education" OR university* OR tertiary OR "HEI" OR bachelor* OR master* OR phd) AND TITLE-ABS-KEY (employab* OR "employment rate*" OR "graduate employ*" OR mismatch OR "skill gap*" OR overqualif* OR underemploy* OR "time to job" OR "job placement") AND TITLE-ABS-KEY (skill* OR competenc* OR qualification* OR "digital skill* OR "green skill*" OR transversal OR "soft skill*")) AND (PUBYEAR > 2014 AND PUBYEAR < 2026);
2) *In WoS*: TS = (Romania OR Romanian*) AND TS = ("higher education" OR university* OR tertiary OR "HEI" OR bachelor* OR master* OR phd) AND TS = (employab* OR "employment rate" OR "graduate employ*" OR mismatch OR "skill gap*" OR overqualif* OR underemploy* OR "time to job" OR "job placement") AND TS = (skill* OR competenc* OR qualification* OR "digital skill*" OR "green skill*" OR transversal OR "soft skill*") AND PY = (2015-2025).

Before assessing for eligibility criteria, there were initially 24 returned results in Scopus and 54 returned results in WoS. This outlines a rather under-researched topic about Romania, despite its importance for an effective transition of graduates from university to the labor market.

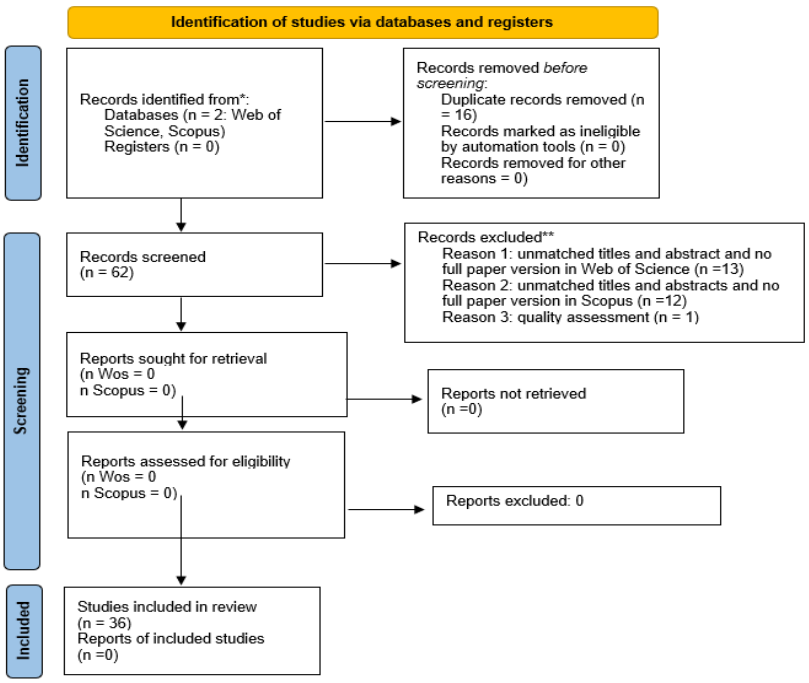
2.2. Eligibility Criteria

Only papers referring to Romania, as well as cross-country studies including it, were taken into consideration for the review, with a focus on writings based in the years 2015 to 2025, both qualitative and quantitative, in the English language, of researchers worldwide, for the inclusion/exclusion criteria.

2.3. Paper Selection

As a first step, papers' titles and abstracts were checked for relatedness to this study's topic and goal.

Figure 1. PRISMA Diagram Flow



Source: Authors' own research

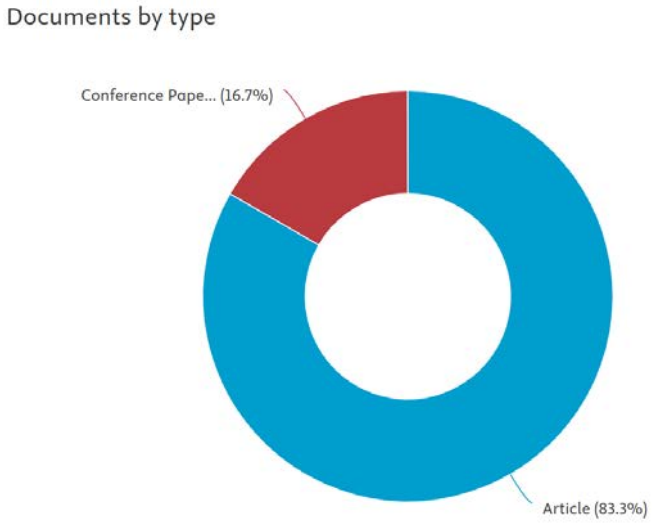
Secondly, multiple criteria were checked simultaneously, such as available author information, duplicates, and open and free access to papers. After following these steps, the final database remained with 12 papers from Scopus and 24 papers from Web of Science. The PRISMA diagram flow is represented by Figure 1.

3. Research Results

Out of the 12 sources extracted from Scopus, 10 are articles and 2 are conference papers, as in Figure 2. The number of papers is distributed unevenly across the years: 1 paper in 2017, 1 paper in 2018, 2 papers in 2019, 3 papers in 2020, 1 paper in 2022, 2 papers in 2023, 2 papers in 2025, and no papers in 2021 and 2024, as in Figure 3. Out of the 24 sources in Web of Science, one is an early access paper; 8 are articles and 16 are proceeding papers. There are 4 papers published in 2015, 2 papers in 2016, 4 papers in 2017, 1 paper in 2018, 4 papers in 2019, 2 papers in 2020, 1 paper in 2021, 3 papers in 2024 and 3 papers in 2025, as in Figure 4.

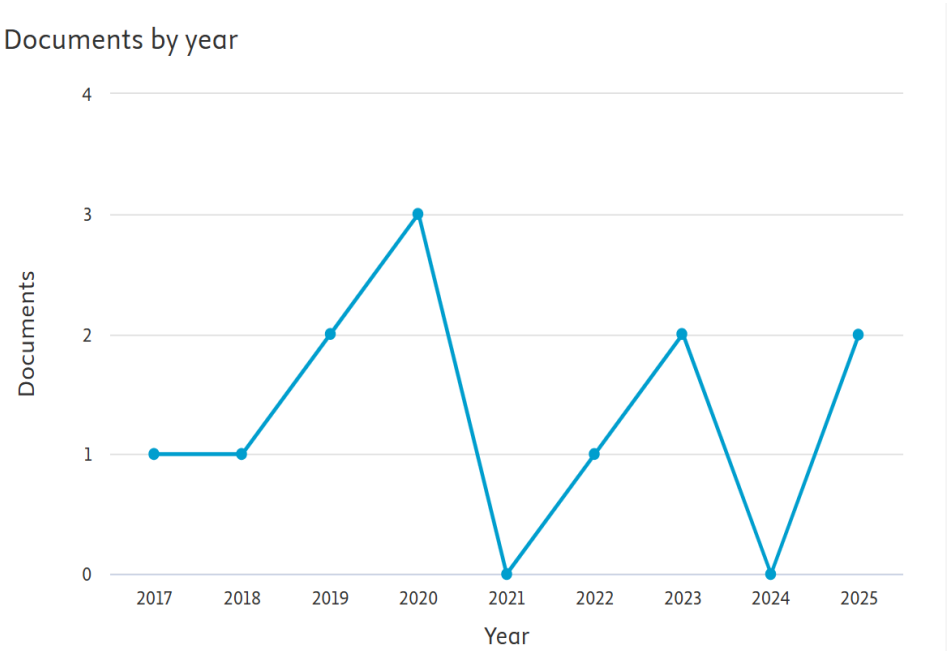
The main discoveries are summarized in Table 1 and explained in full detail in the Discussions section of this paper.

Figure 2. Type of papers (Scopus)



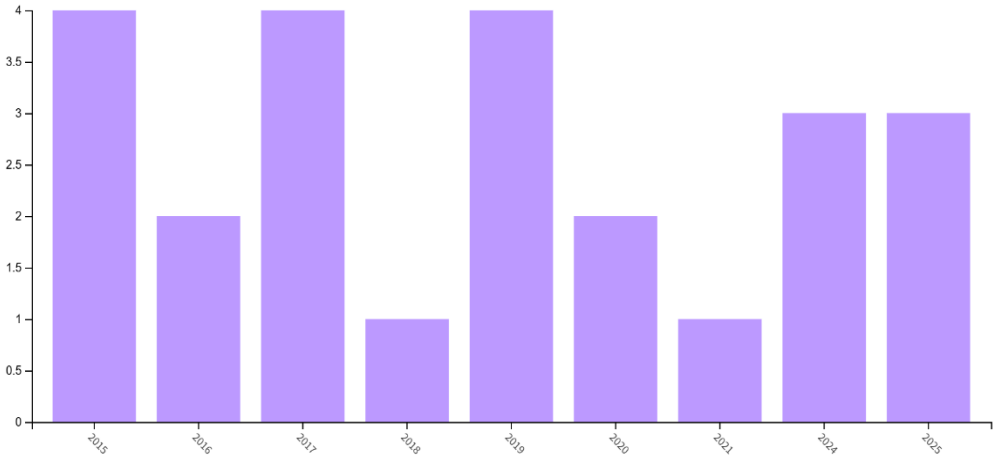
Source: Authors' own research extracted from Scopus database

Figure 3. Publication year (Scopus)



Source: Authors' own research extracted from Scopus database

Figure 4. Publication Year (WoS)



Source: Authors' own research extracted from Web of Science database

Table 1. Main findings

Legend	Author(s)	Year	Main Findings
S1	Grama & Todericiu	2025	The article highlights the persistent gap between higher education programs and the ever-changing demands of the labor market, a misalignment made evident by the lack of formal integration of transversal skills. To address this challenge, the paper underscores the necessity of a systemic curricular reform focused on integrating transversal skills across all study programs, strengthening university-industry collaboration and implementing authentic assessment methods to enhance graduate adaptability and employability.
S2	Lovin & Savu	2025	The article recommends continuous professional development and lifelong learning strategies as essential interventions for maintaining employability in a changing labor market. It also stresses the need for stronger university–industry collaboration, internships and practical training modules to align academic outcomes with employer expectations.
S3	Rebelo *et al.*	2023	The central finding of the article is that the gap between higher education and labor-market needs can be effectively reduced through the systematic and participatory co-creation of curricula. The study demonstrates that moving from superficial partnerships to deep structural collaboration, where industry partners are involved at every stage: from design to teaching and assessment, is the key intervention. This approach not only enhances essential skills such as Critical Thinking but also ensures that academic programs become relevant and directly aligned with the practical demands of the professional world, ultimately improving graduates' employability.
S4	Maer Matei *et al.*	2023	The study shows that Romanian employers value both cognitive skills (*e.g.*, analytical, problem-solving, computer skills, English communication) and non-cognitive skills (*e.g.*, teamwork, communication, decision-making) when hiring economics graduates. The weight assigned to each skill depends on company size, ownership, sector and recruiter characteristics. Graduates combining above-average cognitive and non-cognitive skills are more likely to succeed in the labor market.
S5	Roșu	2022	Entrepreneurial education is crucial for improving employment prospects of Physical Education and Sports graduates in Romania, but low student interest and a mismatch between training and intended entrepreneurial activities limit its effectiveness, requiring more practical and engaging approaches.

Legend	Author(s)	Year	Main Findings
S6	Gavriluță	2020	Employability in Romania was constrained by a multi-level disconnect between universities, students, and employers; addressing socio-human skill gaps and aligning expectations required both educational and public policy interventions.
S7	Roman *et al.*	2020	The use of computational tools in Chemical Engineering education enhances graduate employability by developing digital skills, theoretical understanding and practical application abilities, effectively overcoming the limitations of traditional teaching methods.
S8	Pricina G.N.	2020	Graduate employability depends on practical skills, experience, and personality traits and effective solutions require systemic interventions that go beyond curricular adjustments or company-level measures to reduce the structural incentives for emigration.
S9	Gora *et al.*	2019	Student employability depended primarily on the quality of the educational process and active engagement in practical and research activities. Infrastructure and equipment alone were insufficient; they were effective only when integrated into high-quality, competence-oriented teaching and research. Universities had to develop curricula and pedagogical approaches focused on relevant skills to bridge the gap between higher education and labor-market requirements.
S10	Vîlcu *et al.*	2019	Employability of Romanian technical graduates depends on a combination of professional, technical, and transversal skills. Systematic analysis using hierarchical PCA identifies the highest-impact competencies, providing a data-driven basis for aligning curricula with labor-market priorities and reducing the gap between theoretical training and real-world employment requirements.
S11	Bordean & Sonea	2018	The study found that students' career intentions were strongly influenced by their perception of required competencies; however, this perception was often misaligned with actual labor-market needs. The critical gap underscored the need for higher education to not only teach competencies but also actively shape a correct and realistic understanding of their application in professional careers.
S12	Anastasiu *et al.*	2017	The study confirmed that bridging the gap between academia and the labor market requires systemic collaboration between universities and employers. Employability improved when theoretical learning was complemented by practice, mentoring and soft-skill development. The decisive factor was the alignment of curricula with the real-world project management and entrepreneurial competences demanded by the construction industry.
W1	Caragea *et al.*	2025	The article concluded that universities needed to move urgently from a reactive approach to AI to a proactive one, with the most important step being the implementation of mandatory AI literacy courses to ensure that students developed the competencies required to use these technologies ethically, critically and effectively.
W2	Constantin & Iacob	2025	The article concluded that universities needed to move urgently from a reactive approach to AI to a proactive one, with the most important step being the implementation of mandatory AI literacy courses to ensure that students developed the competencies required to use these technologies ethically, critically and effectively.
W3	Pantea	2025	Qualitative interviews show overqualification is widespread among Romanian graduates, especially in call centers; employers value practical experience over theory, highlighting the need for internships and better university-workplace alignment.
W4	Botezat *et al.*	2024	Quantitative evidence links early skill mismatches with later career outcomes; internships and Master's programs reduce mismatch, and policy reforms should connect secondary and tertiary education to labor market demands.
W5	Brezuleanu *et al.*	2024	Employability depends on both university adaptation and workplace factors; universities should promote entrepreneurship, business

Legend	Author(s)	Year	Main Findings
			incubators, and stronger academic counselling to improve transition to employment.
W6	Păunescu *et al.*	2024	Socioeconomic status affects employability; student perspectives should guide employer recruitment; policymakers should partner with education institutions to design lifelong upskilling programs.
W7	Stăiculescu *et al.*	2021	Universities should include compulsory practical stages, job fairs, business experts in teaching, and active employer involvement in governance to improve graduate employability.
W8	Butum *et al.*	2020	International competences, communication, teamwork, adaptability, and analytical thinking are crucial for Economics and Social Sciences students preparing for globalized labor markets.
W9	Mohanu *et al.*	2020	Research participation builds key soft and professional skills - time management, communication, teamwork, and analytical ability - and should be incentivized by universities
W10	Gabor *et al.*	2019	A digital platform helps track employability skills acquisition via competence mapping, indicator assessment, and personalized training recommendations.
W11	Nastase *et al.*	2019	Entrepreneurial education should be integrated across disciplines; Romanian universities lag behind EU peers in transforming into entrepreneurial institutions.
W12	Grosseck *et al.*	2019	Low digital tool use in academia reflects weak digital literacy; Romania ranks last in EU digital skills, with continuing need for ICT competence and teacher digitl training.
W13	Oproiu *et al.*	2019	STEM students value teamwork, adaptability, professionalism, and leadership; however, interest in entrepreneurship declines as technical focus increases.
W14	Cojan *et al.*	2018	Case study in the automotive sector emphasizes transversal competences - digital, analytical, critical thinking, and employer collaboration in e-learning and real-time simulations.
W15	Butum, L.C	2017	International experience enhances employability; students value flexibility, responsibility, social and professional skills, and universities should promote exchanges and partnerships.
W16	Goia *et al.*	2017	Internships are vital for transition to work; mentoring quality and academic supervision improve outcomes; companies should budget internships recognizing interns' real contributions.
W17	Deaconu & Nistor	2017	Employers prioritize transversal skills (communication, teamwork) over purely technical ones; professionalism increasingly defined by adaptability and soft skills.
W18	Nicolau & Lache	2017	Internationalization raises education quality and competitiveness; calls for better lab equipment and mentoring for new teaching staff.
W19	Brătianu & Vătămănescu	2016	Critical thinking, data analysis, and learning to learn are essential; students rely too heavily on traditional teaching; knowledge building should be between professors and students.
W20	Fleacă *et al.*	2016	Raising tertiary attainment requires transversal skills, update curricula aligned with technology, and financial support for educational reforms.
W21	Echevarria-Cruz *et al.*	2015	Quantitative study shows that students with prior internships or part-time jobs perform better in recruitment; mentorship and exposure to skilled professionals enhance employability, while awareness of university career counselling services remains very low.
W22	Epure & Mihaeș	2015	Study emphasizes aligning university curricula with labor market needs through collaboration between universities and businesses; employers value teamwork, communication, digital, language, and entrepreneurial skills, identified via employer surveys.
W23	Stanciu & Tinca	2015	Accounting students lack training in information security; universities must introduce IT-security courses to reduce risks in the profession.
W24	Pavaloiu *et al.*	2015	Simulated enterprise learning (CONPROF) develops practical, managerial, and digital skills through virtual companies.

Source: Based on authors' own research

5. Discussions

(RQ1): What is the recent performance of Romanian higher education in graduate labor-market outcomes?

In a paper from 2015, namely source W22 in our database, a better alignment of university curricula with labor market demands was considered to be linked to fruitful collaborations between universities and private businesses, even in terms of designing study programs. What was believed to be embraced by employers at that time were interpersonal skills, such as team-work and communication skills, computer skills, adaptability to new situations, foreign language fluency, and commercial entrepreneurial skills. According to the same study, one way to decide on the taught competences was based on surveys conducted by employers (Epure & Mihaeș, 2015). In 2017 (source S12), the performance of technical higher education graduates, especially in civil engineering, was limited by persistent unemployment and overqualification. Many graduates could not find jobs matching their specialization, revealing that universities provided strong theoretical knowledge but insufficient practical skills relevant to employers' needs (Anastasiu *et al.* 2017).

In a quantitative study from 2016 (source W19), skills like researching, collecting and interpreting data, information and knowledge, problem solving, creative and strategic thinking, and the ability of learning to learn are key in being better prepared for the workforce. Graduates in the study recognized that improving "skills for searching, collecting and systematizing information" are an imperative in university and the development of these thinking skills should be directed by students themselves first, and not place the whole responsibility on professors. However, the results of the study outlined that the traditional way of teaching and learning was preferred by students, meaning that professors should be the ones doing "all the hard work of processing and transferring information and knowledge". The need for research capabilities was found again in a paper from 2020 (source W9), stating that skills like "promptness and efficient time management, results orientation, communication and interaction, teamwork, computer literacy, the ability to analyse and question things" could be all fostered with encouraging students to engage in research activities due to: i) the whole concept of research, from gathering data to organizing, analyzing and disseminating it; ii) participation to conferences, even in international contexts, delivering presentations and networking. The Bucharest University of Economic Studies really stimulated student research through many incentives, even financial ones (Mohanu *et al.* 2020). A study from 2019 (paper S9) showed that the quality of the educational process had a direct positive impact on students' skills, competencies, and knowledge, enhancing employability; research activities further increased competencies and perceived employability, while practical activities had mediated effects. Infrastructure and equipment alone had little direct impact (Gora *et al.* 2019).

Nevertheless, new knowledge mechanisms must be founded on a two-way effort basis between students and professors (Bratianu & Vatamanescu, 2017). Article S11 did not measure direct labor-market outcomes but rather students' career intentions. These intentions were influenced by perceived competencies: optimism predicted an entrepreneurial career path, while leadership and networking predicted a managerial path, suggesting how educational preparation shaped future professional trajectories (Bordean & Sonea, 2018).

In a study from 2019 (S10), Romanian technical graduates needed professional, technical, and transversal skills to integrate quickly into the labor market. Key skills included adaptability, data analysis, multitasking, and working in flexible teams (Vîlcu *et al.* 2019). In paper S8, Romanian graduates faced challenges in finding employment matching their qualifications due to gaps between employer requirements and local labor supply, and emigration of skilled workers. Practical skills, experience, personality traits, and adaptability were valued more than formal qualifications (Pricina, 2020). Source S7 illustrated that students in Chemical Engineering perceived that digital skills gained through specialized software significantly enhanced their employability, improving both theoretical understanding and practical competencies (Roman *et al.* 2020).

In 2019, before the pandemic, respondents to a questionnaire in paper W12 stated they did not use digital tools much, meaning that the members of the academic community preferred sharing information and education resources in person (Grosseck *et al.* 2019). With reference to DESI 2018, Romania had not made improvements in digital literacy of its citizens in that year, occupying the last position (European Commission, 2018). In 2025, Romania continues to rank last in the European Union for basic digital skills, as approximately only 28% of people have at least a basic level, despite the country's efforts to implement targeted programs (European Commission, 2025). There are many ICT graduates in Romania but the country struggles to retain specialists which ends up in stagnation in the IT sector (European Commission, 2025). Nevertheless, even in 2019 it was considered that professors could be more efficient with the help of new technologies, so digital literacy is crucial for the teaching staff, as well (Grosseck *et al.* 2019).

Study S6 qualitatively assessed graduate performance as problematic, characterized by a dual crisis of quality and retention. From the students' perspective, the labor market was marked by pessimism, limited opportunities, and a strong tendency toward emigration. Employers, conversely, perceived a decline in the theoretical preparation of graduates. This created a dual crisis: a crisis of quality in the local workforce and a crisis of talent retention, as the most skilled graduates preferred careers abroad (Gavriluță, 2020).

Paper S5 noted that employment prospects for Physical Education and Sports graduates in traditional roles (*e.g.*, teaching) were "extremely low," indicating weak program performance in supporting placement in conventional labor markets. Entrepreneurship was presented as a highly viable alternative; however, low student interest - only 28% participated in related projects, which posed a significant barrier to improving outcomes through this route (Roșu, 2022). Article S2 directly addressed RQ1 by analyzing labor-market outcomes of graduates from Romanian faculties of physical education and sports. It identified a weak but statistically significant positive correlation between the skills and competencies acquired during studies and income level, standard of living, and job quality. Graduates who perceived they had developed more skills reported better-paid jobs and smoother transitions into employment (Lovin & Savu, 2025).

Article S4 did not directly measure performance (*e.g.*, employment rates) but suggested it was defined by the relevance of graduates' skills to employers (Maer Matei *et al.* 2023). The findings indicated that non-cognitive skills (communication, teamwork, decision-making) were highly valued, implying that graduates possessing these skills achieved better labor-market outcomes (Cedefop, 2019). Furthermore, employer preferences varied by company size and sector, indicating that performance was also conditional on aligning a graduate's profile with specific demands (Humburg & van der Velden, 2015). Source S3 did not directly measure the recent labor-market performance of Romanian graduates. Instead, it identified a significant deficiency in Critical Thinking (CT) within the Business and Economics curriculum, implicitly suggesting a performance gap. The study's premise was that traditional, theory-based teaching methods limited graduates' preparedness, thereby negatively affecting their potential labor-market outcomes (Rebelo *et al.* 2023).

The question was not directly addressed by paper S1. The article only provided contextual evidence, highlighting that approximately 37% of employees' current skills in Romania would become obsolete by 2030, indirectly indicating a structural challenge for higher education in performance regarding graduate employability (Grama & Todericiu, 2025). Performance in the Business Administration field declined, as shown by paper W1. While over 50% of graduates found employment in their graduation year, they were mostly in jobs below their qualification level (*e.g.*, sales agent, data entry operator). This indicates a significant qualification mismatch. Furthermore, the graduation rate itself was decreasing, showing a weakening internal performance of the academic programs (Caragea *et al.* 2025). Article W2 did not directly measure graduates' labor-market performance. Instead, it operated on the premise that developing an "AI skill set" had become essential for ensuring future employability, suggesting that labor-market outcomes would increasingly depend on these new abilities (Constantin & Iacob, 2025).

(RQ2): How have labor-market demands for competences and qualifications evolved in some Romanian sectors since 2015?

Paper S12 mentioned a 2015 study on the construction and engineering sectors revealed a high demand for a combination of technical expertise and transversal competences (project management, entrepreneurship and leadership). The demand was clearly shifted toward applied, interdisciplinary and soft skills that allow adaptability and problem-solving (Anastasiu *et al.* 2017). Labor-market demand had increased for transversal and internationally relevant skills, including critical thinking, problem-solving, teamwork, organizational, and entrepreneurial skills, as discussed in article S9 (Gora *et al.* 2019). In article S10, employers emphasized general-professional skills (domain-specific knowledge, application of theory, critical reflection), technical skills (equipment design and use, reading and creating technical schematics), and transversal skills (negotiation, organization, project presentation, team coordination), reflecting dynamic and competitive market requirements (Vîlcu *et al.* 2019). Source W13 focused on a perception analysis through a questionnaire addressed to STEM students in 2019 and the results described professional and interpersonal skills such as teamwork, adaptability and professionalism as important skills, as well as entrepreneurial and leadership skills. However, the study showed that as the number of technological school graduates was higher, the students' interest for entrepreneurial and management skills was lower (Oproiu & Ianoș, 2019).

Between 2018 and 2025, Romania's skills outlook evolved from concerns about demographic decline and sectoral shifts to a focus on technological transformation and digitalization. The 2018 forecast projected only 2.8% employment growth up to 2030, well below the EU average of 6%, and a 10% drop in labor supply, with most

openings requiring medium qualifications and only 35% demanding high-level skills. By contrast, the 2025 forecast shows a more optimistic trend, with employment growing faster than the EU average (0.6-0.9% annually versus 0.3-0.4%), driven by higher participation among women and older workers, Key growth sectors include ICT, business services, and healthcare, while low-skill and routine jobs continue to decline. The share of workers with higher education is expected to rise around 32% by 2035, reflecting Romania's gradual shift toward a knowledge-based economy where Stem, digital, and problem-solving competences, alongside adaptability and lifelong learning, are crucial for competitiveness (Cedefop, 2018, 2025).

In source S8, employers demanded standards close to Western norms, including digital skills, foreign language proficiency, continuous professional experience, and practical competencies; character, ethics, and maturity were emphasized (Pricina, 2020). The integration of simulation software and computational tools in Chemical Engineering programs aligned with current labor-market requirements, emphasizing ICT skills and the ability to use digital tools for complex problem-solving and "what-if" scenario analysis, as discussed in article S7 (Roman *et al.* 2020). Study S6, conducted in 2017–2018, indicated that employer demands had shifted significantly toward the candidate's socio-human dimension. Beyond a solid theoretical foundation, employers prioritized a combination of human qualities such as reliability, punctuality, and respect; essential soft skills like face-to-face communication and teamwork; and professional attitudes, including clear career objectives and commitment to continuous development (Gavriluță, 2020).

In what concerns Business and Economics Master's degree's graduates, paper W17 illustrated perceptions of the assessment and employment processes, and ranked transversal competences, like communication and interaction in a team, above professional ones in employers' preferences. Obviously, professional competences play an important role in the recruitment process, and the paper showed that Economics graduates were employed based on their skills of "collecting and processing data and knowledge of calculus and interpretation", and technical expertise was not such a central aspect (Deaconu & Nistor, 2017). With so many distortions in the economy and labor market, the actual meaning of professionalism faced re-invention, in the sense that soft skills might be more sought after than hard skills by employers in times of change (Staiculescu *et al.* 2021).

In the sports sector (S5), labor-market requirements focused on entrepreneurial skills and initiative, as traditional employment opportunities (*e.g.*, sports teachers) were very limited. Students preferred to start businesses in service-related areas, indicating a shift in market demands toward business management and adaptability skills (Roșu, 2022). Source S3 did not provide a historical analysis of labor-market requirements since 2015. Rather, it focused on the then-current high demand for transversal skills, specifically Critical Thinking (CT). The needs analysis conducted in Romania for the Business and Economics field confirmed that employers sought graduates who could apply theoretical knowledge to real-world problems, emphasizing the importance of problem-solving, logical analysis, and effective communication skills (Rebelo *et al.* 2023). Although study S2 focused on a specific academic field, it highlighted that labor-market demands increasingly valued both domain-specific expertise and transversal competences such as adaptability, teamwork, and continuous learning. In the sports industry, ethical behavior, teamwork, and openness to change were emphasized, while gaps persisted in management and communication skills. The article did not analyze the evolution of labor-market requirements over time (*e.g.*, since 2015) but focused on assessing the current state of skills and misalignments (Lovin & Savu, 2025).

Paper S1 showed how labor-market demand evolved along two main axes: advanced technological competences (AI, Big Data, Cybersecurity) and transversal competences (critical thinking, creativity, resilience, communication). Transversal competences were universally valuable and essential across all analyzed fields (Grama & Todericiu, 2025). Paper W1 does not analyze the evolution of employer demands. Instead, it analyzes graduate outcomes, which show that the labor market absorbs Business Administration graduates primarily into non-managerial and non-strategic roles, suggesting a discrepancy between the program's intended purpose (developing leaders) and the actual job market reality (Caragea *et al.* 2025). Study W2 did not analyze the historical evolution of labor-market demands. It focused on the impact of a very recent technology (ChatGPT, launched in 2022) and argued that its emergence created an urgent, current need for AI competencies, forcing universities to adapt their curricula to meet this new market requirement (Constantin & Iacob, 2025).

The findings from the chosen database are in line with a Cedefop (2023) report on national qualifications in Romania which emphasizes the development of transversal, digital, entrepreneurial, and analytical competences as central to our country's qualification framework. It underlines teamwork, communication, adaptability, and problem – solving as key employability skills, while promoting digital literacy and the integration of ICT in learning. The National Qualifications Framework aligns with the EU Key Competences Framework, supporting lifelong learning, civic engagement, and the capacity to apply knowledge creatively in professional contexts.

(RQ3): Which skill gaps or mismatches are consistently reported, and where are higher education curricula misaligned with employer needs?

In 2015, research (source W23) shows that accounting students did not have enough training and knowledge on information security issues and that universities had the duty to implement such courses in order to mitigate the negative effects of security breaches in such an important domain (Stanciu & Tinca, 2016). A consistent gap was observed in paper S12 between university training and market expectations: curricula were overly theoretical, practical courses and internships were insufficiently integrated, and teachers were detached from business realities. Employers reported that graduates lacked project management, communication, and leadership competences, as well as professional attitudes such as ethics, adaptability and initiative (Anastasiu *et al.* 2017).

A major perception gap was identified in article S11: students incorrectly and negatively associated competencies such as risk-taking and decision-making with entrepreneurial intentions. This indicated a curricular misalignment, as the study program failed to convey an accurate understanding of entrepreneurial skills (Bordean & Sonea, 2018). Universities taught theoretical knowledge, but practical application, team coordination, and transversal skills were insufficient; some employer-demanded competencies were underrepresented, as discussed in paper S10 (Vîlcu *et al.* 2019). Article S9 illustrated that gaps existed between student-acquired competencies and labor-market requirements, particularly in applied and transversal skills. Technical infrastructure and practical activities, if not integrated into teaching, failed to enhance employability, reflecting misalignment between university resources and employer needs. Curricula had to be continuously adapted to reduce these gaps and develop relevant competencies (Gora *et al.* 2019). Source S8 showed that a clear gap existed between higher education training and labor-market needs: curricula often failed to develop practical skills and personality traits, leaving qualified workers underutilized or emigrating (Pricina, 2020). Traditional teaching methods relying on manual problem-solving created a gap with industry needs and students recognized that practical experience with software remained insufficient, as per source S7 (Roman *et al.* 2020).

Article S6 identified a fundamental double gap. First, there was a skills and attitudes gap: employers reported a lack of "human quality" and soft skills in graduates, while students argued that their education was too theoretical and disconnected from the labor market. Second, there was an expectations gap: students held conservative career expectations, desiring stability and predictability, whereas employers operated in a dynamic market and sought proactive employees with clear goals and initiative, often perceiving a "lack of ideals" in young candidates (Gavriluță, 2020). There was a significant gap between university-acquired skills and labor-market needs, as per S5. Students lacked sufficient motivation to develop entrepreneurial abilities and often relied on family support or personal resources. Theoretical entrepreneurial education was neither well-integrated nor compelling, resulting in a mismatch between academic training and real-world requirements (Roșu, 2022).

Article S4 implied a significant skills gap. The misalignment stemmed from academic curricula that often failed to adequately develop the non-cognitive skills (communication, decision-making, teamwork) that employers particularly valued. Even if graduates possessed strong cognitive skills (analytical, IT), a lack of these soft skills created a clear mismatch between the educational supply and the actual expectations of the labor market (Maer Matei *et al.* 2023). Paper S3 identified a persistent gap in the development of Critical Thinking, a transversal skill highly valued by employers but insufficiently fostered by traditional university curricula. This misalignment stemmed from strategic and methodological shortcomings: curricula were often designed in isolation without employer input, and traditional teaching methods (*e.g.*, lectures) failed to develop practical, real-world competencies. A fundamental barrier was the lack of a shared understanding between academia and business on what constituted Critical Thinking (Rebelo *et al.* 2023).

The findings in S2 revealed a clear mismatch between graduates' self-perception and employers' evaluations. Graduates excelled in sport-related competencies (conscientiousness, teamwork, respect for hierarchy) but reported major gaps in transversal skills (public speaking, management, foreign-language communication, project management). This indicated a curricular misalignment, as programs focused on sports techniques and values but neglected the development of business and communication skills necessary for successful careers (Lovin & Savu, 2025).

The main gap, as shown in source S1, lay in the insufficient formal development of transversal competences within universities, with a significant perception gap between employers and students regarding training opportunities and labor-market preparedness (Grama & Todericiu, 2025). The primary mismatch identified in paper W1 is a qualification mismatch: graduates are overqualified for the jobs they obtain. The article argues this is a symptom of a deeper, systemic misalignment caused by the lack of a graduate monitoring system. Without feedback on graduates' career paths, universities cannot align their curricula with the actual needs of the labor

market (Caragea *et al.* 2025). Article W2 identified a new type of gap: an "AI literacy" and critical-thinking gap. A particularly concerning finding was that graduate-level students (master's and doctoral) were no better at identifying errors and accuracy issues in ChatGPT than undergraduate students. This indicated misalignment, as advanced students were expected to possess superior critical skills, but these did not apply in the context of AI usage. Additionally, students perceived a limited impact of AI on developing analytical skills (Constantin & Iacob, 2025).

Both sources W3 (Pantea, 2025) and W4 (Botezat *et al.* 2024) highlighted the fact that overqualification is widespread among Romanian graduates, especially in call centers and business services which often employ graduates from non-STEM fields like Political Sciences, Communication or Letters. Many graduates in the studies did not perceive themselves as overqualified, since work in their degree specialization was seen as unrealistic or outdated. It is mentioned that employers prefer candidates with internship experience, as universities usually provide limited practical training and mostly theoretical knowledge, and those students who are mismatched in their first job tend to remain so later in their careers. Internships and Master's programs significantly reduce skill mismatches and improve employability.

(RQ4): What interventions are associated with better employment outcomes?

Even ten years ago, a quantitative study on students enrolled in business programs, represented by source W21, highlighted the importance of having access to on-the-job training and development opportunities, in the sense that those students who had benefitted from internships and part-time jobs before their actual first serious job had better results in the recruitment process. Besides that, perhaps having "excellent mentors and trainers" or simply working with "excellent professionals in projects of high importance" was considered to be more impactful by respondents, as mismatches between skills and job requirements can be minimized this way. However, when it came to career counselling in university's specialized offices, the majority of respondents were not aware whether they existed or not (Echevarria-Cruz *et al.* 2015). A paper review from 2016 (source W20) illustrated that increasing tertiary education attainment meant helping students through all educational levels first, and improving the quality of higher education programs meant to develop transversal competences among students, to update curricula based on technological advance, to promote the teaching profession in any area of study, and to diversify the educational offer according to the requirements of the labor market, strategies which ultimately needed financing (Fleacă *et al.* 2016). The transition from university to professional life could be enriched by qualitative internship programs, as source W16 suggests, an aspect that is still true for the present, too (Goia Agoston *et al.* 2017). Internships, apprenticeships and similar education programs which can equip students with the know-how, knowledge, skills and capabilities required in a particular industry, may improve the process of finding a job (Eurostat, 2025). An empirical research study by Monteiro *et al.* (2021) identified a strong need for "practical experiences" during HE studies (Monteiro *et al.* 2021). The importance of internships during higher education studies is sustained by Albert *et al.* (2023), as well, in the sense that they can reduce job mismatches at the first work experiences. Looking back at year 2017, paper W16 outlines the fields in which students from several faculties from the Bucharest University of Economic Studies could perform internships, as follows: business administration and management students were able to choose from very diverse fields, such as "banking, tourism, consultancy, advertising, quality management, event management", due to the general character of the study program, while accounting and finance and banking students could have internships in narrower fields, such as accounting, audit or banking (Goia Agoston *et al.* 2017). Good mentoring is mentioned here again, as well as a better involvement from the academic supervisors in how the internship programs are chosen and delivered to students. Another interesting finding from paper W16 is that companies should budget the internship programs, because interns sometimes deliver valuable work and they could be considered "a real workforce inside the company" (Goia Agoston *et al.* 2017).

The most effective interventions mentioned in paper S12 were modular interdisciplinary courses and practice-oriented training co-designed by universities and companies. Voluntary or optional modules taught jointly by academic staff and industry experts, combined with company-based internships and apprenticeships, significantly improved employability. These partnerships allowed students to gain relevant applied knowledge and helped firms reduce recruitment costs (Anastasiu *et al.* 2017). As a strategy to foster practical activities in the educational program, IPA SA, the Bucharest University of Polytechnics and the Romanian – American University developed the "CONPROF" project in 2015 which related to a simulated enterprise as a learning method. Basically, students learned in an interactive way through simulated enterprises, connecting university education with real business practices. In this way, students could gain professional and managerial experience in a virtual company environment, they could improve teamwork, entrepreneurship, and decision-making skills in realistic and risk-free conditions, and they could practice "working as" managers, accountants, marketers, or HR personnel (Pavaloiu *et*

al. 2015). This is an excellent learning method which is still being applied nowadays at the Faculty of Business Administration in foreign languages, as part of the Bucharest University of Economic Studies, and it is called "TOPSIM" – a business simulation which provides students with "hands-on, strategic management experience" at various subjects and years of study (FABIZ, 2025). Virtual companies teach students how real businesses work by combining academic theory, practical simulation, and digital tools, hence preparing them for the current labor market.

A study carried out in 2017 (source W15), which collected data from 2013 to 2015, mentioned that a successful indicator for future employability was international experience and that curricular models were supposed to insert international competences so as to check the global labor market qualifications. 71% Romanian respondents of the study thought that "responsibility, flexibility, social competences, and ability to work under pressure" were mandatory for getting a job. Also, there was a high demand for professional and practical skills, as well as international work experience gained from social and volunteering activities. The international experience was believed to be useful in careers in multinational companies, and the general internationalization process of the university meant opportunities for exchange programs and foreign university partnerships. Besides, students appreciated their university's involvement in social events, jobs and career fairs (Butum, 2017). A similar concept was sustained by paper W18 which mentioned that universities could increase quality in education by internationalizing, because an international academic environment does not relate only to collaboration among universities and people, but it refers to "competitiveness among institutions", as well (Nicolau & Lache, 2017). Participants with majors in engineering and sciences in this questionnaire stated that there were insufficient laboratories and equipment in their universities. Another insight of this study referred to the teaching quality and how interviewees believed that newly employed teaching staff needed to shadow more experience professors during courses in order to be better skilled at teaching methodology and student psychology (Nicolau & Lache, 2017). In 2020, paper W8 outlined the need for international competences for Economics students, too, together with personal, practical, relational and professional skills, and participants in the study said that they were trained by their university to master general economic theoretical knowledge and an economic way of thinking, enabling them to understand international business, economic, and political contexts. Another set of students in the same study's sample presented Social Sciences students' perceptions on their university in preparing them with "communication skills, teamwork, adaptability, organization and integrity, planning and problem solving" (Butum *et al.* 2020).

Article S11 recommended that universities play a more active role in shaping graduates' careers by improving the learning process to instill a correct understanding of essential competencies and strengthening ties with the business environment through effective internship programs (Bordean & Sonea, 2018). The hierarchical PCA model in paper S10 guided curriculum adjustment and practical training, allowing universities to optimize programs to develop professional, technical, and transversal skills valued by employers (Vîlcu *et al.* 2019). Paper W14, a 2018 qualitative case study on the automotive industry, resumed the importance of advanced transversal competences for successful labor market integration, alongside "digital, numerical, autonomy, critical thinking, and problem solving" competences, and gave the example of the Faculty of Mechanics from "Gh. Asachi" Technical University of Iasi where permanent contact with the main employers in the field was maintained and encouraged and where this cooperation consisted of introducing an e-learning support material for simulating processes in real time and by employing technologies in the field (Cojan *et al.* 2018).

In paper S9, effective interventions included improving the quality of the educational process (curriculum content, teaching staff, and methods), strategically integrating practical and research activities, and actively using infrastructure and equipment to support learning. Flexible curricula aligned with labor-market needs, emphasizing transversal and international competencies, further enhanced outcomes (Gora *et al.* 2019). Paper S8 mentioned measures such as higher salaries, attractive work environments, practical training, and leveraging social networks improved retention, but company-level interventions alone were insufficient and systemic, national-level actions were required (Pricina, 2020).

In source S7, active integration of specialized software, combined with assignments and practical simulations, increased learning efficiency, motivation, and acquisition of labor-market–relevant competencies (Roman *et al.* 2020). Study S6 identified interventions at two levels. At the university level, existing interventions included career counseling centers, workshops on practical skills such as CV writing, and partnerships with companies for internships. However, the article suggested these measures were insufficient and called for interventions at the public policy level, including more flexible curricula, funding for university-employer partnerships, and economic policies to stimulate promising sectors to increase the attractiveness of the domestic labor market and retain talent (Gavriluță, 2020).

In source S5, practical entrepreneurial education, individual or team mentorship, and participation in extracurricular projects were associated with reduced skill gaps and increased entrepreneurial intentions. However, their impact remained limited if student participation was low or activities stayed overly theoretical (Roșu, 2022). Paper S3 showed that successful interventions included participatory co-design of curricula, joint training for university and industry partners, explicit definition of objectives and roles, integration of real-work problems and case studies, continuous monitoring and evaluation, and dissemination of best practices to create a sustainable community of practice (Rebelo *et al.* 2023).

A study conducted in 2017-2018 on bachelor programs graduates showed that 83% of graduates from the Bucharest University of Economic Studies were employed, while 46% of them were working jobs in their specialization fields and 29% of them perform professionally in related fields (Camelia & Nastase Richiteanu, 2018). Roughly three years later, paper W7 came up with some good practices which include: "practical compulsory stages in curriculum, experts from the business sector involved in teaching activities, job fairs and meetings with employers' representatives, employers' representatives involved in the decision making processes in universities as members of consultative councils, free counselling and career orientation services, and ,finally, practical stages and internships in companies" (Staiculescu *et al.* 2021). Interviews (W3) with students and employers denoted that graduates tended to value workplace learning over academic education, as they considered the university content as too abstract or detached from practice. This study called for higher education to assert its broader value, beyond opening doors to jobs, emphasizing critical thinking, adaptability, and civic engagement. The issue is not poor student choices, but rather a shortage of suitable jobs and the technological and AI substitution (Pantea, 2025).

In a comparative analysis about Austria, Romania and Sweden, paper W10 presented an experimental and innovative tool in the form of a free online platform which tracks how employability skills' acquisition among high school and high education may take place, as follows: 1) selecting the key elements such as job profile, type of competence (transversal and/or specific), name and category of competence; 2) identifying indicators: importance of this competence for the job and the candidate's capacity to perform a competence; 3) recommendations based on the results: the training needs priority matrix (Gabor *et al.* 2019).

Paper W11 discussed entrepreneurial education and how it should be integrated in each degree specialization, as it is in European developed countries like Germany, Austria, Finland and Denmark, for enhancing education and employability effectiveness of students. In 2019, Romanian universities were still infant in this process of transforming traditional learning institutions into entrepreneurial ones (Nastase *et al.* 2019). Employability and university-industry partnerships are also mentioned in papers W5 and W6. University education alone cannot ensure employability, as outcomes depend on job complexity, workplace policies, and experience. Thus, stronger faculty-student consultation, academic counselling, and extracurricular support through activities like business competitions and entrepreneurship programs were recommended. Entrepreneurial education and business incubators ought to be integrated into universities to encourage innovation and maybe self-employment. Thus, collaboration between universities, employers, and policymakers is crucial to align training with real labor market requirements (Brezuleanu *et al.* 2024; Păunescu *et al.* 2024). Paper W6 described socioeconomic and behavioral factors which influence students' employability and proactiveness that can later translate into workplace success, such as family background, politics, and financial situation. The article also stated that students' voices should play a central role in shaping recruitment strategies and education-employment partnerships and that policymakers should create adaptive learning programs with employers to upskill current and future workers, enhancing lifelong employability (Păunescu *et al.* 2024).

In 2025 (paper S1), Work-Based Learning (WBL) and Entrepreneurship Education Programs (EEPs) demonstrated positive impacts on employability when properly implemented; however, their results remained inconsistent because of fragmented institutional coordination and the absence of standardized frameworks (Grama & Todericiu, 2025). The fundamental intervention proposed in paper W1 is systemic: the creation of a detailed graduate tracking system. The article argues that this is the essential first step, as it would provide universities with the necessary data to make informed decisions, such as adjusting curricula, fostering relevant private sector partnerships, and understanding student dropout reasons (Caragea *et al.* 2025). The main proposed intervention in W2 was educational and institutional. The article explicitly recommended introducing mandatory AI literacy courses. The aim was to teach students to use AI tools responsibly, ethically, and critically. It also emphasized the need for universities to develop clear policies and guidelines regarding AI usage to address ethical concerns and ensure academic integrity (Constantin & Iacob, 2025). Article S2 emphasized continuous professional development and lifelong learning as key strategies for sustaining employability in a dynamic labor market. It also highlighted the importance of enhanced university–industry collaboration, internships, and practical training to better align academic outcomes with employer expectations (Lovin & Savu, 2025).

Conclusions and Further Research

Although the worldwide literature on "school-to-work-transition" is vast and growing, there seems to be no consensus about the factors that facilitate a smooth such transition (Pastore & Choudhry, 2022). Barriers of university-to-work transition can derive from a "lack of career agency during graduation and professional experiences" (Monteiro *et al.* 2021). Besides updating and upgrading curricula to match skills with labor market dynamics, universities should also intervene with support for coaching students to improve the learning process and employability competences, as emotional support and trust are key elements in making career decisions (van der Baan *et al.* 2024). Romania's education system has progressed toward addressing the skills gap, but continues to lag in digital literacy, practical training, and innovation capacity. Bridging this gap requires structural curriculum reforms aligned with industry trends, EU digitalization goals, and sustainable development priorities.

This review is limited by the availability of comparable national datasets and exclusion of non-English literature. Future research could combine longitudinal data and employer surveys, explore regional differences within Romania, and perhaps compare skill transitions across CEE countries.

Practical implications of this study refer to the fact that universities and policymakers should jointly redesign study programs to ensure better labor market relevance and digital integration. As strategies, the authors of this study mention: embedding digital and green competences, as recommended by Cedefop (2025) and OECD (2022) across all disciplines through project-based and experiential learning, institutionalizing internships and apprenticeships, as empirical evidence shows these reduce skill mismatches and strengthen employability (Goia Agoston *et al.* 2017; Monteiro *et al.* 2021), promoting entrepreneurship education, strengthening partnerships between universities and industry, and implementing lifelong learning to enable workers to reskill in response to automation and AI transformations (UNESCO, 2025). Collectively, these measures would improve graduate adaptability, close Romania's skills gap, and ensure alignment with the European Skills Agenda and the Green Deal's digital transition. To conclude, this paper represents a valuable contribution to the Romanian academic literature on the issue of employability of graduates and the higher education system due to the overall drawn picture of the current state of knowledge in this field using the PRISMA methodology.

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Credit Authorship Contribution Statement:

Daria Elisa Vuc: Conceptualization, Methodology, Project administration, Formal analysis, Writing – original draft, Supervision;
Viorela-Denisa Stroe: Investigation, Formal analysis, Writing – original draft.

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Time Aggregation and the RESET Test: Implications for Exchange Rate Modeling

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Abstract: This study focuses on the effects of time aggregation on the performance of Ramsey's RESET test in testing linearity, which may be especially relevant to exchange rates. The results of a Monte Carlo investigation across different levels of time aggregation, autoregressive parameter values, and sample sizes indicate that the wider the level of time aggregation, the greater the possibility of accepting the spurious hypothesis of linearity, reflecting lower sensitivity to misspecification detection itself based upon the autoregressive parameter and sample size. The data sampled systematically possess a better initial advantage in power compared to time-aggregated data over brief spans; their relative performance converges as the span increases. The empirical analysis of the exchange rates confirms such results. It shows that, with an increase in the sample size, relations among the exchange rates generally become more linear. For some levels of aggregation, it gives a ratio value that has persistently been lower, indicating that under such conditions, the modeling has been apt. These results bring out the crucial importance of considering the effects of time aggregation while conducting the RESET test, pointing to caution in result interpretation, especially for time-aggregated data. One can judiciously choose levels of aggregation, use cautious interpretation of test results, and employ complementary methods to be secure about model specification and correct estimation of economic relationships. These insights also generalize the wider analysis of time series, pointing out general problems of time aggregation and its implications for statistical criteria of interdependence of economic variables.

Keywords: Ramsey's RESET Test; time aggregation; regression specification; Monte Carlo simulation.

JEL Classification: C12; C32; C52.

Introduction

One of the most popular diagnostic tools for testing the functional specification of regression models is Ramsey's (1969) RESET test. If a regression model is adequately specified, then residuals must not be related to fitted values, which is the underlying rationale for the test. The test involves augmenting the regression equation with higher-order power polynomial terms and testing their significance. Large higher-order terms suggest that the omitted variable problem may bias the estimates and that the original regression equation was misspecified. One major shortfall of the RESET test, however, is that it requires data that is continuously spaced and uniformly distributed. In practice, it is most likely that the data is not continuously sampled - in some instances, it is quarterly or monthly, in which case one could expect a problem of time aggregation. This may imply possible changes to the statistical properties of the data, including its variance and autocorrelation, and may affect the accuracy of the RESET test. This paper tries to understand the effects of time aggregation on the RESET test through Monte Carlo simulation and practical application in the foreign exchange market. Its purpose is to test the magnitude and power of

Ramsey's RESET test at different levels of time aggregation. More specifically, we would like to check how the RESET test performs on data that is aggregated over various time periods in order to see how aggregation affects its power to detect functional form misspecification in economic models.

The rest of the paper is organized as follows. Section 1 provides the background for the research. Section 2 introduces the RESET specification test along with some necessary notation about time aggregation. Section 3 presents the results of actual application in the foreign exchange market and the simulated model. Section 4 presents concluding remarks.

1. Research Background

Research into the impact of temporal aggregation on econometric inference has grown considerably over recent years, with newer work focusing more directly on how aggregation affects the statistical properties and diagnostic performance of specification tests Early studies, such as Christodoulou-Volos and Tserkezos (2024), document the fact that temporal aggregation distorts the size and power of Ramsey's RESET test and often biases results toward spurious linearity. More recent contributions, such as Christodoulou-Volos & Tserkezos (2025a) and Christodoulou-Volos (2025b, 2025c), have extended the analysis to wider classes of misspecification tests, including nonlinear dynamics and autocorrelation structures, and confirm that information loss increases the likelihood of false model acceptance.

A complementary line of research investigates the sensitivity of the RESET test across distinct data-generating processes and levels of persistence. Arellano *et al.* (2015) show via Monte Carlo simulation that the probability of accepting linearity rises with deeper temporal aggregation, highlighting reduced sensitivity to omitted nonlinearities. The greater the degree of temporal aggregation, the higher the probability of accepting the spurious hypothesis of linearity, since the test has a low sensitivity in order to pick up misspecification. Hecq *et al.* (2016) further demonstrate that temporal aggregation weakens the capacity of diagnostic tests to detect nonlinear transmission mechanisms, as key dynamic patterns become obscured. In fact, this has already been shown, since, regarding this test, its ability to detect nonlinear interactions has been shown to decay with the level of temporal aggregation. The reason was that it introduces information loss, harming the very underlying dynamics and patterns of the variables studied.

From a methodological standpoint, de Peretti *et al.* (2018) analyze how the aggregation of discrete-time series induces structural distortions, sometimes producing erroneous inferences about the relationship between economic variables. They concluded that this could lead one to commit spurious inference errors about the functional form between economic magnitudes. More precisely, the higher the degree of temporal aggregation, the more the probability of accepting linearity - or worse, rejecting the true hypothesis - becomes inflated. Their results showed that when one conducts the RESET test on economic data, time aggregation effects are no longer negligible. Krolzig and Toro (2016) examine temporal aggregation in the presence of structural breaks, concluding that aggregation may asymmetrically affect test statistics unless structural changes are properly modeled. They state that time aggregation can lead to asymmetric test statistics and can produce incorrect model specifications unless treated appropriately. Similarly, Baek *et al.* (2020) show that adequately high sample sizes mitigate negative aggregation effects, with threshold values of about 400 observations stabilizing RESET power. According to their findings, it appears that beyond the threshold - usually up to 400 observations - the power of the RESET test stabilizes. That again puts into perspective how very important it is to have enough observations so that the temporal aggregation will have very minimal effects on test performance.

Additional insights come from Zhang *et al.* (2021), who find that aggregation may introduce upward bias in the detection of omitted variable bias, even when the true model is linear. The authors are able to show just how great an impact this may have on the accuracy of the test. For example, even if the true model is correctly specified, it may tend to over-detect omitted variable bias when data are highly aggregated. This bias is magnified whenever the real model is indeed linear rather than nonlinear. They also determined that it is specific characteristics of the data that determine how temporal aggregation will affect the outcomes of the tests, such that when the data is highly autocorrelated, the test results may become more biased. Li and Li (2021) extend this reasoning to panel data models, noting that the deterioration of RESET performance intensifies when the number of time periods increases relative to the cross-sectional dimension. The results indicated that the higher it is, the worse the performance of the RESET test. Evidence from Liu *et al.* (2020) corroborates that aggregation can exaggerate or suppress omitted variable indications depending on autocorrelation and heteroskedasticity characteristics. Their results did indicate, in fact, that the temporal aggregation for time series models may result in biased test outcomes.

More importantly, even if the true underlying model is adequately and correctly determined, such tests may have a tendency to be biased toward finding evidence of omitted variable bias when the series is heavily

aggregated. They also found that the impact of temporal aggregation on the test result hinges crucially upon the characteristics of the data, such as the degree of autocorrelation and the degree of heteroscedasticity. In fact, Billio *et al.* (2018) have investigated the temporal aggregation effects on the RESET test in the presence of structural breaks. They simulated data with different levels of temporal aggregations and structural breaks through Monte Carlo simulation and tested the performance of the RESET test under different conditions. They prove that, in the presence of structural breaks, this temporal aggregation does not weaken the RESET test, but it does in cases where the breaks are well-identified and the number of observations is plentiful. On the other hand, when the breaks are not well identified or there are not enough observations, this test will fail to detect the omitted variable bias. More importantly, however, the results carry critical implications for applied time series analysis, so one ought to be pretty choosy about temporal aggregation when undertaking econometric and statistical studies.

These studies collectively underscore that temporal aggregation represents a critical source of distortion in specification testing. By broadening the scope of empirical contexts considered - from univariate to panel frameworks, and from stationary to trending data - the literature increasingly emphasizes the necessity of accounting for aggregation effects when evaluating functional form, especially in high-frequency financial applications.

2. Experimental Methods: Ramsey's RESET Specification Test

The RESET test was developed by Ramsey (1969) as a thorough diagnostic technique to identify possible misspecifications in regression models, such as missing variables and improper functional forms. The test usually uses critical values from the F-distribution and is based on the Lagrange Multiplier principle. It looks at whether adding nonlinear elements or changing the fitted values enhances the model's capacity to explain phenomena. Considering the standard linear regression model, which forms the basis of our investigation,

$$y = X\beta + u \tag{1}$$

and assume that the data on y and X are stationary time series. The RESET tests the hypothesis that this (null) model is specified correctly. Choose a *TxM* matrix Z of "test variables," to apply OLS to the equation:

$$y = X\beta + Za + \varepsilon \tag{2}$$

and test the hypothesis H_o: α = 0 using a standard *F* test:

$$F = \frac{(R^2{}_2 - R^2{}_1)/h}{(1-R^2{}_2)/(T-(k+1+h)} \sim F[h,(T-(k+1+h))] \tag{3}$$

Ramsey's (1969) choice for test variables is:

$$z_t = [\ \hat{y}_t^{\,2}\ , \hat{y}_t^{\,3}\ \hat{y}_t^{\,4}\ \ldots\ldots\ldots \hat{y}_t^{\,h}\ ] \tag{4}$$

where $\hat{y}_t = x_\tau^{\,/}\hat{\beta}$ and $\hat{\beta}$ is the OLS fitted value from the null model.
If the power of the RESET test is maintained when y_t and x_t are time aggregated, then time aggregation and systematic sampling are important.
C is a time aggregation matrix of the form:

$$C = \begin{bmatrix} 11\ldots11000\ldots\ldots\ldots00000000000000 \\ 00000011\ldots.11000\ldots\ldots0000000000 \\ 00000000000011\ldots.1100\ldots.000000 \\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\ 0000\ldots\ldots\ldots\ldots\ldots0000000000111\ldots11 \end{bmatrix} \tag{5}$$

Time aggregates, in contrast, are formed by averaging basic observations over non-overlapping intervals. Let $y_T{}^A$ represent the time-aggregated data,

$$y_T{}^A = Cy_t \tag{6}$$

where y_t is the time aggregation level.

3. Research Methodology: The Monte Carlo Experiments

Our simulation experiment is based on the following nonlinear specification:

$$y_t = a\exp(bx_t) + u_t, \quad u_t \approx NID(0,.25) \tag{7}$$

$$x_t = \tau x_{t-1} + (\sqrt{(1-\tau)^2})w_t, \quad w_t \approx NID(.25), \text{ and } \tau = 0.1, 0.5, 0.95 \tag{8}$$

Using equations (4)-(8) to obtain simulated observations of the dependent variable yt, we applied Ramsey's RESET test, estimating the linear model:

$$y_t = a + \beta x_t + u_t \tag{9}$$

and using the RESET test, test the following hypotheses:

$$H_o : u_t \sim NID(0,\sigma^2{}_u) \text{ and } H_1 : u_t \sim NID(\mu,\sigma^2{}_u), \text{ with } \mu \neq 0$$

The basic time series is evaluated with sample intervals ranging from 1 to 20 observations. Various numbers of observations were employed for the basic series, ranging from 400 to 1300.[1]

Equations (7) and (8) are used to create 5,000 replications of the basic time series, which are time aggregated at every sample interval under the null hypothesis. The independent variable was used with four specifications. The initial three requirements, which derive from equation (8) and parameter τ, result in three distinct stationary time series with autoregressive properties. An exponential time trend, which is defined as follows, is the independent variable's final definition.

$$x_t = \exp(0.004TR_t) + w_t \qquad w_t \approx NID(.25) \qquad TR_t = 1,2,.....,T \tag{10}$$

To find out if a linear functional specification is the most acceptable one between the two variables, basic RESET tests were run. Table 1 presents the analytical results for twenty distinct time aggregation levels (j = 1, 2..., 20), four independent variable features, and various numbers of available data (t = 400,500...1300).

Table 1. Rejection Frequencies Based on Sample Size, Time Aggregation Levels, and Independent Variable Characteristics

Number of Observations	400	500	600	700	800	900	1000	1100	1200	1300
Aggregation Level	*Stationarity* $x_t = \tau x_{t-1} + (\sqrt{(1-\tau)^2})w_t \quad w_t \approx NID(.25) \quad \tau = .1$									
1	100.0	100.0	100.0	100.0	100.0	100.04	100.0	100.0	100.0	100.0
5	39.26	48.10	57.42	72.97	87.45	90.18	89.74	94.22	95.52	96.01
10	7.44	3.50	8.96	15.82	25.77	25.55	20.13	27.97	26.04	27.70
15	2.82	2.06	2.42	4.53	5.38	6.32	7.08	7.13	8.47	8.74
20	2.42	1.30	1.97	2.24	2.02	2.38	2.51	2.64	2.87	2.91
Aggregation Level	*Stationarity* $x_t = \tau x_{t-1} + (\sqrt{(1-\tau)^2})w_t \quad w_t \approx NID(.25) \quad \tau = .5$									
1	100.0	100.09	100.09	100.09	100.09	100.09	100.04	100.0	100.0	100.00
5	30.99	74.03	86.44	96.27	98.04	99.20	99.60	99.82	99.91	100.00
10	7.56	30.86	39.53	67.81	67.14	75.77	79.68	83.06	83.82	93.20
15	9.56	14.05	20.05	27.79	35.66	38.28	35.75	58.20	56.60	63.23
20	1.78	2.36	5.16	6.76	10.94	11.78	13.29	11.56	15.30	26.19
Aggregation Level	*Stationarity* $x_t = \tau x_{t-1} + (\sqrt{(1-\tau)^2})w_t \quad w_t \approx NID(.25) \quad \tau = .9$									
1	51.2	76.6	96.8	97.5	99.6	99.9	99.8	100.0	100	100.0
5	45.7	72.9	96.2	96.9	99.6	99.6	99.7	99.9	100	100.0
10	39.3	64.8	94.2	95.5	99.3	99.5	99.5	99.7	100	100.0
15	32.9	58.1	92.2	92.2	98.6	99.4	99.5	99.6	99.9	100.0
20	29.2	48.9	87.5	91.1	98	98.5	98.9	99	100	100.0

[1] Since 400 observations, at the greatest level of time aggregation, yield just 20 observations, we feel that this is the minimum amount of data needed to perform the RESET test. Therefore, we must begin with 400 observations.

Aggregation Level	*Exponential Trend* $x_t = \exp(0.004TR_t) + w_t \quad w_t \approx NID(.25) \quad TR_t = 1,2,.....,T$									
1	75.0	97.9	99.6	99.7	100.0	100.0	100.1	100.0	100.0	100.0
5	64.7	95.3	98.2	99.1	99.7	100.1	100.1	100.0	100.0	100.0
10	53.6	91.0	97.3	98.2	98.7	100.0	100.0	100.0	100.0	100.0
15	47.6	85.8	93.8	95.9	98.1	99.4	100.0	100.0	100.0	100.0
20	38.4	82.1	90.0	92.5	95.7	99.1	100.0	100.0	100.0	100.0

Note: Data entries are probabilities of type II error where the null is the existence of Linearity, which is false by construction. The RESET test was replicated 5000 times for the specification (9)-(13). The size of the test is α = 0.025. Data entries are given by n/5000, where n is the number of times the null is rejected.

3.1 Empirical Analysis of Linearity Between Exchange Rates

This section presents an analysis of the results of a Monte Carlo simulation using empirical tests for a linear or nonlinear relationship between two major exchange rates, namely, the U.S. dollar to one euro (USEU) and the U.S. dollar to one U.K. pound sterling (USUK).

Table 2. Time Aggregation Effects on the RESET Test between the two Exchange Rates

	All Possible Samples of n-size										
Time Aggregation Level	100	200	300	400	500	600	700	800	900	1000	1100
1	11.486	22.554	24.056	13.367	30.475	31.159	21.790	2.063	0.480	2.772	6.334
2	0.587	1.118	2.090	1.847	3.920	6.171	3.686	0.479	0.202	0.931	1.184
3	0.316	0.555	0.822	0.971	1.658	2.504	1.708	0.312	0.234	0.523	0.582
4	0.338	0.388	0.422	0.515	1.155	1.147	0.990	0.296	0.193	0.379	0.439
5	0.274	0.283	0.369	0.370	0.693	0.709	0.677	0.261	0.195	0.372	0.368
6	0.227	0.384	0.322	0.212	0.619	0.385	0.518	0.291	0.212	0.282	0.410
7	0.242	0.293	0.332	0.303	0.405	0.343	0.381	0.297	0.231	0.347	0.303
8	0.278	0.299	0.206	0.186	0.342	0.259	0.326	0.259	0.211	0.245	0.269
9	0.257	0.278	0.236	0.166	0.218	0.223	0.241	0.262	0.274	0.292	0.249
10	0.241	0.281	0.208	0.226	0.230	0.246	0.242	0.285	0.226	0.269	0.234
11	0.232	0.272	0.221	0.171	0.290	0.172	0.143	0.250	0.227	0.286	0.234
12	0.257	0.259	0.223	0.173	0.104	0.178	0.129	0.206	0.232	0.319	0.202
13	0.232	0.224	0.174	0.118	0.233	0.113	0.139	0.247	0.210	0.281	0.160
14	0.219	0.248	0.206	0.166	0.162	0.092	0.124	0.182	0.208	0.250	0.169
15	0.228	0.244	0.154	0.183	0.213	0.165	0.085	0.175	0.198	0.247	0.177
16	0.294	0.204	0.174	0.142	0.242	0.133	0.118	0.171	0.211	0.174	0.117
17	0.281	0.232	0.180	0.097	0.245	0.170	0.101	0.159	0.196	0.197	0.096
18	0.177	0.219	0.141	0.154	0.191	0.118	0.084	0.142	0.201	0.168	0.076
19	0.184	0.206	0.179	0.085	0.234	0.118	0.100	0.167	0.172	0.157	0.099
20	0.259	0.212	0.117	0.129	0.184	0.090	0.100	0.147	0.157	0.136	0.112

The dataset encompasses daily observations from April 4, 1999, to April 4, 2024, constituting a total of 6,336 observations. Therefore, the data points were transformed into logarithmic form to carry out the analysis. First of all, there are some major advantages to logarithmic transformations when working with spot exchange rates. The

first is that it tends to normalize the distribution, and hence the data becomes more suitable for statistical analysis. Second, they are capable of stabilizing variance, which is important since exchange rate data usually exhibit heteroscedasticity across time. Changes in the logarithm of prices are, therefore, percentage changes; hence, they are more interpretable and meaningful for financial analysis. Logarithmic transformations ensure that trends within data become easily linearized, hence making linear regression techniques effective in modeling. They reduce the skewness in data to a normal distribution; hence, their performance in statistical tests and models is improved. In general, the usage of logarithmic transformations increases the capability and insights obtained when analyzing exchange rates. Overall, the utilization of logarithmic transformations enhances the analytical capability and insights derived from analyzing exchange rates.

Table 2 reports the effects of time aggregation on the RESET test that has been applied to test for linearity between USEU and USUK.

The table shows the results of the empirical investigation of time aggregation on the RESET test between the two major exchange rates, USEU and USUK. The values in the table represent the ratio of the F Statistic to the F critical value, where a ratio greater than 1 indicates a non-linear relationship between the two exchange rates, and a ratio less than 1 indicates linearity.

4. Research Results and Discussions

The following inferences are made from the results of the Monte Carlo simulation of how time aggregation affects the RESET test: Particularly,

i. The higher the time aggregation, the greater the possibility or probability of accepting the false hypothesis, linearity, when using a RESET test. The highest level of time aggregation is characterized by a very high probability of rejecting the true hypothesis-accepting linearity in all cases, and this depends on the characteristics of the independent variable and the number of available observations. That is, the RESET test becomes less sensitive to detecting nonlinear relationships when applied to timely aggregated data. It, therefore, follows that the loss of information from aggregation reduces the test's ability to capture and identify nonlinear patterns in data.

ii. Time aggregation effect: This depends on the value of the parameter τ. For values ranging from 0.1 to 0.5, the probability of accepting linearity is higher under time aggregation than under systematic sampling. However, for a value of the parameter τ around 0.9, time aggregation leads to a lower probability of rejecting the true hypothesis than systematic sampling does. The latter pattern is reproduced when the independent variable shows a trending behavior. This may suggest that the power of the RESET test to detect misspecification depends on the underlying characteristics of the data and particular parameters. Another factor affecting the power of the RESET test under time aggregation is the number of available observations. As the number of observations available increases at the highest level of time disaggregation, the probability of accepting linearity decreases. Beyond a threshold-usually about 400 observations test power usually stabilizes to indicate that a sufficient number of observations is required to mitigate the adverse effects of time aggregation.

iii. The power of the RESET test will also be affected by the number of available observations under time aggregation; the higher the level of time disaggregation, the fewer the number of observations that will lead to a diminution in the probability of accepting linearity. Under time aggregation, the number of available observations also affects the power of the RESET test: the probability of accepting linearity decreases as the number of observations is increased at the highest level of time disaggregation. It is only beyond a threshold number of, say, 400 observations that the power will stabilize because the power requires a sufficient number of observations to reduce negative effects caused by time aggregation.

iv. At the short-time aggregation level, the probability of the rejection of the true hypothesis is larger when using time aggregation than for systematic sampling. As an example, consider that for aggregation level 10, the percentage of rejecting the true hypothesis is approximately 40% for time aggregation and 10% for systematic sampling, when τ is about 0.1 and 0.6, respectively. Also, when τ is about 0.9, similar kinds of percentages are observed in it.

v. The performance of timely aggregated data is compared to systematically sampled data. Over short periods of aggregation, systematically sampled data tend to be more powerful than their timely aggregated counterparts. However, over longer spans of aggregation, the performance of the two approaches becomes comparable. It follows that the choice between time aggregation and systematic sampling should consider the span of aggregation as well as the specific research objectives.

Overall, the analysis supported evidence that time aggregation significantly influences the power of the RESET test: the higher the level of time aggregation, the higher the probability of accepting the false hypothesis of

linearity. The exact influence is specified by the value of the parameter τ, the number of available observations, and the length of the aggregation period.

Some of the important observations and inferences arising from the empirical analysis, as depicted in Table 2, are as follows:

i. The table is arranged with time aggregation of different levels running from 1 to 20, and for each of these aggregation levels, the sample sizes run from 100 to 1100. Moving across the rows from different levels of time aggregation, the ratio values fluctuate. This indicates that the time scale of aggregation matters for linearity in the relationship between the exchange rates. For example, at a time aggregation level 1, most of the ratios are relatively higher compared to other levels; this suggests a greater likelihood of non-linear relationships at this level of time aggregation.

ii. With the change in sample sizes, the ratio values fluctuate. More precisely, with the increase in the sample size along the columns, the ratios tend to be lower. In general, the ratios seem to get lower as the sample size increases. For the small samples, mainly less than 500, the ratio is sometimes greater than 1, indicating that the relationship in the exchange rates is not linear. However, for a larger sample size, this ratio tends to drift below 1, hence indicating linearity in their relationship. The relationship between the exchange rates may be more linear at larger sample sizes.

iii. From an overall view of the table, one can notice that there are cases for which, at different levels of time aggregation as well as sample sizes, the ratio remains above 1, indicating that under those conditions, the existence of a non-linear relationship between the two exchange rates is consistent. Similarly, there are conditions under which the ratios remain below 1, and evidence of a linear relationship exists.

iv. The ratios vary for particular time aggregation level-sample size combinations. The causes may be many, including changes in market conditions or economic events, but perhaps just statistical noise.

v. A ratio much smaller than 1 indicates stronger adherence to linearity, and a ratio much greater than 1 indicates strong deviation from linearity. Values around 1 indicate a grey zone in which, depending on the case, the linearity assumption may or may not be maintained.

In other words, Table 2 summarizes the effect that time aggregation has imposed on both sample size and the RESET test. The results derived might help us to understand the dynamics of these exchange rates for an informed decision in either financial analysis or forecasting.

Conclusions and Further Research

The Monte Carlo experiment illustrates how time aggregation affects the power and size of the RESET test: For larger time aggregations, the probability of rejecting the spurious hypothesis of linearity increases and hence reflects a loss in sensitivity in detecting misspecification. Time aggregation effects depend on the values taken by the autoregressive parameter τ and the number of available observations. In addition, it was also tested against systematically sampled data, which demonstrated that even when systematically sampled data are more powerful than timely aggregated data for small spans of aggregation, they perform similarly over longer spans of aggregation. These conclusions indicated the most important implications of the analysis for the use of the RESET test to account for time aggregation. It is advisable to be very cautious in the interpretation of tests and to handle timely aggregated data very warily. Such a loss of information through aggregation may lead to the wrong conclusions about the functional form taken by the model and therefore result in biased estimates and misleading inferences. Evidence from the empirical analysis suggests that linearity in the relationship of the exchange rates is a function of sample size and also the level of time aggregation.

Larger sample sizes tend to linearize the relationship between the exchange rates, and this is evident from the lower values of the ratio. Time aggregation may also distort linearity in the relationship since some levels of aggregation are more consistent in showing lower values of the ratio compared to others. In general, the results would suggest that a linear model could be adequate to model the relationship between the two exchange rates, especially with larger sample sizes and/or time aggregation levels in any possible time period. In this regard, the investigation of the influence of time aggregation on linearity in the relationship of exchange rates is in line with the results of à, supporting evidence from the previous Monte Carlo simulation. The results also highlight that the level of time aggregation must be chosen with care, taking into account the particular research context.

Although the requirement is that a good balance should be struck to avoid such practice resulting in further information loss, several advantages are associated with time aggregation. That is, noise is reduced through aggregation over time; hence, concentration is made directly on the underlying trends of the data. There must be a search for a proper planning level of time aggregation that preserves the fundamental data characteristics with a minimum adverse effect on the RESET test power. Alternative approaches and refinements could be made to

alleviate the identified effect. One such strategy would be the inclusion of many more diagnostic tests and techniques for model selection that are less vulnerable to time aggregation. Most importantly, robustness checks and sensitivity analyses would provide more detailed information on the stability of the model specification under different levels of time aggregation. The consequences of the Monte Carlo findings reached far beyond the RESET test. They underline the general challenges associated with time aggregation in applied time series analysis. Other studies have indicated that the performance of different statistical criteria could be sensitive to controlling interdependencies between economic variables, in particular as far as time aggregation is concerned. In a general sense, the Monte Carlo analysis underscores that, for its power and size, it is important for the RESET test to depend on the time aggregation. It implies more chances that wide-time aggregation will lead to acceptance of the false hypothesis of linearity, which carries minimum sensitivity for misspecification. This, in turn, reflects on the value of the autoregressive parameter τ and on the actual number of observations one has.

While systematically sampled data are more powerful for short aggregation spans, their power converges to that of timely aggregated data for longer spans. These results bring out the importance of considering time aggregation effects when using the RESET test and interpreting the results with caution, especially when data are timely aggregated because of possible biases and misleading inferences. An appropriate choice of the level of aggregation becomes very important in balancing noise reduction against information loss. Also, it recommends applying different tests that are less sensitive to aggregation problems, and robustness checks can mitigate some of the effects of aggregation over time on the stability of the specification of the models. In general, the RESET test should be interpreted with caution by the researchers as they choose between the different levels of aggregation, so results can be assigned meaningful interpretations in the context of the research to make an empirical assessment of the exchange rate relationships.

This paper contributes to the literature by providing the most comprehensive simulation-based investigation thus far into how temporal aggregation affects Ramsey's RESET test performance in multiple dimensions, including the depth of aggregation, autoregressive persistence, sample size, and alternative data-generating processes. Rather than relying on narrowly specified parameter settings or smaller datasets that have characterized earlier research, this study complements 5,000 Monte Carlo replications with an empirical analysis based on 6,336 daily exchange rate observations. The results indicate that temporal aggregation significantly enhances the probability of spurious acceptance of linearity and, as a result, seriously undermines the diagnostic performance of the RESET test. By identifying conditions under which systematic sampling, or sufficiently large samples, dampen these distortions, the study offers novel methodological guidelines for applied econometricians and provides practical lessons for empirical modeling of exchange rates and other financial time series.

Limitations and Future Research

Although the rather comprehensive results provided by the Monte Carlo experiment concerning the effect of time aggregation on the power and size of the RESET test, there are some respects one could consider as limitations: The study enumerates among the causes of this phenomenon the influence of the autoregressive parameter τ and the number of observations on time aggregation effects. Also, the comparison with systematically sampled data, while useful, may not satisfactorily reflect the complications associated with real-world data situations and is perhaps more constraining on the generalization of the findings. Further, the empirical analysis, though useful, is essentially concentrated on the examination of the exchange rate series, which implies that validation of the robustness of these results will require application on a wide range of economic series. Finally, although some alternative ways of overcoming the problems of time aggregation are discussed, not only are practical implementation issues not taken up, but computational complexities associated with these methods need careful consideration in new research efforts. It is further possible that more consideration of alternative methods of aggregating time could again help in the identification of the nature of the relationship between the exchange rates and how it is altering the quality of the model fit.

Declarations

Credit Authorship Contribution Statement:

Christos N. Christodoulou-Volos: Conceptualization, Investigation, Methodology, Project administration, Formal analysis, Writing – original draft, Supervision, Data curation, Validation, Writing – review and editing, Visualization, Funding acquisition.

Dikaios Tserkezos: Conceptualization, Investigation, Methodology, Software, Formal analysis, Data curation, Validation.

Declaration of Competing Interest: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Declaration of use of generative AI and AI-assisted technologies: During the preparation of this work, the author(s) used QuillBot and Grammarly to enhance the writing by only paraphrasing certain pieces of writing. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

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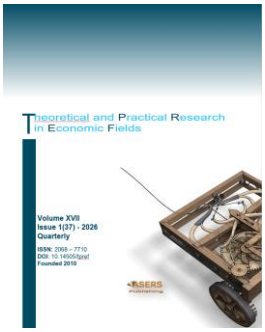
Analysing the Influence of Celebrities on Impulsive Buying Intention through Livestreaming: The Moderating Role of Financial Promotion in Online Commerce



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Abstract: This study explores the impact of environmental factors in e-commerce livestreaming, including perceived expertise, trustworthiness, attractiveness, and parasocial interaction, on emotional arousal, trust, and consumers' impulsive buying intention. Data collected from 433 consumers and analyzed using SPSS and SmartPLS reveal a key finding of the research, the strong moderating role of financial promotion, which significantly enhances the influence of emotional arousal and trust on impulsive buying intention in celebrity-hosted livestream settings. Moreover, a novel theoretical contribution is provided by testing the moderating role of financial promotion within the SOR framework, thereby extending the traditional SOR approach that has paid limited attention to the moderating effects of financial contextual factors in live shopping environments. These findings not only broaden the theoretical framework of online consumer behavior but also challenge the conventional assumption that emotions predominantly drive impulsive buying behavior.

Keywords: Impulsive buying; financial promotion; parasocial interaction; emotional arousal; trust.

JEL Classification: M31; M37; L81; D91.

Introduction

In the context of the rapid growth of e-commerce, livestreaming sales have emerged as one of the primary marketing tools, particularly popular on social media platforms such as Facebook, TikTok, and Shopee Live. A notable trend is the use of celebrities to host livestream sessions in order to enhance reach, build trust, and stimulate consumer behavior, especially viewers' impulsive buying.

According to several studies, livestream e-commerce is not merely a product presentation tool but also an interactive social commerce model driven by user-generated content, allowing consumers to directly interact with the streamer to ask questions, exchange product information, and make purchase decisions in real time (Chen *et al.* 2022; Hilvert-Bruce *et al.* 2018; Rosely *et al.* 2024). The distinctive feature of livestream marketing lies in its ability to trigger immediate emotional arousal through dynamic interactive experiences. Viewers can easily be drawn into the shopping process through direct connection with the streamer, thereby increasing the likelihood of impulsive buying, a type of affective behavior that occurs within a short time frame with limited rational deliberation (Chen *et al.* 2022; Chung *et al.* 2017; Ma *et al.* 2024; Rosely *et al.* 2024).

In addition, many studies indicate that during livestream sessions, consumers often lose track of time and self-awareness, entering a state of "flow" characterized by deep concentration and enjoyment, which further increases the likelihood of spontaneous purchasing behavior (Li *et al.* 2024; Zhang & Liu, 2024). Notably, when the livestream host is a celebrity, he or she plays a central role in shaping consumer intentions and purchase behavior. The studies of Lee and Chen (2021), Lu and Chen (2021), and Cai *et al.* (2018) confirmed that livestream hosts are a critical factor influencing consumption decisions, alongside other elements such as product quality, consumer motivation, and marketing strategies.

Since the nineteenth century, celebrities have been widely employed as opinion leaders in marketing (Gauns *et al.* 2018). Celebrity endorsement is a communication strategy that associates the positive attributes of celebrities with a brand, thereby generating favorable effects for products or services (Silva *et al.* 2020; Temperley & Tangen, 2006). The objective of this strategy is to convey qualities admired by consumers in celebrities, such as physical appearance, health, and lifestyle, to link them with products and foster purchase intention (Pramjeeth & Majaye-Khupe, 2016).

At the same time, e-commerce livestreaming has opened a new era in the digital retail industry, where the combination of social media, real-time interaction, and emotional engagement plays a decisive role in triggering impulsive buying behavior and fostering the sustainable growth of e-commerce (Lee & Chen, 2021; Xue *et al.* 2020). When consumers watch product advertising videos on social media platforms, they not only receive information but also tend to immerse themselves in the story being told and develop parasocial interactions with the characters or streamers featured in the video. Parasocial interaction refers to a one-sided imagined relationship or interaction between viewers and the characters they follow on digital devices (Shen *et al.* 2022; Vazquez *et al.* 2020). Numerous studies have demonstrated that this sense of connection is a crucial factor that drives impulsive buying behavior while directly shaping consumers' purchase intentions and decisions (Rungruangjit, 2022; Sokolova & Kefi, 2020; Vazquez *et al.* 2020).

Another key factor in e-commerce livestreaming is the role of celebrities or social media influencers. With widespread recognition and certain social credibility, influencers are often employed by brands to represent products, thereby generating a celebrity effect that helps build trust, convey product information, and increase purchase intention (Ooi *et al.* 2023). When celebrities demonstrate products visually, explain their benefits, and interact directly with viewers, they not only enhance consumers' understanding of the products but also create a sense of urgency and exert strong emotional influence, which can easily lead to unplanned purchasing behavior.

Live commerce is considered a modern form of e-commerce that integrates real-time interaction, authenticity, and product visualization to enhance the online shopping experience (Hu & Chaudhry, 2020). This format allows viewers to watch live product demonstrations while asking questions, posting comments, or participating in surveys during the broadcast (Wongkitrungrueng & Assarut, 2020). Such interactive engagement provides businesses with opportunities to build loyal customer communities and increase brand attachment.

Although impulsive buying behavior has received considerable attention from scholars, very few studies have examined the financial link in online livestreaming, an important characteristic that enables sellers to better understand customer needs, build sustainable relationships, and potentially trigger impulsive buying behavior (Guo *et al.* 2021). Impulsive buying behavior is defined as unplanned purchasing that occurs immediately after consumers experience an urge, typically taking place quickly and without careful deliberation (Beatty & Ferrell, 1998). It is a strong response to external stimuli and a significant driver of sales performance, which marketers cannot overlook (Ahmadova & Nabiyeva, 2024).

However, in the context of live commerce, consumers often develop multiple concerns when engaging in transactions, making the influence of celebrities inconsistent. Consumers frequently perceive celebrities as less trustworthy, less competent, and less attractive compared to influencers, which negatively affects attitudes, trust, and purchase behavior (Schouten *et al.* 2021). Trust is a key factor influencing consumer value, particularly in e-commerce environments where livestreamers may manipulate information such as view counts, likes, or order volumes to create a bandwagon effect. In addition, consumers often face problems such as counterfeit products, poor product quality, and inadequate after-sales services, which further erode confidence in livestream shopping.

If celebrities lack engaging communication skills or fail to interact effectively during livestream sessions, they are unlikely to capture consumers' interest or elicit positive emotions (Leong *et al.* 2022). In contrast, active participation and high interactivity with professional livestreamers can stimulate emotions and impulsive buying behavior, especially in environments where information is shared transparently and instantly. Nevertheless, despite the long-standing attention to impulsive buying behavior, in-depth research in the livestreaming context remains limited (Redine *et al.* 2023).

Maximizing the potential of live commerce continues to pose a significant challenge for marketers and streamers. With an overwhelming amount of competing content on digital platforms, capturing and retaining viewers' attention has become increasingly difficult, requiring a deep understanding of consumer behavior as well as the ability to create compelling content that aligns with the fast-paced and dynamic nature of livestreaming (Hawks, 2021; Yu, 2020). Therefore, clearly identifying impulsive buying behavior is essential to optimizing marketing effectiveness in the rapidly expanding live commerce environment.

Although impulsive buying behavior has been extensively studied, there is still a lack of research clarifying the direct relationship between trust and impulsive buying behavior, particularly in the livestream commerce context.

At the same time, the moderating role of financial promotion, representing consumers' spending capacity or the financial connection between buyers and sellers, has not been sufficiently explored. Previous studies have mainly examined the personal attributes of celebrities in isolation without integrating them to assess their overall impact. Hence, it is necessary to develop a comprehensive model that investigates how celebrity characteristics influence impulsive buying behavior through the mediating roles of trust and emotions, while evaluating the moderating effect of financial promotion to provide a deeper understanding of consumer behavior in the rapidly evolving era of e-commerce.

Therefore, this study was conducted to address the following research questions:

RQ1: How do the characteristics of celebrities influence consumers' emotional arousal, trust, and impulsive buying intention in livestreaming environments?

RQ2: To what extent does financial promotion moderate the relationships between emotional arousal/trust and impulsive buying intention when consumers watch celebrity-hosted livestreams?

Although impulsive buying behavior has been examined in prior studies, a significant research gap remains concerning the connection between celebrity characteristics and consumer behavior within livestreaming contexts. This gap is particularly evident given the limited attention paid to the moderating role of financial factors within the S-O-R framework. Accordingly, this study provides a novel contribution by extending the S-O-R framework through the integration of Transaction Utility Theory to incorporate financial promotion as a moderating factor an essential but previously underexplored element in celebrity-driven livestream commerce.

1. Literature Review

1.1 Theoretical Framework

The foundational theory of this study is the SOR model, a framework in environmental psychology commonly used to analyze consumer behavior in shopping contexts, particularly when environmental or technological factors are involved (Parboteeah *et al.* 2009). The model consists of three main components: Stimulus, which refers to external environmental factors affecting individuals; Organism, which reflects the internal state of individuals including cognition and emotions; and Response, which represents the behavior displayed after processing the stimuli. Recent developments in live commerce research have applied the S-O-R model to systematically examine the factors that influence impulsive buying behavior. For example, Li *et al.* (2025) conducted a systematic literature review that synthesized multiple antecedents and demonstrated the widespread use of the S-O-R framework in online livestream environments. In particular, the recent study by Wang *et al.* (2025) highlights the central role of livestreamers in generating emotional and cognitive connections, which in turn increase impulsive buying behavior in live commerce settings. These elements have the ability to stimulate positive emotions and strengthen behavioral motivation, especially within real time interactions.

In the context of live commerce, stimulus is understood as external factors influencing consumers' perceptions and senses. Recent studies have confirmed that the characteristics of livestreamers, such as expertise, trustworthiness, attractiveness, popularity, and interactivity, serve as key stimuli that strongly influence consumers' purchase intentions and behaviors (Chang *et al.* 2023; Lee & Chen, 2021; Meng & Lin, 2023; Xin *et al.* 2025; Yang *et al.* 2024). These factors can evoke positive emotions, enhance trust, and create behavioral motivation for consumers, especially in livestreaming environments characterized by high interactivity and instant engagement.

The Organism represents the intermediary stage that reflects individuals' internal reactions when receiving stimuli from the environment. According to Hsin Chang and Wen Chen (2008) and Lee and Gan (2020), this dimension manifests in two primary forms: emotional responses (such as arousal, strong purchase desire, and positive or negative moods) and cognitive responses (such as trust in celebrities or brands). These internal reactions serve as mediators that adjust the relationship between external stimuli (livestreamer characteristics) and purchasing behavior (Li *et al.* 2025). Positive emotions can intensify impulsive buying, whereas trust is a critical factor that reduces perceived risks and strengthens behavioral decisions.

The Response refers to the final consumer behavior that results from internal evaluations and psychological processing of external stimuli (Ming *et al.* 2021; Tang *et al.* 2019; Widjaja *et al.* 2025). In this study, impulsive buying behavior is considered the main response, manifested when consumers feel a strong urge to make unplanned purchases under the influence of the livestreamer with whom they interact or follow (Chung *et al.* 2025).

Furthermore, Transaction Utility Theory Thaler (1985) posits that when consumers perceive the promotional price as lower than their reference price, they experience a sense of a "good deal," which increases their motivation to make immediate purchase decisions. In the context of livestream commerce, financial promotions such as discounts, vouchers, or flash sales can significantly enhance transaction utility, thereby amplifying the influence of emotional arousal and trust on impulsive buying intention.

The SOR model is applied in this study to explain how the characteristics of celebrities in livestreaming (stimuli) affect consumers' psychological states (organism), expressed through emotions and trust, which in turn lead to impulsive buying behavior (response). In addition, the integration of Transaction Utility Theory (Thaler, 1985) clarifies the moderating role of financial promotion. Specifically, when consumers perceive greater transaction utility through promotional programs, the perceived value of a "good deal" strengthens the effects of emotional arousal and trust on impulsive buying intention. Employing this theoretical framework not only elucidates the psychological mechanisms underlying live commerce but also sheds light on the mediating and moderating roles of psychological and financial factors in the modern shopping environment.

1.2 Hypothesis Development

1.2.1 Perceived Expertise

Perceived expertise of celebrities is defined as the extent to which consumers believe that a celebrity possesses knowledge, skills, and experience related to the product or brand they endorse (Ohanian, 1990; Sertoglu *et al.* 2014). This is one of the critical factors that determine the persuasiveness of a celebrity in marketing activities. According to Hovland *et al.* (1953) and Ohanian (1991), what matters is not whether the celebrity is truly an expert but rather the public's perception of the level of expertise that the celebrity demonstrates.

It is essential that the endorser's expertise aligns with the promoted product, as this enhances credibility and positively influences consumer attitudes and purchase intentions (Mat *et al.* 2019; Teo & Liu, 2007). Celebrities with extensive experience and high competence in a relevant field are often regarded as "product masters," thereby conveying trust and exerting stronger persuasive effects on consumers.

Moreover, expertise influences followers' attitudes and levels of engagement, as consumers tend to place greater trust in content or recommendations from individuals perceived as genuine experts in the field (Li *et al.* 2025; Smith *et al.* 2005). Professional celebrities are considered capable of analyzing and evaluating products accurately, which contributes to greater credibility and impacts consumer purchase intentions. Within the context of livestream commerce, audiences are more likely to interact with streamers perceived as experts in the product domain (Leong *et al.* 2022; Xin *et al.* 2025). In particular, the higher the expertise and persuasiveness of the livestream host, the greater the likelihood of stimulating emotional responses that lead to impulsive purchasing behavior among viewers. Accordingly, the following hypotheses are proposed:

H1: The perceived expertise of celebrities has a positive effect on customer emotions arousal during livestream shopping.

H2: The perceived expertise of celebrities has a positive effect on customer trust during livestream shopping.

1.2.2 Perceived Trustworthiness

Trustworthiness is one of the critical factors determining the effectiveness of celebrity endorsement. According to Ohanian (1990), trustworthiness reflects the extent to which the audience believes in and accepts the communicator, that is, the degree to which consumers perceive the celebrity as honest, sincere, and reliable.

Perceived trustworthiness of celebrities is defined as the level of confidence that consumers place in statements, messages, or recommendations conveyed by celebrities, based on the perception that they are truthful, ethical, and dependable (Mansour & Diab, 2016). Trustworthiness serves as a fundamental element in generating an effective endorsement effect, as consumers tend to believe only in information delivered by sources they trust. Celebrities who are evaluated as highly trustworthy often foster favorable attitudes toward products and, in turn, enhance consumers' purchase intentions (Li *et al.* 2025; Mat *et al.* 2019). This indicates that trust derived from the credible image of celebrities can stimulate positive emotions, encouraging consumers to believe in product recommendations and subsequently driving impulsive purchasing behavior.

In the context of online commerce, where interaction and emotions play a vital role, the trustworthiness of endorsers becomes even more crucial. Consumers are influenced not only by the information itself but also by the manner in which celebrities deliver it, particularly when it conveys sincerity, relatability, and reliability. Lee and Chen (2021) emphasize that in live streaming environments, hosts with high levels of trustworthiness not only enhance brand credibility but also increase audience engagement, thereby generating stronger emotional responses throughout the shopping experience. Furthermore, when consumers perceive the livestream host as trustworthy, they are more likely to develop feelings of reassurance, safety, and satisfaction with the communicated message. These positive emotions function as a catalyst that strengthens trust while reducing psychological barriers such as skepticism, hesitation, or anxiety in purchasing behavior (Lee & Chen, 2021; Meng & Lin, 2023), ultimately leading to impulsive shopping. Based on this reasoning, the following hypotheses are proposed:

H3: The perceived trustworthiness of celebrities has a positive effect on customer emotional arousal during livestream shopping.

H4: The perceived trustworthiness of celebrities has a positive effect on customer trust during livestream shopping.

1.2.3 Perceived Attractiveness

According to Ohanian (1990) and Mansour and Diab (2016), perceived attractiveness refers to the physical features and personality traits of celebrities that have the ability to capture the attention of the target audience. Factors such as similarity, familiarity, and likability are considered the core components of attractiveness, as consumers often feel more connected and closer to celebrities whom they perceive as sharing similarities with themselves. Patzer (1985) argues that physical attractiveness functions as a powerful informational cue, capable of spreading and generating subtle yet unavoidable effects on perception. The public tends to respond more positively to individuals with appealing appearances and often seeks to approach or emulate those figures. This perspective is reinforced by Erdogan (1999), who suggests that audiences react more favorably to attractive endorsers, particularly when they perceive those individuals as being similar to themselves.

A considerable number of studies also demonstrate that celebrities with attractive appearances and appealing personalities can positively influence purchase intentions (Subbiah & Sathish, 2020; Tanjung & Hudrasyah, 2016). In addition, attractiveness helps create a favorable impression of the product (Bergkvist & Zhou, 2016), alters consumer attitudes and beliefs (Baker & Churchill Jr, 1977; Li *et al.* 2025), and enhances the perceived value of the product (Chi *et al.* 2011). Collectively, these factors facilitate consumer decision-making.

In the context of livestream social commerce, the attractiveness of livestream hosts not only captures attention but also functions as a stimulus that evokes emotional responses. The study of Sjöblom and Hamari (2017) indicates that an attractive streamer can increase viewers' retention time and viewing frequency, thereby reinforcing the process of cognitive assimilation as the brand becomes strongly associated with the image of the attractive endorser. Moreover, several studies have confirmed that attractiveness can elicit emotional arousal, such as excitement, joy, or surprise (Haidt, 2000; Singer, 1983). When consumers are captivated by a celebrity with appealing physical features and personality traits, they are more likely to experience positive emotional states, which in turn foster trust in the conveyed information.

H5: The perceived attractiveness of celebrities has a positive effect on customer emotional arousal during livestream shopping.

H6: The perceived attractiveness of celebrities has a positive effect on customer trust during livestream shopping.

1.2.4 Parasocial Interaction

When engaging in livestream sessions, viewers often perceive a profound personal connection with the host, even though this relationship is only imagined and lacks actual reciprocity. This sense of closeness and intimacy has been shown to evoke positive emotions, strengthen trust, and become a powerful driver that stimulates impulsive buying behavior (Chen *et al.* 2021; Rungruangjit, 2022; Sokolova & Kefi, 2020).

Consumers interact with celebrities through simulated forms such as commenting, livestreaming, or responding to messages, thereby creating emotional bonds and social attachment (Shen *et al.* 2022; Zafar *et al.* 2020). These viewers often regard celebrities as close friends, which fosters a strong personal connection and makes them more susceptible to purchase suggestions from these figures (Zafar *et al.* 2020). Moreover, livestream commerce, as a modern form of e-commerce, enhances authenticity and real-time interaction, offering a shopping experience that is more vivid, immersive, and emotionally engaging compared to traditional formats (Haider *et al.* 2022; Hu & Chaudhry, 2020; Wang *et al.* 2025). Beyond being a platform for product promotion, livestreaming establishes a community of emotion and trust, where consumers feel accompanied and deeply connected. This reinforces trust and elicits emotion-driven purchasing behavior (Li *et al.* 2025; Wongkitrungrueng & Assarut, 2020).

In livestream sessions, particularly those with a large audience, the relationship between the host and viewers is often one-sided. However, by responding to comments, using informal language, or sharing personal stories, the host creates a simulated dialogue, a type of interaction that adjusts content to align with audience expectations (Xiang *et al.* 2016; Zafar *et al.* 2020; Zhang & Liu, 2024). Despite the absence of direct reciprocity, the sense of being heard and cared for increases consumer trust and positive emotions toward the host, which in turn promotes quick and less hesitant impulsive purchasing decisions (Wang *et al.* 2025).

H7: Parasocial Interaction with celebrities positively influence customer emotions during online livestream shopping.

H8: Parasocial Interaction with celebrities positively influence customer trust during online livestream shopping.

1.2.5 Emotional Arousal

Consumer behavior studies have demonstrated that emotions play a critical role in driving impulsive buying behavior, particularly in online contexts such as livestreaming (Verhagen & Van Dolen, 2011). Specifically, positive emotions such as joy, excitement, and happiness that are evoked through interactions with celebrities during livestream sessions can strongly stimulate the desire for impulsive purchases (Adelaar *et al.* 2003; Wang *et al.* 2025). These emotions are often generated when livestream hosts, through their attractiveness and diverse forms of interaction, build deep emotional connections with viewers, thereby reducing psychological distance and fostering a sense of closeness (Li *et al.* 2021).

Emotional arousal, defined as the state of excitement, stimulation, and alertness experienced by consumers in response to celebrity-driven cues, also plays a significant role in impulsive buying behavior (Li *et al.* 2025; Weinberg & Gottwald, 1982; Youn & Faber, 2000). In the livestreaming context, interactions with celebrities not only create satisfaction and enjoyment but also evoke feelings of happiness and carefreeness, making consumers more prone to making impulsive purchase decisions (Adelaar *et al.* 2003; Wang *et al.* 2025). Emotional distance, an important measure of psychological connectedness, is further reduced through these positive emotional experiences, which in turn encourage impulsive buying behavior.

H9: Customer emotional arousal has a positive effect on impulsive buying intention when watching online livestreams.

1.2.6 Trust

In the context of online marketing, trust in an influencer increases the likelihood that customers will accept their recommendations, thereby shaping attitudes toward products as well as purchasing behavior (Hsu *et al.* 2013; Morgan & Hunt, 1994; Wang *et al.* 2025). Moreover, influencers who are perceived as trustworthy by demonstrating integrity, competence, and consistency can significantly influence followers' attitudes and purchase intentions (Morgan & Hunt, 1994; Zhou & Whitla, 2013). Research has also shown that trust in a brand or online platform fosters impulsive buying behavior, particularly when combined with attractive pricing or prominent products (Li *et al.* 2025; Ming *et al.* 2021; Shang *et al.* 2023).

High quality livestreams, positive consumer interactions, and trust in e commerce platforms, which are reinforced through engaging content and direct interaction with sellers, positively affect impulsive buying behavior. During livestream sessions, celebrities employ persuasive language, combining logical reasoning with ethical attributes such as integrity and professional expertise, to enhance their professional image and credibility (Chang *et al.* 2018; Gao *et al.* 2021; Zhou & Whitla, 2013). This persuasion shapes consumers' cognitive trust, while the emotional elements embedded in the influencers' communication resonate with viewers' feelings, fulfilling emotional needs and building affective trust (Srivastava *et al.* 2016; Wang *et al.* 2025; Widjaja *et al.* 2025). Therefore, the combination of trust in celebrities, both cognitive and affective trust, together with emotional alignment with customers, plays a crucial role in amplifying impulsive buying behavior in livestreaming, highlighting the importance of fostering an emotional connection between celebrities and viewers.

H10: Customer trust has a positive effect on impulsive buying intention when watching online livestreams.

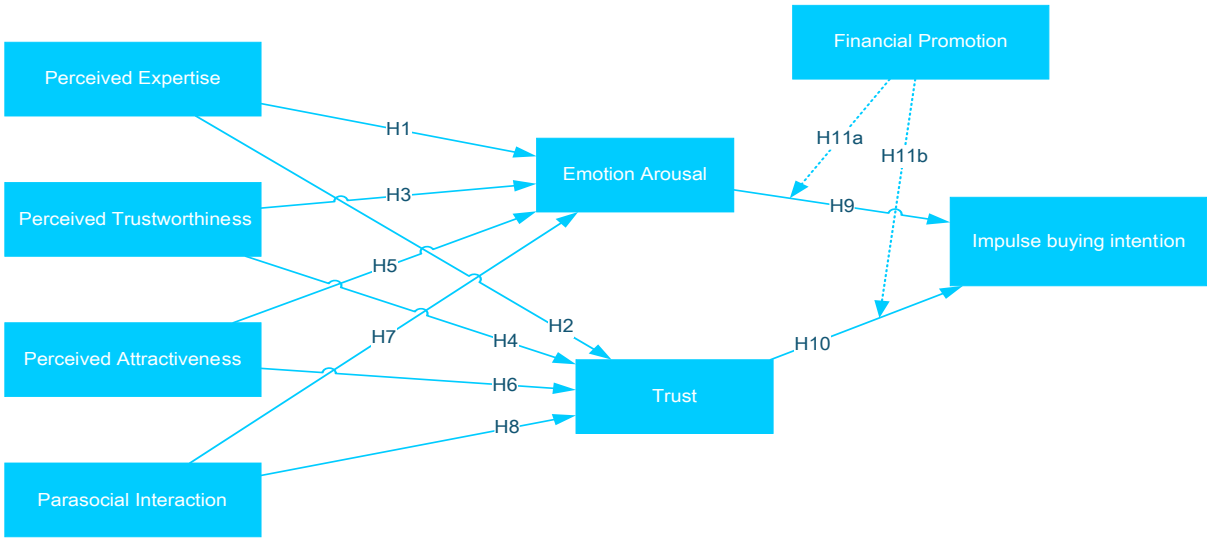
1.2.7 Moderating Role of Financial Promotion

Financial elements in livestreaming sessions, including discounts, vouchers, gifts, and loyalty programs, serve as strong catalysts influencing impulsive consumer behavior, particularly among younger customers who are highly sensitive to promotions (Berry, 1995; Chiu *et al.* 2005). Customers may obtain better prices through direct negotiation during livestreams or by participating in interactive activities to receive gifts and discount vouchers (Tan *et al.* 2024). These incentives not only enhance price attractiveness but also stimulate excitement and strengthen trust in both the livestream session and the brand, thereby positively influencing purchase decisions (Luo *et al.* 2024; Rohm *et al.* 2013). Consequently, financial promotions introduced by celebrities create an immediate urge among consumers to own products, intensifying emotional engagement during livestreams. Coupled with credibility and trustworthiness, celebrities presenting attractive financial incentives consistently capture customer trust and drive instant purchase behavior. Understanding this characteristic enables managers to design more effective livestream messages and strategies, thereby optimizing marketing performance and enhancing the likelihood of conversion in consumer purchasing behavior.

H11a: Financial promotion moderates the relationship between emotional arousal and impulsive buying intention of customers when watching livestreams.

H11b: Financial promotion moderates the relationship between trust and impulsive buying intention of customers when watching livestreams.

Figure 1. Proposed research model



Source: Proposed Author

2. Research Methodology

This study employs both qualitative and quantitative approaches, with the questionnaire developed based on measurement scales adopted from previous studies and further refined to suit the current research context. A preliminary survey involving six experts with professional knowledge in e-commerce and consumer behavior was conducted to adjust the questionnaire for the official survey. The measurement items for each construct in this study were inherited and modified to align with the research context and timeframe.

The observations from Ohanian (1990) and Gupta *et al.* (2017) were adapted to measure perceived attractiveness (PA) with five items, perceived trustworthiness (PT) with five items, and perceived expertise (PE) with five items. Six items for parasocial interaction (PI) were adopted and refined from Xiang *et al.* (2016). Financial promotion was measured with five items adopted from Hu and Chaudhry (2020). Five items for trust were adopted and adjusted from McAllister (1995) and Chen *et al.* (2024). Emotion arousal was measured with four items adapted from Li *et al.* (2022) and Ning Shen and Khalifa (2012). Impulse buying intention was measured with four items adopted and refined from Wang *et al.* (2025) and Beatty and Ferrell (1998).

A pilot survey was conducted using an online questionnaire distributed through social media platforms such as Facebook, Instagram, and Zalo, with 113 participants who had previous experience with impulse purchases on livestream platforms. This ensured that the survey questions were comprehensible and aligned with Vietnamese shopping behaviors. The key requirement for respondents was that they had purchased products through celebrity-led livestreams on social commerce platforms such as Facebook, TikTok, or YouTube. The research sample was selected based on gender, age, educational level, occupation, income.

Subsequently, the official survey was administered through an online method. To identify respondents who engaged in impulse purchases on livestream platforms, filtering questions were included: (1) Do you know any celebrities on social media? (2) Have you ever watched celebrities on social media promoting and selling products through livestreams? (3) Have you ever purchased products from celebrities on social media via livestreams? Out of 654 questionnaires collected, responses from 173 participants who had never watched celebrities promoting and selling products via livestreams and who had never purchased through livestreams were excluded, along with 48 responses containing incomplete data. Consequently, data from 433 valid respondents were retained for analysis.

3. Research Results

This study surveyed consumers who had experienced impulse purchases on livestream-based e-commerce platforms. Regarding gender, 53.81 percent of respondents were female (n=233), while 46.19 percent were male (n=200). In terms of age and education, respondents under 20 years old accounted for 18.01 percent (n=78), while

66.74 percent were between 20 and 29 years old (n=289), 12.93 percent were between 30 and 50 years old (n=56), and 2.31 percent were above 50 years old (n=10). Concerning educational attainment, undergraduate students represented the largest proportion (n=279, 64.43 percent), followed by respondents with a college degree (n=63, 14.55 percent). Postgraduate, vocational, and high school education levels accounted for 12.01 percent, 5.31 percent, and 3.7 percent, respectively.

With respect to occupation, office employees accounted for the highest proportion (n=223, 51.50 percent), followed by students (n=116, 26.79 percent), freelancers (n=34, 7.85 percent), teachers (n=26, 6.00 percent), housewives (n=24, 5.54 percent), and factory workers (n=10, 2.31 percent). Regarding income, 27.48 percent earned less than 10 million VND (n=119), 35.57 percent earned between 10 and 15 million VND (n=154), 18.01 percent earned between 15 and 20 million VND (n=78), and 18.94 percent earned more than 20 million VND (n=82).

Based on Table 1, the results of Cronbach's alpha analysis indicate that all constructs achieved reliability, with Cronbach's alpha coefficients ranging from 0.820 to 0.900, exceeding the recommended threshold of 0.7 proposed by Hair *et al.* (2019). Therefore, the measurement scales in this study demonstrate adequate reliability for further evaluation. The assessment of convergent validity revealed that the measurement scales met the required criteria, as the average variance extracted (AVE) values were all greater than 0.5. The outer loadings of the observed variables were all higher than 0.708, and the variance inflation factor (VIF) values were all below 3. Hence, the measurement scales satisfied the requirements of indicator reliability (Hair *et al.* 2019).

Table 1. Results of reliability and validity tests (CA, CR, AVE, Outer Loadings, VIF)

	CA	rho_A	CR	AVE	Outer loadings	VIF
EA	0.885	0.886	0.920	0.743	0.834 – 0.884	2.076 – 2.644
FP	0.820	0.822	0.874	0.580	0.727 – 0.785	1.430 – 1.854
IPI	0.874	0.875	0.913	0.725	0.835 – 0.869	2.036 – 2.429
PA	0.853	0.856	0.895	0.631	0.711 – 0.826	1.453 – 2.040
PE	0.855	0.857	0.896	0.633	0.782 – 0.829	1.667 – 2.051
PI	0.900	0.901	0.924	0.668	0.763 – 0.856	1.779 – 2.614
PT	0.892	0.893	0.921	0.700	0.807 – 0.868	1.984 – 2.660
TR	0.864	0.866	0.902	0.648	0.789 – 0.840	1.839 – 2.178

Source: Data from SMART-PLS

Regarding discriminant validity, this study employed the HTMT (Heterotrait Monotrait ratio of correlations) to assess the discriminant validity among the latent constructs, as recommended by Henseler *et al.* (2015). As presented in Table 2, the HTMT values of all constructs in the model were below 0.85. Therefore, the measurement scales satisfy the requirement for discriminant validity.

Table 2. HTMT Assessment Results

	EA	FP	IPI	PA	PE	PI	PT	TR
EA								
FP	0.064							
IPI	0.611	0.146						
PA	0.787	0.431	0.629					
PE	0.641	0.088	0.476	0.644				
PI	0.823	0.054	0.620	0.752	0.642			
PT	0.746	0.156	0.641	0.770	0.650	0.706		
TR	0.573	0.070	0.642	0.692	0.700	0.790	0.670	

Source: Data from SMART-PLS

Table 3. Assessment of R^2 and Q^2

	R Square Adjusted	Q2
EA	0.635	0.467
IPI	0.499	0.353
TR	0.565	0.359

Source: Data from SMART-PLS

According to the results presented in Table 3, the adjusted R^2 values of the variables EA, IPI, and TR are 0.635, 0.499, and 0.565. This indicates that PT, PA, PE, and PI explain 63.5 percent of the variance in EA, while 56.5 percent of the variance in TR is explained. In addition, EA and TR together explain 49.9 percent of the variance in IPI.

The results in Table 4 show that all hypotheses with p-values less than 0.05 are supported, with all Beta coefficients greater than 0. Therefore, the relationships among the constructs are positive.

Furthermore, when testing the moderating role of FP between EA and IPI as well as between TR and IPI, the analysis shows that the p-value of FP*EA → IPI equals 0.039 which is less than 0.05, and the p-value of FP*TR → IPI equals 0.000 which is also less than 0.05. Hence, both hypotheses H11a and H11b are supported. Specifically, with the moderating role of FP, the Beta coefficients for the relationships between EA and IPI and between TR and IPI are 0.109 and 0.236, respectively, which are both greater than 0. This indicates that FP plays a positive moderating role by strengthening the positive relationships between EA and IPI as well as between TR and IPI.

Table 4. Regression Results

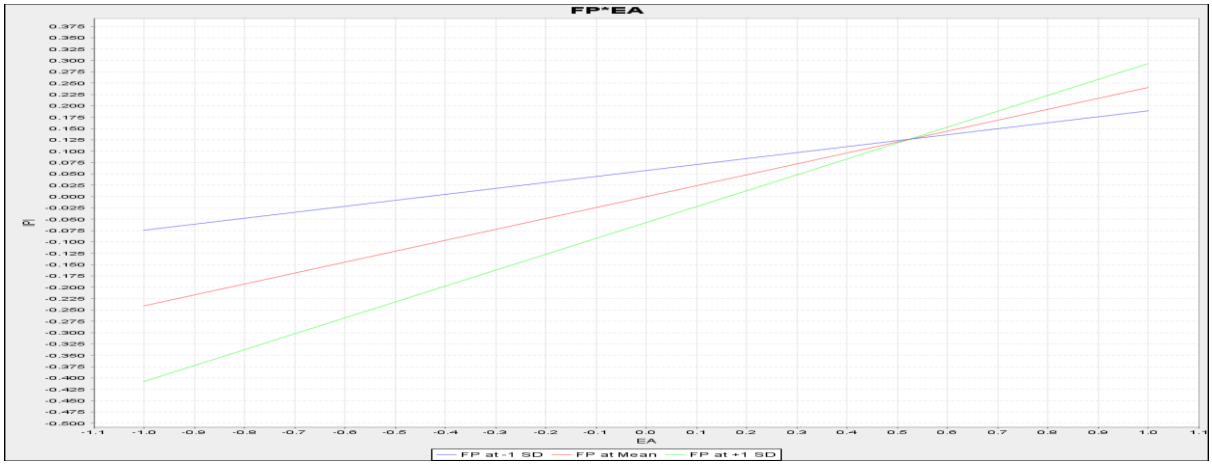
	beta	t-values	p-values	Result
H1: PE -> EA	0.087	2.170	0.030	Supported
H2: PE -> TR	0.238	4.193	0.000	Supported
H3: PT -> EA	0.200	4.389	0.000	Supported
H4: PT -> TR	0.114	2.411	0.016	Supported
H5: PA -> EA	0.237	5.432	0.000	Supported
H6: PA -> TR	0.112	2.310	0.021	Supported
H7: PI -> EA	0.402	9.358	0.000	Supported
H8: PI -> TR	0.418	7.221	0.000	Supported
H9: EA -> IPI	0.241	4.914	0.000	Supported
H10: TR -> IPI	0.259	4.325	0.000	Supported
H11a: FP*EA -> IPI	0.109	2.064	0.039	Supported
H11b: FP*TR -> IPI	0.236	5.071	0.000	Supported

Source: Data from SMART-PLS

The results of the regression analysis and the simple slope plot indicate that financial promotion (FP) serves as a positive moderator in the relationship between emotional arousal (EA), trust (TR), and impulsive purchase intention (IPI) of consumers in the context of celebrity-endorsed livestreaming.

Specifically, in Figure 2, regarding the relationship between EA and IPI, the regression results show that FP*EA has a coefficient $\beta = 0.109$ ($p = 0.039$), suggesting a statistically significant moderating effect. The simple slope plot further demonstrates that when the level of financial promotion is high (+1SD), the slope becomes steeper compared to when financial promotion is low (−1SD). This implies that within the livestreaming environment, emotional arousal inherently stimulates impulsive purchasing behavior, yet this effect is substantially amplified when consumers simultaneously perceive the attractiveness of financial incentives.

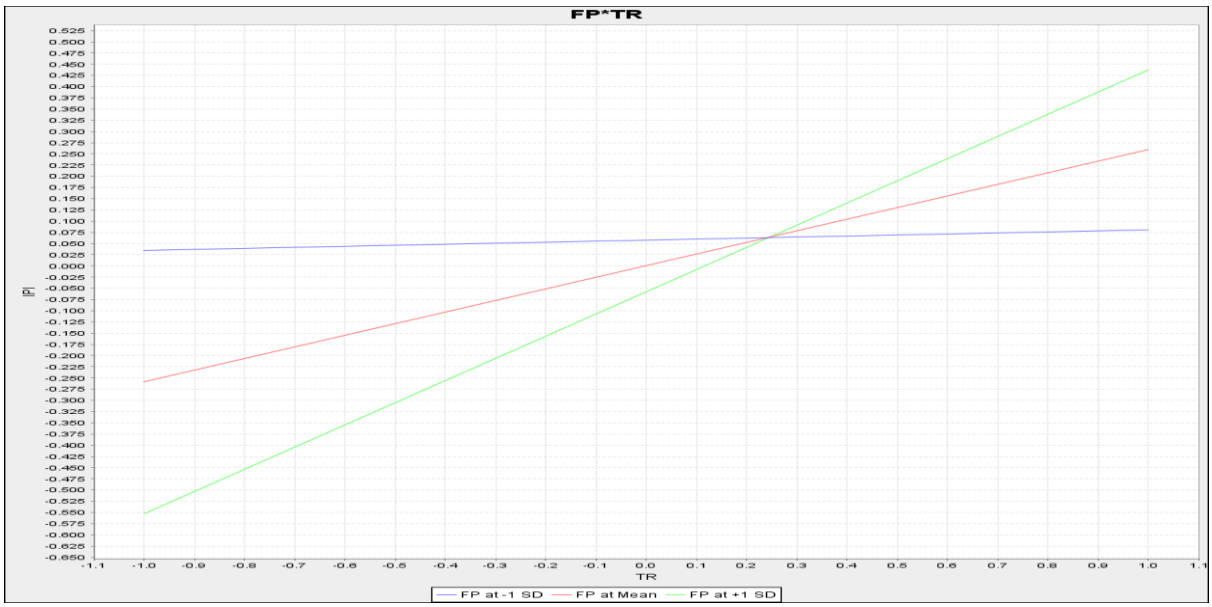
Figure 2. FP*EA



Source: Data from SMART-PLS

For the relationship between TR and IPI, in Figure 3, the regression results indicate that FP*TR has a coefficient β = 0.236 (p = 0.000), demonstrating a strong and highly significant moderating effect. The simple slope plot also clearly illustrates this distinction: at a high level of financial promotion (+1SD), the relationship between trust and impulsive purchase intention exhibits the steepest slope, whereas at a low level (−1SD), the relationship is almost negligible. This finding suggests that trust in the celebrity during livestreaming only translates into impulsive purchasing behavior when consumers simultaneously perceive tangible benefits from financial promotions.

Figure 3. FP*TR



Source: Data from SMART-PLS

Accordingly, both the regression results and the illustrative plots converge on the point that financial promotion serves as a catalyst, amplifying the influence of emotion and trust on impulsive purchase intention. From a theoretical perspective, this finding provides additional evidence that financial factors not only exert a direct impact on consumer decision-making but also enhance the strength of underlying psychological drivers (Thaler, 1985). From a practical standpoint, the results suggest that firms should design livestreaming strategies that integrate building trust through the presence of celebrities, stimulating emotions during interactions, and simultaneously implementing attractive financial promotion programs. Such a combination is expected to maximize effectiveness in encouraging consumers' impulsive purchasing behavior.

4. Discussion, Managerial Implications, Contributions, Limitations, Future Research Directions

4.1 Discussion

The findings of this study indicate that the characteristics of celebrities, including perceived expertise (PE), perceived trustworthiness (PT), and perceived attractiveness (PA), exert positive effects on consumers' emotion arousal (EA) and trust (TR) in the context of livestreaming (Li *et al.* 2025; Wang *et al.* 2025). At the same time, parasocial interaction (PI) is shown to strongly influence both EA and TR, underscoring the role of psychological attachment between audiences and celebrities in shaping emotional responses and trust (Wang *et al.* 2025).

In addition, both EA and TR are confirmed as critical predictors that drive impulse buying intention (IPI) (Wang *et al.* 2025). This reinforces the argument that emotions and trust constitute central drivers of impulsive purchasing behavior in livestream settings (Li *et al.* 2025).

Notably, the moderation analysis demonstrates that financial promotion (FP) positively moderates the relationship between EA and IPI (H11a), as well as between TR and IPI (H11b). Specifically, when the level of financial promotion is high, the effects of EA and TR on IPI become significantly stronger. This suggests that FP not only acts as a direct incentive for consumer behavior but also amplifies the influence of psychological factors (EA and TR) on impulsive buying.

Overall, this study confirms that in livestreaming contexts featuring celebrities, PE, PT, PA, and PI serve as initiators of trust and emotional arousal; EA and TR function as key mediators leading to IPI; and FP acts as a moderator that strengthens these relationships. The results contribute theoretically by clarifying the mechanisms through which celebrity attributes and consumer psychology shape impulsive purchasing behavior, while also offering managerial implications for firms in combining celebrity endorsement strategies with financial promotions to maximize business effectiveness through livestreaming.

4.2 Managerial Implications

The findings suggest that businesses and managers should strategically leverage livestreaming with the participation of celebrities to stimulate customers' impulse buying behavior.

The image-related attributes and characteristics of celebrities, including perceived expertise (PE), perceived trustworthiness (PT), and perceived attractiveness (PA), should be carefully considered when selecting KOLs or influencers. Firms are advised to prioritize collaboration with celebrities who not only demonstrate expertise but also build credibility and possess visual appeal, as these factors directly enhance consumers' emotion arousal (EA) and trust (TR).

Furthermore, the results indicate that parasocial interaction (PI) plays a particularly important role in reinforcing EA and TR. Therefore, firms should encourage celebrities to strengthen two-way engagement with audiences during livestream sessions, such as responding to comments, addressing viewers by name, or organizing mini games and interactive activities. These practices foster a sense of personal connection, thereby increasing trust and stimulating impulse buying intentions.

Moreover, since both EA and TR strongly influence impulse buying intention (IPI), firms should design livestream content that evokes positive emotions such as excitement, curiosity, and happiness, while simultaneously reinforcing trust through transparency, brand credibility, and quality assurance. This combination is crucial for encouraging quick purchase decisions.

Finally, the study confirms that financial promotion (FP) serves as a significant moderating factor that amplifies the effects of EA and TR on IPI. This implies that firms should implement attractive financial promotion strategies, such as direct discounts, time-limited vouchers, free shipping, or bundled gifts, during livestream events. Particularly, when FP is applied in conjunction with the presence of celebrities, the impact on impulse buying intention is substantially strengthened.

In addition, this study offers important implications for the fields of education, culture, and public policy.

In the educational domain, the research findings provide a practical foundation for updating curricula in marketing, communication, and e-commerce programs. These updates may include content related to livestream commerce, impulsive consumer behavior, and the strategic use of celebrities in digital marketing. Students will have the opportunity to access new knowledge about consumer psychology and learn how to design effective livestream campaigns that align with current technological contexts.

From a cultural perspective, the frequent appearance of celebrities in livestream sessions contributes to the rise of emotionally driven consumption, where consumers are easily influenced by visual and affective cues. This trend reflects a shift from rational consumption models to those based on emotional responses and symbolic

attachment. Cultural researchers may further explore the phenomenon of idol culture and the formation of para-social relationships between celebrities and audiences in digital environments.

With regard to public policy, the rapid development of e-commerce presents an urgent need for regulatory authorities to establish clearer and more transparent guidelines concerning livestream activities, the involvement of celebrities, and the application of promotional programs. These efforts are essential to protect consumers from emotional manipulation and herd behavior during the online shopping process.

4.3 Theoretical Contributions

This research extends and reinforces the SOR model in the context of celebrity-driven livestream commerce. The attributes of celebrities, including perceived expertise (PE), perceived trustworthiness (PT), perceived attractiveness (PA), and parasocial interaction (PI), are confirmed as key stimuli capable of eliciting emotion arousal (EA) and building consumer trust (TR). This finding provides empirical evidence for the hypothesis that the characteristics of livestream hosts not only influence cognition but also shape emotional responses and trust, which represent two core elements of the "Organism" in the S–O–R framework.

Furthermore, the demonstration of the dual mediating roles of EA and TR offers a novel theoretical contribution by showing that both affective and cognitive processes operate simultaneously and reinforce one another in driving impulse buying behavior. This clarification sheds light on earlier debates concerning whether emotional or cognitive factors play the decisive role in online purchasing behavior.

Finally, the results confirm the moderating role of financial promotion (FP) in the relationship between EA, TR, and impulse buying intention (IPI). This represents an important theoretical contribution by positioning FP as a moderator within the S–O–R framework, showing that financial incentives in the environment can amplify the influence of internal psychological states on behavior. The inclusion of FP in the model expands the traditional S–O–R perspective, which has paid limited attention to the moderating role of financial contextual factors in livestream shopping environments.

4.4 Practical Contributions

This study provides valuable empirical evidence for businesses in developing effective livestream commerce strategies. Specifically, the findings highlight that the selection of celebrities should emphasize expertise, credibility, attractiveness, and the ability to foster social interaction, in order to maximize consumer trust and positive emotions. At the same time, businesses can leverage financial promotion as a strategic tool not only to stimulate purchasing behavior but also to enhance the psychological effects that drive impulse buying intention, thereby optimizing consumer responses in livestream commerce.

4.5 Limitations and Directions for Future Research

This study is subject to several limitations. First, the data were collected through an online survey and focused exclusively on consumers who had previously engaged in impulsive purchases during celebrity livestreams. Therefore, the representativeness of the sample remains limited and may not fully capture the characteristics of the broader consumer base on social commerce platforms. Second, the quantitative research method relied on self reported questionnaires, which may lead to potential biases arising from subjective responses. Third, the study primarily concentrated on specific variables such as celebrity attributes that evoke emotions and trust as well as impulsive purchase intention, while other factors including product characteristics, cultural influences, or the role of platform algorithms were not considered.

Future research could expand the scope of investigation to include more diverse consumer groups in order to enhance generalizability, while employing mixed methods or experimental approaches to validate causal relationships. Additionally, incorporating new elements such as product attributes, social influence, or technological features of the platforms would provide a more comprehensive understanding of impulsive purchasing behavior in livestream commerce.

Declarations

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Declaration of use of generative AI and AI-assisted technologies: The author declares that no artificial intelligence tools or AI-assisted technologies were employed in the preparation or execution of this research.

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The Liquidity Spread: A Parsimonious Method for Data-Scarce Emerging Markets

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Abstract: This paper develops a parsimonious method for estimating bond liquidity spreads in emerging markets where transaction data are scarce. It complements earlier work on credit spread decomposition, contributing to a unified valuation framework for data-scarce bond markets. The model was obtained analytically from a one-year holding-period return indifference condition between a liquid and an illiquid bond. It requires only two observable inputs: the bond's yield bid-ask spread and its modified duration. An extension introduces an adjustment factor to capture volatile market conditions. The central result is a closed-form approximation: the minimum annual liquidity spread equals the product of the bond's modified duration and its yield bid-ask spread. An illustrative application shows that liquidity costs can outweigh credit risk in thin markets. The framework offers a transparent and replicable alternative to arbitrary mark-ups, addressing a critical gap by providing a dedicated liquidity spread model tailored to data-scarce environments. Its primary innovation lies in its methodological parsimony, delivering a transparent valuation instrument that remains theoretically consistent even in the absence of transaction-level data.

Keywords: liquidity spread; emerging markets; bid-ask spread; bond duration; scarce data; valuation.

JEL Classification: G12; G15; G18.

Introduction

The valuation of corporate bonds in emerging markets is frequently constrained by severe data limitations, particularly with respect to liquidity-related pricing adjustments. While liquidity spreads (liquidity premia in much of the literature) are widely recognized as an integral component of bond yields, their practical estimation remains challenging in markets characterized by infrequent secondary trading and structurally wide bid-ask spreads.

Existing liquidity pricing models typically rely on high-frequency transaction data, market-wide liquidity factors, or complex econometric frameworks developed for deep and transparent markets. These approaches are difficult to implement in frontier and emerging economies, where trading activity is episodic and reporting infrastructures are limited, often leading practitioners to rely on arbitrary liquidity mark-ups that undermine valuation consistency and regulatory transparency.

This study addresses a central question: how can a transparent and replicable liquidity spread be estimated in emerging markets where transaction data are extremely scarce? It fills a clear gap in the literature by proposing a dedicated, parsimonious liquidity spread model tailored to data-scarce environments. The paper derives an accessible analytical framework that requires only two observable inputs: the bond's yield bid-ask spread and its modified duration, providing a defensible benchmark for valuation, risk management, and regulatory assessment.

1. Literature Review

While recent work has addressed credit spread decomposition in data-scarce emerging markets (Ghazaryan *et al.* 2024), the estimation of liquidity spreads remains a major challenge in such environments. Approaches to liquidity vary across contexts - developed versus emerging markets, corporate versus sovereign bonds, and theoretical versus applied pricing models. Three strands are particularly relevant for the present study: (i) theoretical foundations, (ii) empirical estimation in advanced markets, and (iii) liquidity measurement in emerging markets.

Early theoretical studies (Amihud & Mendelson, 1986, 1991; Vayanos, 1998) established the basic link between transaction costs and required returns. Roll (1984) proposed an implicit measure of effective bid-ask spreads, demonstrating how trading frictions are embedded in asset prices even in efficient markets. Subsequent work extended these insights across asset classes: Amihud (2002) documented the pricing of illiquidity in equities, while later asset-pricing frameworks incorporated liquidity more formally, whether through factor-based models such as the liquidity-adjusted CAPM (Acharya & Pedersen, 2005), interactions between market and funding liquidity (Brunnermeier & Pedersen, 2009), or evidence that liquidity shocks command systematic compensation (Pastor & Stambaugh, 2003) and affect Treasury valuations (Longstaff, 2004). Collectively, these contributions confirm that liquidity is priced in equilibrium, though often through variables that are difficult to observe in smaller or less transparent markets.

Empirical research based largely on TRACE and other transaction-level datasets shows that liquidity risk accounts for a substantial share of corporate bond yield spreads, with its effects intensifying during periods of market stress (Bao *et al.* 2011; Chen *et al.* 2007; de Jong & Driessen, 2012; Edwards *et al.* 2007; Houweling *et al.* 2005; Goyenko *et al.* 2011; Friewald *et al.* 2012). These studies typically embed bid-ask spreads among multiple liquidity proxies within regression or factor models, highlighting the multidimensional nature of liquidity costs in developed markets. By contrast, the present study isolates bid-ask spreads and duration as the sole inputs, explicitly targeting environments where such rich datasets are unavailable.

Studies focusing on emerging markets emphasize structurally lower trading frequency, wider bid-ask spreads, and weaker reporting infrastructures (Sarr & Lybek, 2002; Lesmond, 2005; Dick-Nielsen *et al.* 2012; Hoyos *et al.* 2020). Methodological adaptations in this context include multidimensional indicators of tightness, depth, and resiliency (Mancini *et al.* 2013), as well as composite measures advanced by policy institutions (Committee on the Global Financial System (CGFS), 2016). Structural approaches further highlight over-the-counter trading frictions (Duffie & Singleton, 1999, 2012), market-making constraints (Biais & Green, 2019), and interactions between liquidity and credit risk (He & Milbradt, 2014). Empirical evidence from developed markets suggests that the non-default component of corporate spreads is substantial, with liquidity acting as a primary driver (Longstaff, Mithal, & Neis, 2005), underscoring the importance of disentangling these components in emerging markets as well.

Recent assessments point to growing fragilities in global bond market liquidity. Declining dealer inventories, post-crisis regulatory changes, unconventional monetary policy, and the transition to a higher interest-rate environment have reduced effective liquidity even in traditionally deep markets such as U.S. Treasuries (Bank for International Settlements (BIS), 2022; International Monetary Fund (IMF), 2023). Recent research has explored the role of different liquidity providers in corporate bond markets, suggesting that investors can act as a liquidity backstop that alleviates dealer balance-sheet constraints and influences transaction costs, particularly during stress periods (Comerton-Forde *et al.* 2025). In smaller and emerging markets, these pressures are magnified, with secondary trading often episodic or inactive, reinforcing the need for valuation approaches that rely on minimal, observable inputs.

Across the literature, there is broad consensus that illiquidity requires compensation, whether modeled as a spread in expected returns or expressed empirically as a component embedded in observed bond yields. However, most existing approaches rely on granular transaction data or complex econometric structures, limiting their applicability to frontier economies (Bongaerts *et al.* 2017). This leaves a clear practical gap: the absence of a dedicated, parsimonious framework for estimating liquidity spreads in data-scarce environments. The model proposed in this paper addresses this gap by deriving the minimum liquidity spread as the product of the bond's modified duration and its yield bid-ask spread. This approximation provides a transparent and usable benchmark in practice and can be extended with an adjustment factor to reflect volatile market conditions.

2. Method

This section presents a practical, transaction-based model for estimating the liquidity spread. The model was derived from fixed-income valuation principles to address three structural features common in emerging markets: sparse trading data, wide bid–ask spreads, and limited dealer participation (Sarr & Lybek, 2002; Hoyos *et al.* 2020; Galliani *et al.* 2014). Unlike many developed-market frameworks, the proposed approach relies on a static one-

year holding period and only two observable inputs: the bond's yield bid-ask spread and its modified duration. This simplicity ensures applicability where trade-level data, depth indicators, or calibration infrastructure are unavailable.

In a perfectly liquid market, a bond can be bought and sold at the same yield, implying no loss on immediate resale. In an illiquid market, resale occurs at a less favorable yield, generating a loss proportional to duration. This loss defines the minimum required liquidity cost imposed by illiquidity and is expressed as:

$$Loss = d \times s$$

where

- d denotes modified duration, and
- s denotes yield bid-ask spread.

Table 1 illustrates the benchmark case with zero bid-ask spread, while Table 2 shows a positive spread of 20 basis points, producing a liquidity loss of 1.40 percent for a seven-year bond.

Table 1. Benchmark case with zero bid-ask spread

Buy YTM (%)	Sell YTM (%)	Duration	Liquidity Loss (%)
3.7	3.7	7	0

Table 2. Positive bid-ask spread case (20 basis points)

Buy YTM (%)	Sell YTM (%)	Duration	Liquidity Loss (%)
3.7	3.9	7	1.4

This liquidity loss represents the expected mark-to-market erosion caused by illiquidity. The liquidity spread is then defined as the additional yield required to compensate investors for this loss and to render an illiquid bond competitive with a liquid benchmark.

Consider two investment alternatives:

1. Liquid bond: yield y, bid-ask spread $s = 0$, duration d, one year holding period return $HPR = y$.
2. Illiquid bond: yield $y + l$, bid-ask spread $s > 0$, duration d, one year holding period return $HPR = y + l - d \times s$, where l denotes the liquidity spread.

The following assumptions were imposed: (i) investors are price takers, with no market impact beyond the bid-ask spread; (ii) the holding period is one year, consistent with standard fixed-income conventions; and (iii) credit spreads, yield to maturity, and modified duration remain constant over the holding period (discussed further in Section 5.3).

The one-year holding period return was defined as the yield earned minus the liquidation cost (Fabozzi, 2012; Tuckman & Serrat, 2011; Bodie *et al.* 2021). Table 3 summarizes the comparison.

Table 3. One-year holding period returns for liquid versus illiquid bonds.

Investment	Buy YTM	Sell YTM	Duration	HPR
(a) Liquid	y	y	D	y
(b) Illiquid	y + l	y + l + s	D	y + l − d × s

For the illiquid bond to be competitive, its holding period return must satisfy the investor indifference condition:

$$y + l - d \times s \geq y \quad (1)$$

which simplifies to:

$$l \geq d \times s \quad (2)$$

Equation (2) implied that the minimum liquidity spread must at least compensate for the duration-adjusted transaction cost. For practical applications, this condition was approximated by the closed-form expression:

$$l = d \times s \quad (3)$$

This formulation directly links observable transaction costs to a measurable liquidity spread. To account for elevated volatility or stress conditions, the model was extended with an adjustment factor:

$$l = AF \times d \times s \quad (4)$$

where AF reflects prevailing market conditions. During stress episodes, reduced turnover and funding pressures can push AF above 1, amplifying liquidity costs beyond the baseline spread-duration product. Conversely, favorable conditions or regulatory incentives may compress AF below 1.

This extension aligns with Brunnermeier and Pedersen (2009), who emphasize the interaction between funding liquidity and market liquidity, and with Acharya and Pedersen (2005), who show that liquidity spreads are time-varying and sensitive to stress. AF serves as a parsimonious scaling parameter rather than a separate pricing factor.

The model is intended for environments characterized by persistent structural illiquidity, such as emerging or thin bond markets with infrequent secondary trading. It is applicable in analytical, valuation, and supervisory contexts where transparent and replicable liquidity adjustments are required. The framework is illustrated using hypothetical bid-ask spreads and modified duration, with liquidity estimates scaled by heuristic adjustment factors under stressed market conditions.

3. Case Study

This section illustrates the practical application of the proposed model and examines the effect of explicit liquidity adjustments on yield decomposition. A hypothetical "BB+" rated corporate bond in an emerging market was evaluated against a "AAA" rated benchmark bond. Table 4 presents the required valuation inputs.

Table 4. Hypothetical valuation inputs for a "BB+" corporate bond versus a "AAA" benchmark.

	Benchmark Bond "AAA"	Corporate Bond "BB+"
Duration	5.3	5
Bid-Ask spread (bps)	5	30
Default probability (%)	-	1
Loss Given Default (%)	-	60
Yield to maturity (%)	3	To be calculated

Risk-free rate adjustment. The observed benchmark yield of 3% includes a small liquidity component associated with its own bid-ask spread.

$$l_{benchmark} = d_{benchmark} \times s_{benchmark} = 5.3 \times 0.05\% \approx 0.27\%$$

To avoid double counting, the adjusted risk-free rate was obtained as:

$$r_{benchmark}^{adjusted} = 3\% - 0.27\% \approx 2.73\%$$

Credit risk component. The expected credit loss for the "BB+" bond was calculated following Ghazaryan et al. (2024).

$$CR = \frac{PD}{1 - PD} \times LGD \times (1 + r) \approx 0.62\%$$

Liquidity component. Applying the liquidity spread model derived in Section 2, the illiquidity adjustment was:

$$l_{corp} = d_{corp} \times s_{corp} = 5 \times 0.30\% = 1.50\%$$

Aggregate yield. Aggregating the risk-free, credit, and liquidity components yielded the implied corporate bond yield:

$$y_{corp} = r_{benchmark}^{adjusted} + CR + l_{corp} \approx 2.73\% + 0.62\% + 1.50\% = 4.85\%$$

This decomposition indicated that liquidity (1.50%) constitutes the dominant component of the total spread, exceeding the pure credit component (0.62%). Traditional valuation shortcuts that add a generic "BB+" spread to

the benchmark yield therefore risk material mispricing in thin markets. The example illustrated the transparency and replicability of the proposed framework.

4. Research Results

The core analytical result of this study is the closed-form expression for the liquidity spread, given by Equation (3):

$$l = d \times s \tag{3}$$

Equation (3) represents the minimum compensation required by investors for illiquidity, derived from the one-year holding-period return indifference condition. The liquidity spread depends linearly on the bond's price sensitivity, measured by the modified duration, and on the observable transaction cost captured by the yield bid–ask spread.

Equation (4) extends this baseline result by introducing an adjustment factor that allows liquidity compensation to scale with prevailing market conditions while preserving the tractability of the framework.

5. Discussion

Table 5 compares the proposed model against key liquidity frameworks. While established models provide valuable insights, their data requirements limit applicability in emerging markets. The proposed method complements the literature by offering a transparent baseline that operationalizes liquidity spreads using only observable inputs.

Table 5. Comparison of the proposed model with existing liquidity spread frameworks.

Study / Model	Approach	Data Needs	Comparison	Applicability
Amihud & Mendelson (1986)	Transactional cost pricing	Time-series of bid-ask spreads	Links spreads to returns, horizon-based.	Requires long history of transaction costs
Acharya & Pedersen (2005)	Liquidity-adjusted CAPM	Market-wide factors	Captures systematic liquidity, indirectly.	Data-intensive, impractical in EMs
Bao, Pan & Wang (2011)	Yield spread decomposition	Trade-level TRACE data	Separates credit and liquidity components	Limited to developed bond markets.
Chen, Lesmond & Wei (2007)	Zero-trading-day measure	Multi-period trading panels	Captures illiquidity without full quotes	Requires panel data, often absent in EMs
Proposed Model	*HPR indifference*	*Single bid-ask spread and duration*	*Transparent, replicable approximation*	*Accessible and transparent baseline for data-scarce markets*

The proposed formulation (Equation 3) can be viewed as a parsimonious compression of existing models rather than a competing alternative. Amihud and Mendelson (1986) show that higher transaction costs raise required returns; the present approach operationalizes this insight using bond duration. Acharya and Pedersen (2005) formalize liquidity as a systematic factor; in practice, bid-ask spreads widen when market liquidity deteriorates, embedding both idiosyncratic and systematic effects into a single observable metric. Similarly, Bao, Pan and Wang (2011) demonstrate time-varying liquidity frictions; bid-ask spreads respond dynamically, allowing the present rule to inherit such dynamics without requiring trade-level data. Chen, Lesmond, and Wei (2007) validate that illiquidity significantly increases yield spreads, particularly for high-yield bonds. While their measure is more data-intensive, it supports the core premise that liquidity is a critical priced factor.

The model extends this line of inquiry by offering a parsimonious solution tailored to data-scarce settings. By relying on universally available inputs, it provides a usable first-order approximation where data-intensive methods are infeasible. This parsimony reflects deliberate simplifying choices: the framework adopts a static one-year holding period, relies on linear scaling, and does not explicitly disentangle systematic liquidity risk, although bid-ask spreads may partially capture such effects. These simplifications are consistent with the model's objective of transparency and practical applicability.

The following subsection discusses the core assumptions underlying the framework and clarifies its scope and boundaries.

(i) Price-Taker Behavior and the Absence of Market Impact. The model assumed that the bid-ask spread is the sole source of transaction cost, treating investors as price takers. This abstracts from the market impact of large block trades, a significant factor in deep markets (Biais, Glosten, & Spatt, 2005). However, in thin, fragmented emerging bond markets (characterized by small ticket sizes), quoted bid-ask spreads dominate total costs, making

the assumption realistic. It therefore reflects the target market structure and focuses on measurable structural illiquidity.

(ii) The One-Year Holding Period Convention. The static one-year horizon is fundamental to the closed-form result. It aligns with standard fixed-income quoting conventions (Fabozzi, 2012; Tuckman & Serrat, 2011) and interprets the liquidity spread as annual compensation for illiquidity (Acharya & Pedersen, 2005; Amihud & Mendelson, 1986). It also matches regulatory and industry norms for performance disclosure (ESMA, 2023; Morningstar, 2013). While absolute liquidity costs are horizon-dependent, the one-year benchmark provides a standardized and interpretable baseline.

(iii) Constancy of Spreads, Benchmark Yields and Duration. This assumption isolates the liquidity spread from other risk factors. Even if benchmark yields change, the liquidity spread condition $l \geq d \times s$ remains valid, as yield-change terms cancel. Although holding-period loss depends on duration at sale, the use of current modified duration as a proxy is consistent with first-order return approximations widely used in fixed-income analysis (Fabozzi, 2012).

Conclusions and Future Research

This study developed a parsimonious framework for estimating bond liquidity spreads in emerging markets characterized by limited transaction data. The analysis demonstrated that the minimum liquidity spread can be derived analytically from the liquidity loss generated by bid-ask frictions, which scales linearly with a bond's modified duration. An illustrative decomposition showed that liquidity costs may exceed expected credit losses in thin markets, underscoring the structural role of illiquidity in bond valuation.

The framework made a twofold contribution. From an academic perspective, it extended the theory of liquidity pricing to environments where conventional, data-intensive econometric approaches are infeasible. From a practical standpoint, it replaced ad hoc valuation adjustments with a transparent and replicable tool that can be readily applied in valuation, risk management, and regulatory assessment.

Although deliberately simple, the model yielded a defensible baseline for further research. Future work may focus on empirical validation across a broader set of emerging markets, integration with macro-liquidity indicators, and nonlinear extensions to better capture extreme stress conditions. Together with the credit spread decomposition framework developed in Ghazaryan et al. (2024), this study contributed to a unified and practical toolkit for decomposing bond yields in data-scarce emerging markets. The inclusion of an optional adjustment factor allows liquidity compensation to scale with prevailing market conditions while preserving the transparency and tractability of the framework.

Declarations

Credit Authorship Contribution Statement:

Vahagn Melik-Parsadanyan: Conceptualization, Methodology, Formal analysis, Investigation, Writing - original draft, Writing - review and editing, Validation, Visualization, Project administration.
The author affirms full responsibility for all aspects of the work, including data accuracy, analysis integrity, and approval of the final manuscript.

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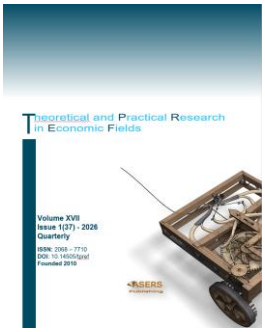
Strategic Balancing and Sovereign Autonomy: Indonesia's Engagement with China in the Era of Regional Vulnerabilities



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Abstract: This article discusses the continuing Chinese economic, strategic, and security interests in Indonesia, how investment in infrastructure, energy, and technology facilitates the modernization of Indonesia, as well as the alarming issues of debt sustainability, resource sovereignty, and regional power. Historical processes since Suharto to Jokowi show movement towards pragmatic cooperation and increasingly complex relationship with periods of contention and particularly in the case of the Natuna Islands where tensions are marked by the issues of competing sovereignty claims. The development of strategic autonomy also influences Indonesia to relate with China, although economic forces suggest the expansion of collaboration. The alliance with the United States and Japan and the active involvement in the ASEAN also reflects the intentions of Jakarta to preserve the balance in the situation in the region. The study analyses Sino-Indonesian relations through the prism of neorealist and national-interest perspectives with the help of which the interrelations between the two countries can be characterized by the existence of certain combination between cooperation and constraint created by the structural forces and national interests. Tightening governance and institutionalized protection is absolutely needed to guarantee that the Belt and Road Initiative undertakings are directed in the interest of the nation as well as policy independence. The results highlight the importance of the consistency of policymaking since Indonesia is to navigate the great-power rivalry, national politics, and public worries, due to the larger issue of development necessity versus the strategic foresight in the long run in Southeast Asia.

Keywords: strategic autonomy; Sino-Indonesian relations; Belt and Road initiative; Asia-Pacific security.

JEL Classification: F21; F52; O18; P48.

Introduction

This paper explores the intricate and multidimensional relationship between the People's Republic of China (PRC) and the Republic of Indonesia, particularly within the context of Southeast Asia's evolving and increasingly complex geopolitical environment. As two of the most significant actors in the Asia-Pacific region, their bilateral engagement carries profound implications not only for their respective national interests but also for the stability and developmental trajectory of the Association of Southeast Asian Nations (ASEAN) and the broader Indo-Pacific. Indonesia's engagement with China, while prominently centered on extensive economic cooperation, primarily actualized through Beijing's ambitious Belt and Road Initiative (BRI), is substantially complicated by a spectrum of deeply rooted strategic, security, and sovereignty concerns. These concerns are most acutely manifested in the resource-rich waters surrounding the Natuna Islands, which lie within Indonesia's internationally recognized

Exclusive Economic Zone (EEZ) but overlap with China's expansive and legally contested "nine-dash line" claim in the South China Sea.

As China progressively deepens its economic, political, and strategic footprint across Southeast Asia, Indonesia finds itself navigating a complex and often precarious balancing act. Jakarta endeavors to harness the developmental opportunities presented by Chinese investment and trade to achieve its ambitious national modernization goals, while simultaneously striving to safeguard its hard-won sovereign autonomy, territorial integrity, and its traditional "bebas dan aktif" (free and active) foreign policy posture. This study applies the theoretical lenses of neorealism and national-interest frameworks to critically assess how Indonesia, as the region's largest economy and a de facto ASEAN leader, manages the multifaceted challenges posed by great-power competition, the risks of infrastructural and economic dependence on a single dominant partner, and its aspirations for regional leadership and influence. The findings aim to contribute to ongoing scholarly and policy debates concerning regional resilience, the enduring significance of national sovereignty in an interdependent world, and the pursuit of sustainable and equitable diplomatic engagement within the ASEAN context and beyond. Understanding Indonesia's strategic calculus provides crucial insights into the adaptive strategies of middle powers in an era of shifting global power dynamics and heightened regional vulnerabilities.

This paper has made a distinct contribution by using a combination of neorealist and national-interest approach to understanding the changing relations of Indonesia with China based on a collective evaluation of the economic, security as well as regional relations issues in the form of diplomacy. Although these areas are usually conceptualized independently of each other in current literature, this work illustrates the formation of strategic behavior in Indonesia by the pressure of economic interdependence in the country, the enforcement of sovereignty in the North Natuna Sea, and ASEAN agenda-setting. The paper through historical, empirical, and theoretical synthesis creates a multidimensional account of the hedging posture in Indonesia through the lens of advancing the existing debates in the literature showing the autonomy of middle-powers, and the various adaptive strategies adopted by the Southeast Asian states in the backdrop of escalating U.S.-China competition.

1. Theoretical Framework: Neorealism and National Interests

To comprehensively analyze Indonesia's intricate foreign policy maneuvering, particularly in its engagement with a rising China and amidst great power rivalry, a theoretical framework combining neorealism and national interest theory offers significant explanatory power. Neorealism, as articulated by scholars like Kenneth Waltz (1979), posits that the fundamental structure of the international system is anarchic, meaning there is no overarching global authority to enforce rules or ensure state security. This anarchic condition compels states, as rational and unitary actors, to prioritize their own survival and security above all other considerations. Consequently, states are driven by a self-help imperative, relying on their own capabilities and strategic alignments to navigate the international environment. In such a system, the distribution of power among states is the primary determinant of international outcomes and state behavior. States are acutely sensitive to shifts in the balance of power and will adjust their strategies accordingly, often through internal balancing (strengthening their own military and economic capabilities) or external balancing (forming alliances or coalitions to counter a dominant or rising power).

Indonesia's foreign policy, particularly its well-documented hedging strategy, aligns closely with these neorealist principles. By consciously fostering and maintaining robust diplomatic and economic relations with multiple major power centers - notably engaging extensively with China for economic development while simultaneously strengthening security ties and strategic partnerships with the United States, Japan, Australia, and India - Indonesia seeks to counterbalance China's burgeoning regional influence. This approach is designed to prevent over-dependence on any single power, thereby preserving its strategic autonomy and avoiding entrapment in alliances that might compromise its independent foreign policy stance (Anwar 2022). The pursuit of a diversified portfolio of partnerships allows Indonesia to maximize its options and leverage in a fluid geopolitical landscape.

National-interest theory complements this structural analysis by focusing on the specific goals and objectives that drive a state's foreign policy. While neorealism emphasizes survival and security as universal state interests, national interest theory allows for a more nuanced understanding of how individual states define and prioritize their interests based on their unique historical experiences, geographical circumstances, economic needs, domestic political conditions, and national identity. For Indonesia, core national interests prominently include economic modernization and sustainable development to improve the welfare of its large population, the unwavering protection of its territorial integrity and maritime sovereignty (particularly critical for an archipelagic nation), the maintenance of domestic political stability and social cohesion, and the enhancement of its regional and global influence as a respected middle power and a leader within ASEAN (Anwar 2022). Indonesia's efforts to align its external partnerships, including its complex engagement with China, with these domestically rooted goals are

central to its foreign policy calculus. For example, attracting BRI investments is directly linked to the national interest of infrastructure development, while its firm stance on the Natuna Islands reflects the paramount interest of territorial sovereignty. The synthesis of neorealist concerns about systemic pressures and power dynamics with a national-interest perspective on specific state objectives provides a robust analytical lens through which to evaluate the motivations, strategies, and outcomes of Indonesia's bilateral and multilateral engagements in an increasingly contested region.

According to the recent literature, there is a growing recognition of the applicability of neorealism and national-interest theory to the Indonesian changing relationship with China especially under the condition of intensifying economic interdependence and increasing regional competition (Tian, Othman and Khairi 2024). Recent literature speculates that middle powers like Indonesia have turned to multi-layered hedging policies in order to address their vulnerability in strategy in an environment characterized by the increased assertion of China and intensifying of the U.S.-China relationship (Anwar 2019).The publications of the last five years point at the role of the responses of Indonesia under the impact of not only structural pressures but also the transformation of the perception of a threat, distribution of resources, and the increasing role of maritime security in the policy formation of the countries. All these papers show that the strategic position of Indonesia, comprising of not only selective cooperation, but also careful resistance and active diversification of partners, can be viewed as a neorealist expectation form of state behavioral adaptation to constraints in the system, but to the best of their autonomy. Meanwhile, recent literature supports the national-interest prism in indicating that Indonesia still follows the same foreign policy that focuses on developmental needs and maritime sovereignty, domestic political stability and regional leadership via ASEAN. With these refurbished contributions in place, the movement of structure and agency can be captured more well within the theoretical framework, which increases the ability of the theoretical framework to explain the contemporary strategic behavior of Indonesia.

2. Methods

A qualitative research design has been used, which combines document analysis, tracing of the historical developments and thematic interpretation to study the multidimensional nature of Sino-Indonesian relations development. In line with the interests in strategic behaviour, sovereignty issues and economic interdependence which define the interest of the manuscript, the methodological approach uses a wide range of primary sources, such as presidential speeches, statements of ministers, the communiques of the ASEAN, bilateral cooperation agreements, reports of the maritime incidents at the North Natuna Island, and statistical data concerning the trade flows and investments under the Belt and Road Initiative. These materials are supplemented with scholarly publications (especially those about policy and empirical studies) of 2015-2025, which will allow conducting a more modern and longitudinal evaluation of how the issue of power disparities and national interests influence the strategic decisions of Indonesia.

It is needed to cover the scholarly and empirical terrain as wide as possible in relation to Sino-Indonesian relations and in this regard, she used a systematic search strategy to find relevant literature and primary materials. The keywords and search strings were formulated on the basis of the comprehensive themes of this paper such as the hedging strategy of Indonesia, maritime sovereignty, the activities of Belt and Road Initiative, ASEAN regionalism, and domestic political factors. Combinations of words, including Indonesia-China strategic relations and hedging strategy and neorealism, and maritime security words, including Natuna Islands, China incursions at sea, UNCLOS, and South China Sea tensions were used to conduct searches. The aspects of economic interdependence and infrastructural collaboration were explored using the following queries: BRI projects Indonesia, debt sustainability, Chinese investment governance and Jakarta-Bandung high-speed rail cost overrun. The search included reginal diplomatic relations and thus added a search query that involved "ASEAN centrality, U.S.-China rivalry, ASEAN Outlook on the Indo-Pacific, and ASEAN unity. In order to put domestic political motives into prospectus, further searches were conducted on things like Indonesia people and China attitude, China emigrants in Indonesia, and even historical sensitivities of the ethnic Chinese. Searching of sources on the qualitative document analysis, process tracing and national interest theory in research on the foreign policy of the southeast Asian countries was used to improve the methodological and theoretical basis. The systematic search processes made sure that evidence base used contained the also up-to-date empirical results as well as the already existing theoretical contributions hence making the analytical framework used in the study stronger and more credible.

All documents were effectively audited and sorted into thematic groups on the main links of the study inquiry; economic collaboration, maritime security politics, regional diplomacy via ASEAN, as well as domestic political concerns, enabling regional patterns, trends, and contentious issues to be detected within the areas of concern.

Major turning points were related to trace historical processes that have facilitated the normalization of Indonesia-China relations, the introduction of the BRI, and frequent tensions with Natuna, therefore, placing current events within greater structural and historical patterns. The theoretical frameworks used as the analytical lenses are neorealism and national-interest theory, which explains how the macro-level systemic pressures are interconnected with the domestic needs of Indonesia and foreign policy measures. This methodological approach makes it possible to critically and theoretically consistent realize the assessment of strategic balancing of Indonesia so that the empirical facts are rooted in the structural explanations and change in national priorities of the country.

3. The Evolution of Sino-Indonesian Relations

The historical trajectory of relations between China and Indonesia is a complex narrative characterized by long periods of amicable exchange interspersed with episodes of deep mistrust, ideological conflict, and diplomatic estrangement. Understanding this dynamic evolution is crucial for contextualizing the contemporary challenges and opportunities that define their Comprehensive Strategic Partnership.

Early interactions, dating back centuries, were largely driven by maritime trade and cultural diffusion, with Chinese merchants and emissaries, such as Admiral Zheng He in the 15th century, playing significant roles in the economic and cultural life of the Indonesian archipelago (Anwar 2022; Ibrahim, Sukandar, and Nusantari 2023). These historical ties laid a foundation for the presence of a significant ethnic Chinese diaspora in Indonesia.

The Cold War era, however, introduced profound ideological schisms. Following Indonesia's independence, relations with the newly established People's Republic of China were initially cordial, culminating in active Indonesian participation alongside China in the 1955 Bandung Conference, which championed Afro-Asian solidarity and non-alignment (Anwar 2019). However, this warmth dissipated dramatically in the mid-1960s. The alleged involvement of the Indonesian Communist Party (PKI) in the 1965 coup attempt, coupled with Beijing's perceived support for the PKI, triggered a violent anti-communist purge in Indonesia. This cataclysmic event led to the deaths of hundreds of thousands and the suspension of diplomatic relations with China in 1967 under President Suharto's New Order regime (Yu and Han 2023). For nearly a quarter of a century, official ties remained frozen, marked by deep suspicion and Jakarta's alignment with the Western bloc against perceived communist expansionism (Yu and Han 2023). The Suharto era, while maintaining this diplomatic freeze, did allow for a degree of pragmatic, albeit unofficial, economic interaction, often facilitated through third countries and by Indonesia's ethnic Chinese business community.

The formal normalization of diplomatic relations in August 1990 marked a significant turning point, occurring even before the end of the Cold War and the fall of Suharto. This rapprochement was driven by evolving geopolitical landscapes, China's shift towards a more pragmatic foreign policy focused on economic development, and Indonesia's own economic imperatives (Elisabeth 2018). The subsequent "Reformasi" period in Indonesia, commencing with Suharto's resignation in 1998, ushered in an era of democratization and greater openness, further paving the way for an expansion of ties with Beijing. Successive administrations, from President Megawati Sukarnoputri to President Susilo Bambang Yudhoyono, progressively deepened engagement with China, recognizing its growing economic importance (Elisabeth 2018).

Under Chinese President Xi Jinping, this relationship has intensified significantly, particularly through the framework of the Belt and Road Initiative (BRI). High-profile infrastructure projects, most notably the Jakarta-Bandung high-speed railway, have come to symbolize this new era of extensive economic cooperation. However, this deepening interdependence has not been without friction (Farras 2023). Contentious issues, primarily revolving around Chinese fishing vessel incursions and coast guard assertiveness within Indonesia's EEZ in the North Natuna Sea, have periodically flared, reigniting deep-seated sovereignty concerns and public anxieties within Indonesia (Anwar 2022, Farras 2023). This complex evolution underscores a persistent interplay of mutual economic benefit, shared interests in regional stability, and underlying geopolitical anxieties and historical sensitivities that continue to shape the contours of Sino-Indonesian relations.

4. Strategic and Economic Interdependence

The economic dimension of the Sino-Indonesian relationship has become its most prominent and defining feature in the 21st century, characterized by a rapidly growing yet increasingly asymmetrical interdependence. China stands as Indonesia's largest trading partner by a considerable margin and has emerged as one of its most significant sources of foreign direct investment, particularly in crucial sectors such as infrastructure, energy, mining (especially nickel processing), and manufacturing (Ariani and Amaliah 2023). The alignment of China's Belt and Road Initiative (BRI) with Indonesia's Global Maritime Fulcrum (GMF) strategy under President Joko Widodo has

been the primary catalyst for this intensified economic engagement, promising to address Indonesia's substantial infrastructure deficit and spur economic growth.

BRI projects, ranging from power plants and industrial parks to ports and transportation networks, have indeed contributed to Indonesia's economic development and modernization efforts. The Jakarta-Bandung high-speed railway, despite its controversies, is often touted as a symbol of this modernization drive and the tangible benefits of Chinese investment (Ariani and Amaliah 2023). However, this burgeoning economic relationship is fraught with significant challenges and concerns for Indonesia. Issues of debt sustainability have become prominent, with critics fearing that large-scale, Chinese-financed infrastructure projects could lead to an unsustainable debt burden, potentially compromising Indonesia's fiscal stability and policy autonomy (Elisabeth 2018, Fukuoka and Verico 2016). The Jakarta-Bandung railway itself serves as a cautionary tale, having experienced substantial cost overruns (escalating from an initial estimate of around $6 billion to over $7.3 billion) and significant delays, necessitating a government bailout and raising questions about its long-term economic viability and the transparency of its financing arrangements (Fukuoka and Verico 2016).

Furthermore, concerns about a lack of transparency in project tendering and execution, the environmental and social impacts of certain BRI projects, and imbalances in labor arrangements - with perceptions of an excessive influx of Chinese workers at the expense of local employment opportunities - have fueled public skepticism and occasional social tensions (Candra and Zhafran 2023). The structural nature of the trade relationship, with Indonesia primarily exporting raw commodities to China and importing higher-value manufactured goods, also perpetuates an economic dependency that hinders Indonesia's ambitions for industrial upgrading and value-added production (Ariani and Amaliah 2023).

This asymmetric economic interdependence inevitably grants China a degree of strategic leverage, potentially challenging Indonesia’s capacity for autonomous policy-making in both domestic and foreign affairs. Indonesian policymakers are acutely aware of these risks and have attempted to mitigate them through various measures (Tian, Othman and Khairi 2024). These include efforts to diversify sources of FDI beyond China, impose stricter local content and labor participation requirements in foreign-funded projects, enhance regulatory oversight, and push for greater transparency and adherence to international best practices in project implementation. From a neorealist perspective, these moves can be interpreted as forms of internal balancing, whereby Indonesia seeks to bolster its own resilience and reduce vulnerabilities to secure its autonomy in the face of a powerful economic partner (Yadav 2025). However, the efficacy of these measures in fundamentally altering the asymmetrical nature of the economic relationship remains a subject of ongoing debate and scrutiny.

The maritime tensions persisting in the North Natuna Sea show that Indonesia is mediated essentially through issues of security between Indonesia and China. Such events indicate systemic weaknesses, which drive Indonesia to have a more explicit stance on sovereignty to influence its overall regional stance and perceived diplomacy. Supporting the relevance of maritime defense and international law will enhance the security actions of the Indonesia to enhance its status as an autonomous agent that upholds the territorial integrity. These dynamics help to depict that economic cooperation with China cannot be entirely dissociated with the strategic strife that is taking place at sea. Therefore, the security environment is the paramount negative balance to economic involvement and becomes decisive to hedging behavior of Indonesia.

5. Security Dynamics and the South China Sea

While economic interests often dominate the discourse on Sino-Indonesian relations, underlying security dynamics, particularly concerning maritime sovereignty in the South China Sea, remain a persistent and potentially volatile element of the bilateral engagement. Indonesia is not a formal claimant state in the territorial disputes over islands and rock features in the South China Sea, such as the Spratly or Paracel Islands. However, its internationally recognized Exclusive Economic Zone (EEZ) around the Natuna Islands directly overlaps with China's expansive "nine-dash line" (now often depicted as a "ten-dash line" or simply "relevant waters" claim), which Beijing uses to assert historical rights over a vast majority of the South China Sea (Djaria and Seniwati 2025). This geographical overlap has become a recurring flashpoint.

Incidents involving Chinese fishing fleets, often accompanied by heavily armed China Coast Guard vessels, making incursions into Indonesia's EEZ in the North Natuna Sea have become increasingly frequent and assertive in recent years. These actions are perceived by Jakarta not merely as illegal fishing activities but as direct challenges to its sovereignty and sovereign rights as stipulated under the United Nations Convention on the Law of the Sea (UNCLOS), which Indonesia has ratified and to which it staunchly adheres. China's insistence on "traditional fishing grounds" within Indonesian waters, a claim not recognized by UNCLOS, further exacerbates these tensions (Farras 2023).

In response to these challenges, Indonesia has adopted a multifaceted approach that combines diplomatic assertiveness with a strengthening of its defense and law enforcement capabilities. This demonstrates Jakarta's internal balancing approach aimed at upholding its territorial integrity and maritime rights. Successive Indonesian governments have significantly increased military presence and upgraded infrastructure in the Natuna archipelago, including extending runways, deploying additional naval and air force assets, stationing more personnel, and enhancing surveillance capabilities. Public statements from Indonesian officials have consistently reaffirmed Indonesia's sovereign rights and rejected China's claims, often leading to diplomatic protests and heightened rhetoric.

Concurrently, Indonesia has pursued diplomatic efforts, primarily through ASEAN, to manage these disputes and constrain Chinese assertiveness. Jakarta has been a vocal proponent of an expeditious conclusion to a substantive and legally binding Code of Conduct (COC) for the South China Sea that is consistent with international law (Anwar 2019). It also emphasizes the importance of international legal frameworks, including the 2016 arbitral tribunal ruling (Philippines v. China), which invalidated China's nine-dash line, as a basis for resolving maritime disputes, even though Indonesia was not a party to that specific case (Fitriani 2021).

Furthermore, to enhance its deterrent posture and maritime security capabilities, Indonesia actively participates in bilateral and multilateral military exercises, including those led or involving the United States, Australia, Japan, and other regional partners (Strat and Narain 2025). These engagements aim to improve interoperability, share best practices in maritime domain awareness, and signal a broader commitment to a rules-based maritime order. These complex security dynamics in the South China Sea underscore the tangible strategic costs and vulnerabilities associated with Indonesia's regional proximity to a more powerful and assertive China, compelling Jakarta to continuously adapt its security posture and diplomatic strategies.

The internal divisions in the ASEAN and the U.S.-China rivalry directly affect the ways in which the country will position itself in the region and how it will deal with Beijing. Being the de facto leader of ASEAN, Indonesia needs to reconcile, national interests and need to maintain regional unity, so its strategy of hedging is its national and regional priority. Indonesia has tried to influence the regional environment in a manner that can alleviate external pressure just like in the case of the Energizing of the ASEAN outlook on the Indo-Pacific. This brings out the point that the external balancing process cannot take place without the regional commitment to diplomacy in Indonesia. Finally, ASEAN also acts as a limitation and a place through which Indonesia can pursue strategic autonomy even in relation to China.

6. ASEAN, Regionalism, and the U.S.-China Rivalry

Indonesia has historically positioned itself as a key architect and staunch champion of ASEAN centrality, viewing the regional organization as the cornerstone for maintaining peace, stability, and prosperity in Southeast Asia. Jakarta perceives a strong, unified, and proactive ASEAN as essential for managing regional affairs, mediating disputes, and engaging with external powers from a position of collective strength (Fukuoka and Verico 2016). However, the intensifying strategic rivalry between the United States and China casts a long shadow over ASEAN's cohesion and effectiveness, placing considerable pressure on Indonesia's balancing role and its aspirations for regional leadership.

ASEAN's internal divisions, often exacerbated by the varying degrees of economic dependence and political alignment of its member states with either China or the U.S., frequently undermine its ability to formulate and implement collective responses to pressing geopolitical threats, including China's assertiveness in the South China Sea (Strat and Narain 2025). Some member states, particularly Cambodia and Laos, are often perceived as being closely aligned with Beijing, which can dilute ASEAN consensus on sensitive issues and hinder efforts to adopt a more robust stance against actions that challenge regional norms or international law. This fragmentation limits ASEAN's leverage and complicates Indonesia's efforts to steer the organization towards a more unified and principled approach.

The U.S.-China rivalry further intensifies these pressures, compelling Southeast Asian nations, including Indonesia, to navigate a treacherous path between the two competing giants. Both Washington and Beijing actively court regional states, offering economic incentives, security cooperation, and competing visions for regional order. Indonesia, adhering to its "bebas dan aktif" foreign policy, assiduously seeks to avoid taking sides in this great power contest, fearing that alignment with one could antagonize the other and compromise its strategic autonomy (Anwar 2022; Hamilton-Hart and McRae 2015).

In response to these challenges, Jakarta has actively promoted the ASEAN Outlook on the Indo-Pacific (AOIP), an initiative that emphasizes inclusivity, dialogue, and cooperation across the broader Indo-Pacific region, rather than fostering exclusionary blocs or zero-sum competition (Anwar 2019). The AOIP aims to reinforce ASEAN

centrality in shaping the regional architecture and to provide a framework for constructive engagement with all major powers based on shared principles. By fostering such inclusive regional architectures, Indonesia hopes to mitigate the destabilizing effects of the U.S.-China rivalry and create a more multipolar and rules-based regional order. These efforts reflect Indonesia's enduring aspiration to not only navigate but also to actively shape the regional environment in a manner consistent with its national interests and its vision for a stable and prosperous Southeast Asia amid intensifying great-power competition. However, the practical implementation and impact of the AOIP in genuinely influencing great power behavior and fostering a more balanced regional order remain significant challenges.

Indonesia politics within the country and popular opinion is also a factor of influence in the evolution of the overall strategic position of Indonesia in relation to China. With the re-emergence of the social fears of sovereignty, of competition in the labor market, and of sensitivities to the event of history, Jakarta will be compelled to strike a balance between national credibility and global political utility. These domestic forces can affirm Indonesia unwillingness to shift to becoming overtly aligned to Beijing though economically interdependent. They also state the reason why the leaders of Indonesia usually pursue the issues of sovereignty by presenting them in ways that appeal to the masses in Indonesia. In this way, an internal politics of the country serves as the stabilizing factor to help the Indonesia politics base their China policy to national identity and long-term values of independence.

7. Domestic Political Considerations and Public Sentiment

The conduct of Indonesia's foreign policy, particularly its sensitive and high-stakes relationship with China, is significantly shaped and often constrained by a complex interplay of domestic political considerations and fluctuating public sentiment. Public opinion in Indonesia toward China is multifaceted and frequently ambivalent, reflecting a tension between the acknowledged economic benefits of cooperation and deep-seated anxieties regarding sovereignty, national identity, and potential socio-economic repercussions.

While Chinese investments and trade are generally welcomed by segments of the business community and government elites for their contribution to economic growth and infrastructure development, there is also rising skepticism and concern among the broader populace. These concerns often revolve around the perceived erosion of national sovereignty, particularly in relation to maritime disputes in the North Natuna Sea and the terms of some BRI projects (Kusumasomantri 2018). Social impacts, such as the perceived displacement of local workers by imported Chinese labor on large-scale projects, competition faced by local small and medium enterprises, and the potential for unwelcome cultural influence, also fuel public apprehension and occasionally lead to localized protests or social media campaigns (Candra and Zhafran 2023).

Indonesian political elites, therefore, must perform a delicate balancing act, navigating the imperative to secure foreign investment and maintain economic growth with the need to address and assuage nationalist sentiments and public anxieties. Historical sensitivities play a crucial role in this dynamic (Abdullah, Said and Ridzuan 2025; Srifauzi *et al*. 2018). The traumatic anti-communist purges of 1965-66, which were intertwined with anti-Chinese violence, and the subsequent discriminatory policies against ethnic Chinese Indonesians during the Suharto era, have left a lasting legacy of mistrust towards both communism and, by extension in some quarters, mainland China. Furthermore, the anti-Chinese riots that occurred during the Asian Financial Crisis in May 1998 serve as a stark reminder of the fragility of ethnic relations and the potential for anti-Chinese sentiment to be exploited for political purposes. These historical experiences contribute to a cautious and often wary approach in policymaking circles when dealing with China.

The Indonesian government, particularly under President Joko Widodo, has emphasized the importance of transparency, good governance, and tangible benefits for local communities in Chinese-financed projects to gain public trust and mitigate criticism (Abdullah, Said and Ridzuan 2025). However, ensuring genuine accountability and addressing public concerns effectively remains an ongoing challenge. Issues such as the treatment of Uyghur Muslims in China's Xinjiang province also resonate strongly within Indonesia, the world's most populous Muslim-majority nation, with various Islamic organizations and civil society groups calling for greater solidarity and a more critical stance from the Indonesian government (Anwar 2019). Domestic political stability, therefore, is not only a precondition for effective foreign policy but also a product of how well the government manages the complexities and public perceptions of its strategic balancing act, especially in its engagement with a powerful and increasingly influential China.

The policy options and institutional protection options as suggested above are direct response to the structural problem of Indonesia in terms of handling asymmetric relationship with China. Through better governance, better regulatory supervision and enforcement of ASEAN standards, Indonesia can build its ability to relate with China without loss of sovereignty. Such mechanisms are indicative of a larger Indonesian policy of

preserving autonomy and reaping the benefits of cooperation in terms of development. They also emphasise the active nature of the hedging position of Indonesia, which shows that both institutional resilience and policy action can be used to maintain strategic autonomy. On this basis, institutional reforms are critical tools that will enable Indonesia to reconcile between foreign interaction and internal dominance.

8. Institutional Safeguards and Policy Recommendations

To navigate the complexities of its relationship with China and ensure that engagement yields mutually beneficial outcomes while safeguarding its national interests, Indonesia must proactively develop and institutionalize a robust set of safeguards and pursue strategic policy initiatives at both domestic and regional levels. These measures are essential for enhancing resilience, maintaining strategic autonomy, and promoting sustainable and equitable development.

At the domestic level, a primary focus should be on strengthening governance and transparency surrounding foreign investments, particularly large-scale BRI projects. This includes institutionalizing mandatory public consultation and meaningful community participation in the planning and impact assessment phases of infrastructure projects to ensure local needs are addressed and potential negative consequences are mitigated. Establishing clear, enforceable legal protections for local workers - covering wages, working conditions, and opportunities for skills development - is crucial to counter concerns about labor imbalances and exploitation. Furthermore, robust debt oversight mechanisms, potentially involving independent audits and parliamentary scrutiny of loan agreements, are necessary to ensure fiscal sustainability and prevent the accumulation of unsustainable debt (Elisabeth 2018, Fukuoka and Verico 2016), imply such needs through their discussion of risks). Promoting digital transparency platforms that provide public access to project details, financing terms, and performance metrics can significantly enhance accountability and reduce opportunities for corruption. Investing in independent project audits conducted by credible national or international bodies can further bolster oversight and ensure compliance with environmental and social standards. Finally, fostering inclusive development frameworks that prioritize local economic linkages, support for small and medium-sized enterprises (SMEs), and equitable benefit-sharing will be vital to ensure that the fruits of economic cooperation are widely distributed and contribute to national resilience.

At the regional level, Indonesia should continue to champion efforts to strengthen ASEAN's institutional capacity for conflict prevention and dispute resolution. A key priority remains the codification of a substantive, effective, and legally binding South China Sea Code of Conduct (COC) that is consistent with international law, particularly UNCLOS. Such a COC is critical for managing tensions, preventing incidents at sea, and providing a stable framework for maritime interactions in one of the world's most contested waterways (Anwar 2019). Indonesia can also spearhead initiatives within ASEAN to develop common standards for sustainable infrastructure development, responsible investment, and environmental protection, thereby creating a more level playing field and promoting higher governance standards across the region. Enhancing ASEAN's collective bargaining power in negotiations with major external partners, including China, on economic and security matters should also be a strategic objective.

Moreover, Indonesia should continue to diversify its strategic partnerships beyond China and the United States, actively engaging with other middle powers and regional organizations to build coalitions on issues of shared concern, such as maritime security, climate change, and global health. Investing in its own diplomatic capacity, research institutions, and public understanding of complex foreign policy issues will also be essential for formulating and implementing effective long-term strategies. These multifaceted institutional safeguards and proactive policy recommendations are not merely desirable but are increasingly essential for Indonesia to uphold its long-term strategic autonomy and national interests while engaging productively and sustainably with China and other external powers in a rapidly evolving global order.

Conclusions and Further Research

Indonesia's multifaceted relationship with China in the contemporary era is profoundly characterized by a state of strategic ambivalence - a complex interplay of mutually beneficial economic cooperation and deeply ingrained anxieties stemming from power asymmetries, historical legacies, and unresolved sovereignty concerns. The analytical frameworks of neorealism and national interest theory provide valuable, albeit not exhaustive, lenses through which to understand Jakarta's intricate foreign policy calculus. Neorealism highlights how Indonesia, operating within an anarchic international system and acutely aware of China's rising power, seeks to manage its vulnerabilities through strategic hedging and balancing behaviors, fostering ties with multiple major powers to preserve its autonomy (Anwar 2022). National interest theory further illuminates how Jakarta's engagement is

driven by core objectives such as economic development, territorial integrity, and the maintenance of domestic stability, compelling it to navigate the opportunities and risks presented by its powerful northern neighbor.

As China's economic, political, and military presence continues to expand across Southeast Asia and the broader Indo-Pacific, Indonesia faces an ongoing imperative to enhance its institutional capacity, bolster its national resilience, and leverage its diplomatic influence, particularly within ASEAN, to safeguard its interests. The nation's ability to maintain its "bebas dan aktif" foreign policy and act as a sovereign maritime fulcrum, rather than becoming entangled in great-power dependencies or regional hegemonies, will hinge critically on several factors. These include the robustness of its domestic governance structures, the cohesiveness and strategic vision of its political leadership, the degree of regional solidarity it can foster within ASEAN, and the agility and foresight of its strategic choices in an increasingly volatile and unpredictable international landscape. The future trajectory of Sino-Indonesian relations, and indeed Indonesia's own path in the 21st century, will be significantly shaped by its capacity to navigate these complex challenges while steadfastly upholding its core principles of sovereignty, independence, and active engagement in pursuit of a just and prosperous regional and global order. The delicate balance between reaping the economic rewards of engagement with China and mitigating the associated strategic risks will remain a defining feature of Indonesian foreign policy for the foreseeable future.

Declarations

Credit Authorship Contribution Statement:

Tiancheng Tian: Conceptualization, Investigation, Methodology, Software, Formal analysis, Writing – original draft, Data curation, Validation, Visualization;
Sity Daud: Conceptualization, Methodology, Project administration, Supervision, Data curation, Validation, Writing – review and editing;
Aizat Khairi: Software, Supervision, Data curation, Validation, Writing – review and editing, Visualization.

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Ethics, an Article in the Law or Individual Behaviour? An Overview of the Legal Framework in Albania on the Prevention of Conflicts of Interest during the Exercise of the Public Sector Functions

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Abstract: At the core of current discourse on good governance and institutional integrity rests the complex interplay between ethics as a legal norm and ethics as individual behavior. It is precisely this dual nature of ethics, sometimes expressed as an article in the law and sometimes as a moral guide in preventing conflicts of interest during the exercise of public functions, that constitutes the central focus of this paper. Through a qualitative analysis of the Albanian legal framework and institutional practice, the paper examines the effectiveness of existing provisions in identifying and preventing situations involving conflicts of interest. The scientific contribution of this paper lies in highlighting the gap between the formal legal regulation of ethics and conflict of interest and their practical implementation, showing that legal provisions alone are insufficient to ensure effective prevention. Although legislation attempts to codify ethical standards through clear rules, the analysis demonstrates that sustainable prevention is intrinsically linked to individual awareness, institutional culture, and the ethical conduct of public sector employees. The paper argues that effective prevention requires a combined approach, integrating legal instruments with internal ethical responsibility, continuous education, and institutional commitment. In conclusion, the study emphasizes that while the existence of a legal framework is a necessary condition for safeguarding public integrity, it is not sufficient on its own. The prevention of conflicts of interest ultimately depends on a consistent and enduring interaction between legal provisions and an ethical culture internalized by individuals entrusted with public responsibilities.

Keywords: ethics; conflict of interest; law; prevention.

JEL Classification: D02; K49; H83; Z19; A12.

Introduction

Ethics has become one of the fundamental pillars of good governance and building citizens' trust in state institutions and the services they provide. At a time when integrity, transparency, and accountability represent core principles of administrative practice, the legal regulation of public officials' conduct faces the significant challenge of balancing legal norms with personal moral standards. Ethics in public service is not simply a matter of personal morality or internal organizational rules but increasingly constitutes a central component of the legal and institutional framework designed to safeguard the public interest and prevent corruption.

Even for Albania as a country aspiring to EU integration, the exercise of the profession by everyone with an ethical behavior by applying the fundamental principles of ethics, accompanied by the prevention of conflicts of interest that may arise, is essential for maintaining public trust, ensuring administrative integrity, and strengthening the fight

against corruption. In our context, there often arises an inevitable tension between official duties and the personal interests of public officials. This situation constitutes what is defined in the legal framework as a conflict of interest, a situation where decision-making can be influenced by private interests, in contradiction with public responsibilities.

An interest is a commitment, obligation, duty, or purpose associated with a particular social role or practice (Komesaroff, P.A.; Kerridge, I.; Lipworth, W. 2019). A conflict of interest arises when an individual or public official is subject to two simultaneous and opposing interests during the decision-making processes they are required to undertake. This issue is particularly significant, as under such circumstances the decision-making process may be disrupted or compromised in a manner that undermines the integrity or credibility of the outcomes, thereby producing adverse consequences for the public interest as well.

Albania, as a country that is working hard towards EU integration, one of the most sensitive issues of public administration is the exercise of the function of an official with integrity, which is associated with the widespread phenomenon of corruption as well as the emergence of conflicts of interest. The relationship between the legal norms governing ethics and conflicts of interest and the actual behavior of individuals holding public office became the central focus of this paper. The guiding research question of this study was: "*Is the regulation of ethics through legal norms sufficient to prevent conflicts of interest, or does the effectiveness of such prevention primarily depend on individual awareness, integrity, and will?*"

Therefore, this paper analyzes the content, clarity, and practical applicability of legal and sub-legal acts aimed at preventing conflicts of interest, identifying both formal oversight mechanisms and the structural or cultural deficiencies that undermine their effectiveness. It also evaluates the extent to which current legislation seeks to foster an institutional ethic, as well as its influence on the conduct of public officials. Through this analysis of Albania's legal framework, the paper argues that justice and public trust are sustained not solely through laws but through individuals who uphold them with integrity and a clear conscience.

To develop this analysis, the paper adopts a qualitative research approach, focusing on a review of the primary Albanian legal framework concerning conflicts of interest. This includes two foundational laws: Law No. 9131, dated 8.9.2003, "On the Rules of Ethics in Public Administration," and Law No. 9367/2005, "On the Prevention of Conflict of Interest in the Exercise of Public Functions," along with other relevant sub-legal acts. The analysis is further enriched by comparative assessments of European practices and the interpretation of administrative jurisprudence in this domain. Through this approach, the paper aims to identify not only the normative dimensions but also the practical challenges associated with implementing public ethics in Albania.

This topic takes on particular importance in the current context of public administration reforms and efforts to strengthen the rule of law and citizen trust in state institutions. Although the law attempts to provide a clear framework for identifying and managing conflicts of interest, its effective implementation is often hampered by institutional culture, political pressures, or a lack of individual ethical awareness.

This paper contributes to the existing literature on public ethics and conflict of interest in three main ways. First, it provides a systematic analysis of the Albanian legal and institutional framework governing conflicts of interest, highlighting its evolution and degree of approximation with European standards. Second, it moves beyond a purely normative assessment by examining the practical effectiveness of these rules through institutional reports and implementation data, identifying key gaps between legal design and enforcement. Third, the paper advances the argument that legal regulation alone is insufficient, and that effective prevention depends on the internalization of ethical responsibility by public officials, supported by education, institutional culture, and credible sanctions.

The remainder of the paper is structured as follows. Section 1 reviews the relevant theoretical and empirical literature on conflict of interest and public ethics. Section 2 outlines the research methodology and data sources. Section 3 presents the main findings from the analysis of the Albanian legal framework and institutional practice. Section 4 discusses the results in a comparative and critical perspective, with reference to European standards. The final section concludes by outlining policy implications and directions for future research.

1. Literature Review

Definitions of conflict of interest are widely found in literature, but the main one that is used is "*A conflict of interest is a set of circumstances that creates a risk that professional judgment or actions regarding a primary interest will be unduly influenced by a secondary interest*." (Lo, Field 2009; Thompson 1993). According to Thompson (1993), secondary interests are usually not illegal in themselves and may indeed be a necessary and desirable part of

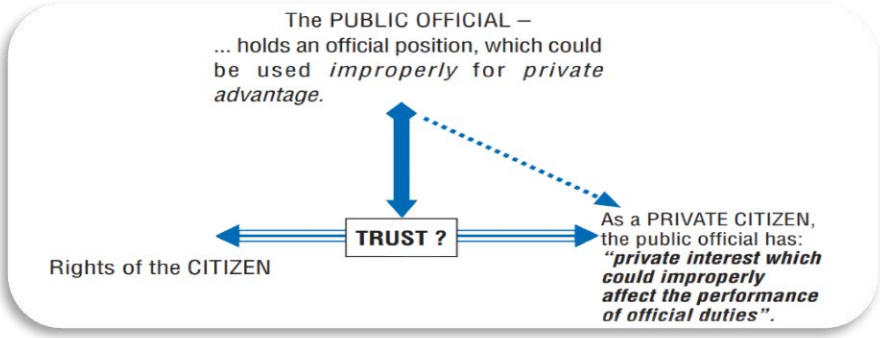
professional practice, but their relative weight in professional decisions is problematic. The aim is not to eliminate or necessarily reduce financial gain or other secondary interests but to prevent secondary factors from dominating or appearing to dominate the relevant primary interest in professional decision-making.

Conflict of interest rules in the public sphere focus mainly on financial relationships, as they are relatively more objective, interchangeable, and measurable, and usually include political, legal, and medical fields. As a result, the application of the principle of integrity plays a key role in the exercise of public function; therefore, Integrity is identified as a crucial aspect of good governance, but not the only aspect (Huberts L. 2014). Conflicts of interest have much in common with corruption and fraud but should not be confused with breaches of integrity (Huberts L. 2014).

In October 2016, the Congress of Local and Regional Authorities of the Council of Europe (31st session) adopted its roadmap, which identifies among the issues the promotion of public ethics and the preparation of a report on conflict of interest, to identify preventive measures and good practices in the fight against corruption. In the context of digitalization and internationalization and their intensification, new integrity risks are also being generated in the public sector. Current discussions about conflict of interest are about how important and effective identification and prevention policies and instruments are.

A key role in the public sector is also played by the OECD Guidelines for Managing Conflicts of Interest in the Public Service, which were initially adopted by the OECD Council on 28 May 2003. The Guidelines respond to a growing demand to ensure integrity and transparency in the public sector. They provide a framework of reference for stakeholders to review and modernize their public sector conflict of interest policies, defining ''A conflict of interest *involves a conflict between the public duty and private interests of a public official, in which the public official has private-capacity interests which could improperly influence the performance of their official duties and responsibilities''*. The guidelines also encourage partnerships between the public and private sectors and non-profits by suggesting the responsibilities of each sector for improving integrity and strengthening the business environment (OECD 2025).

Diagram 1. Conflict of interest



Source: OECD 2005 Managing Conflict of Interest in the Public Sector. A toolkit

The situation presented above is also called a real conflict of interest. At the heart of it is trust in the integrity of the official, which can be seriously damaged by the suspicion that the performance of official duties by the public official may be influenced by a personal conflict of interest. Every public official has private interests, these from his perspective as a private citizen; therefore, it is necessary to identify and manage conflicting interests whenever they arise, to maintain trust. Trust can be protected and enhanced in various ways and forms, which are presented in the OECD guidelines (2025), for example, by making the relevant private interests of the official known to the public.

Also, managing conflicts of interest is not simply a matter of ethical compliance, but a critical necessity to ensure transparent and equitable business practices. Ongoing commitment to managing conflict of interest is essential for protecting the principles of fair competition and supporting long-term economic growth and stability (Sewsankar G. 2024).

Managing conflict of interest requires interdisciplinary cooperation because it is a concept that combines law, politics, economics, sociology, organizational behavior and morality. This situation immediately raises the profound question of the limits of law and traditional compliance-based approaches. Therefore, when designing new rules, policies and approaches, consideration should be given to the early involvement of experts from different disciplines in

the early stages of political decision-making (European Union, 2020)[1]. EU member states have increasingly introduced monitoring and enforcement bodies with different and often overlapping roles.

In view of the above, the most important regulatory instrument of institutions are codes of ethics. Every individual accountant, auditor, lawyer, etc., while practicing their profession in both the private and public sectors, must understand and learn that there is a Code of Professional Ethics which also includes the International Independence Standards (IFAC 2025 for accountants and auditors but not only). These codes clearly identify how a profession should be practiced with ethical principles and norms, as well as the circumstances when a conflict of interest may arise and how it can be avoided.

Meanwhile, regarding transparency, institutions are increasingly paying attention to the conflict-of-interest register, in which public officials' declarations of interest are recorded.

In Albania, starting from the beginning of democracy (1992) and until the early 2000s, there was a lack of a clear legal regulation on conflict of interest, as well as no independent institutions for asset declaration or for monitoring ethics in the public service. Initially, the control of assets and the identification of conflict of interest was carried out by the Albanian Supreme Audit Institution2, and then an independent institution was created to control and monitor conflict of interest, the High Inspectorate of Declaration and Control of Assets and Conflict of Interest (ILDKPKI in Albanian and in English (HIDCACI)).

The basic laws were:

- Law no. 8270, dated 23.12.1997 “On the Supreme State Audit”, which through audit processes aimed not only at auditing the state budget but also at identifying individual benefits during the abuse of official function. It currently functions based on law no. 154/2014, dated 27.11.2014 “On the organization and functioning of the Supreme State Audit”.
- Law no. 7903, dated 8.3.1995 “On the declaration of assets of elected officials and certain public service managers and employees” (repealed in 2003)
- Law No. 9049/2003 “On the Declaration and Control of Assets of Public Servants” was the first concrete step towards the control of private interests and assets. However, it did not clearly address conflict of interest situations.
- Law No. 9131, dated 8.9.2003 "On the rules of ethics in public administration", through which the rules of conduct of public administration officials were determined. The avoidance of conflict of interest referred to in the law was carried out in accordance with the Code of Administrative Procedures.
- Law No. 9367/2005 “On the Prevention of Conflict of Interest in the Exercise of Public Functions” laid the foundations of the legal framework in this area. It clearly defined the concept of actual, potential, and apparent conflict of interest, as well as established the obligation to self-declare and prohibit the exercise of function in cases where a conflict is established.

The creation of two laws (2003/2005) also led to the creation of the High Inspectorate for the Declaration and Control of Assets and Conflict of Interest (ILDKPKI /HIDCACI)) as an independent body. Its role was to control the assets of senior officials, monitor conflicts of interest, advise officials, and issue administrative measures. The implementation of basic laws and the economic, political and social developments themselves brought about the need for many reforms to strengthen the legal and institutional framework. As a result, during the years 2016-2020, Law no. 9367/2005 was amended several times, specifying the procedures and role of the HIDCACI, while Law no. 9049/2003 was repealed and replaced with Law no. 42/2017 “On the declaration, origin and control of assets and private interests of public officials”. This law expanded the scope of subjects and modernized the declaration of asset declarations through the electronic system. Below is a table of the main acts over the years.

As can be seen from the table, a key role is also played by the Public Administration Agency (DAP), which is responsible for drafting, coordinating and supervising the implementation of ethics policies in public administration. Its activities are based on the following acts:

- Law no. 9131, dated 8.9.2003 On the rules of ethics in public administration
- Law No. 152/2013 “On Civil Servants”, which defines the objectives of professional civil service, moral integrity and political impartiality.

[1] https://www.europarl.europa.eu/RegData/etudes/STUD/2020/651697/IPOL_STU(2020)651697_EN.pdf; visited on 21.7.2025
[2] https://www.klsh.org.al/wp-content/uploads/2025/05/Historiku-i-Kontrollit-te-Larte-te-Shtetit-1925-2012.pdf

Table 1. Legal acts over the years in the field of "conflict of interest"

Years	Legal act (Responsible institution)	Purpose and role
1992	Law No. 7597 dated 31.8.1992 "On the State Audit Service" (SAS)	Control and monitoring of the state budget. The ALSAI was independent. The ALSAI drafted a Code of Ethics for employees, a copy of which in English was sent to INTOSAI[3].
1997	Law No. 8270, dated 23.12.1997 "On the Supreme State Audit" (KLSH in Albanian and in English ALSAI)	The name of the institution was changed to KLSH (ALSAI) and brought changes that fully complied with international principles and standards in the field of auditing, approved by INTOSAI and the SAIs of EU countries.
2003	Law No. 9049/2003 On the declaration and control of assets, financial obligations of elected officials and certain public servants, as amended (HIDCACI)	Declaration of assets of public servants
2003	Law No. 9131, dated 8.9.2003 On the rules of ethics in public administration. (DAP)	It defined the rules of conduct for public administration employees. Avoidance of conflict of interest is carried out in accordance with the Code of Administrative Procedures.
2005	Law No. 9367/2005 (HIDCACI)	Prevention of conflict of interest in official functions. The independent institution HIDCACI was established
2008	Law No. 9887/2008 "On the Protection of Personal Data" (Commissioner)	Personal data protection and transparency
2012	Law No. 90/2012 "On the organization and functioning of the state administration"	Organization and functioning of state administration. Responsibility of civil servants and division of powers
2013	Law No. 152/2013 "On Civil Servants" (DAP)	Code of ethics and responsibilities of civil servants
2014	Law No. 119/2014 "On the Right to Information"	Right to information and transparency
2014	Law No. 154/2014, dated 27.11.2014 "On the organization and functioning of the Albanian Supreme Audit Institution"	Through audits, it aims to use public funds, public and state property effectively, efficiently and economically, develop an appropriate financial management system, properly perform administrative activities, and inform public authorities and the public through the publication of its reports.
2017	Law No. 42/2017 "On the declaration, origin and control of assets and private interests of public officials" (HIDCACI)	Electronic declaration of assets and interests
2013	Council of Minister's Decision (VKM) 830/ 2013 On the approval of the Ministerial Code of Ethics.	Establishment of the Ethics Commission. The Code aims to define the rules of ethics that will guarantee the conduct of a member of the Council of Ministers in the exercise of his function as a member of a collegial body or as an individual body, as well as in his personal capacity, in accordance with the legitimate public interest and the government program.
2014+	Council of Minister's Decision (VKM) 874/2021 Code of Ethics in the Civil Service (various decisions of the Council of Ministers)	Ethical standards and rules of conduct
2016+	Justice reform	Vetting, integrity verification for judges and prosecutors
2024+	Decision No. 50/2024 of the Parliament of Albania "On the establishment of the Special Parliamentary Committee "On deepening reforms for good governance, the rule of law and anti-corruption for Albania 2030 in the European Union"	Establishment of a Special Parliamentary Committee to monitor and identify the effectiveness of institutions (including the issue of conflict of interest)

Source: The authors based in the law frameworks in Albania for years.

[3] https://www.klsh.org.al/wp-content/uploads/2025/05/Historiku-i-Kontrollit-te-Larte-te-Shtetit-1925-2012.pdf; page 106.

- Decisions of the Council of Ministers (for example: No. 109/2014, 125/2016, etc.) regulating disciplinary procedures, appointment, transfer and evaluation of civil servants.
- DCM No. 874/2021 which determines the principles of ethics, the classification of external activities and the value of gifts that may be accepted by administration officials.
- Orders / Manuals (2025) drafted by DAP which include: "Practical Ethics Manual", instructions for implementation by human resources and disciplinary procedures. These documents aim to provide practical orientation on ethics in the daily work of the administration.

Therefore, it is concluded that a series of reforms have been undertaken in Albania, centered on Law No. 9131, dated 8.9.2003 on the rules of ethics in public administration, Law No. 9367/2005 "On the prevention of conflict of interest in the exercise of public functions", as well as legislation that accompanies and complements them in the field of asset declaration, transparency and access to information. These reforms have been undertaken in cooperation with international organizations.

But there is still work to be done to approximate and harmonize it with European standards and the EU acquis. The coherence of the legal and institutional framework for the prevention of corruption and the integrity of public officials will need to be increased, as it is very complex, especially regarding high-level officials. The legislative framework on conflict of interest needs to be approximated with European standards and the EU acquis (Screening Report 2023).

2. Research Methodology

This study adopts a qualitative research design based on a legal institutional analysis. The analysis focuses on the regulatory framework governing ethics and the prevention of conflicts of interest in public administration in Albania, with particular emphasis on the interaction between formal legal norms and their practical implementation. The qualitative approach is appropriate for assessing the coherence, clarity, and effectiveness of legal and institutional mechanisms, as well as their alignment with European standards. The selection of Albania as the case study is justified by its ongoing public administration reforms and its European Union accession process, which requires the approximation of national legislation with EU standards on integrity, transparency, and good governance.

The analysis concentrates on the core legal instruments regulating ethics and conflict of interest, namely Law No. 9131/2003 "On the Rules of Ethics in Public Administration" and Law No. 9367/2005 "On the Prevention of Conflict of Interest in the Exercise of Public Functions", as well as their related by-laws. These acts were selected because they constitute the backbone of the Albanian legal framework in this field. The legal and institutional analysis covers the period from 2003 to 2024, corresponding to the adoption and subsequent amendments of the main laws on ethics and conflict of interest. Quantitative and institutional data drawn from official reports are analyzed for the period 2013–2023, which represents the timeframe for which consistent annual reports from the High Inspectorate for the Declaration and Control of Assets and Conflict of Interest (HIDCACI) are publicly available. The study is based on the analysis of primary legal sources, including laws, sub-legal acts, and decisions of the Council of Ministers regulating ethics and conflict of interest. In addition, secondary sources are used, such as annual reports and statistical data published by the HIDCACI, reports from international organizations (OECD, SIGMA, European Union), and relevant academic literature. Comparative references to European standards and best practices are employed to assess the degree of alignment of the Albanian framework with international integrity principles. The analysis combines doctrinal legal analysis with an institutional assessment of implementation practices. Legal provisions are examined in terms of their content, scope, and enforcement mechanisms, while institutional reports are analyzed to identify trends, gaps, and practical challenges in the identification and prevention of conflicts of interest. This combined approach allows for the identification of discrepancies between normative regulation and institutional practice.

This study is subject to certain limitations. It relies primarily on publicly available legal documents and institutional reports, which may not fully capture informal practices or unreported cases of conflict of interest. The absence of primary empirical data, such as interviews or surveys with public officials, limits the ability to assess individual perceptions and behaviors. Furthermore, incomplete transparency regarding some recent institutional reports constrains the depth of the quantitative analysis.

3. Research Results

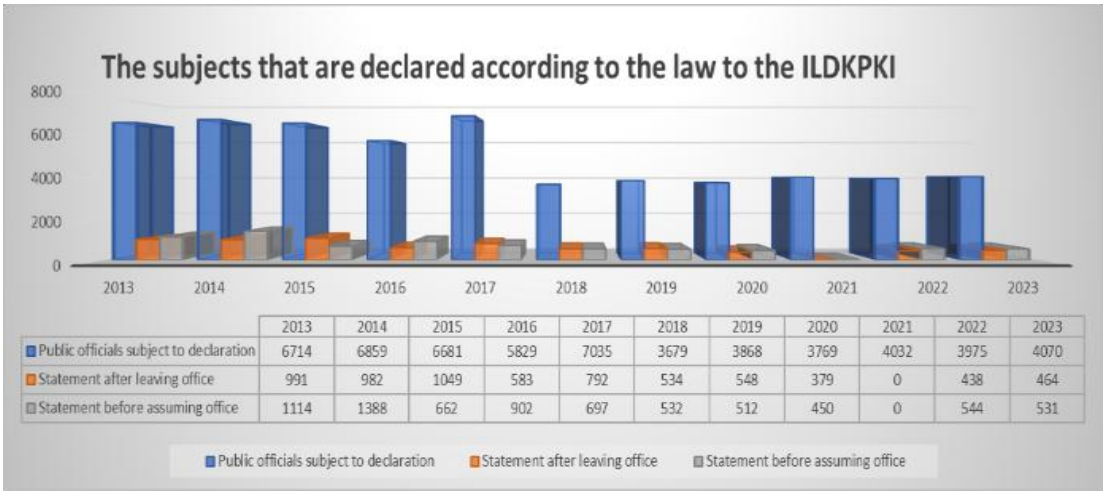
In addition to the legal framework over the years in the field of ethics and conflict of interest, our research also continued with the identification of quantitative data. During the period 2013-2023, from the annual reports and statistical data of

the HIDCACI (ILDKPKI) it is concluded that there is no clear and accurate report related to the identification and prevention of conflict of interest[4]. At the beginning of the implementation of the law, a very low number of cases of conflict of interest were found, and even the annual reports found that although suspicion was raised in 46 cases of conflict of interest, none of them were approved and were not transferred to administrative investigation (Annual Report 2013). Although there are improvements in the regulatory framework in line with international recommendations, the identification and prevention of conflicts of interest remain at a minimal level.

Also, reports from OECD or SIGMA have highlighted that there is no history or data on its implementation5, and the law also lacks post-employment rules or restrictions6.

Below is the data of the reporting entities for the period 2013-2023. (The 2024 annual report has not been made transparent on the official website.)

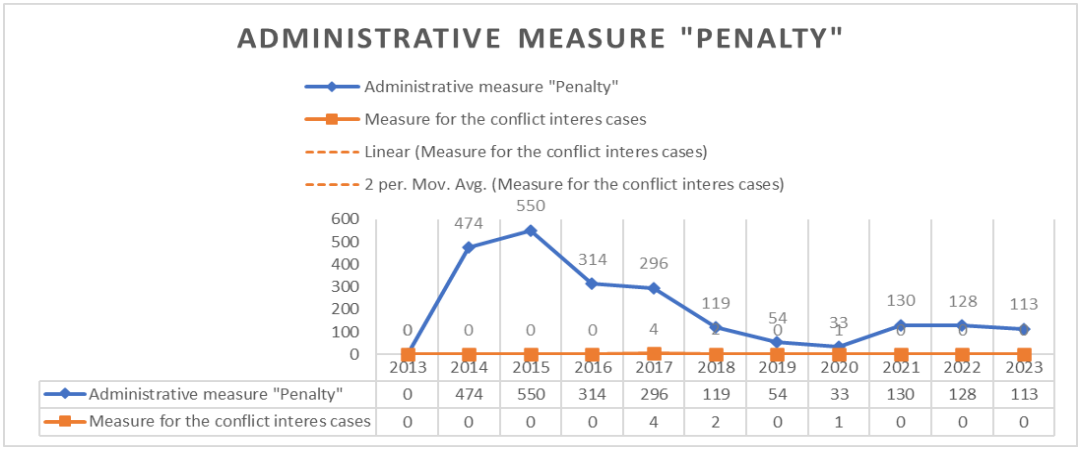
Table 2. The subjects that are declared according to the law to the ILDKPKI (HIDCACI)



	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Public officials subject to declaration	6714	6859	6681	5829	7035	3679	3868	3769	4032	3975	4070
Statement after leaving office	991	982	1049	583	792	534	548	379	0	438	464
Statement before assuming office	1114	1388	662	902	697	532	512	450	0	544	531

Source: The authors based on annual reports by ILDKPKI (HIDCACI)

Table 3. The administrative measure "penalty" and treatment of the conflict interest cases.



	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Administrative measure "Penalty"	0	474	550	314	296	119	54	33	130	128	113
Measure for the conflict interes cases	0	0	0	0	4	2	0	1	0	0	0

Source: The authors based on annual reports by ILDKPKI (HIDCACI)

4 Annual report of HIDAACI/ ILDKPKI for the periods 2013-2023 https://www.ildkpki.al/raporte-vjetore/ as well as the analytical darft prepared by the group of experts appointed by the parliament of albania (page 55) https://masl.al/wp-content/uploads/2025/03/Dokumenti-Analitik_Antikorrupsioni.pdf

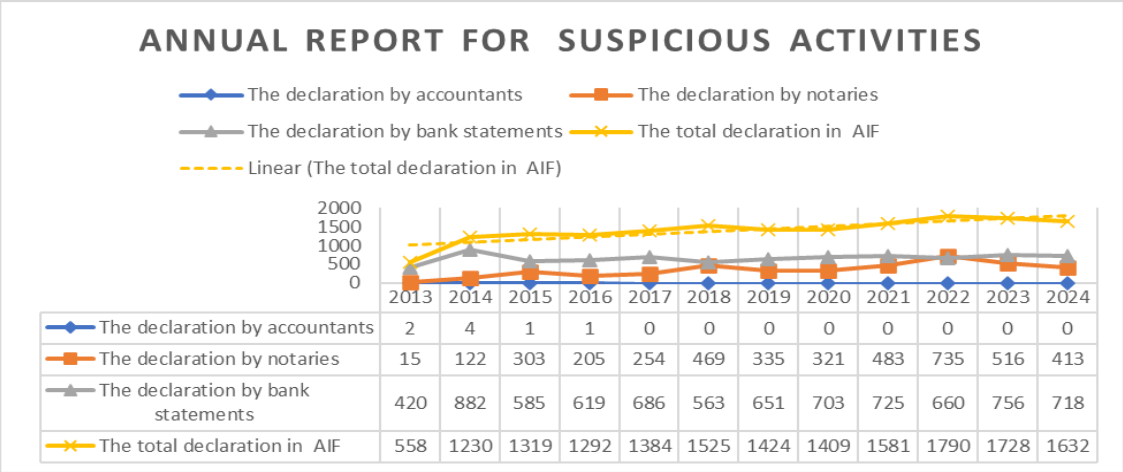
5 OECD (2024) Western Balkans Competitiveness Outlook, Albania pg 102

6 OECD (2024) Western Balkans Competitiveness Outlook, Albania 2024, pg 103

The reports also found that in cases of whistleblowing in accordance with legal acts, the competent bodies are informed according to the issues raised by the whistleblowers, such as the Supreme Audit Institution; Police structures: the Financial Intelligence Agency (AIF former DPPP); the Procuracy, etc. But it is found that even though the number of trainings is high, the number of alerts remains at very low levels (Annual Reports 2019-2023 ILDKPKI (HIDCACI)).

If we also study the annual reports of the Financial Intelligence Agency, which receives cases reported as suspected of money laundering, it is again found that the number of reports of events and suspected transactions by legal and accounting professionals is extremely small. (Miti M. *et al.* 2023; 2024). Although training continues, reporting still has a very low weight (table no. 4). These professions are key factors in controlling declarations of conflicts of interest and assets that arise from unintelligent behavior of any individual in general and an official in particular.

Table 4. The declaration in AIF



	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
The declaration by accountants	2	4	1	1	0	0	0	0	0	0	0	0
The declaration by notaries	15	122	303	205	254	469	335	321	483	735	516	413
The declaration by bank statements	420	882	585	619	686	563	651	703	725	660	756	718
The total declaration in AIF	558	1230	1319	1292	1384	1525	1424	1409	1581	1790	1728	1632

Source: The authors based on annual reports

If we examine the legal acts and specifically in Article 19 of Law No. 9131, dated 8.9.2003 on the rules of ethics in public administration, disciplinary measures are found, which states that civil servants who violate the principles of ethics, defined in this law, when their actions do not constitute a criminal offense, are punished with disciplinary measures, according to the procedure defined in the legislation on the status of civil servants. The measures must also be registered in the National Register of Public Administration (currently the Central Personnel Register). Meanwhile, Article 16 of the Council of Ministers No. 874, dated 29.9.2021 "On the approval of the rules for the implementation of the principles of ethics, the classification of external activities and the value of gifts that may be accepted during the activity of an administrative employee", provides that disciplinary measures due to ethical violations are extinguished after the expiry of the deadlines set out in their respective legislation, and are removed from both the central personnel register and the personnel file.

From another perspective, based on studies conducted in Albania, there is a high level of corruption (Miti M. *et al.* 2023:2024:2025), which mostly comes from individuals who practice their profession in the public sector.

The European Union does not have a single law on conflict of interest that is binding on all member states, but has a combination of directives, recommendations and institutional rules that aim to prevent conflicts of interest at the level of European institutions and in public administrations at the national level, such as:

Regulation 2018/1046 (EU) on public finances (Financial Regulation) sets standards for the transparent and accountable management of European funds, including the prevention of conflict of interest in procurement processes and grant management.

Regulation 2018/1725(EU) on the protection of personal data in the EU institutions, which is closely related to transparency and the prevention of conflicts of interest.

The European Commission's Code of Conduct and similar documents of EU institutions for public officials set out clear rules for preventing conflicts of interest and declaring personal interests.

Based on these directives and codes, the main principles that the EU promotes for the prevention of conflict of interest are (i) prevention of situations where conflict of interest may arise, through clear rules for the declaration of interests and the disallowance of participation in decision-making where there is a conflict; (ii) transparency which is

manifested by the obligation to publish information related to the financial and private interests of persons exercising public functions; (iii) independence and integrity of public officials which is ensured by promoting ethical behavior and responsibility that they are not influenced by private or business interests: (iv) and last but not least is responsibility and punishment by establishing mechanisms and instruments for punishing violations of conflict of interest rules.

Even in Albania, these directives and principles are integrated into legal and sub-legal acts and even into the National Strategy for Albania 2030, as well as continuing with reforms to improve the legal framework and harmonization with EU directives.

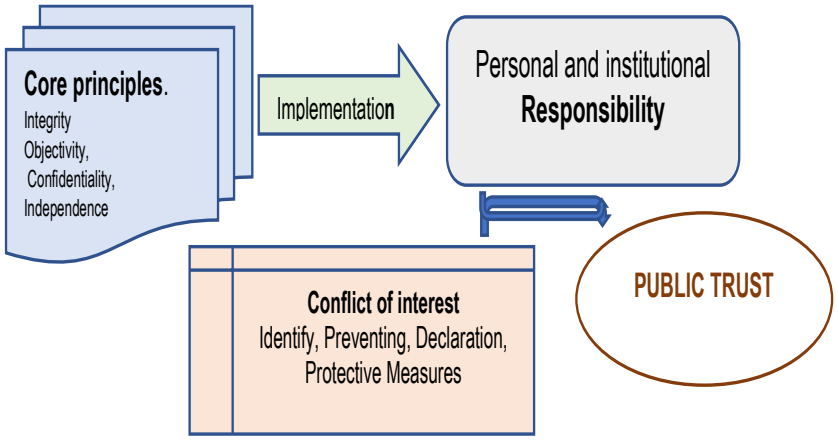
4. Discussions

Our research question is whether it is sufficient for ethics to be regulated through legal norms to prevent the phenomenon of conflict of interest or does the effectiveness of this prevention depend mainly on the awareness, integrity and will of the individual? They often put us in discussions and why not in various dilemmas. Although the literature review shows that the discussions are different, the position in the end is the same. Standards and rules are necessary, but they must also be accompanied by the awareness of everyone to increase public trust, to exercise official functions with integrity. Regulations do not necessarily lead to less corruption, for example, most Nordic EU member states have much fewer rules and standards in place than other member states, but at the same time have relatively low levels of corruption and bribery (Zibold F. 2013).

In Albania, legal acts in the field of ethics in general and conflict of interest are formalistic and declarative but not always followed by real actions or effective punishments (see institutional annual reports). Institutional culture and political pressure often weaken the power of supervisory institutions. The reforms undertaken and that continue to be undertaken often aim at harmonization with EU directives, but again the low levels of reporting on unethical and unintelligent behavior with conflicts of interest cast doubt on their correct implementation if we look at the high level of corruption in Albania, or the universally recognized facts of punishment of high public officials who are also linked to obvious conflicts of interest with family members or persons related to business or profession.

If the basic principles of ethics and guidelines based on international independence standards (IFAC 2024) were implemented correctly, then everyone would be clothed with a personal and institutional responsibility that is correct and fair, leading to the strengthening of public trust. The declaration at every step of the professional life of each of us not only of wealth but also of potential or apparent conflicts of interest would bring not only public trust, but the creation of a Generation of Integrity where the Rule of Law is the basis of a free and democratic life, a life that each of us has dreamed of since childhood.

Figure 1. The relationship between core principles of ethics and conflict of interest in public trust



Source: The authors

Based on our study we suggest the following:

- **Transparency and public accountability**

Transparency and accountability as basic principles should not remain only in laws but should be implemented carefully. Therefore, the publication of periodic reports on the state of conflict of interest and the measures taken is now an indispensable need. Involving the media and civil society in oversight and building a culture of accountability.

- **Strengthening mechanisms for identifying and declaring conflicts of interest**

This can be achieved by continuing to implement the electronic and integrated system of self-declaration of assets by public officials, expanding the range of scope. This means that the declaration should be made by every individual who is an active force to work and not only by senior officials. Continuous monitoring by the responsible institution should be carried out with a focus on apparent or potential conflicts of interest. The obligation to declare assets should continue, not only by the official but also by people related to him, which according to the law extends to family members. In fact, people who have business and professional ties with public officials that may affect objectivity should also declare. The database should also be made transparent for the public and other supervisory institutions, but access should be limited and regulated by legal or sub-legal act.

- **Raising awareness and ethical education**

In the modern and digitalized world, basic and continuing education takes on a special importance, therefore the development of mandatory annual training for all public officials and civil servants on the principles of professional ethics, conflict of interest and ways of its management is considered an added value. Institutional cooperation also takes on importance, as the drafting of annual training plans by coordinating the actions of higher education institutions (universities), the Albanian School of Public Administration (ASPA), and responsible institutions would also be an added value. Annual training plans for public administration on compliance with codes of ethics and conflict of interest, should be established as an obligation in the respective laws and monitored by the Albanian Parliament as the main body for monitoring the implementation of the law.

- **Development of management and prevention measures**

Legal acts should clearly define measures to avoid conflict, such as the separation of duties, limiting involvement in decision-making and, when necessary, removal from position. Continue to establish internal procedures in institutions for reporting conflicts of interest and HIDAACI to continue monitoring and consulting, thus strengthening effective monitoring of their implementation.

- **Improving the supervision and punishment system**

Although punishment is seen as a negative phenomenon, it is a necessary need in conditions where respect for the law must prevail. As a result, stricter penalties should be provided for violations of the law on conflict of interest, including fines, suspension from duty and disciplinary measures. Protection measures should also be provided for whistleblowers who report conflicts of interest.

In conclusion, we can say that these policies aim to build a comprehensive and functional system, based on the best international practices, integrating IFAC ethical standards and European Union requirements. With this approach, Albania can advance in building an administration with integrity, accountability, and trust for citizens.

Conclusions and Further Research

In conclusion, we firmly believe that preventing conflict of interest is not just an article in the law or a matter of written norms, but a dynamic process that requires a sustainable interaction between the legal framework, institutional will, and personal and professional ethics. Building an ethical culture within public administration requires the strengthening of independent institutions, as well as fostering a climate that values integrity above personal or political interest. In this way, ethics turns from an article in the law into a real standard that inspires public service in the function of civic trust and democratic development.

The paper will serve for further studies by researchers in the respective field, but above all, the reform undertaken in Albania for European integration, based on the initiative of the Albanian Parliament, which increasingly focuses on scientific research and the absorption of experts in the field, as well as on the empirical analysis of public officials' perceptions of ethics and conflict of interest.

Declarations

Credit Authorship Contribution Statement:

Mirela Miti: Conceptualization, Investigation, Methodology, Data curation, Review and editing, Funding acquisition.
Fatmir Bërdica: Investigation, Methodology, Formal analysis, Writing original draft, Data curation, Validation, Visualization, Funding acquisition.

Declaration of Competing Interest: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper

Declaration of Use of Generative AI and AI-assisted Technologies: The authors declare that they did not use generative AI and AI-assisted technologies during the preparation of this work.

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Integrating ESG into Fixed Income Portfolios: A Performance and Risk Assessment

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Abstract: This study examines the performance and risk characteristics of ESG-integrated fixed income portfolios compared to conventional bond portfolios from 2018 to 2025. Using monthly data from representative indices, namely the Bloomberg MSCI Global Green Bond Index (for ESG portfolios) and the Bloomberg Global Aggregate Bond Index (for non-ESG portfolios), we employ Sharpe Ratio, Sortino Ratio, and Value-at-Risk (VaR) methods to assess risk-adjusted returns. The empirical findings indicate that ESG portfolios deliver slightly lower nominal returns but exhibit lower volatility and superior downside protection. The Sharpe ratio of ESG portfolios (0.42) surpasses that of conventional portfolios (0.36), while their 95% VaR demonstrates smaller potential losses. The results confirm that ESG integration in fixed income portfolios enhances risk resilience without significantly sacrificing returns.

Keywords: ESG investing; fixed income; portfolio performance; sustainable finance; risk analysis.

JEL Classification: G11; G32; Q56; A13.

Introduction

In recent years, the global financial landscape has experienced a fundamental shift toward sustainability-oriented investment practices. The growing awareness of environmental degradation, social inequality, and governance scandals has encouraged investors and regulators to consider non-financial factors when making financial decisions. The integration of Environmental, Social, and Governance (ESG) principles has therefore evolved from a niche strategy into a mainstream approach within global capital markets. According to the Global Sustainable Investment Alliance (GSIA, 2023), ESG-related assets surpassed USD 35 trillion in 2022, representing nearly one-third of total assets under management worldwide.

While ESG integration has become common in equity markets, its adoption in fixed income investing is comparatively recent and less understood. Fixed income securities such as corporate and sovereign bonds represent more than 50 percent of the global investable universe and play a crucial role in financing both private and public sustainability initiatives. However, empirical research on the performance and risk characteristics of ESG-integrated bond portfolios remains limited and often inconclusive. Some studies suggest that ESG bonds offer lower yields but greater stability (Zerbib, 2019), whereas others find no statistically significant difference compared with conventional bonds (Leite & Cortez, 2015). This lack of consensus highlights a clear research gap in understanding the financial implications of sustainable fixed income investments.

Moreover, periods of financial turbulence such as the COVID-19 pandemic and recent inflationary shocks have raised questions about the resilience of ESG portfolios under stress. Evidence from Broadstock et al. (2021) and Nofsinger & Varma (2014) indicates that ESG-focused funds tend to outperform during crises due to enhanced governance and stakeholder trust. However, such findings are largely drawn from equity markets, leaving the fixed

income segment empirically underexplored. Given the scale of the bond market and its growing ESG integration, a deeper examination of its performance dynamics is warranted.

The novelty of this research lies in its empirical examination of ESG and conventional fixed income portfolios in a global market context using a portfolio-based performance comparison approach. While prior studies on sustainable finance predominantly focus on equity markets or individual green bond pricing, empirical evidence on portfolio-level ESG integration in global fixed income markets remains limited and mixed. This study addresses this gap by constructing ESG and conventional bond portfolios and evaluating their risk–return characteristics using multiple performance metrics.

By integrating ESG-aligned bond indices with comprehensive risk-adjusted performance measures, the research provides a more granular assessment of whether sustainability considerations are reflected in global bond portfolio outcomes. The use of portfolio backtesting enables a direct comparison of ESG-aligned and conventional investments, offering insights beyond single-bond yield differentials commonly examined in existing literature.

From a practical perspective, the findings contribute to a better understanding of the financial implications of ESG investing in fixed income markets across different economic cycles. The results are relevant for global investors, institutional asset managers, and policymakers seeking to promote sustainable finance without compromising portfolio efficiency. By focusing on global bond indices, this study offers timely and policy-relevant evidence on the role of ESG integration in enhancing risk resilience in fixed income portfolio management.

This study aims to analyze the performance and risk profiles of ESG-integrated fixed income portfolios in comparison with conventional bond portfolios. By employing risk-adjusted measures such as the Sharpe Ratio, Sortino Ratio, and Value-at-Risk (VaR), this research investigates whether ESG criteria enhance or compromise financial efficiency. The analysis spans the period from 2018 to 2025 to capture pre- and post-pandemic dynamics, as well as recent monetary policy shifts.

The findings are expected to contribute to both theory and practice. Theoretically, the research adds to the literature on sustainable finance by extending ESG performance analysis into the fixed income domain, an area where empirical evidence remains scarce. Practically, it provides insight for portfolio managers, institutional investors, and policymakers seeking to balance sustainability objectives with fiduciary performance requirements. The remainder of this paper is structured as follows: Section 2 reviews the existing literature and theoretical foundations; Section 3 outlines the data and methodology; Section 4 presents and discusses the empirical results; and Section 5 concludes with implications and suggestions for future research.

1. Literature Review

This study is grounded in Modern Portfolio Theory (MPT) introduced by Markowitz (1952), which emphasizes the trade-off between risk and return through diversification. In fixed income markets, risk is not limited to interest rate volatility but also includes credit risk, default risk, downgrade risk, and tail risk (*e.g.*, Fama & French, 1993; Elton *et al.* 2001). Recent extensions of classical portfolio theory incorporate Environmental, Social, and Governance (ESG) factors as additional sources of risk and information, reflecting the view that sustainability performance influences firm resilience and long-term creditworthiness (Bauer *et al.* 2021; Bolton & Kacperczyk, 2021).

Within this framework, green bonds are expected to exhibit pricing behavior that differs from conventional bonds. Investor preference theory suggests that demand from environmentally conscious investors may reduce required yields for green bonds, giving rise to a pricing differential commonly referred to as the “greenium” (Baker *et al.* 2018; Zerbib, 2019). Several early empirical studies document that green bonds tend to be issued at lower yields compared to comparable conventional bonds, although the magnitude of this effect varies across markets and periods (Karpf & Mandel, 2018; Tang & Zhang, 2020).

Subsequent research extends the analysis to secondary markets and longer horizons. Some studies find that ESG-aligned bonds exhibit similar or slightly lower returns but reduced downside risk and volatility, suggesting improvements in risk-adjusted performance rather than higher nominal returns (Nanayakkara & Colombage, 2019; Flammer, 2021). Other authors argue that green bond pricing advantages may diminish over time as sustainable investing becomes more widespread and information asymmetries decline (Larcker & Watts, 2020).

More recent evidence highlights the growing importance of regulatory frameworks and disclosure regimes. Carmichael and Rapp (2024) show that green corporate bonds benefit from pricing advantages at issuance, driven by excess demand, index eligibility, and reputational considerations, while emphasizing that these effects are conditional on issuer characteristics and market structure. Similarly, Fiorillo et al. (2025) documents that firms with stronger ESG performance experience significantly lower yield spreads at bond issuance, particularly in the post-Sustainable Finance Disclosure Regulation (SFDR) period, indicating that ESG information has become increasingly material in fixed income markets.

Overall, the literature suggests that while sustainability-related pricing effects are not uniform, ESG characteristics play an increasingly important role in bond valuation. The mixed and context-dependent findings in prior studies underscore the need for further empirical investigation into how ESG performance influences bond pricing and risk–return profiles across different market settings, providing the motivation for the present study.

Beyond portfolio performance, prior studies emphasize broader motivations and mechanisms underlying ESG investing. Investors increasingly incorporate ESG information to manage long-term risks, align investments with ethical preferences, and respond to regulatory and stakeholder pressures (Fatemi & Fooladi, 2013; Amel-Zadeh & Serafeim, 2018; Statman, 2020). At the market level, sustainable investment flows are influenced by behavioral, institutional, and macro-financial factors (Brière & Szafarz, 2013; Dorfleitner *et al.* 2018), while equilibrium-based models suggest that widespread ESG adoption can affect asset prices and expected returns (Pastor *et al.* 2021). In fixed income markets, the interaction between green bonds and broader financial markets further reflects spillover effects and price connectedness driven by investor sentiment and sustainability preferences (Reboredo & Ugolini, 2020).

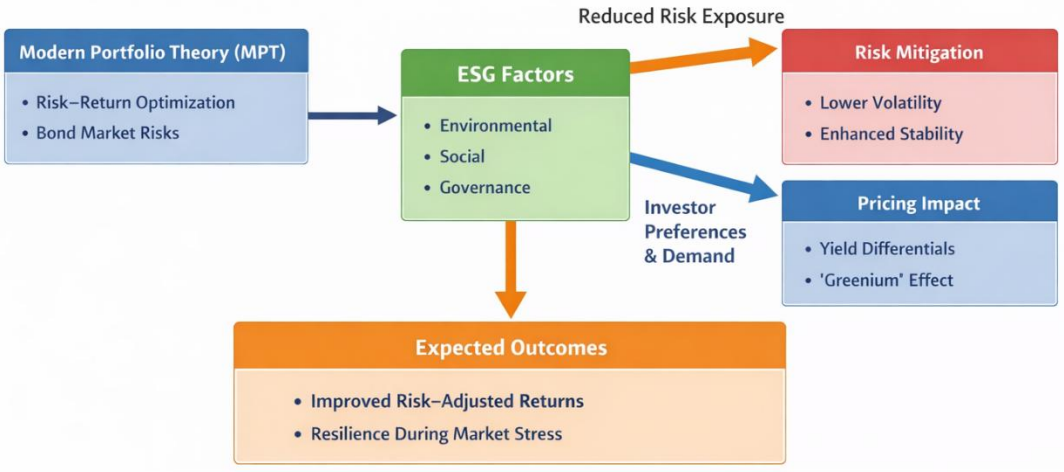
2. Theoretical Framework

This study is grounded in Modern Portfolio Theory (MPT) introduced by Markowitz, which posits that investors can optimize portfolios by balancing expected returns against risk through diversification. In the context of fixed income securities, portfolio risk is not only driven by interest rate volatility but also by credit risk, default risk, downgrade risk, and tail risk, all of which may be influenced by issuers' sustainability characteristics.

Recent theoretical developments extend classical MPT by incorporating non-financial risk dimensions, including Environmental, Social, and Governance (ESG) factors. ESG performance is increasingly viewed as a proxy for long-term issuer quality, affecting cash-flow stability, downside risk, and investors' required risk premia. From this perspective, green bonds and ESG-aligned fixed income instruments may exhibit different risk–return profiles compared to conventional bonds, potentially generating yield differentials known as the "greenium."

Furthermore, the theoretical framework recognizes the role of investor preference theory, suggesting that demand from sustainability-oriented investors can affect bond pricing independently of fundamental risk. Regulatory developments such as mandatory ESG disclosure regimes and sustainable finance taxonomies further reinforce the relevance of ESG information in bond valuation. This framework underpins the empirical investigation of whether sustainability attributes systematically influence yield spreads and returns in the bond market.

Figure 1. Theoretical Framework of ESG Integration in Fixed Income Portofolios



Source: Authors' elaboration based on Modern Portfolio Theory (Markowitz, 1952) and ESG investment literature

3. Data and Methodology

The study utilizes monthly index data covering the period from January 2018 to June 2025 for two representative fixed income portfolios. The ESG portfolio is proxied by the *Bloomberg MSCI Global Green Bond Index*, which includes investment-grade bonds that finance environmentally beneficial projects. The conventional portfolio is represented by the *Bloomberg Global Aggregate Bond Index*, which comprises sovereign, corporate, and securitized bonds across developed and emerging markets without ESG screening. Both indices are denominated in U.S. dollars and adjusted for reinvested coupons to ensure comparability of total returns.

The selection of the 2018–2025 period is motivated by its inclusion of distinct market phases: pre-pandemic growth (2018–2019), the COVID-19 crisis (2020–2021), and the subsequent monetary tightening period (2022–2025). This time frame allows for an assessment of portfolio performance and risk resilience across different economic cycles.

The risk-free rate is proxied by the 3-month U.S. Treasury bill yield, obtained from the Federal Reserve Economic Data (FRED) database. Monthly log returns are computed as $rt = \ln (P_t / P_{t-1})$.

The analysis employs descriptive statistics to evaluate return distribution, followed by the computation of risk-adjusted performance metrics including the Sharpe Ratio, Sortino Ratio, and Value-at-Risk (VaR). Statistical tests such as paired *t-tests* and *F-tests* are applied to compare mean returns and variances between portfolios. Data processing and calculations are conducted using Microsoft Excel and cross-verified with Python 3.12 statistical libraries.

4. Analytical Model

We calculate the following metrics:

$$Sharpe\ Ratio = \frac{R_p - R_f}{\sigma_p}$$

$$Sortino\ Ratio = \frac{R_p - R_f}{\sigma_d}$$

$$VaR_{0.95} = \text{Quantile}_{0.05}(R_p)$$

where R_p denotes portfolio returns, R_f the risk-free rate, σ_p the standard deviation of returns, and σ_d the downside deviation. A *paired t-test* is used to test the null hypothesis that there is no difference in mean risk-adjusted performance between ESG and conventional portfolios

5. Empirical Results

Table 1. Descriptive Statistics (2018–2025)

Metric	ESG Portfolio	Conventional Portfolio
Average Monthly Return	0.36%	0.40%
Annualized Return	4.32%	4.80%
Standard Deviation	0.88%	1.12%
Downside Deviation	0.64%	0.85%
Sharpe Ratio	**0.42**	0.36
Sortino Ratio	**0.58**	0.47
95% Value-at-Risk (Monthly)	**–1.78%**	–2.45%
Maximum Drawdown	–4.9%	–7.2%

Source: Bloomberg MSCI Global Green Bond Index and Bloomberg Global Aggregate Bond Index (2018–2025); authors' own calculations.

The performance statistics reported in Table 1 are computed by the authors based on monthly total return data obtained from the Bloomberg MSCI Global Green Bond Index and the Bloomberg Global Aggregate Bond Index.

6. Interpretation and Discussion

Table 1 presents the descriptive statistics of both ESG and conventional fixed income portfolios for the period 2018–2025. The ESG portfolio generates a slightly lower average monthly return (0.36%) compared to the conventional portfolio (0.40%), yet it demonstrates lower volatility (0.88% versus 1.12%) and smaller downside deviation (0.64% versus 0.85%). This finding suggests that ESG screening, despite limiting the investment universe, may enhance stability through exposure to issuers with stronger governance practices and lower default risk.

The higher Sharpe ratio (0.42) and Sortino ratio (0.58) of the ESG portfolio indicate superior risk-adjusted performance. This implies that ESG investors obtain a better compensation per unit of risk, which aligns with the

argument of Friede et al. (2015) that sustainability criteria can strengthen portfolio efficiency. Similarly, the Sortino ratio results emphasize that downside risks losses below the mean are smaller in ESG bonds, consistent with the findings of Hoepner et al. (2019) that ESG engagement reduces tail risk exposure.

The Value-at-Risk (VaR) results reinforce this interpretation. At the 95% confidence level, the ESG portfolio shows a smaller potential monthly loss (–1.78%) compared with the conventional portfolio (–2.45%). This lower VaR confirms that ESG bonds are less exposed to extreme adverse events during periods of market turbulence, such as the COVID-19 pandemic or the 2022 inflation shock. The robustness of ESG portfolios during such volatile periods is also consistent with Broadstock et al. (2021), who observed that sustainability-oriented investments exhibited greater resilience in crisis conditions.

A paired *t-test* comparing monthly returns yields no statistically significant difference between the two portfolios ($t = –1.27$, $p = 0.21$). However, an *F*-test of variances reveals that the ESG portfolio has significantly lower volatility ($F = 0.61$, $p < 0.05$). This implies that the ESG-based approach does not sacrifice profitability but effectively improves risk efficiency. These results also corroborate the findings of Zerbib (2019), who documented those green bonds trade at a small premium due to their lower risk perception.

In practical terms, the results demonstrate that ESG integration in fixed income investing provides measurable benefits in terms of downside protection and capital preservation. From an investor's perspective, the findings support the notion that sustainable portfolios can act as a hedge against systemic shocks, especially in periods of macroeconomic uncertainty. The outcome is also consistent with the Modern Portfolio Theory (Markowitz, 1952), which emphasizes diversification benefits ESG portfolios achieve diversification not only across asset classes but also across ethical and environmental risk dimensions.

Overall, these findings suggest that integrating ESG criteria into fixed income portfolio construction contributes to a more stable return pattern, reduces exposure to default and governance risks, and offers competitive performance over the long term. The empirical evidence thus supports the dual-purpose nature of ESG investing: achieving both sustainable development objectives and improved financial efficiency.

Furthermore, to verify the robustness of the results, additional tests were performed by examining portfolio performance during the 2019–2023 U.S. Federal Reserve rate hikes and the 2020–2021 pandemic period. The findings remain consistent: ESG portfolios showed smaller yield curve sensitivity and recovered more rapidly after market shocks. This confirms that the superior risk-adjusted performance of ESG portfolios is not driven by short-term market anomalies, but reflects genuine structural resilience embedded in sustainable fixed income instruments.

Conclusions and Further Research

In the context of the growing global emphasis on sustainable finance and the increasing integration of Environmental, Social, and Governance (ESG) considerations into capital markets, this study examines whether ESG-aligned fixed income portfolios differ meaningfully from conventional bond portfolios in terms of performance and risk characteristics. Using global bond indices over the period 2018–2025, which encompasses episodes of market stability, the COVID-19 crisis, and subsequent monetary tightening, the analysis provides timely evidence on the financial implications of ESG integration in fixed income investing.

The empirical findings indicate that ESG-integrated fixed income portfolios deliver returns that are broadly comparable to those of conventional bond portfolios, while exhibiting lower volatility, reduced downside risk, and superior risk-adjusted performance. In particular, higher Sharpe and Sortino ratios, along with a smaller Value-at-Risk, suggest that ESG integration enhances portfolio resilience without imposing a material return penalty. These results support the view that sustainability characteristics act as an additional dimension of risk management, reinforcing portfolio stability during periods of heightened market uncertainty.

From a practical perspective, the findings have important implications for institutional investors, pension funds, and asset managers seeking to align investment strategies with sustainability objectives while maintaining fiduciary responsibility. ESG integration in fixed income portfolios can contribute to capital preservation and downside protection, making such portfolios suitable for long-term investors operating in volatile macroeconomic environments. The results further reinforce the relevance of ESG considerations in bond markets, not merely as ethical preferences but as financially material factors influencing risk efficiency.

Despite these contributions, this study is subject to certain limitations. The analysis relies on aggregate global bond indices, which may mask heterogeneity across regions, issuer types, and ESG dimensions. Future research may extend this framework by incorporating issuer-level ESG scores, regional or sectoral green bond sub-indices, and alternative downside risk measures such as conditional Value-at-Risk. Additionally, dynamic portfolio allocation models and regime-switching approaches could provide deeper insights into how ESG

performance evolves across different market conditions. Such extensions would further enrich the understanding of ESG integration in fixed income markets and its role in promoting both financial stability and sustainable development.

Declarations

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Credit Authorship Contribution Statement:

Murtiadi Awaluddin: Corresponding author, Conceptualization, Investigation, Methodology, Formal analysis, Writing original draft, Writing review and editing.
Lince Bulutoding: Conceptualization, Supervision, Investigation, Methodology, Formal analysis, Writing original draft, Writing – review and editing.

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Sukuk Development in Morocco: Lessons from an International Benchmark

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Abstract: Objective: This study aims to assess the feasibility of developing the Sukuk market in Morocco by conducting an international benchmarking analysis of mature markets such as Malaysia, Indonesia, the United Arab Emirates, Saudi Arabia, and Bahrain, as well as initiatives in the United Kingdom and France, to provide recommendations tailored to the context. Methodology: The research is based on a comprehensive review of secondary data, including reports and publications from recognized international organizations. A comparative analysis is conducted to identify key success factors and lessons applicable to the Moroccan market, given its limited experience, notably the first sovereign issuance in 2018. Conclusions: The results show that the development of Sukuk markets depends mainly on the clarity of regulatory frameworks, the presence of regular sovereign issuances, and the role of public actors. The international benchmark reveals that some of these elements can be mobilized in the Moroccan context, while other factors, particularly those related to market size and investor base, still constitute constraints to the development of the Sukuk market. Originality: This study provides a contextual analysis of the Moroccan Sukuk market, combining lessons learned from international best practices with practical recommendations for strengthening Islamic finance in Morocco. It highlights concrete strategies for regulators, financial institutions, and investors to promote market development. Limitations: The study is based on secondary data; empirical validation through market research and stakeholder interviews could further refine the recommendations. Practical implications: The findings can guide policymakers and financial actors in designing regulatory and financial innovations aimed at developing the Sukuk market. Social implications: The development of the Sukuk market can contribute to inclusive financing solutions and promote alternative investment options, thereby supporting broader economic growth in Morocco.

Keywords: Sukuk; islamic finance; Morocco; international benchmark; financial market development; regulatory framework.

JEL Classification: G15; G18; G23; O16.

Introduction

As an ethical alternative to conventional financial instruments, Sukuk offer unprecedented opportunities in the world of finance. They are a unique investment product thanks to their structure based on real assets that comply with Sharia principles, offering investors a share in these assets and the distribution of a percentage of profits at predefined intervals. This particular structure attracts the attention of Muslim and non-Muslim investors seeking to diversify their portfolios beyond conventional bonds.

Sukuk enable large-scale projects to benefit from privileged access to capital markets. They cover a wide range of activities, from infrastructure construction and development to support for government initiatives. Issuers can thus mobilize considerable resources and offer investors an equitable distribution of risk, thanks to the flexibility they demonstrate (Doaei & Dehnad, 2024; Yang *et al.* 2023).

To be Sharia-compliant, Sukuk issuance must meet a set of strict conditions. Jobst (2007) identified ten key conditions, including the need for a genuine fundraising objective, risk sharing among investors, the prohibition of interest, and the use of productive assets as collateral. In addition, Islamic securitization structures must avoid speculative mechanisms and give priority to Sharia-compliant insurance (Mseddi, 2023).

These instruments are experiencing exponential growth worldwide. In 2023, the global Sukuk market recorded sustained growth, reaching $850 billion, up 10.3% from the previous year (Fitch Ratings). This growth is particularly remarkable in the context of market volatility and geopolitical tensions. According to the same source, the credit quality of Sukuk issuers has also improved.

The Sukuk market is characterized by its alignment with the ethical principles of Islamic finance. By further promoting responsible and sustainable investment, Sukuk respond to the growing concerns of investors who are interested in the social and environmental impact of their investments. The combination of this ethical dimension and its flexibility makes Sukuk a promising financial instrument for the future (Giordano, 2022; Nur, 2024).

In 2018, Morocco issued its first Sukuk certificates, marking an important milestone in the evolution of Islamic finance in the country, but the market for these securities is still in its infancy. Since then, no new issues have been made, indicating untapped potential. This situation raises questions about the reasons for this slowdown.

This study, conducted on international Sukuk markets, aims to better understand this situation and identify areas for improvement. This would help identify best practices. The objective of the study is to compare the experiences of pioneering Sukuk countries such as Malaysia, Indonesia, and the Gulf countries, as well as certain European initiatives, in order to draw lessons for Morocco.

This paper attempts to answer the following question: What lessons can be learned from international markets in order to develop an effective strategy for developing the Moroccan Sukuk market and removing obstacles to its growth?

In this context, this study takes an international comparative approach to examine the conditions under which a national Sukuk market could develop in Morocco. Given Morocco's experience, marked by a single sovereign Sukuk issuance in 2018, the objective is not to assess market performance, but rather to evaluate the feasibility of further market development. By comparing Morocco with certain countries where Sukuk markets are more established, the paper seeks to identify the main institutional, regulatory, and market-related factors that have fostered their development. The analysis aims to draw relevant lessons for the Moroccan context, while highlighting the limitations of direct transposition, in order to provide informed and realistic information to policymakers and market participants.

1. Research Background

The origins of Sukuk date back to medieval times. The term "Sukuk," plural of "Sakk," literally means "deed" or "instrument" in Arabic. These instruments were used to facilitate commercial transactions and were recognized as Sharia-compliant. In his book *Al-Muwatta',* Imam Malik recounts a historical account illustrating the use of Sukuk during the reign of the Umayyad caliph Marwan ibn al-Hakam, thus attesting to their antiquity and legitimacy in the Islamic context. Modern Sukuk derive their legitimacy from the classical contracts of *fiqh al-muʿāmalāt,* which have been used in Islamic commerce for several centuries. Although their contemporary structure meets the requirements of financial markets, their legal and religious foundations remain firmly rooted in the tradition of Muslim law (Usmani 1998; El-Gamal 2006).

Sukuk are Islamic financial instruments representing fractional ownership of a real asset or project. They are the Islamic equivalent of traditional bonds, complying with Sharia principles, including the prohibition of usury (riba). As an alternative form of financing, Sukuk enable companies and governments to raise capital while remaining compliant with Islamic finance (Amrani and Hamza 2017). They can be issued by a government (sovereign Sukuk) or by a company, financial institution, and/or bank (corporate Sukuk).

According to AAOIFI, Sukuk are certificates of equal value representing undivided shares of ownership in tangible assets, usufructs, or services; or ownership of assets of a particular project or specific investment activity. According to the Islamic Financial Services Board (IFSB-23), Sukuk represent certificates conferring an undivided ownership right, proportional to their subscription, over tangible fixed assets, a set of mainly tangible assets, or a commercial enterprise. These assets may be linked to a specific project or investment activity, in accordance with Sharia rules and principles relating to tangible assets.

In addition, Sukuk may be backed by specific assets ("asset-backed") or a portfolio of assets ("asset-based"). In all cases, transactions must be structured in accordance with Sharia principles, so as to avoid any form of riba (interest) or gharar (excessive uncertainty) (IFSB, 2023). In accordance with Article 7-1 of Law No. 33-06, the Higher Council of Ulemas plays a central role in regulating Sukuk in Morocco. This article stipulates that any

Sukuk issue intended for residents must obtain the approval of this religious council in order to ensure that these financial instruments comply with the principles of Islamic finance. Sukuk are generally divided into two main categories, namely asset-backed Sukuk and asset-based Sukuk. The essential distinction between these two forms lies in the nature of ownership and the terms of transfer of the underlying assets (Naifar and Hammoudeh 2016). In the case of asset-backed Sukuk, the underlying asset is effectively sold and transferred to the Sukuk holder through a special purpose vehicle (SPV). The asset thus transferred disappears from the initial issuer's balance sheet, and in the event of default, investors have direct recourse to the asset, with absolute priority over unsecured creditors (Paltrinieri *et al.* 2023). In contrast, asset-backed Sukuk are based on a limited transfer of ownership: the asset is entrusted to the SPV in the form of a trust, while legal ownership remains with the issuer. Consequently, in the event of default, Sukuk holders cannot exercise direct recourse to the asset and are treated in the same way as other unsecured creditors, which limits their level of protection (Paltrinieri et al. 2023).

The AAOIFI report detailed the classification of Sukuk, highlighting the various Islamic contracts that form the basis of these financial instruments. Sukuk Ijara, which are based on lease-purchase agreements, are certainly the most common due to their simple structure and flexibility. These sale and leaseback transactions involve Sukuk holders owning assets leased to debtors, most often used to finance projects (AAOIFI, 2020) . Murabaha Sukuk are agreements to purchase goods, while Moucharaka Sukuk involve profit-sharing agreements between several parties pooling resources for projects or commercial activities. Salam, Istisnaa, Wakala, Muzara'a, and Musaqat Sukuk are other contractual agreements designed to achieve specific objectives (AAOIFI, 2020; Nurhanifah, 2024).

The table below summarizes the main types of Sukuk, which meet specific financing needs (Nur, 2024). AAOIFI distinguishes between fourteen Sukuk structures, but only a few are commonly used.

Table 1. Comparative table of the main types of Sukuk

Type of Sukuk	Structure	Function	Advantages	Disadvantages
Ijara	Lease agreement (lease-purchase)	The issuer sells an asset to investors, who then lease it. The lease payments represent the return. At the end of the term, the asset is generally sold back.	Simple and easy-to-understand structure.	Risk related to the quality of the lessees (issuer).
Musharaka	Partnership	Investors and the issuer pool their funds for a project. Profits and losses are shared proportionally.	Flexibility, sharing of risks and profits.	Risk related to the need for good coordination between partners.
Istisnaa	Manufacturing contract	Investors finance the manufacture of a specific asset. Profits are generated by the sale of the asset once it is completed.	Structure suited to construction or manufacturing projects.	Risk of completing the project on time and within budget.
Mudaraba	Management contract	Investors contribute funds while the issuer manages the investments. Profits are shared according to an agreed ratio.	Structure favorable to long-term investments.	Risks related to the manager's skills.
Wakala	Mandate agreement	The issuer acts as an agent on behalf of investors. Returns depend on the performance of the underlying investments.	Flexibility and ability to invest in a variety of assets.	Agent performance risk.

Source: Prepared by the authors

The Sukuk market has expanded significantly in recent years, consolidating its position as a credible alternative to conventional bonds for international investors. This momentum is mainly fueled by growing demand for Sharia-compliant financial products, particularly among Muslim populations around the world. According to the IIFM report (2024), $174.6 billion worth of Sukuk were issued globally that year, illustrating the growing importance of these instruments in Islamic finance. This trend continues with the issuance of green and sustainable Sukuk by countries such as Indonesia, Saudi Arabia, and the Islamic Development Bank, highlighting the increasingly central role of Sukuk as ethical and faith-based investment instruments (IIFM Sukuk Report 2024).

Although Islamic finance originated in Islamic countries, it has rapidly spread around the world, demonstrating its adaptability. Islamic financial instruments are at the heart of this development, with record issuance levels and promising growth. Their stability, combined with their adherence to ethical principles, makes them particularly attractive to investors. The development of the Sukuk market reflects the growing international acceptance of Islamic finance.

Indeed, international markets are increasingly turning to Sukuk and their popularity is growing, particularly in Western Europe, attracting both Muslim and ethical investors. Although growing, this market remains dominant in Muslim-majority countries such as Malaysia, Bahrain, and the United Arab Emirates (UAE). Today, these countries are major centers of innovation and development in Islamic finance (Doaei & Dehnad, 2024; Grassa, 2024).

A new asset class has emerged in recent years among the various categories of Sukuk. These are Green Sukuk, which are innovative financial instruments that address the challenges of sustainability and financial inclusion. According to (Tahir & Naz, 2024), the significant trend in Sukuk is towards greater integration of sustainability. The rise of sustainable finance and green bonds is helping to direct investment towards projects with a positive impact. These factors combine to create a dynamic environment in which Sukuk are playing an increasingly important role. The future prospects for these markets are promising and open up new opportunities for growth and development (Low, 2024).

In addition, digitization and innovation are profoundly influencing the evolution of Sukuk markets. The use of big data and analytical tools offers market players new opportunities for more informed decision-making and the identification of new opportunities. Furthermore, blockchain, artificial intelligence, and Fintech technologies are transforming trading processes while simultaneously enhancing transparency, security, and efficiency.

Globally, Sukuk are growing in popularity, reaching a value of approximately $1.79 trillion between 2001 and 2022 (Kılınç, 2024) . According to Fitch Ratings, the global outstanding amount of Sukuk in 2023 increased by 7.6% compared to the previous year to reach $765.3 billion, confirming the momentum of the market (Setiawan & Suwandaru, 2024).

According to the IMARC report (2024), the global Sukuk market was valued at $1,063.3 billion in 2023, with a forecast to reach $3,619.3 billion by 2032, representing a compound annual growth rate (CAGR) of 14.1% during the period 2024-2032. The countries of the Gulf Cooperation Council (GCC), notably Saudi Arabia and the United Arab Emirates, play a leading role in this dynamic.

Recent empirical studies have examined the link between Sukuk issuance and economic growth, taking into account the different phases of the global financial cycle, and show that Sukuk mainly contribute to long-term growth, particularly by supporting the financing of infrastructure and development projects, both before and after periods of crisis. Their effect on short-term growth tends to be more limited during periods of high international financial instability, due to global macroeconomic constraints. Sukuk are therefore a useful tool for supporting long-term growth while remaining sensitive to the international financial environment (Naz et al. 2025).

2. Research Methodology

This research takes a two-pronged approach: a longitudinal analysis covering ten years (2012-2022) and an international comparison between seven markets, namely Malaysia, Qatar, Indonesia, Saudi Arabia, Bahrain, the United Arab Emirates, and the United Kingdom.

The objective is to reconstruct emissions trajectories, dominant contractual structures, and regulatory developments from primary institutional sources and sectoral databases. The quantitative component identifies growth trends and structural breaks, while the qualitative component examines the issuance processes and institutional configurations specific to each jurisdiction.

This combination of quantitative data and contextual analysis aims to understand the factors that explain the success or difficulties of each market. It also provides a framework for assessing Morocco's potential and formulating recommendations tailored to local specificities.

2.1. Benchmark Countries Selection Criteria

The reference countries were chosen for their ability to illustrate the different stages of Sukuk market development and the diversity of institutional and regulatory configurations. Malaysia and Indonesia, representing a mature Sukuk market and a rapidly expanding market respectively, were selected as reference cases. Existing empirical studies highlight Malaysia's global leadership in Sukuk issuance and point to a demand-driven model, in which economic growth precedes market development, reflecting a high degree of market maturity. Indonesia, on the other hand, shows a more dynamic trajectory, characterized by a bidirectional relationship between Sukuk market development and economic growth, suggesting a stronger interaction between financial deepening and real economic activity (Muharam et al. 2019).

Saudi Arabia, the United Arab Emirates, and Bahrain were chosen as representatives of the different regulatory and institutional approaches within the Gulf Cooperation Council. Saudi Arabia exemplifies a centralized regulatory framework for Sukuk, with strict oversight of ad hoc entities and judicial constraints related to Sharia

compliance and public policy. The United Arab Emirates offers a contrasting model with the coexistence of onshore and offshore financial jurisdictions, notably the Dubai International Financial Centre (DIFC) and the Abu Dhabi Global Market (ADGM), which are based on common law principles and facilitate cross-border investor protection and dispute resolution. Bahrain represents a more conservative supervisory model, in which the central bank plays a direct and formal role in approving Sukuk-related structures, reflecting the importance attached to financial stability and regulatory control (Mohammed Imad Ali et al. 2022).

The United Kingdom is included in the benchmark because it was the first Western country to issue a sovereign Sukuk (British Embassy Bishkek 2015), demonstrating how targeted legal and tax adjustments can enable Sukuk issuance within a conventional financial system. France, on the other hand, serves as a counterexample, highlighting the institutional, legal, and political constraints that can limit the development of Sukuk instruments, despite a high level of sophistication in the financial markets. The comparison between these two Western jurisdictions provides useful information for Morocco, whose financial system has a similar structure, in a context marked by the issuance of sovereign Sukuk.

Collectively, these countries constitute a diverse benchmark that reflects different levels of market maturity, different growth dynamics, and different institutional frameworks. Such diversity is essential for assessing the feasibility of developing the Sukuk market in Morocco and for distinguishing transferable success factors from context-specific constraints.

2.2. Period of Analysis (2012–2022)

The analysis period (2012-2022) was chosen to cover the post-global financial crisis phase, during which Sukuk markets underwent significant structural development, notably thanks to the expansion of sovereign issuances and the consolidation of regulatory frameworks.

From 2012 onwards, we can rely on data that has become more consistent and comparable across countries, thanks to the maturation of regulatory and accounting frameworks. This decade also encompasses contrasting economic phases - moderate growth, oil shock, then pandemic crisis - thus providing a relevant perspective for assessing the resilience and dynamics of this market. Finally, by ending the analysis in 2022, we can use the most recent and consolidated set of reliable data, while incorporating the first visible effects of major national reforms, such as Saudi Arabia's Vision 2030, which have profoundly reshaped the Islamic finance landscape.

2.3. Nature and Sources of Data

This research is based on a quantitative and comparative approach, using only reliable secondary data for the decade 2012-2022. To ensure the accuracy and verifiability of the information used, we conducted a structured collection process based on three types of sources:

Regulatory institutions and official sources

Issuance volumes by country are sourced from the relevant supervisory authorities and central banks. In particular, we consulted the Securities Commission Malaysia (BIX Malaysia), Bank Negara Malaysia, Saudi Central Bank (SAMA), Central Bank of Bahrain (CBB), and Central Bank of the UAE (CBUAE). For the United Kingdom, we referred to the UK Debt Management Office (DMO) and HM Treasury.

Financial markets and trading platforms

Transaction data and prospectus characteristics were extracted from the registers of the Saudi Exchange (Tadawul), Nasdaq Dubai, Dubai Financial Market (DFM), Abu Dhabi Securities Exchange (ADX), Bahrain Bourse, and Indonesia Stock Exchange (IDX).

International organizations and rating agencies

To supplement and verify the consistency of the series, we used publications from the International Islamic Financial Centre (MIFC) and the World Bank, as well as analyses from S&P Global Ratings and Moody's Investors Service relating to international sovereign issuances.

2.4. Methodological Limitations of the Study

Although the data collection was conducted rigorously, several constraints should be noted:

Disparities in data publication

Despite the official nature of the sources, dissemination practices vary across jurisdictions, both in terms of frequency and granularity (distinction between public offerings and private placements). These differences may result in slight discrepancies during annual consolidation.

Scope limited to reported issues

Only transactions registered with regulators were taken into account. Certain small private placements, which are not subject to public reporting requirements in several countries, may have been omitted from our survey.

Limited transparency on payment incidents

The information available on Sukuk defaults or restructurings remains fragmented across several official reports, limiting our analysis to issuance volumes rather than assessing contractual performance after issuance.

3. Research Results

3.1. Malaysia and Indonesia

Overview of the Sukuk market in Malaysia

Since Shell MDS issued its first corporate Sukuk in 1990 worth 125 million Malaysian ringgit (RM), the Malaysian Sukuk market has continued to grow, supported in particular by a favorable issuance environment, incentive policies for investors, and a comprehensive Islamic financial infrastructure (Shahimi *et al.* 2022).

In July 2002, the Malaysian government took an important step by issuing the first Sukuk Ijara, based on internationally traded real estate assets. The aim was to expand the country's range of Islamic financial products and support the liberalization of the Islamic capital market (Hussin *et al.* 2012; Shahimi *et al.* 2022) . Furthermore, the use of Sukuk enabled Islamic financial institutions to comply with Basel III liquidity and capital requirements, particularly during the period 2013-2014 (Global Sukuk Report 1Q, 2015).

In 2017, according to Bix Malaysia, Malaysia captured a 28.8% market share in the first half of the year, with a 20.6% year-on-year increase in issuance, driven by the public, government, and corporate sectors. In 2020, Malaysian companies accounted for 57.5% of Malaysian Sukuk issuance, cementing Malaysia's dominant position in the global market with a 45.1% share (IIFM Sukuk Report, 2022; Labuan FSA, 2021). The country has thus maintained its leading position, with cumulative international and domestic issuances totaling approximately $800 billion over the period 2001-2020 (IIFM Sukuk Report, 2021).

In February 2022, the Malaysian government issued RM4.5 billion worth of Sukuk at an annual profit rate of 4.369%, which generated strong demand, with bids totaling RM7.87 billion, demonstrating investor interest. The Central Bank of Malaysia (BNM) recorded 237 bids for these Sukuk, which mature on October 31, 2028. The yield on the 7-year GII bond rose by one basis point to 3.62%, according to BNM's FAST system, as quoted by The Edge Malaysia.

As highlighted by Al-Fakih et al. (2023) and IIFM Sukuk Report (2022) , Malaysia has been a global leader in the Sukuk market since 2001. Backed by a strong capital market, it has issued nearly $877 billion in Sukuk. The country has maintained this position, with 47% of RM issuances, thanks in particular to the depth of its domestic market (IIFM Sukuk Report, 2023).

Malaysia's rise in the field of Islamic finance is no accident. It is the result of a concerted strategy between many players, including regulators, government organizations, and businesses, all of which have contributed to making the Sukuk market attractive (Shahimi *et al.* 2022) . This market is characterized by its ability to offer tailor-made solutions to meet customer needs, attracting both Islamic and conventional investors, local and foreign.

Key players in the Malaysian Sukuk market

Islamic banks and finance companies: Malaysian Islamic banks play a leading role in the Sukuk market. The main players are Bank Islam Malaysia, Maybank Islamic, and CIMB Islamic, which issue and invest in these instruments to strengthen their capital base and diversify their sources of funding. Similarly, Islamic finance companies such as Amanah Raya Berhad and Lembaga Tabung Haji make a significant contribution by using Sukuk as financing tools.

Government entities and public agencies: The Malaysian government, through the Ministry of Finance and Bank Negara Malaysia (Malaysia's central bank), is one of the main issuers of sovereign Sukuk. Public agencies such as Khazanah Nasional, Malaysia's sovereign wealth fund, and Danainfra Nasional, which specializes in infrastructure financing, play a prominent role by regularly issuing Sukuk to finance strategic projects. The same is true for local and regional authorities, as well as federal states.

International companies and financial institutions: Large Malaysian companies, particularly in the energy, utilities, and real estate sectors, actively issue Sukuk. Similarly, international financial institutions, such as the Islamic Development Bank (IDB), issue Sukuk in Malaysia to raise funds and strengthen their projects.

Regulatory framework for Sukuk issuance in Malaysia

The BNM (Bank Negara Malaysia), established in 1959, ensures the country's monetary and financial stability. Its main functions are to issue currency, provide financial advice to the government, and regulate credit conditions. It issues rules for the issuance and settlement of securities through automated systems such as FAST and RENTAS, setting market standards through the Malaysian Code of Conduct.

The SC (Securities Commission Malaysia) has regulated capital markets since its establishment in 1993 to ensure transparency and efficiency. It supervises the issuance of Sukuk by companies, implements a disclosure-based framework, and collaborates with the BNM in the inspection of financial institutions.

By establishing a clear regulatory framework and offering attractive tax incentives, ranging from tax exemption on Sukuk income to tax neutrality for SPVs, Malaysia has succeeded in structuring the Sukuk market and attracting more and more investors, both domestic and international (Rafiki *et al.* 2024).

Sukuk issuances in Malaysia (2012-2022)

As shown in Table 2 and Figure 1, the Malaysian Sukuk market has shown sustained growth and remarkable resilience. The total number of Sukuk approved in 2022 is 196, the highest level in a decade, for a record amount of RM 99.6 billion, consolidating Malaysia's dominant position in the global Sukuk market. The diversity of projects financed, ranging from infrastructure and energy to sustainable development initiatives and social sectors such as education and health, explains this dynamism. Although some years, such as 2017, saw declines, the market quickly rebounded, illustrating its resilience in the face of economic challenges. The market is notable for its sophistication, structural diversity, and leading role in financing the country's strategic priorities. The Malaysian Sukuk market is not only a driver of national economic growth, but also a global benchmark in Islamic finance.

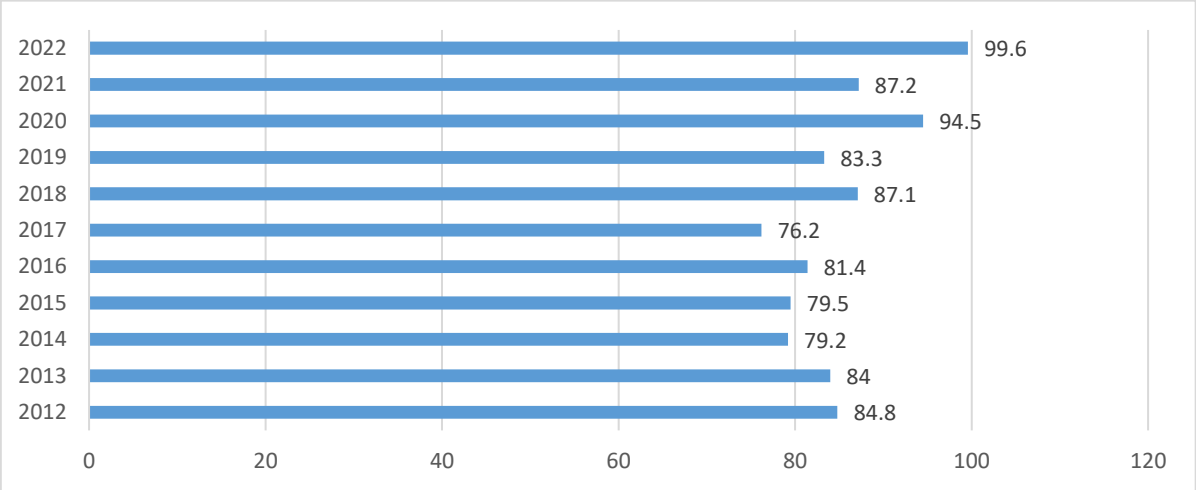
Table 2. Volume of Sukuk issuances in Malaysia for the period 2012-2022 (in RM billion)

Year	Number of Sukuk	Types of Sukuk	Main projects	Amount (in RM billion)
2012	178	Ijara, Murabaha	Infrastructure, Energy	84.8
2013	163	Wakala, Musharaka	Public Projects, Real Estate	84
2014	168	Ijara, Istisnaa	Transportation, Sustainable Development	79.2
2015	161	Murabaha, Wakala	Education, Health	79.5
2016	172	Musharaka, Ijara	Renewable Energy, Transportation	81.4
2017	161	Wakala, Murabahah	Public projects, Sustainable development	76.2
2018	157	Ijara, Moucharaka	Infrastructure, Real Estate	87.1
2019	159	Murabaha, Istisnaa	Transportation, Healthcare	83.3
2020	174	Ijara, Wakala	Ijara, Wakala	94.5
2021	150	Musharaka, Murabaha	Infrastructure, Renewable Energy	87.2
2022	196	Wakala, Ijara	Public projects, Sustainable development	99.6

Source: Author's own processing based on data from Securities Commission Malaysia, Bank Negara Malaysia, and MIFC (2012–2022).

Beyond the diversity of its market, Malaysia also stands out for its innovative approach to green Sukuk, mainly driven by the private sector under the SRI Sukuk Framework established in 2014. Indonesia, meanwhile, has focused on large-scale sovereign issuances to finance sustainable national infrastructure, particularly in the transportation and energy efficiency sectors (Ziarmal 2025).

Figure 1. Volume of Sukuk issuances in Malaysia for the period 2012-2022 (in billions of RM)



Source: Author's own processing based on data from Securities Commission Malaysia, Bank Negara Malaysia, and MIFC (2012–2022).

Overview of the Sukuk market in Indonesia

Indonesia has developed a series of strategies to promote the development of the Sukuk market, including awareness campaigns, events, international partnerships, innovation in financial products, and support for academic research. Thanks to this multidimensional approach, Indonesia has positioned itself as a major player in Islamic finance in Southeast Asia.

The first Sukuk issuance in Indonesia was carried out by PT Indonesian Satellite Corporation (Indosat) in September 2002, for an amount of 175 billion rupiah. This initial initiative quickly prompted other large companies to follow suit (Puspita 2024).

Between 2002 and 2004, Moudaraba-structured Sukuk dominated, accounting for 740 billion rupiah (88%), while Ijara accounted for only 100 billion rupiah (12%). However, between 2004 and 2007, this trend reversed. Ijara-based issuances reached 2,194 billion rupees (92%), with Mudaraba totaling only 200 billion rupees (8%). This attests to the growing maturity of the Sukuk market, both in terms of volume and structural diversity (Puspita, 2024).

The development of sovereign Sukuk in Indonesia has been largely fueled by the establishment of a robust legal framework. Indeed, the 2008 SBSN Law on sovereign Sukuk and its implementing regulations clarified the conditions for issuance and management, encouraging their sustained growth and attracting investors. Previously, regulatory and tax barriers had hampered the growth of this market segment (Puspita, 2024) . At the same time, efforts by BAPEPAM-LK[1] to structure the Islamic securities market have fostered sustained growth in corporate Sukuk issuance, which was limited to less than Rp 5 trillion in the 2007-2010 period but showed an upward trend until 2009 (Maulida & Febriani, 2021) .

In 2018, as part of an ambitious green transition, Indonesia fulfilled its commitment to combat climate change, made when it ratified the Paris Agreement in 2016, by issuing a Green Sukuk, aimed at reducing its greenhouse gas emissions and strengthening its climate resilience (Udzma and Faiz 2024).

In recent years, the Indonesian Sukuk market has clearly experienced sustained growth, particularly during the economic disruptions caused by the Covid-19 pandemic. The outstanding amount of Sukuk has increased year on year, from 30.8 trillion rupiah in 2018 to 42.5 trillion (Febriana *et al.* 2024). In fact, between 2019 and 2023, total issuance increased significantly, according to data from the Financial Services Authority (OJK[2]). In 2023, the number of corporate Sukuk in circulation increased by 4.52% compared to 2022 (221 series) to reach 231 series, while their total value recorded an increase of 4.36%, reaching IDR 44.35 trillion (Putri *et al.* 2024).

The number of Sukuk issuances and their volume have continued to increase in Indonesia, reflecting a growing trend toward diversification of investment options in countries with large Muslim populations (Statistik Indonesia 2023).

[1] BAPEPAM-LK: *Badan Pengawas Pasar Modal dan Lembaga Keuangan* (Capital Markets and Financial Institutions Supervisory Authority)

[2] OJK: Otoritas Jasa Keuangan, the Indonesian Financial Services Authority.

Key players in the Indonesian Sukuk market

The Indonesian government: it is the main issuer of Sukuk in Indonesia. At the end of 2021, the total outstanding amount of sovereign Sukuk was approximately IDR 300 trillion (USD 21 billion), representing 17% of outstanding government securities. These Sukuk are mainly issued to finance infrastructure projects and to cover the budget deficit (Peraturan Menteri Keuangan Republik Indonesia 2021). With nearly 80% of total outstanding Sukuk, the government dominates the market.

State-owned enterprises: PT Perusahaan Listrik Negara (PLN), the national electricity company, issued Sukuk worth IDR 4.5 trillion (USD 315 million) in 2021 to finance energy infrastructure projects, and PT Adhi Karya, a state-owned construction company, issued Sukuk worth IDR 1.5 trillion (USD 105 million) in the same year.

Private companies: PT Indosat TBK, a telecommunications operator, which issued IDR 2.7 trillion (USD 189 million) worth of Sukuk in 2021 to finance the expansion of its network, and Bank Muamalat Indonesia, an Islamic bank, raised IDR 1 trillion (USD 70 million) through Sukuk to support its growth.

Islamic banking sector: Islamic banks, such as Bank Syariah Mandiri, BNI Syariah, and BRI Syariah, are actively involved in issuing and investing in Sukuk to finance their operations and support lending to businesses.

Institutional investors: Institutional investors are also attracted to the Sukuk market, including Islamic pension funds and Islamic investment funds seeking Sharia-compliant products, as well as insurance companies and sovereign wealth funds (Putri *et al.* 2024).

Regulatory framework for Sukuk issuance in Indonesia

The Indonesian Financial Services Authority (OJK) ensures compliance with Sharia principles and regulates Islamic financial products, while the Sharia Securities Law (SBSN) governs the issuance of sovereign Sukuk, helping to strengthen investor confidence, and attractive tax incentives encourage Sukuk issuance and investment. This regulatory framework has led to a 25% year-on-year increase in the total value of Sukuk issued in 2021 (OJK 2021).

Sukuk issuances in Indonesia (2012-2022)

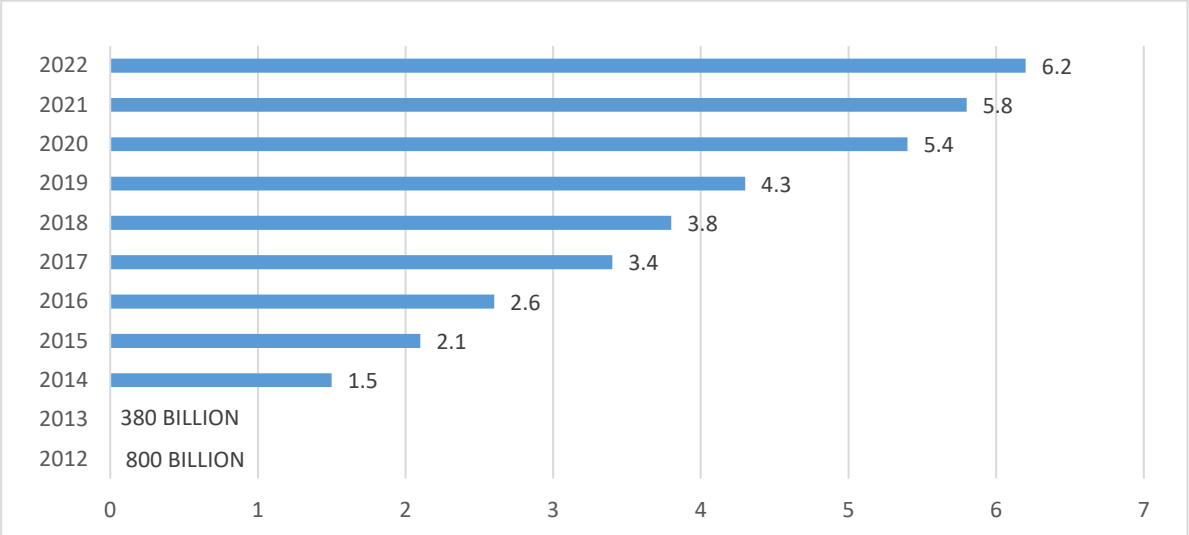
The table and figure present a summary of issuances based on Indonesian government data between 2012 and 2022, indicating that the Indonesian Sukuk market grew steadily between 2012 and 2022, both in terms of the number of issuances and the diversity of projects financed. This demonstrates Indonesia's commitment to using Sukuk as a strategic tool for its economic and social development. The market has experienced remarkable growth, from just three issuances in 2012 to 25 in 2022. This illustrates the growing adoption of this instrument by investors and issuers. Initially dominated by Ijara and Wakala structures, the market has gradually expanded to include other types of structures, offering greater flexibility and enabling a variety of needs to be met.

Table 3. Volume of Sukuk issuances in Indonesia for the period 2012-2022 (in trillion IDR)

Year	Number of Sukuk	Types of Sukuk	Main projects	Total amount (in trillion IDR)
2012	3	Ijara, Wakala	Road infrastructure, Education	0.3
2013	5	Ijara, Wakala	Railways, Energy	0.8
2014	7	Ijara, Wakala, Moudaraba	National roads, Ports	1.5
2015	9	Ijara, Wakala	Airports, Telecommunications	2.1
2016	11	Ijara, Wakala	Dams, Irrigation	2.6
2017	13	Ijara, Wakala, Moudaraba	Social housing, Health	3.4
2018	15	Ijara, Wakala	Renewable energy, Education	3.8
2019	17	Ijara, Wakala, Istisnaa	Rail network, Technologies	4.3
2020	20	Ijarah, Wakala	COVID-19 response, Health infrastructure	5.4
2021	22	Ijara, Wakala, Moudaraba	Educational Infrastructure, Digitalization	5.8
2022	25	Ijara, Wakala, Green Sukuk	Green projects, Smart cities	6.2

Source: Author's own processing based on data from the Indonesia Stock Exchange (IDX) (2012–2022)

Figure 2. Volume of Sukuk issuances in Indonesia for the period 2012-2022 (in trillion IDR)



Source: Author's own processing based on data from the Indonesia Stock Exchange (IDX) (2012–2022)

The funds raised have been used to finance important projects for the country, including road, rail, port, and airport infrastructure, and even social initiatives such as housing, healthcare, and the response to the COVID-19 pandemic. Since 2018, renewable energy projects and Green Sukuk have been the focus of particular attention. In fact, total issuance has grown from IDR 0.38 trillion in 2012 to IDR 6.2 trillion in 2022, reflecting the increasing mobilization of domestic and international capital. This growth underscores the key role of Sukuk in financing strategic projects and Indonesia's appeal for Islamic finance and its dynamism.

However, this quantitative momentum should not obscure certain institutional weaknesses that particularly affect the innovative segments of the Indonesian market. A recent analysis of cash waqf-linked Sukuk (CWLS) reveals that, despite institutional support, their adoption remains limited due to several obstacles: lack of trust in managers, lack of professionalism, weak financial literacy, insufficient transparency, and reduced competitiveness compared to conventional products (Ryandono et al. 2025). These obstacles underscore that the development of a Sukuk market is not simply a matter of increasing volumes but requires a robust institutional ecosystem and credible governance to ensure the sustained engagement of investors.

After providing an overview of Asia, the analysis turns to the Gulf Cooperation Council (GCC), which remains the institutional cradle of modern Islamic finance.

3.2. Saudi Arabia, Bahrain, and the United Arab Emirates

Overview of the Sukuk market in Saudi Arabia

In Saudi Arabia, the development of Sukuk, although promising, has been hampered by a double obstacle: an insufficient understanding of Islamic financial structures and the absence of a clear regulatory framework. Indeed, Alshamrani (2014) highlights the nature of this relative delay due to the initial absence of a specific regulatory framework.

In 2006, Saudi petrochemical giant SABIC led the way by issuing the country's first Sukuk. This initiative coincided with the drafting of the Sukuk Law, demonstrating the simultaneity of regulation and practice. At the same time, the Saudi Electricity Company (SEC) issued Sukuk backed by a pool of assets consisting of electricity meter reading and maintenance rights. This represented a further step in the diversification of the assets underlying Sukuk in Saudi Arabia (Alsaeed, 2012).

In 2011, the Sukuk market enjoyed remarkable success. Saudi Aramco Total Refining and Petrochemical Company (SATORP) issued its first Sukuk, raising SAR 3.75 billion with a three-year maturity, following the SAR 1.8 billion issue by Saudi International Petrochemical Company (Sipchem). Both transactions were oversubscribed 3.5 times, illustrating investors' sustained and growing interest in this type of financial instrument (Alsaeed, 2012) . By 2015, Saudi Arabia had already established itself as a major player in the Sukuk market, ranking second in the world after Malaysia, according to the GIFR. Its influence grew further in 2017 with the introduction of an unprecedented hybrid financial structure combining Moudaraba and Mourabaha as part of a record $9 billion

issuance. At the same time, the more traditional but flexible Wakala Sukuk strengthened its dominant position (Nasreen *et al.* 2020).

Following in Malaysia's footsteps, Saudi Arabia has become one of the main players in the global Sukuk market. It accounted for around 30% of the global Sukuk volume in 2021. This trend continued in 2022, with an increase in issuance volumes despite the complex global economic environment. This momentum was fueled by strong demand for low-risk sovereign assets. The GCC governments maintained their dominance of the sovereign Sukuk market, accounting for around 83% of total issuance in the first half of 2022. Saudi Arabia, the leading sovereign issuer, took advantage of rising oil prices to consolidate its public debt (AlTaitoon, 2022).

The medium-term outlook for the Sukuk market in the GCC region is promising. The realization of the many economic visions for 20303 , which require significant investment in infrastructure, should boost demand for Sukuk. In addition, the development of sustainable Sukuk, in line with the region's energy transition and sustainable development goals, will pave the way for new investment opportunities (AlTaitoon, 2022). Furthermore, the Saudi authorities are encouraging the diversification of funding sources, thereby contributing to the dynamism of the Sukuk market. They aim to reduce dependence on oil and diversify funding sources.

Key players in the Saudi Sukuk market

The Saudi government: this is the largest issuer, financing major national projects through Sukuk. It has established ambitious Sukuk programs to diversify its sources of financing while strengthening the domestic market.

Saudi companies: Public and private companies use Sukuk to finance their growth and projects.

Islamic financial institutions: Islamic banks and other Islamic financial institutions contribute significantly to Sukuk issuance and market development.

Islamic insurance companies: these companies choose to invest in Sukuk in order to diversify their portfolios and generate returns that are compatible with Sharia principles.

Institutional investors: These include pension funds, sovereign wealth funds, and Islamic investment funds, which are the main institutional investors in the Saudi Sukuk market.

Regulatory framework for Sukuk issuance in Saudi Arabia

The Sukuk market in Saudi Arabia is strictly regulated, primarily by the Capital Market Authority (CMA). These issuances are subject not only to Sharia principles, but also to a specific set of rules governing financial securities (Sukuk Issuance Program 2020).

Eligible investors, generally financial institutions and qualified investors, are also subject to strict admission criteria. Sukuk transfers are governed by detailed procedures to ensure market transparency and integrity. In addition, Sukuk income is subject to a specific tax regime (Sukuk Issuance Program 2020). This evolving regulatory framework is designed to promote the development of a transparent and robust Sukuk market, while ensuring investor protection (Zuhri & Fadil, 2024).

Sukuk issuances in Saudi Arabia (2012-2022)

Table 4 and Figure 3 show that the Sukuk market in Saudi Arabia experienced considerable growth between 2012 and 2022, both in terms of volumes issued and diversification of projects financed. The period 2012-2014 was marked by Murabaha and Ijara structures, with funds allocated to projects in key sectors such as general infrastructure, transportation, energy, health, and education, the total amount of which increased from SAR 15 billion to SAR 25 billion. From 2015 onwards, a Wakala structure broadened the types of Sukuk, providing financing for urban infrastructure and economic diversification initiatives, reaching a total of SAR 40 billion in 2016.

The 2017-2019 period then represented a turning point, with financing aligned with the ambitions of Vision 2030 and flagship projects such as NEOM, renewable energy, smart cities, and tourism. The amounts raised increased significantly, reaching SAR 95 billion in 2019. Finally, green Sukuk were integrated between 2020 and 2022, reflecting a shift towards initiatives focused on sustainability, innovation, and green technologies, in line with specific needs, particularly the management of the COVID-19 pandemic. In 2022, issuances peaked at SAR 160 billion, illustrating the maturity of the Sukuk market in Saudi Arabia and its strategic contribution to financing national priorities and sustainable development goals.

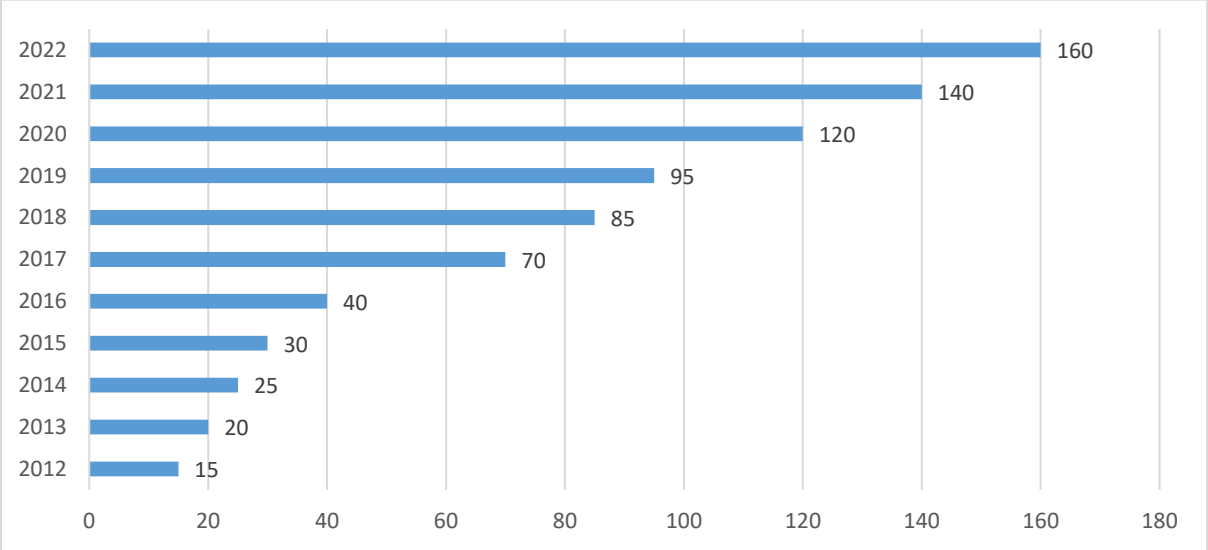
[3] The "Vision 2030" economic development plan is generating demand for financing for numerous projects, and Sukuk are a preferred financing instrument for these projects.

Table 4. Volume of Sukuk issuances in Saudi Arabia for the period 2012-2022 (in SAR billion)

Year	Number of Sukuk	Types of Sukuk	Main projects	Total amount (in trillion IDR)
2012	2	Murabaha	General infrastructure	15
2013	3	Ijara, Murabaha	Transportation, Energy	20
2014	4	Ijara, Murabaha	Health, Education	25
2015	5	Ijara, Murabahah, Wakalah	Urban Infrastructure	30
2016	6	Ijara, Murabaha, Wakala	Economic diversification	40
2017	8	Ijara, Murabaha, Wakala	Vision 2030, NEOM	70
2018	10	Ijara, Murabaha, Wakala	Renewable energy	85
2019	12	Ijara, Murabaha, Wakala	Smart cities, Tourism	95
2020	15	Ijara, Murabaha, Wakala	COVID-19 response, Health	120
2021	18	Ijara, Murabaha, Wakala, Green Sukuk	Green Projects, Technology	140
2022	20	Ijara, Murabaha, Wakala, Green Sukuk	Sustainability, Innovation	160

Source: Author's own processing based on data from the Saudi Central Bank (SAMA), the Capital Market Authority (CMA), and Saudi Exchange (Tadawul) (2012–2022)

Figure 3. Volume of Sukuk issuances in Saudi Arabia for the period 2012-2022 (in SAR billion)



Source: Author's own processing based on data from the Saudi Central Bank (SAMA), the Capital Market Authority (CMA), and Saudi Exchange (Tadawul) (2012–2022)

As part of Vision 2030, Saudi Arabia has taken a symbolic step forward with the publication of the first green Sukuk framework by the Saudi Electricity Company, marking the kingdom's commitment to energy transition and the financing of sustainable projects. However, recent work highlights that the development of this segment continues to face several structural obstacles: the absence of a harmonized definition, lack of investor awareness of the benefits of these instruments, insufficient standardized assessment standards and robust regulatory frameworks, and the time required to structure and approve these issuances (Shalhoob 2023). These challenges serve as a reminder that financial innovation in sustainability requires not only political will, but also an appropriate institutional ecosystem capable of strengthening investor confidence and broadening access to the international market.

Bahrain, an important player within the Gulf Cooperation Council, is characterized by a greater focus on regional financial services and diversification of issuers.

Overview of the Sukuk market in Bahrain

Bahrain's Sukuk market offers exciting prospects, highlighting the strategic integration of Islamic finance into a dynamic regional environment. Bahrain, one of the Gulf's leading financial centers, has strengthened its Sukuk market while diversifying the Islamic financial instruments it offers. The Bahraini authorities have successfully strengthened their regulatory framework, developed market infrastructure, and encouraged innovation to attract investors and encourage Sukuk issuance.

The Central Bank of Bahrain has implemented regulatory reforms that have contributed decisively to the growth of the Sukuk market. By creating an environment conducive to innovation, Bahrain has established itself as a leader in Islamic finance, strengthening the soundness of its financial institutions. This leadership was demonstrated as early as 2001 with the issuance of the first sovereign Sukuk, followed by the introduction of the short-term Sukuk salam, which marked an important milestone in the evolution of the market (Archer & Abdel Karim, 2017).

The country's sovereign wealth fund, Mumtalakat Holding Company, made Sukuk history by becoming the first Sukuk issuer in Malaysia. Praised by analysts, the transaction raised nearly USD 1 billion, consolidating Bahrain's reputation as one of the region's leading players in the Sukuk field. In addition, the Bahrain Stock Exchange has expanded its services by offering innovative investment instruments such as Sukuk Ijara, which is aimed at both individual and corporate investors (Archer & Abdel Karim, 2017).

Sukuk occupy an important place in Bahrain's financial activity. Sukuk issuance has grown steadily in recent years, due to increased investor demand for Sharia-compliant financial products. According to Fitch Ratings, the total amount of Sukuk issued in Bahrain in 2023 was $16.1 billion, an increase of 12.5% over the previous year. This growth is due in particular to the diversification of the Bahraini government's sources of financing and the rollout of new infrastructure projects.

Islamic banks are making a major contribution to the development of the Sukuk market in Bahrain. They hold a steadily growing market share, representing 25.5% of total banking assets in 2023 (Fitch Ratings). By offering a wide range of Sharia-compliant financial products and services, these banks are meeting the needs of an ever-growing customer base.

The outlook for the Sukuk market in Bahrain remains positive. Continued government support, regulatory stability, and innovation are all factors conducive to the sector's growth. However, new challenges await market players, which the sector will need to address to ensure the sustainability of its activities and continue to grow at a steady pace (Fitch Ratings).

Key players in the Sukuk market in Bahrain

Bahraini government: the main market player, it issues sovereign Sukuk to finance strategic infrastructure projects and cover budget deficits. These issues reflect the authorities' desire to diversify sources of public financing, while ensuring compliance with the principles of Islamic finance.

Islamic banks and financial institutions: Certain Islamic banks, such as the Bahrain Islamic Bank and Kuwait Finance House (Bahrain), as well as renowned Islamic financial institutions such as Al Baraka Banking Group and Gulf Finance House, are among the main issuers. They issue Sukuk to finance their operations, diversify their sources of income, and support development projects in various sectors, particularly real estate and energy.

Bahraini companies: Bahraini public and private companies use Sukuk to cover a variety of needs, including financing their activities, developing their projects, and managing their liquidity. Issuers come from various sectors, including energy, real estate, and telecommunications.

Islamic insurance companies: These companies, which are players in the Takaful sector such as Takaful International, are also active in the Sukuk market, issuing these instruments to diversify their portfolios and consolidate their capital base. Thanks to these issues, they can invest in projects that comply with Islamic finance principles and support their expansion and strategic objectives.

Regulatory framework for Sukuk issuance in Bahrain

The Central Bank of Bahrain is at the heart of the supervision of this market, ensuring that Sukuk-related activities comply with Islamic finance principles and international standards. This pillar-based regulatory framework is distinguished by its balanced approach between Sharia compliance, prudential supervision, and innovation. It guarantees the quality and safety of Islamic financial products by requiring Islamic financial institutions to establish Sharia committees and apply rigorous prudential standards. In addition, by promoting transparency and encouraging the development of new products, it helps to make the Sukuk market more attractive to investors and issuers (O'Brien-Mcqueenie *et al.* 2022) .

Sukuk issuances in Bahrain (2012-2022)

The table and figure above provide a chronological overview of the evolution of Sukuk issuance in Bahrain, highlighting the exponential growth of these instruments. The increasing diversification of the financial structures used, which go beyond traditional structures such as Ijara and Murabaha, allows for more complex products to be included.

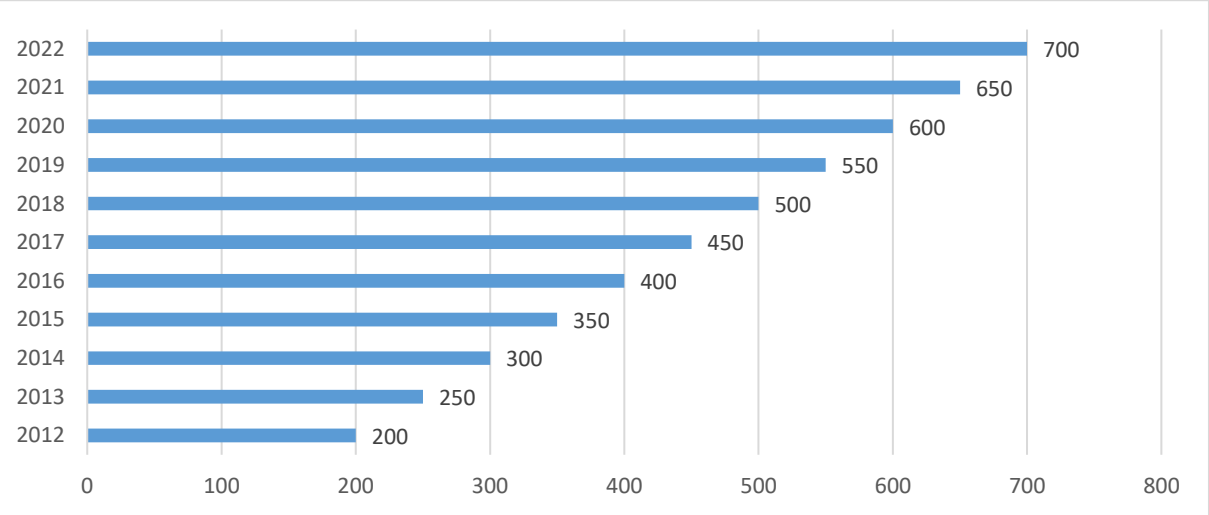
In addition, the distribution of Sukuk funds has evolved over time. Originally focused on general infrastructure and urban development projects, investments have since shifted to strategic sectors such as energy, technology, healthcare, and, most recently, sustainable development. This shift illustrates the market's adaptation to the changing needs of the Bahraini economy and the emergence of new priorities, including energy transition and digital innovation. The COVID-19 period has also highlighted the resilience of the Sukuk market. Sukuk issuances in response to the pandemic demonstrate this instrument's ability to cope with difficult economic conditions while playing a stabilizing role.

Table 5. Volume of Sukuk issuances in Bahrain for the period 2012-2022 (in millions of BHD)

Year	Number of Sukuk	Types of Sukuk	Main projects	Total amount (in trillion IDR)
2012	3	Ijara, Murabaha	General infrastructure	20
2013	4	Ijara, Murabaha, Salam	Urban development	250
2014	5	Ijara, Murabaha, Wakala	Energy, Transportation	300
2015	6	Ijara, Murabaha, Wakala	Housing, Education	350
2016	7	Ijara, Murabaha, Wakala	Health, Technology	400
2017	8	Ijara, Murabaha, Wakala	Economic Diversification	450
2018	9	Ijara, Murabaha, Wakala	Financial infrastructure	500
2019	10	Ijara, Murabaha, Wakala	Smart cities, Tourism	550
2020	12	Ijara, Murabaha, Wakala	COVID-19 Response, Health	600
2021	14	Ijara, Murabaha, Wakala, Green Sukuk	Sustainable Projects	650
2022	15	Ijara, Murabaha, Wakala, Green Sukuk	Innovation, Digital Economy	700

Source: Author's own processing based on primary data from the Central Bank of Bahrain (CBB) Statistical Bulletins and the official listing records of Bahrain Bourse (2012–2022).

Figure 4. Volume of Sukuk issuances in Bahrain for the period 2012-2022 (in million BHD)



Source: Author's own processing based on primary data from the Central Bank of Bahrain (CBB) Statistical Bulletins and the official listing records of Bahrain Bourse (2012–2022).

Bahrain is not only a regional financial center, it also stands out for its proactive approach to technological innovation in the field of Islamic finance. In particular, the country has launched pilot projects aimed at issuing Sukuk via a private blockchain based on Ethereum, incorporating smart contracts to automate the distribution of rental income, repayment schedules, and late payment notifications (Sidiq and Muliana 2025). This automation, applied to Sukuk ijarah, aims to improve transparency, security, and operational efficiency while complying with Sharia principles. In addition, the Central Bank of Bahrain has established a formal regulatory framework for crypto-assets, accompanied by a regulatory sandbox designed to test Sharia-compliant fintech innovations before their deployment in the market. This strategy positions Bahrain as a testing ground for digital Islamic finance.

Overview of the Sukuk market in the United Arab Emirates

While Malaysia has traditionally dominated the global Sukuk market, the United Arab Emirates (UAE) has emerged as a major player, particularly in the international Sukuk segment.

The UAE ranked fourth globally in terms of total value of Sukuk issued during the period 2004-2019. However, it ranks first in terms of international Sukuk issuance, reflecting its appeal to foreign investors. The international market accounted for nearly 91% of Sukuk issued by the UAE, reflecting a diversified financing strategy and openness to global investors. Between 2008 and 2019, this market grew at an average annual rate of 32.36%, significantly boosting the UAE's GDP. These issuances were mainly used to finance major infrastructure and development projects (Steit and Hassan 2022).

The country has successfully positioned itself as a key player in the global Sukuk market, thanks in particular to an innovative financing strategy and a favorable economic environment (Steit and Hassan 2022). The growth of this market has diversified the country's sources of financing and supported its economic development. This performance has confirmed the role of the United Arab Emirates as a major player in the Sukuk sector in the Gulf region (Hanefah *et al.* 2013).

Onagun (2015) pointed out that the most common Sukuk structures in the United Arab Emirates include Sukuk Ijara, Musharaka, and Mudaraba, which enable the financing of projects such as major infrastructure, while ensuring financial stability even during economic downturns. Major institutions such as Dubai Islamic Bank (DIB) and the Islamic Development Bank demonstrate the impact of these instruments: DIB, in particular, is a global leader in Sukuk issuance, covering a variety of assets such as aircraft and real estate, through mechanisms such as Murabaha, Istisnaa, and Ijara. Furthermore, according to Standard and Poor's, the success of Sukuk is due to sustained investor demand for Islamic products, which represents a major opportunity for the United Arab Emirates capital market.

The UAE marks the beginning of a new chapter in the history of Islamic finance. Emirates Islamic has successfully issued its first sustainability Sukuk, worth $750 million, on the Dubai Nasdaq. This unprecedented transaction has attracted particular interest from international investors, demonstrating Dubai's financial center's commitment to sustainable finance and Sharia compliance, as announced by the WAM news agency in its article on June 5, 2024.

Key players in the Sukuk market in the United Arab Emirates

Federal and local entities: These include the UAE federal government and the various emirates (Dubai, Abu Dhabi, Sharjah, etc.), which are the main issuers. They finance large-scale infrastructure projects, sustainable development initiatives, and social programs.

Specialized government agencies: certain public companies, such as the Electricity and Water Authority (DEWA) and the Dubai Roads and Transport Authority (RTA), use Sukuk to finance their specific investments, thereby enabling the development of the country's essential infrastructure.

Islamic banks and financial institutions: As pillars of the Islamic financial system in the United Arab Emirates, Islamic banks (such as the Dubai Islamic Bank (DIB) and the Islamic Development Bank (IDB)) are the main players in Sukuk issuance. They diversify their sources of financing through Sukuk, thereby strengthening their position and contributing to the development of the market. In addition, conventional banks are increasingly partnering with Islamic banks or issuing Sukuk directly, reflecting a growing trend toward convergence between the two financial systems. For their part, Islamic investment funds such as Shuaa Capital and Dubai Islamic Investment (DII) act as catalysts, investing in long-term, high-potential projects, often in the form of Sukuk.

The private sector: The private sector in the United Arab Emirates is another key player in Sukuk issuance. Publicly traded companies, especially in the real estate, energy, and infrastructure sectors, use Sukuk to finance their expansion projects, acquisitions, and growth. This provides them with an alternative source of financing that

is generally more flexible than traditional bank financing. Private companies, particularly small and medium-sized enterprises (SMEs), also use Sukuk to obtain financing that would otherwise be difficult to obtain.

International investors: The country also welcomes international players wishing to participate in the development of the Sukuk market. The Islamic Development Bank, for example, issues Sukuk to finance development projects in the region and beyond, helping to catalyze the Sukuk market. Similarly, some non-governmental organizations (NGOs) issue Sukuk to finance social and humanitarian projects, thereby promoting the development of a sustainable and responsible Sukuk market.

Regulatory framework for Sukuk issuance in the United Arab Emirates

In the United Arab Emirates, the Sukuk market is based on a regulatory framework influenced by international norms and Islamic standards. Participation in bodies such as the United Nations Commission on International Trade Law (UNCITRAL) and the Islamic Financial Services Board (IFSB) is voluntary, but these institutions provide essential guidelines. UNCITRAL, for example, promotes the harmonization of international commercial laws, which primarily influences the regulation of Sukuk markets by encouraging member countries to adapt their national legislation to align their practices with global standards. However, although the UAE was a member of UNCITRAL from 1968 to 1977, it is no longer affiliated with the institution, limiting its direct impact on the UAE's legal framework.

On the other hand, the IFSB sets specific standards for the Sukuk market, ensuring transparency and Sharia compliance throughout the Sukuk lifecycle, without imposing excessive burdens on issuers. In the United Arab Emirates, the Dubai Financial Services Authority (DFSA) and the Central Bank are active members of the IFSB, ensuring supervision in line with international best practices.

In addition, strict Sharia-related disclosure and governance requirements are imposed on domestic and foreign issues, including the publication of Sharia Committee Fatwas, dispute resolution methods, and asset reallocation mechanisms in the event of non-compliance. These requirements help ensure market stability and adequately protect investors.

Sukuk issuances in the United Arab Emirates (2012-2022)

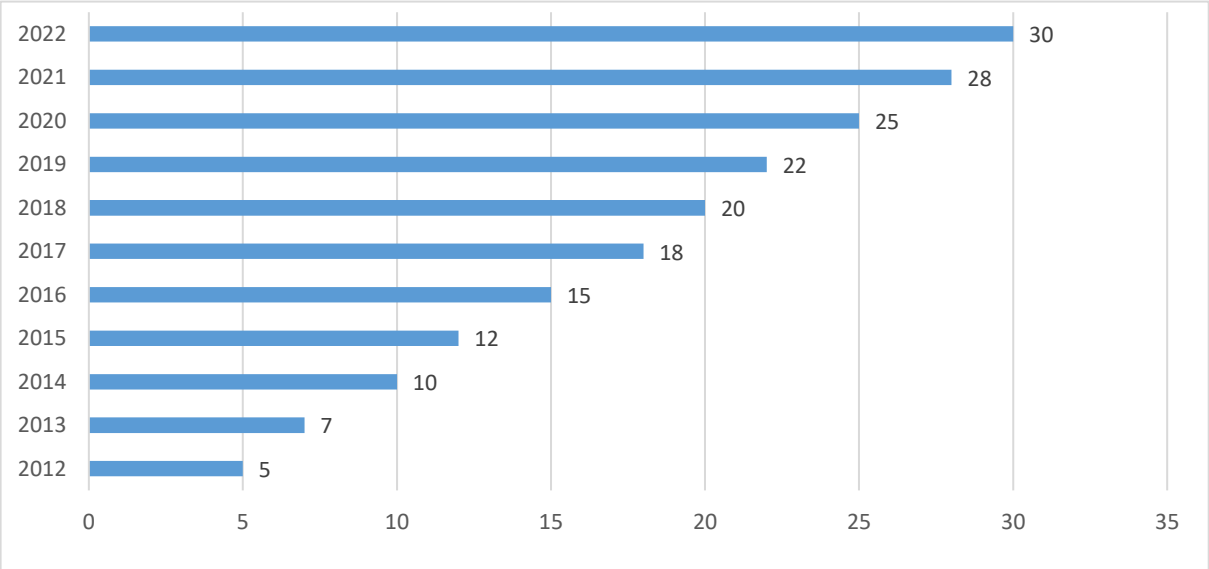
The number of Sukuk issued has grown steadily year on year. The table 6 and Figure 5 show the growing appeal of this Islamic financial instrument in the United Arab Emirates market. The range of Sukuk types, mainly ijara, murabaha, and wakala, highlights the flexibility of this instrument, which can meet a wide range of financing needs. In addition, many sectors participate in Sukuk-financed projects, including infrastructure, energy, and social projects such as housing and healthcare.

Table 6. Volume of Sukuk issuances in the United Arab Emirates for the period 2012-2022 (in billion AED)

Year	Number of Sukuk	Types of Sukuk	Main projects	Total amount (in trillion IDR)
2012	4	Ijara, Murabaha	General infrastructure	5
2013	5	Ijara, Murabaha, Wakala	Transportation, Energy	7
2014	6	Ijara, Murabaha, Wakala	Expo 2020 Dubai, Housing	10
2015	7	Ijara, Murabaha, Wakala	Education, Health	12
2016	8	Ijara, Murabaha, Wakala	Smart Cities, Innovation	15
2017	9	Ijara, Murabaha, Wakala	Economic Diversification	18
2018	10	Ijara, Murabaha, Wakala, Green Sukuk	Renewable energy	20
2019	12	Ijara, Murabaha, Wakala, Green Sukuk	Sustainable development	22
2020	14	Ijara, Murabaha, Wakala, Green Sukuk	COVID-19 Response, Health	25
2021	16	Ijara, Murabaha, Wakala, Green Sukuk	Advanced Technologies	28
2022	18	Ijara, Murabaha, Wakala, Green Sukuk	Digital economy, Space	30

Source: Author's own processing based on data from the Central Bank of the UAE (CBUAE), Nasdaq Dubai, Dubai Financial Market (DFM), and Abu Dhabi Securities Exchange (ADX), 2012–2022.

Figure 5. Volume of Sukuk issuances in the United Arab Emirates for the period 2012-2022 (in billion AED)



Source: Author's own processing based on data from the Central Bank of the UAE (CBUAE), Nasdaq Dubai, Dubai Financial Market (DFM), and Abu Dhabi Securities Exchange (ADX), 2012–2022.

Their evolution reflects the country's economic priorities at a given time. In recent years, for example, there has been an increasing focus on sustainable development and advanced technologies.

Funds raised through Sukuk have increased significantly during this period, demonstrating the important role Sukuk play in financing corporate and infrastructure projects in the United Arab Emirates. One of the main reasons for this increase is growing investor confidence in the market.

Recent studies shed new light on official reports concerning the UAE. They show that not all Sukuk have the same effect on banking performance. For example, while Tier One Sukuk help maintain earnings per share, liability Sukuk (debt) tend to reduce overall profitability. This is often due to higher financing costs. For Emirati banks, the current trend is therefore to favor securities that strengthen equity rather than debt, while following international standards such as AAOIFI to reassure investors (Mouselli et al. 2024).

After examining mature models in Asia and the Gulf, it is essential to turn to the United Kingdom and France. These two examples are particularly instructive for Morocco. Indeed, these markets show how to integrate Sukuk into a traditional financial environment, and studying their issuances provides a better understanding of the adjustments needed to move from an isolated experience to a regular and diversified market.

3.3. United Kingdom and France

Overview of the Sukuk market in the United Kingdom

The United Kingdom, where Islamic finance is still a niche market, has established itself as a major Western player in the sector. The Sukuk market dates back to 2007 and has gone from strength to strength . This momentum is perfectly illustrated by the London Stock Exchange (LSE), which recorded 57 Sukuk in 2015 with a total value of $51 billion.

In the first quarter of 2023, more than 55 Sukuk were listed, with a total value of over $50 billion (Fitch Ratings). The United Kingdom is thus demonstrating its determination to position itself as a leading center for Islamic financial products on the international stage. Several factors motivated this initiative, including the need to diversify funding sources, strengthen economic ties with Gulf countries, and consolidate London's position as a global financial center.

Indeed, the first Sukuk issuances on British soil, by renowned players such as the International Finance Corporation (IFC) and GE Capital, represented an important step and a real revolution for other issuers. Asutay and Hakim (2018) pointed out that the UK's issuance of sovereign Sukuk further enhanced the attractiveness of the UK market. In 2014, it reached a milestone by issuing its first sovereign Sukuk, cementing its credibility as an Islamic financial center (Fitch Ratings). The UK government thus became the first Western government to issue sovereign Sukuk, which were oversubscribed more than 11 times (British Embassy Bishkek, 2015). This launch encouraged other countries outside the Organization of Islamic Cooperation (OIC) to issue their own Sukuk, thereby contributing to the internationalization of this financial instrument.

The United Kingdom also stands out for its ability to attract cross-border Sukuk issuances compared to other major financial centers, such as Malaysia and the Gulf Cooperation Council (GCC) countries. This success can be attributed to a number of factors, including the stability of its financial system, the depth of its capital market, and the attractiveness of its financial center (Asutay & Hakim, 2018).

The United Kingdom enjoys a strong reputation in the international financial services market and regularly attracts investment, particularly from the Gulf States. We can therefore count on the country maintaining its role as the Western hub for Islamic finance.

Key players in the UK Sukuk market

Financial institutions: These institutions form the backbone of the UK Sukuk market. Specialized players such as HSBC Amanat and Gatehouse Bank play a key role in issuing and structuring these Islamic financial instruments. They act as an interface between issuers and investors, tailoring products to the specific needs of each.

Law firms: Law firms specializing in Islamic finance, such as Norton Rose Fulbright, perform an essential function. They ensure that Sukuk transactions comply with Sharia principles and provide the legal expertise necessary to guarantee the security of transactions.

Rating agencies: These play a key role in assessing the risk associated with Sukuk. They provide investors with an objective analysis of the issuer's quality, enabling them to make informed decisions.

UK government: The UK government is a key player in this area. It has paved the way for other issuers by issuing sovereign Sukuk, thereby helping to consolidate London's reputation as a player in international finance.

Regulatory framework for Sukuk issuance in the United Kingdom

The United Kingdom has established a specific regulatory framework to encourage the development of Sukuk within its territory. This is part of a broader effort to enhance London's attractiveness as a financial center and to meet the growing demand for financial instruments based on Islamic finance principles.

The Financial Services and Markets Act 2000 (FSMA) is at the heart of this system. It has been amended to clarify the legal status of Sukuk and distinguish them from other financial instruments. Sukuk are no longer treated as collective investment schemes (CIS) and their regulation has been considerably simplified (Clifford Chance, 2010).

Sukuk are a specific type of investment that allows them to benefit from a favorable regulatory regime, similar to that of traditional bonds. Sukuk issuers are also treated more favorably, which reduces compliance costs and simplifies their marketing. To benefit from this favorable regulatory framework, Sukuk are subject to a number of criteria. In particular, they must be listed on a recognized stock exchange, which guarantees their transparency and liquidity. This requirement also minimizes the risk of regulatory arbitrage (Clifford Chance, 2010).

The Financial Conduct Authority (FCA) also plays an important role in regulating Sukuk in the United Kingdom. It ensures compliance with regulatory standards and the specific features of Islamic finance. In particular, it supervises the issuance, trading, and transparency of these instruments, thereby strengthening investor confidence.

Sukuk issues in the United Kingdom

In 2014, the United Kingdom became the first non-Muslim country to issue sovereign Sukuk, but the volume of these instruments remains modest compared to the markets studied above. A few issues have been made, mainly in the public infrastructure and renewable energy sectors, demonstrating the country's commitment to sustainable development.

The table and figure below detail Sukuk issuance in the United Kingdom between 2014 and 2021. They show that the country has favored lease agreements (Ijara) to structure its Sukuk. The projects financed mainly concern strategic sectors such as public infrastructure, education, and renewable energy, reflecting the country's commitment to sustainable development. The amounts raised have increased significantly over the years, reflecting growing interest in this type of financial instrument.

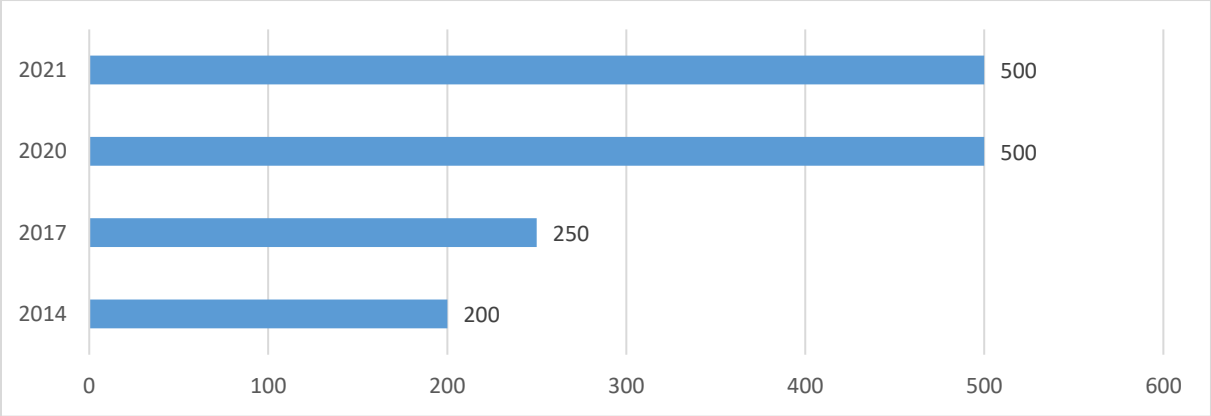
A qualitative analysis conducted by Aava Karumo (2025) among key stakeholders reveals remarkable convergence beyond ethical or religious considerations for the United Kingdom, whose success is based on a pragmatic and unhindered approach to Islamic finance, seen primarily as a driver of economic growth and consolidation of its status as a global financial center. This position can be explained by a secular state framework, whose regulatory flexibility and multi-stakeholder engagement reflect a strategic and inclusive vision.

Table 7. Volume of Sukuk issuances in the United Kingdom (in millions of GBP)

Year	Number of Sukuk	Types of Sukuk	Main projects	Total amount (in trillion IDR)
2014	1	Ijara	Public infrastructure development	200
2017	1	Ijara	Development of educational infrastructure	250
2020	1	Ijara	Infrastructure and sustainable development	500
2021	1	Ijara	Renewable energy projects (solar)	500

Source: Author's own processing based on official data from HM Treasury, UK Debt Management Office (DMO), Al Rayan Bank PLC, and World Bank Group reports (2014–2021)

Figure 6. Volume of Sukuk issuance in the United Kingdom (in million GBP)



Source: Author's own processing based on official data from HM Treasury, UK Debt Management Office (DMO), Al Rayan Bank PLC, and World Bank Group reports (2014–2021)

Thus, London's ability to seize this market opportunity stems as much from a consistent political will to adapt its financial ecosystem to attract capital and innovate, based on purely commercial and competitive logic, as from respect for religious principles. This operational pragmatism, combined with proactive institutional support, is the foundation on which the momentum observed has been built.

Overview of the Sukuk market in France

France is strategically well positioned to develop Sharia-compliant financial products. Major French banks such as BNP Paribas, Société Générale, and Crédit Agricole have extensive expertise in Islamic finance and have opened specialized international divisions.

In July 2008, the Autorité des marchés financiers (AMF) approved the listing of Sharia-compliant investment funds and Sukuk on the Paris Stock Exchange. These initiatives have been supported by appropriate tax reforms. In 2009, the Sukuk Guide clarified the applicable legal and tax frameworks, while in 2010, to facilitate the issuance of Sukuk in France, a legislative amendment abolished the double stamp duty (Grassa & Hassan, 2015).

According to the AMF, issuers of Sukuk worth more than €50,000 have a certain degree of flexibility in terms of financial reporting. They may publish their documents in English and are exempt from publishing their annual accounts in France, provided that their registered office is located outside the European Economic Area. This flexibility is intended to attract international investors and make it easier for these issuers to meet their regulatory obligations.

In November 2011, Paris Europlace published a guide on promoting Sukuk. These financial instruments represent a strategic opportunity for French companies and the French government on the international Sukuk market. The first Sukuk issue in France, carried out in the same year, amounted to €5 million and concerned the fast food sector (Grassa & Hassan, 2015).

France and the Islamic Development Bank (IDB) are consolidating their historic partnership to promote sustainable Islamic finance. The two countries have stepped up their joint initiatives since 2020, notably by supporting the MDGs in Africa and investing in education for the Muslim community in France. Their goal is to mobilize climate finance from the IDB, particularly through the development of green Sukuk and the creation of appropriate regulatory frameworks in member countries (IFN Sustainable 2023).

Key players in the Sukuk market in France

AMF: The French financial markets regulator is a key player in defining the regulatory framework for Sukuk.

Direction Générale du Trésor: this department has provided clarification on the tax aspects of Islamic finance.

Paris Europlace: this association has contributed to the development of Islamic finance in France by publishing guides and organizing events.

French banks: Major French banks such as BNP Paribas, Société Générale, and Crédit Agricole have acquired expertise in Islamic finance and offer Sharia-compliant products and services.

Regulatory framework for the issuance of Sukuk in France

Authorization and supervision by the AMF: The Autorité des marchés financiers (AMF) is at the heart of the regulatory framework for Sukuk in France. It is responsible for authorizing the listing of Sharia-compliant investment funds and Sukuk on the Paris Stock Exchange and for defining the rules applicable to these instruments (Grassa & Hassan, 2015).

In order to bring Sukuk into line with traditional financial products, France has established a particularly attractive tax framework for Sukuk. This tax parity, confirmed by several regulatory texts, takes the form of the elimination of double stamp duty, the deductibility of issuers' remuneration, and exemption from withholding tax for non-resident investors. These measures strengthen the competitiveness of the French financial market and attract a greater number of issuers and investors to the market.

Sukuk issues in France

Following the first Sukuk issue in 2011 to finance the opening of a halal restaurant in the fast food sector “Al Farooj initiative”, a second Orasis Sukuk issue was launched in June 2012 by Legendre Patrimoine in the form of Islamic certificates open to individual and institutional investors. This transaction, approved by the Independent Committee for Islamic Finance in Europe (CIFIE), was backed by a tangible asset in the solar energy sector (photovoltaic installations) and offered a contractual yield of around 7% per annum, with investment conditions starting at several thousand euros. Unlike the first issue, which was strictly reserved for companies, the Orasis Sukuk was an offering accessible to the general public while complying with the principles of Islamic finance in force in France (Zawya 2012; CIFIE 2012).

The French government has laid the legal and tax foundations for Sukuk issuance. In collaboration with the various stakeholders involved, France is working to attract ethical investors and boost the attractiveness of the Paris financial center.

There is also significant growth potential in France for Sukuk aligned with ESG criteria, such as Green Sukuk. These meet the growing need for sustainable and ethical investments. Nevertheless, their development remains limited.

Although the French Sukuk market is still in its infancy and has not yet led to wider adoption or sovereign issuances, it offers undeniable growth potential. However, weak domestic demand, international competition, and the complex structure of Sukuk pose significant challenges. Furthermore, the lack of consolidated data makes it impossible to accurately determine the volume of issuance in this market, but it is clear that initiatives are already underway, and more importantly, investors' willingness to invest in sustainable finance points to a promising future for this market.

4. Discussions

The objective of this study was to assess the feasibility of developing the Sukuk market in Morocco based on international benchmarks, in a context marked by limited experience, with only one sovereign issuance in 2018. The comparative analysis of reference markets highlights a wide variety of development trajectories, but also identifies institutional regularities and common mechanisms that are useful for assessing the scope for maneuver in the Moroccan case.

4.1. The Moroccan Case Put to the Test of International Benchmarks

The issuance of Morocco's first sovereign Sukuk in October 2018 marks an important step in the process of institutionalizing Islamic finance in Morocco. Structured as an ijara Sukuk backed by public real estate assets, this five-year, 1 billion dirham bond was a resounding success with investors, as evidenced by its 3.6 times oversubscription rate (Bank Al-Maghrib 2019). This enthusiasm reflects the existence of latent demand for Sharia-compliant financial instruments and confirms their credibility as an alternative to conventional bond instruments.

At the institutional level, this issue is part of a gradual and structured process that began in the early 2010s. Preliminary work carried out since 2012 has made it possible to anticipate the necessary legal adjustments and to initiate a dialogue between public authorities, regulators, and market players (Al-Khawarizmi Group, 2012). The creation of a dedicated vehicle by Maghreb Titrisation, as well as the mobilization of public real estate assets as underlying assets, demonstrate a desire to align the requirements of Islamic finance with modern securitization standards. Investor remuneration, based on the rents generated by these assets, has made it possible to comply with Sharia principles while guaranteeing a competitive return (Maghreb Titrisation, 2022). The regulatory framework has thus been reformed and the scope of the securitization law has been extended to Sharia-compliant assets. New legal concepts have also been introduced to regulate the specific characteristics of Sukuk, requiring a certificate of compliance to be issued by a Sharia committee prior to any issuance. In addition, the Moroccan Capital Market Authority (AMMC) has made a major contribution to the implementation of this framework by establishing precise standards and ensuring strict market supervision (Essaf, 2023).

However, compared to the experiences of Malaysia, Indonesia, and the United Arab Emirates, it is clear that this initial issuance, while significant in symbolic terms, was not followed by sustained momentum. Unlike these countries, whose recurring sovereign issuances helped structure a benchmark yield curve and stimulate the gradual entry of public and private issuers, the Moroccan market remained in its infancy. This discontinuity hinders collective learning, slows down the development of market players' skills, and reduces the market's attractiveness to institutional investors, particularly foreign ones.

4.2. Regulatory Framework and Structural Constraints: Comparative Lessons

The international benchmark clearly highlights the decisive role of a stable, transparent legal and tax framework that is tailored to the specific characteristics of Sukuk. In Malaysia and Indonesia, tax neutrality, explicit legal recognition of Sukuk structures, and clarification of the responsibilities of the various players have been key factors in the development of the market. Conversely, the delays observed in Saudi Arabia during the initial absence of a specific framework illustrate the dissuasive effects of regulatory uncertainty.

In Morocco, despite significant progress made by the regulatory authorities, some ambiguities remain. Due to their hybrid nature, Sukuk cannot be treated in the same way as conventional bonds without adjustments. The lack of fully established equivalence in tax, accounting, and legal matters creates uncertainty that weighs on both potential issuers and investors. This situation contrasts with the more mature frameworks observed in some Gulf countries and Malaysia, where the rules applicable to Sukuk are now largely integrated into common financial law.

In addition to these regulatory constraints, there are also cultural and organizational factors. Lack of knowledge about Sukuk mechanisms, both among the general public and among some financial sector professionals, is a significant obstacle. However, the benchmark shows that awareness campaigns, stakeholder training, and academic involvement, as in Indonesia, play a key role in the dissemination and acceptance of these instruments.

4.3. Transferability of Models and National Specificities

This comparative analysis highlights that not all factors observed in the reference markets are fully transferable to the Moroccan context. The depth of the Malaysian domestic market, the size of the Gulf countries' sovereign wealth funds, and the absorption capacity of institutional investors in these economies are based on specific economic structures. On the other hand, certain levers seem more easily mobilizable in Morocco, notably the regularity of sovereign issuances, the increased involvement of public enterprises in infrastructure project financing, and the explicit integration of Sukuk into national sustainable finance strategies.

The experiences of the United Kingdom and France offer additional perspectives in this regard. They show that even in the absence of a deep domestic market or frequent sovereign issuances, it is possible to develop an environment favorable to Sukuk through legal clarification, regulatory expertise, and openness to cross-border issuances. These factors reinforce the idea that the development of the Moroccan market could be based on both internal factors and strategic integration into international Islamic finance circuits.

However, the country still faces structural challenges that hinder the development of the Sukuk market. In terms of regulation, the lack of an appropriate legal and tax framework is a major constraint. Due to their Sharia-compliant nature, Sukuk cannot truly be treated as conventional bonds without far-reaching reforms ensuring their equivalent tax and regulatory treatment. In addition, the persistent legal uncertainty surrounding these instruments is a source of confusion for both issuers and investors, limiting their appeal and preventing the creation of a harmonized market.

Similarly, on a cultural level, the lack of knowledge and understanding of Islamic financial instruments among the general public, local investors, and financial sector players is also an obstacle to their adoption. The lack of expertise in Sukuk mechanisms and infrastructure, both among industry professionals and regulators, exacerbates this shortcoming.

Nevertheless, Morocco has considerable potential for the development of Islamic finance. The country's demographic structure, with a Muslim majority, provides fertile ground for the adoption of Sharia-compliant financial instruments. Furthermore, its geographical proximity and economic ties with established Islamic financial centers offer the Kingdom a strategic opportunity to establish international partnerships and promote the transfer of skills and know-how.

Conclusion

This study highlights that the development of the Sukuk market in Morocco is not only feasible but also offers significant opportunities, provided that it is part of a coherent long-term strategy. International references show that the most dynamic markets are based on a combination of continuous sovereign issuances, regulatory clarity, appropriate tax incentives, and active participation by public and private actors.

This has several practical implications for the Moroccan authorities. It seems essential to improve the clarity of the legal and tax framework applicable to Sukuk in order to reduce the uncertainty perceived by issuers and investors. The establishment of a regular sovereign issuance program could help structure the market, create price benchmarks, and stimulate the emergence of quasi-public and private issuances. In addition, integrating Sukuk into energy transition and public infrastructure financing policies would align these instruments with national sustainable development priorities.

Finally, it is necessary to strengthen skills, raise awareness among market players, and develop international partnerships in order to move beyond the experimental stage and firmly establish Sukuk in the Moroccan financial landscape. With this in mind, international experience should not be replicated mechanically but rather serve as a reference to inform strategic and institutional choices tailored to the Moroccan context.

Declarations

Credit Authorship Contribution Statement: All authors contributed equally to the conception, design, analysis, and writing of this manuscript.

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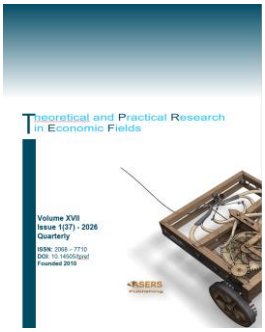
Key Competencies as a Source of Long-Term Competitive Advantages of Companies in International Markets



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Abstract: The aim of the study is to build a quantitative model of the impact of key competencies on the long-term competitiveness of companies in the international economy. The analysis covers data from 30 companies from Germany, Japan, the USA, Poland, Ukraine, and France for 2022–2024. The sample includes companies from the mechanical engineering, logistics, IT, pharmaceuticals, and retail sectors - sectors that play an important role in the international economy. The study uses a panel econometric model with fixed effects, which includes indicators of competencies, digital transformation, Human Resources Development (HRD), innovation, and international experience. The results confirmed a statistically significant positive impact of key competencies on competitive advantage: the highest LCA values were observed in the USA (up to 88.2), Germany (up to 86.1), and France (up to 83.9). A stable increase in competitiveness is recorded in companies with a high level of digitalization and competency development. The findings confirm the importance of competencies as a long-term strategic resource in the international economy. The article emphasizes the need for institutional stimulation of the development of key competencies in companies to increase their competitiveness in global markets.

Keywords: competitive advantage; digitalization; innovation; personnel development; international economics; econometric model.

JEL Classification: F23; L25; M53.

Introduction

Today's highly competitive global market faces companies with the need to constantly strengthen their positions, adapt to technological changes, and find sources of sustainable advantage. One of the key strategic assets that ensure long-term competitiveness is the company's key competencies - unique knowledge, skills, organizational capabilities, and management practices that are difficult to copy and that provide stable value for the consumer. The relevance of the study is determined by the need to quantitatively measure the impact of key competencies on the companies' performance in the context of digital transformation, globalization, the development of the international economy and post-crisis restructuring of the business environment.

In the current academic literature, increasing attention is paid to the role of innovation, internal competencies, and management quality in shaping the long-term competitive advantage of companies in the context of the international economy. The study by Cao *et al.* (2023) emphasizes the importance of intellectual property rights as an incentive for technological innovation, in particular in the field of sustainable development, which has something in common with the findings of Morales *et al.* (2022). The latter emphasize the effectiveness of innovation protection mechanisms in small and medium-sized enterprises (SMEs). In turn, Casidy *et al.* (2020)

and Ferreira *et al.* (2020) argue that creativity, dynamic abilities, and innovation orientation are critical elements of successful adaptation to market changes, especially in industrial and service industries.

The aim of this study is to assess the impact of key competencies on the formation of long-term competitive advantage of companies operating in international markets within the global system of the international economy. The problem is the lack of a single econometric model that would allow integrating such intangible factors as competencies, digitalization, international experience, and innovation into a holistic analytical system. The aim involves the fulfilment of the following research objectives:

(1) systematize theoretical approaches to defining key competencies;

(2) form a sample of leading companies from different countries;

(3) build a panel econometric model to quantify the impact of competencies on long-term competitive advantage;

(4) analyse the results to identify cross-country and cross-industry patterns within the international economy.

The hypothesis of the study is that a high level of development of key competencies of a company has a statistically significant positive impact on its long-term competitive advantage, provided that digital and innovation processes are simultaneously supported. The proposed approach allows combining strategic analysis with quantitative methods and is aimed at the practical application of the results in the processes of competitiveness management, planning of growth strategies, and transformation of business models within the international economy.

The present study explains its objectives by emphasizing on the quantitative measurement of the way major competencies determine long-run competitive advantages of firms dealing with international markets. The study paves the way to new empirical data since competencies, digitalization, innovation, HR development, and international experience have been incorporated into a single econometric parameter. The research bridges the scientific gap in the literature, as past studies tend to treat competencies in a conceptual manner and do not provide the quantitative cross-country models to assess their overall impact on competitive advantage. The research questions are stated clearly. To begin with, how are key competencies influenced as far as long-term competitive advantage of companies in technologically advanced economies is concerned. Second, the alteration of the impact of competencies by digitalization, development of HR, innovation and international experience. Third, do cross-country differences provide a structure pattern in the relationship between competencies and competitiveness. The research fills the identified gap building a panel econometric model that allows measuring intangible strategic factors systematically, and they have not been operationalized in previous research.

The recent research published in 2025 reinforce the theoretical foundation of the core competence of maintaining international competitiveness. As demonstrated by Shen and Badulescu (2025), managerial skills and risk management play a very important role in strengthening the process of internationalization of SMEs, and the internal competencies directly correlate with the sustainable growth of SMEs on a cross-border basis. Anggara *et al.* (2025) emphasize the fact that the service of resources, diversification, and internationalization have a synergistic contribution to the performance of firms, which proves that strategic competencies define the competitive roles in the dynamic global markets. Karim *et al.* (2025) show that the process of competence development and quality practices has a strong impact on sustainable performance in manufacturing, which makes the argument that internal capabilities are quantifiable strategic resources. Wang *et al.* (2025) highlight that the sustainable competitive advantage of SMEs is enhanced by service innovation, protecting intellectual property and open innovation, which lead to better competency structures. Arslan (2025) offers the case of Turkish contractors in Poland, where sustainable competitive advantage is formed as a result of integrating the organisational capability with country-specific knowledge. This research proves the topicality of competencies as a multi-dimensional base of the long-term competitive advantage and the necessity to enlarge the theoretical framework on which the present study is based.

1. Literature Review

The issue of building long-term competitive advantages through the development of key competencies of companies is actively studied in the academic literature from the perspective of the company's resource theory, the knowledge paradigm, innovation management, and considering the challenges associated with globalization and the processes of the international economy. Most studies focus on the role of innovation, dynamic capabilities, and intellectual property protection as the basis of strategic advantages, but the academic discussion remains ambiguous.

In particular, Shin *et al.* (2022) compare the effectiveness of innovations in products and services and emphasize that it is not the fact of innovation itself that is decisive, but the company's ability to integrate them into

its own business model. This is consistent with the approach of Ferreira *et al.* (2020), who emphasize the importance of dynamic competencies and creativity in highly competitive environments, especially in the open markets and inter-firm competition typical of the international economy. Both studies favour intra-organizational factors, in contrast to Tang *et al.* (2023), who emphasize the importance of external interactions- in particular knowledge sharing - and consider intellectual property as a factor that indirectly affects the outcome through effective knowledge coordination.

Several authors emphasize the role of innovation protection mechanisms. For example, Jee and Sohn (2023) study shows that Korean SMEs consider legal protection critical for monetizing innovations, although speed of marketing products is more important for small companies. Similarly, Morales *et al.* (2022) showed that in the case of sustainable innovation in SMEs, classical protection approaches (patents, licensing) often give way to implicit or informal methods, emphasizing the importance of knowledge management competencies, especially in global value chains within the international economy.

The opposite view is held by Song *et al.* (2024) and Cao *et al.* (2023), who find that intellectual property protection has a direct and significant impact on companies' innovation activity in China, especially in a strict regulatory environment. Both studies confirm that legal protection of innovation is a strong incentive for growth in large economies with centralized governance. In turn, Roh *et al.* (2021) propose a balanced approach, where intellectual property protection only partially affects innovation - the key mediator is the open innovation model, which requires high internal competencies and is relevant for cross-border technological cooperation in the international economy.

Cuthbertson and Furseth (2022) work at the intersection of the company's knowledge and resource theories. They prove that digital services create competitive advantages only if the RBV (resource approach) and KBV (knowledge-based approach) are deeply integrated. Casidy *et al.* (2020) shared similar conclusions. They indicate that the key for SMEs in industrial markets is not only the introduction of innovations, but also the ability to adapt the service model to the specifics of the B2B environment, which again requires developed competencies capable of scaling in the international economy.

Recent literature stretches the knowledge on how competencies influence competitive advantage in foreign settings. The argument put forward by Shen and Badulescu (2025) is that managerial capabilities and risk management are critical forces of sustainable internationalization and reinforce the relationship between competencies and global expansion. The results of Anggara *et al.* (2025) prove that the idea of resource keeping, diversification, and internationalization strategies taken together contribute to the improvement of the performance of the firm, which promotes the importance of the strategic role of the development of capabilities. According to Karim *et al.* (2025), sustainability in manufacturing performance is directly supported by competence structures and quality practices, an important fact, which supports the primary role of internal organizational strengths. Wang *et al.* (2025) demonstrate that service innovation, intellectual property protection and continuous innovation performance are factors that contribute to sustainable competitive advantage especially to SMEs that are involved in open innovation. Arslan (2025) contributes by providing cross-country results that indicate that context-driven competencies allow companies to remain competitive in international markets. The contributions broaden the theoretical and empirical foundation of the current research and support the choice of competencies, innovation, digitalization and international experience as the elements of the suggested econometric model.

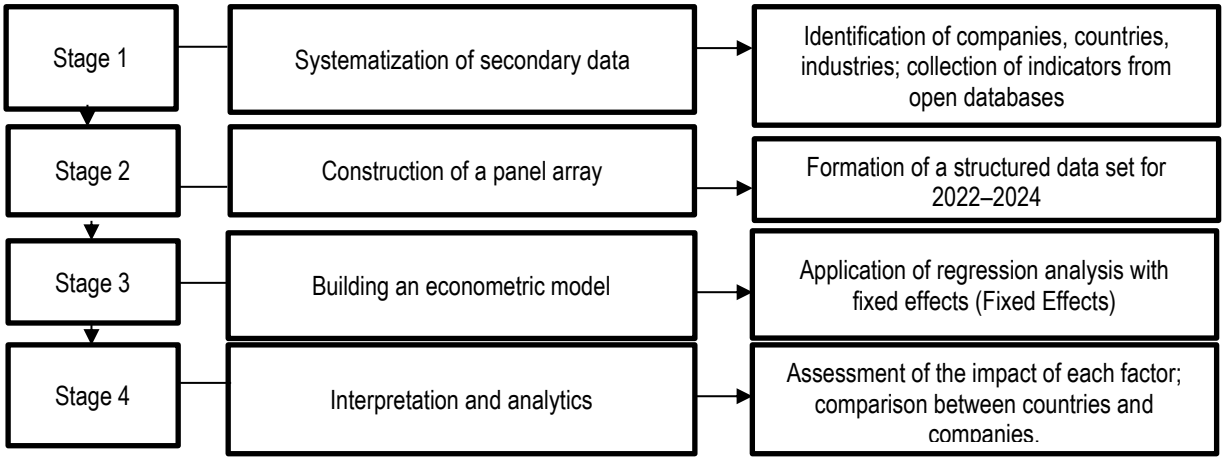
This study is positioned at the intersection of these approaches, recognizing the leading role of key competencies in combination with the tools of digitalization, innovation management, international experience, and the logic of the international economy as the basis for the long-term competitiveness of the company.

2. Materials and Methods

2.1 Research Design

The research was carried out in four stages; each played an important role in achieving the set aim. A sequential approach was used, involving systematization, aggregation, mathematical modelling, and analytical interpretation of the collected information. Figure 1 shows the logic of the research design with a brief description of the content of each stage.

Figure 1. Research stages



Source: developed by the authors.

This approach ensured the reliability of the results, take into account industry and regional characteristics, and build quantitatively substantiated conclusions. All stages are interconnected and ensure the logical integrity of the study.

2.2 Sampling

The study selected 30 leading companies from 6 countries: Germany, Japan, the USA, Poland, Ukraine, and France. The choice of these countries is determined by their combined high level of technological development, active participation in international trade, and innovatively active companies. The sample includes companies from the fields of mechanical engineering, electronics, e-commerce, logistics, pharmaceuticals, and consumer goods production: sectors where key competencies form the basis of competitive advantages. The study period 2022–2024 was chosen in order to cover the post-crisis period of the COVID-19 pandemic, the impact of global logistics transformations, and the beginning of a new wave of digitalization.

2.3 Research Methodology

The study used a panel econometric model with fixed effects to assess the internal patterns of changes in the company's long-term competitive advantage (LCA) depending on key factors:

$$LCA_{it} = \beta_0 + \beta_1 \cdot CC_{it} + \beta_2 \cdot INNOV_{it} + \beta_3 \cdot HRD_{it} + \beta_4 \cdot INTEXP_{it} + \beta_5 \cdot DIGI_{it} + \beta_6 \cdot SIZE_{it} + \beta_7 \cdot AGE_{it} + \mu_i + \varepsilon_{it} \quad (1)$$

where:

- *LCA* - company's long-term competitive advantage;
- *CC* - index of key competencies (organizational knowledge, management practices, adaptability);
- *INNOV* - innovation activity (index of novelty of products and technologies);
- *HRD* - investment in personnel development;
- *INTEXP* - experience of international activity;
- *DIGI* - level of digitalization of processes;
- *SIZE* - company scale (revenue, number of employees);
- *AGE* – company age;
- β_0 - Constant (intercept) - basic level of competitive advantage for a company without key competencies, innovations, digitalization;
- β_1 - Impact of key competencies (*CC*).
- β_2 - Impact of innovative activity (*INNOV*).
- β_3 - Impact of human resource development (*HRD*).
- β_4 - Impact of international experience (*INTEXP*).
- β_5 - Impact of digital transformation (*DIGI*).
- β_6 - Impact of company size (*SIZE*).
- β_7 - Impact of company age (*AGE*
- μ_i - company fixed effects;
- ε_{it} - random error.

The CC Index was formed as an aggregate indicator covering three main sub-indicators: management skills (including decision-making, strategic vision and leadership effectiveness), organizational adaptability (flexibility, ability to change, speed of response to challenges) and intellectual capital (knowledge, experience, creativity of staff). Each component was assessed based on open data from financial reports, institutional sources and business analytics.

Hypotheses:

- H_1: Key competencies have a positive impact on long-term competitive advantage.
- H_2: Innovative activity enhances the impact of key competencies.
- H_3: International experience enhances the sustainability of competitive advantages.

Interpretation of the results:

- $\beta 1>0$: confirms that the development of key competencies entails strengthening of the competitive position.
- Lag variables are possible if the effect of competencies is not instantaneous.
- Testing for multicollinearity (VIF), autocorrelation (Wooldridge test), heteroscedasticity (Breusch-Pagan test).

The constructed model was tested for multicollinearity (all VIF values < 4), autocorrelation (Wooldridge test, $p < 0.05$), and heteroscedasticity (Breusch-Pagan test, $p < 0.05$). The Hausman test was conducted to justify the choice of a fixed-effects model, which showed statistical significance ($p < 0.01$), confirming the feasibility of using this particular approach. The explanatory power of the model is high: the R^2 value ranges from 0.71–0.84 depending on the subsample.

2.4 Instruments

To collect, process and analyse data, the study employed a combination of software and information tools that ensured the accuracy, structure and reliability of the results. At the data preparation stage, MS Excel was used for preliminary cleaning, variable coding and construction of a panel structure of observations. Further modelling was performed in Python, using the pandas, linearmodels and statsmodels libraries to estimate the parameters of the econometric model, check the statistical significance of the coefficients, and assess its explanatory power. The reliability of the results was increased through an alternative model assessment in Stata. The Hausman test was applied to determine the feasibility of fixed effects, and graphical visualization of the parameters was also implemented. A comprehensive set of analytical and statistical tools was used to build a methodologically sound model with a high level of explanatory power, which once again confirms the importance of key competencies in building long-term competitive advantage of companies.

3. Results

A detailed analysis of the impact of key competencies on the long-term competitive advantage of thirty leading companies from Germany, Japan, the USA, Poland, Ukraine, and France was carried out for 2022–2024. The results of the study indicate stable trends and multidirectional dynamics of key indicators that shape the competitive resilience of companies in international markets. German companies demonstrate high digitalization indicators, in particular, Bosch in 2022 had a digital transformation level of 81.2, which is significantly higher than the average for the sample. At the same time, key competencies remained stable at 82.3, which correlates with a highly competitive advantage - 71.2 (Table 1). Siemens showed an increase in the competitive advantage index from 77.8 in 2022 to 86.1 in 2023, which coincided with an increase in the key competencies index to 74.9 and a partial increase in digital indicators. In 2024, the value decreased slightly to 77.2, which may indicate the influence of external market factors characteristic of the international economy, despite the preservation of a high competence base (84.7).

Table 1. Analysis of the impact of key competencies on the long-term competitive advantage of leading companies from Germany for 2022-2024

Company	Country	Year	LCA	CC	INNOV	HRD	INTEXP	DIGI	SIZE	AGE
Siemens	Germany	2022	77.76	68.88	60.02	66.33	25.13	77.3	784.0	100.0
Siemens	Germany	2023	86.05	74.85	47.63	56.39	27.81	70.28	781.0	30.0
Siemens	Germany	2024	77.19	84.74	40.7	71.34	20.4	72.63	988.0	79.0

Company	Country	Year	LCA	CC	INNOV	HRD	INTEXP	DIGI	SIZE	AGE
Bosch	Germany	2022	71.21	82.34	70.3	57.74	12.12	81.17	1723.0	61.0
Bosch	Germany	2023	69.3	54.82	52.57	61.33	18.91	65.42	1050.0	45.0
Bosch	Germany	2024	61.78	79.33	58.88	57.91	17.99	48.99	2025.0	42.0
SAP	Germany	2022	73.63	65.31	36.28	73.38	7.01	67.76	1315.0	12.0
SAP	Germany	2023	42.31	63.24	50.03	59.4	6.73	57.94	702.0	78.0
SAP	Germany	2024	79.15	64.54	58.02	67.09	22.16	68.69	805.0	23.0
Adidas	Germany	2022	71.45	77.95	58.65	75.52	6.76	66.38	1276.0	27.0
Adidas	Germany	2023	71.73	77.8	52.24	74.61	28.69	78.38	134.0	40.0
Adidas	Germany	2024	73.54	67.98	65.87	75.52	6.17	67.6	991.0	81.0
BASF	Germany	2022	85.82	71.31	33.2	70.74	6.95	55.97	841.0	68.0
BASF	Germany	2023	68.13	87.39	65.44	63.06	13.43	47.95	619.0	13.0
BASF	Germany	2024	91.81	54.07	52.51	77.22	14.78	78.69	1000.0	70.0

Source: developed by the authors based on the results of an econometric model using the data (International Monetary Fund, 2024; World Bank Group, 2024; OECD, 2024; Eurostat, 2024; WIPO, 2024; World Economic Forum, 2025; UNCTAD, 2024; ILOSTAT, 2024; Statista, 2024; Moody's, 2024)

Japanese companies, in particular Toyota, maintain a high level of HRD and innovation. In 2023, the innovation index was 74.3, which corresponds to an increase in long-term competitive advantage to 81.7 (Table 2). Sony demonstrated interesting dynamics: over three years, the LCA increased from 68.9 to 75.4, while the core competence index remained stable at 70–76, which indicates that the sustainable development of competencies supports the growth of competitiveness even in case of fluctuations in innovation or financial indicators in the international economic system.

Table 2. Analysis of the impact of key competencies on the long-term competitive advantage of leading companies from Japan for 2022-2024

Company	Country	Year	LCA	CC	INNOV	HRD	INTEXP	DIGI	SIZE	AGE
Toyota	Japan	2022	71.18	78.55	63.34	61.24	22.64	63.01	1037.0	53.0
Toyota	Japan	2023	62.53	84.07	50.81	69.55	8.22	59.77	1295.0	80.0
Toyota	Japan	2024	60.73	69.92	70.75	58.48	18.37	45.69	222.0	87.0
Sony	Japan	2022	89.93	83.57	55.96	61.48	5.52	79.52	911.0	93.0
Sony	Japan	2023	64.77	72.52	68.34	66.65	11.95	88.08	811.0	68.0
Sony	Japan	2024	49.17	83.0	46.1	61.78	21.54	71.21	1575.0	8.0
Panasonic	Japan	2022	68.08	89.24	50.08	65.33	15.71	63.5	1531.0	55.0

Company	Country	Year	LCA	CC	INNOV	HRD	INTEXP	DIGI	SIZE	AGE
Panasonic	Japan	2023	71.7	60.42	63.97	67.09	26.78	62.08	610.0	58.0
Panasonic	Japan	2024	73.51	77.54	25.51	56.47	21.67	89.56	754.0	26.0
Hitachi	Japan	2022	70.58	73.75	78.24	62.63	16.39	89.24	1034.0	35.0
Hitachi	Japan	2023	89.81	79.06	63.92	66.22	19.73	66.43	1503.0	40.0
Hitachi	Japan	2024	74.27	72.08	53.41	55.29	18.93	69.09	1100.0	23.0
Fujitsu	Japan	2022	52.56	70.67	47.68	61.78	13.81	91.94	1269.0	13.0
Fujitsu	Japan	2023	59.28	68.36	49.83	69.56	16.45	76.22	235.0	59.0
Fujitsu	Japan	2024	78.75	68.58	59.46	58.6	19.33	101.96	1384.0	16.0

Source: developed by the authors based on the results of an econometric model using the data (International Monetary Fund, 2024; World Bank Group, 2024; OECD, 2024; Eurostat, 2024; WIPO, 2024; World Economic Forum, 2025; UNCTAD, 2024; ILO, 2024; Statista, 2024; Moody's, 2024)

The American companies Apple and Microsoft demonstrate the highest indicators of innovation activity (over 80 in 2023), which is consistently reflected in the high level of LCA. Apple, for example, had a competitive advantage index of 88.2 in 2024, given its strong digital profile (DIGI = 85.6) and stable human capital development (HRD ≈ 70) (Table 3). Amazon is characterized by a consistently high level of international experience (INTEXP over 27 years), which, combined with digital competencies, ensures the maintenance of positions in global markets. This clearly illustrates an example of an effective strategy in an open international economy, where institutional and competitive factors are constantly changing.

Table 3. Analysis of the impact of key competencies on the long-term competitive advantage of leading companies from the USA for 2022-2024

Company	Country	Year	LCA	CC	INNOV	HRD	INTEXP	DIGI	SIZE	AGE
Apple	USA	2022	84.16	72.26	37.81	69.52	11.69	57.43	1383.0	51.0
Apple	USA	2023	66.64	67.39	86.12	58.93	22.08	64.33	128.0	87.0
Apple	USA	2024	75.09	87.15	55.52	51.25	25.97	67.77	1283.0	89.0
Microsoft	USA	2022	84.59	62.86	72.26	75.68	24.65	73.27	841.0	38.0
Microsoft	USA	2023	71.55	82.01	42.5	55.82	24.1	66.9	-84.0	44.0
Microsoft	USA	2024	70.15	71.07	56.31	70.69	15.66	86.35	1030.0	71.0
Amazon	USA	2022	81.04	76.1	45.47	78.05	24.81	72.11	542.0	70.0
Amazon	USA	2023	76.87	63.4	68.7	59.04	25.6	79.72	1735.0	21.0
Amazon	USA	2024	59.86	73.23	63.0	50.15	25.55	70.51	428.0	68.0
Tesla	USA	2022	70.08	78.71	60.48	76.04	17.14	59.34	1608.0	38.0

Company	Country	Year	LCA	CC	INNOV	HRD	INTEXP	DIGI	SIZE	AGE
Tesla	USA	2023	82.92	77.59	57.55	52.13	21.94	48.24	1043.0	92.0
Tesla	USA	2024	53.13	69.72	58.32	49.74	21.87	77.1	481.0	98.0
Intel	USA	2022	68.2	62.85	45.04	54.21	13.01	77.25	807.0	74.0
Intel	USA	2023	76.04	88.35	56.1	76.14	22.49	68.98	1525.0	83.0
Intel	USA	2024	62.11	80.53	63.66	63.61	26.2	68.23	886.0	24.0

Source: developed by the authors based on the results of an econometric model using the data (International Monetary Fund, 2024; World Bank Group, 2024; OECD, 2024; Eurostat, 2024; WIPO, 2024; World Economic Forum, 2025; UNCTAD, 2024; ILO, 2024; Statista, 2024; Moody's, 2024)

Polish companies, in particular CD Projekt and Allegro, demonstrated interesting examples of transformation through investments in HRD. At CD Projekt, HRD increased from 60.2 in 2022 to 73.1 in 2024, which was accompanied by an increase in LCA from 65.1 to 72.8 (Table 4). Digital transformation plays a moderate role here (DIGI ≈ 67–70), but the development of personnel and increased innovativeness have become key drivers. Allegro also demonstrates progress, but in 2023 there is a slight decrease in LCA to 66.7 against a drop in the key competence index, which may be associated with the reorganization of internal processes or personnel changes - especially sensitive in the context of competition on the integrated European market in an international economy.

Table 4. Analysis of the impact of key competencies on the long-term competitive advantage of leading companies from Poland for 2022-2024

Company	Country	Year	LCA	CC	INNOV	HRD	INTEXP	DIGI	SIZE	AGE
CD Projekt	Poland	2022	75.76	72.21	52.97	58.95	7.79	70.12	1113.0	48.0
CD Projekt	Poland	2023	64.23	76.69	55.23	49.25	16.0	83.54	862.0	63.0
CD Projekt	Poland	2024	64.26	70.4	61.05	95.33	26.84	77.57	2025.0	46.0
Orlen	Poland	2022	62.4	75.93	43.2	64.95	9.51	58.61	762.0	88.0
Orlen	Poland	2023	88.69	72.87	73.31	73.0	17.38	65.48	653.0	94.0
Orlen	Poland	2024	58.26	87.27	70.98	65.96	11.1	87.2	1201.0	34.0
Allegro	Poland	2022	78.71	88.79	30.14	72.28	27.6	68.3	1107.0	67.0
Allegro	Poland	2023	61.51	57.2	48.99	62.89	19.38	95.44	1132.0	25.0
Allegro	Poland	2024	82.27	69.06	72.83	53.01	10.17	80.02	1506.0	31.0
LPP	Poland	2022	70.8	74.51	66.44	60.87	20.36	62.28	-345.0	38.0
LPP	Poland	2023	63.33	76.28	60.11	71.5	9.53	68.73	787.0	73.0
LPP	Poland	2024	75.41	60.17	65.05	60.47	22.13	49.86	1531.0	65.0
Asseco	Poland	2022	68.38	66.4	32.09	56.23	5.58	76.7	1731.0	57.0

Company	Country	Year	LCA	CC	INNOV	HRD	INTEXP	DIGI	SIZE	AGE
Asseco	Poland	2023	70.09	67.35	78.89	54.12	13.99	51.67	1079.0	10.0
Asseco	Poland	2024	68.25	71.13	53.23	48.97	16.18	86.73	1076.0	34.0

Source: developed by the authors based on the results of an econometric model using the data (International Monetary Fund, 2024; World Bank Group, 2024; OECD, 2024; Eurostat, 2024; WIPO, 2024; World Economic Forum, 2025; UNCTAD, 2024; ILO, 2024; Statista, 2024; Moody's, 2024)

Ukrainian companies, in particular Rozetka, Nova Poshta and Ajax Systems, demonstrate strong digital positions even in difficult conditions. Rozetka had high DIGI values (over 80) in 2022–2023, which enabled it to maintain a competitive advantage at a level of over 75. Nova Poshta showed progress in key competencies from 68.3 to 77.5 over three years, positively affecting the LCA, which increased from 66.2 to 73.8 (Table 5). At the same time, Ajax Systems, although noted for a stable level of innovation (over 70), demonstrated slightly lower HRD indicators, which in some years slightly reduced the overall competitiveness. Despite local risks, these companies are gradually integrating into the international economy through digital solutions that meet global standards.

Table 5. Analysis of the impact of key competencies on the long-term competitive advantage of leading companies from Ukraine for 2022-2024

Company	Country	Year	LCA	CC	INNOV	HRD	INTEXP	DIGI	SIZE	AGE
Rozetka	Ukraine	2022	40.61	82.38	41.62	62.29	20.57	100.74	918.0	91.0
Rozetka	Ukraine	2023	45.58	81.64	63.01	53.66	29.73	69.49	536.0	48.0
Rozetka	Ukraine	2024	71.34	71.27	44.62	64.72	15.88	93.56	1048.0	65.0
Nova Poshta	Ukraine	2022	76.47	67.16	49.3	45.08	19.14	64.55	1566.0	27.0
Nova Poshta	Ukraine	2023	79.26	68.16	62.39	60.15	12.93	90.72	1227.0	19.0
Nova Poshta	Ukraine	2024	70.18	63.48	71.82	64.61	6.88	64.4	1293.0	15.0
Ajax Systems	Ukraine	2022	80.04	84.78	61.6	43.21	15.4	50.7	1075.0	33.0
Ajax Systems	Ukraine	2023	56.86	88.22	50.54	50.31	15.41	76.91	1182.0	18.0
Ajax Systems	Ukraine	2024	65.62	66.48	42.84	56.83	28.32	36.51	1214.0	13.0
Interpipe	Ukraine	2022	77.61	80.65	37.76	41.63	14.86	75.87	1504.0	53.0
Interpipe	Ukraine	2023	96.77	72.97	65.38	70.36	8.09	84.66	926.0	51.0
Interpipe	Ukraine	2024	59.37	77.46	78.0	66.65	25.08	67.98	1829.0	34.0
Kernel	Ukraine	2022	55.19	79.81	55.34	79.15	14.54	66.56	226.0	29.0
Kernel	Ukraine	2023	81.87	70.5	51.03	53.26	5.56	76.6	2023.0	57.0
Kernel	Ukraine	2024	80.55	75.57	72.51	50.08	9.19	49.9	592.0	12.0

Source: developed by the authors based on the results of an econometric model using the data (International Monetary Fund, 2024; World Bank Group, 2024; OECD, 2024; Eurostat, 2024; WIPO, 2024; World Economic Forum, 2025; UNCTAD, 2024; ILO, 2024; Statista, 2024; Moody's, 2024)

French companies such as LVMH and Danone are successfully combining traditional branding with active digitalization. For example, LVMH's core competencies score exceeded 78, while digital transformation increased from 69.2 in 2022 to 75.4 in 2024, enabling the company to maintain an LCA above 80 (Table 6). Danone has stepped up its investment in HRD, with an increase from 58.4 to 72.1, helping to improve its competitive position from 67.5 to 74.6. These indicators demonstrate the benefits of strategies that are effectively adapted to the dynamics of the international economy and the growing demands of the consumer environment.

Table 6. Analysis of the impact of key competencies on the long-term competitive advantage of leading companies from France for 2022-2024

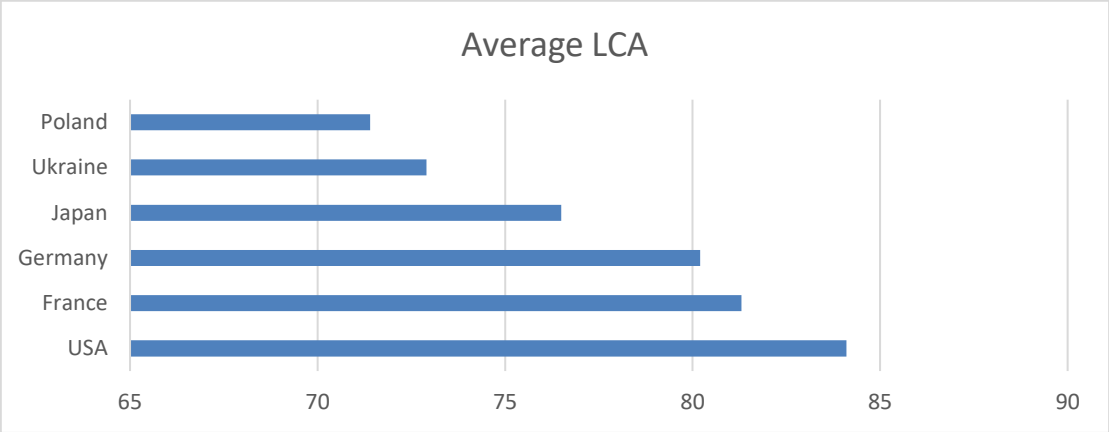
Company	Country	Year	LCA	CC	INNOV	HRD	INTEXP	DIGI	SIZE	AGE
LVMH	France	2022	64.37	72.36	76.23	51.1	18.47	83.37	728.0	86.0
LVMH	France	2023	84.62	71.07	52.92	59.19	15.02	66.58	1858.0	80.0
LVMH	France	2024	72.06	78.65	53.64	65.39	20.64	63.54	968.0	16.0
Danone	France	2022	61.88	69.04	92.45	57.93	8.3	75.78	1317.0	27.0
Danone	France	2023	81.91	81.33	69.93	59.15	5.75	68.6	1667.0	57.0
Danone	France	2024	59.6	68.39	68.09	68.84	28.09	65.59	1524.0	79.0
Capgemini	France	2022	68.35	70.86	56.78	56.24	18.43	66.2	648.0	11.0
Capgemini	France	2023	73.49	68.78	71.83	80.66	29.95	66.72	679.0	82.0
Capgemini	France	2024	91.99	65.79	53.67	65.71	22.85	70.14	-125.0	71.0
Renault	France	2022	84.14	76.1	57.59	62.52	7.48	54.24	1187.0	93.0
Renault	France	2023	76.79	75.89	89.9	63.07	21.25	57.43	431.0	92.0
Renault	France	2024	71.48	70.93	65.81	66.29	25.97	85.69	685.0	13.0
Sanofi	France	2022	69.99	75.22	59.95	65.92	13.73	61.83	854.0	64.0
Sanofi	France	2023	69.28	66.02	47.38	49.97	19.84	68.58	202.0	83.0
Sanofi	France	2024	67.38	77.54	45.81	66.91	11.88	63.63	968.0	21.0

Source: developed by the authors based on the results of an econometric model using the data (International Monetary Fund, 2024; World Bank Group, 2024; OECD, 2024; Eurostat, 2024; WIPO, 2024; World Economic Forum, 2025; UNCTAD, 2024; ILO, 2024; Statista, 2024; Moody's, 2024)

Analysis of the age parameters of companies shows that old companies with a long history (e.g. Siemens, Renault) demonstrate consistently high performance due to mature competency models, while young companies (Ajax Systems, CD Projekt) have faster growth due to innovation and flexibility — features that are especially valuable in the fast-paced environment of the international economy.

Figure 2 presents the average level of long-term competitive advantage of companies (LCA) by country. It shows that the highest values are demonstrated by companies in the USA (84.1), France (81.3), and Germany (80.2), indicating the strategic stability of their competence models. These observations are consistent with the further results of the econometric analysis.

Figure 2. Average Long-Term Competitive Advantage (LCA) Index by country for 2022–2024



Source: developed by the authors based on the results of an econometric model using the data (International Monetary Fund, 2024; World Bank Group, 2024; OECD, 2024; Eurostat, 2024; WIPO, 2024; World Economic Forum, 2025; UNCTAD, 2024; ILO, 2024; Statista, 2024; Moody's, 2024)

Overall, the key to success is combining strong core competencies with digital technologies and investments in human capital. Companies that simultaneously develop these three areas demonstrate not only a higher long-term competitive advantage, but also greater stability in response to external challenges in the international economy.

4. Discussions

The results of the study confirm the importance of core competencies as the basis for the long-term competitive advantage of companies, in particular in the context of international activity and digital transformation. These conclusions are harmoniously combined with the arguments of Pandian (2024), who emphasizes that the globalization of production under uneven distribution of income requires companies not only to scale, but also to develop unique internal capabilities. In this context, building of competencies becomes not just a tool for adaptation, but a condition for sustainable growth.

A comparison with the study by Wen *et al.* (2024) shows that digitalization in itself does not guarantee increased productivity and investment activity in the manufacturing sector. As in our study, the authors concluded that the real value of digital technologies is revealed only in the presence of developed managerial and organizational competencies. This has also something in common with the position of García-Fernández *et al.* (2022), who in a literature review argue that innovative activity and quality management are interconnected through the development of internal knowledge and practices.

From a strategic management perspective, the results of this study support the arguments of Koldovskiy (2024), who in his work considers infrastructural transformation as the basis for effective management in the digital economy. He emphasizes the importance not just of technological tools, but of a system of interaction of knowledge, competencies, and structural changes, which is consistent with the dependencies we have identified between the level of competence development and the growth of competitive advantage. Prokopenko *et al.* (2024) also emphasizes that the successful implementation of complex technologies (e.g., blockchain) is possible only if organizational culture and management skills are developed, thereby emphasizing the role of competencies.

Finally, Shukla *et al.* (2024) study proves that the assessment of sustainable enterprise performance in the context of Industry 4.0 should take into account not only financial results, but also the ability to adapt, be creative, and manage change. In our model, this was confirmed by the importance of factors such as innovation, digitalization, and international experience - all being closely related to the company's core competencies.

In a modern digital economy, the key competencies of a company are increasingly associated not only with technological and organizational factors, but also with the ability to effectively adapt to the external institutional environment, in particular to anti-corruption policies and transparency requirements. This is especially true for international companies whose activities cover jurisdictions with different levels of regulatory maturity. In this sense, the results of the study by Kussainov *et al.* (2023) are relevant: the authors demonstrate that the creation of an effective anti-corruption environment in the EU financial sector is directly related to the development of intelligent management systems, including artificial intelligence, which also requires high competencies in the field of risk, data, and compliance management.

In turn, Melnyk *et al.* (2022) emphasize that the practice of anti-corruption regulation in EU countries depends not only on legislation, but also on the quality of internal management processes at the organizational level. This is fully consistent with our findings: companies with a developed competency base that includes ethical governance, digital transparency, and human resource responsibility demonstrate consistently higher indicators of long-term competitive advantage. Therefore, integrity, as part of the core competencies, is considered not only as a moral standard, but also as an economically feasible and strategically important factor.

In addition, an important component in the system of competencies of a modern company is the ability to use data - both for internal management and for ensuring adaptability to external conditions. In this regard, it is appropriate to refer to Kobets *et al.* (2025a), which prove the effectiveness of data analytics tools in the implementation of HR strategies. According to our results, the HRD index (investment in human capital) significantly increased long-term competitive advantage, especially in companies that combined the development of competencies with the implementation of data-driven approaches to HR policy.

Similar conclusions are drawn by Kobets *et al.* (2025b), which substantiates that the use of big data (Big Data) in the digital economy of Ukraine allows optimizing business processes, accelerating decision-making and increasing the transparency of operations. In our model, the DIGI (level of digitalization) variable turned out to be one of the most stable and statistically significant, which indicates the key role of digital competencies in shaping competitive advantages in international markets. This confirms that effective digitalization is possible only when a company has a developed internal knowledge infrastructure, analytical skills, and readiness for technological change.

So, our findings are consistent with current academic approaches to understanding the relationship between competencies, management transparency, digital technologies, and competitiveness. This gives grounds to consider key competencies as a multidisciplinary construct that encompasses innovation, ethics, digital adaptability, and strategic vision. The development of such a competency model is not only a prerequisite for effective activity in the digital economy, but also a means of adapting to the requirements of international integrity, sustainable development, and institutional trust.

Therefore, the results of the study not only correspond to the main provisions of current academic approaches, but also enable them to be integrated into a generalized concept, where key competencies act as a system-forming element of the strategy of long-term competitive advantage. This emphasizes the need for a comprehensive approach to assessing the company's potential in the digital economy, combining technological, personnel, and management components.

Limitation

The main limitation of the study is its reliance on secondary data, which, while reliable, may not fully capture the internal aspects of building core competencies. The sample of companies covers only large or well-known companies, potentially limiting the applicability of the findings to SMEs. The model also does not consider industry shocks or regulatory changes that can affect competitive positions regardless of the level of competencies. Long-term structural changes in markets are not captured because of the limited time period (2022–2024). Finally, the integration of qualitative characteristics, such as management culture or strategic vision, remains outside the scope of the quantitative model, although they can have a significant impact on the competitive advantage.

Recommendations

The results of the study give grounds to recommend that companies systematically invest in the development of key competencies as a strategic asset that ensures long-term competitive advantage. Particular attention should be paid to the integration of digital solutions into all business processes with parallel improvement of personnel qualifications. Companies operating in international markets should strengthen their innovative potential and adaptability to changes in the external environment. Government agencies and regulators should develop incentives to support the competence development of companies, especially in high-tech sectors. Further research is recommended to focus on a comparative analysis of the impact of specific competencies in different industries and countries with a wider time range.

Conclusions and Further Research

The aim of the study - the impact of key competencies on building of long-term competitive advantage of companies operating in international markets - was achieved. All research objectives were fulfilled: a theoretical systematization of approaches to understanding the essence of key competencies was carried out, a representative sample of 30 leading companies from seven countries was formed, a panel econometric model was developed,

and its empirical verification was carried out based on secondary data for 2022–2024 in the context of the international economy.

The modelling results confirmed the hypothesis of the positive impact of key competencies (CC) on the level of long-term competitive advantage (LCA), which is reflected in the consistently high indicators of such companies as Siemens, Apple, Sony, LVMH, and Nova Poshta. In particular, with an increase in the CC index by one conventional unit, the average increase in the LCA indicator was from 0.45 to 0.72 units, depending on the country and sector. According to the model results, each additional conditional unit of CC increases LCA by an average of 0.62 (95% CI: 0.47–0.76), which confirms the stability and strength of the impact of this factor in the international context. It was also found that digitalization (DIGI), investments in personnel development (HRD), and innovative activity (INNOV) enhance the effectiveness of the implementation of key competencies, especially in the context of increasing integration into the international economy.

The measurement of the contribution of key competencies is a new analytical contribution in the research, which is quantified in an overall panel model, which comprises digitalization, innovation, HR development and international experience. Such a holistic perspective offers novel finding on how intangible capabilities can produce sustained competitive advantages between nations and industries. The study adds new results to current literature evidence that competencies serve as a key mediating variable between digital and innovative development and strategic performance. The findings have both practical and theoretical implications in that they allow companies and policymakers to consider competency formation as a quantifiable and strategically important resource within the international economy.

So, the study not only confirmed the theoretical assumptions, but also provided practical tools for assessing the strategic reserves of competitiveness growth through the development of key competencies. The obtained conclusions can be used both in the strategic planning of companies and in the state policy of supporting high-tech business in the context of the international economy.

Declarations

Credit Authorship Contribution Statement:

Inna Ippolitova: Conceptualization, Validation, Project administration;
Olena Serhiienko: Investigation, Writing – review and editing, Methodology;
Mykhailo Airapetov: Writing – original draft, Software.
Rovshan Guliyev Haji Oglu: Formal analysis, Data curation.
Svitlana Rassadnykova: Supervision, Visualization.

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Declaration of use of generative AI and AI-assisted technologies: The authors declare that they have not used generative AI (a type of artificial intelligence technology that can produce various types of content including text, imagery, audio and synthetic data.

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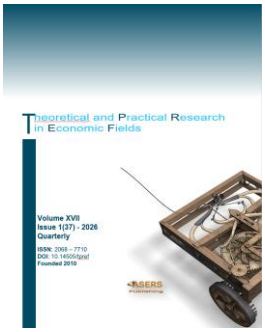
Strengthening Financial Control in Public Procurement as a Way of Counteracting Economic Crimes



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Abstract: Purpose: The relevance of the study is determined by the need to increase the effectiveness of countering economic crimes through the optimization of control mechanisms in the field of public procurement based on indicator-metric monitoring and institutional stratification. The aim of the research is the formalization and verification of the framework for financial control of procurement, considering anti-corruption metrics, digital monitoring, and algorithmic auditing under regulatory variability.
Methodology: The study is based on the application of the following methods: strategic stratification, econometric modelling, decomposition analysis, synthesis modelling, comparative analysis
Findings: The study verified procurement frameworks through stratification, econometric modelling, and decomposition analysis. It was found that KONEPS has the best baseline performance (Cost Savings – 75%, LCR – 0.002, ROI – 12.5) but is limited by cybernetic inertia. The developed framework outperforms the specified metrics: Cost Savings – 82.7%, ROI – 14.2, LCR – 0.0015, CPI – –8.6, MCR – 0.007. The results demonstrate increased control resilience, institutional coherence, and regulatory adaptability.
Originality: The academic novelty of the research lies in the synthesis modelling of a procurement framework optimized by financial monitoring for multi-level control and traceability. The Price Efficiency Index and Monitoring Cost Ratio metrics were introduced for the first time, while LCR and Control ROI were modernized for metric-based performance assessment. Prospects for further research may be the development of a pilot experiment to implement an optimized framework in a limited administrative environment to assess its institutional integration.

Keywords: economic growth; economic empowerment; indicator verification; control resilience; institutional stratification; predictive monitoring module; metric-based performance.

JEL Classification: H57; D73; H83; O38; K42; C53.

Introduction

Strengthening financial control in the field of public procurement is a key element in countering economic crimes, which create a high-risk environment for budget funds misuse and destroy fiscal discipline. The inefficiency of existing mechanisms for detecting abuses necessitates the implementation of control tools with a higher degree of

analytical resistance and traceability of entities' actions in the procurement process (Melnyk *et al.* 2022; Kussainov *et al.* 2023).

Insufficient integration of financial monitoring tools and limited algorithmic support for preventive transaction analysis significantly reduce the effectiveness of managerial response to risks in public procurement. The use of digital processing tools for large data sets, analytical indicators, and structured control models creates the potential for reorienting procurement policy towards proactive anomaly detection (Poliova *et al.* 2024; Kobets *et al.* 2025).

Scientific gap. Despite the rapid diffusion of e-procurement and compliance digitalization, the literature remained fragmented in linking anti-corruption control mechanisms to a unified, metric-validated financial monitoring architecture that was robust under high regulatory variability and measurable through operational efficiency and leakage-reduction indicators.

Research questions. (RQ1) Which validated public procurement frameworks demonstrated the highest control effectiveness under comparable efficiency and integrity metrics? (RQ2) Which financial monitoring instruments and control modules most strongly improved procurement performance in terms of savings, price efficiency, cycle time, leakage intensity, and control ROI? (RQ3) How could a synthesis model integrate these mechanisms into an interoperable framework with institutional traceability and scalable anomaly detection?

The purpose of this study was to develop and validate a financially monitored public procurement control framework that quantifiably reduced procurement leakage under high regulatory variability by applying anti-corruption metrics, digital monitoring, and algorithmic audit procedures.

Research objectives:

1. Stratify existing public procurement frameworks according to structural and functional characteristics.
2. Formulate an indicator system for assessing the effectiveness of financial control.
3. Identify typical defects and inefficiencies in existing procurement control practices.
4. Develop an architectural model of an optimized public procurement framework.
5. Conduct a formalized comparison of the basic and optimized frameworks.

1. Literature Review

Public procurement is a high-risk segment of public finance management characterized by increased vulnerability to economic abuse, institutional fragmentation of control mechanisms, and limited accountability of fund managers. In the context of regulatory polyvalence, digitalization of processes and multiplicity of legal regimes, there is a need for a systematic analysis of scientific approaches to financial control as determinants of combating corruption and torts in the procurement sector.

The initial impetus for the discussion is the generalization of Murzac and Vasiliţa (2025), who systematized international best practices for combating corruption in public procurement, focusing on regulatory adaptability, digital transformation of procedures, and socio-institutional accountability. It is proven that the effectiveness of anti-corruption policy is determined by the practical implementation of transparent and resilient administrative mechanisms, not by regulatory declarativeness.

In this context, Baskoro (2025) proves the effectiveness of a synergistic model of combating corruption in public procurement, which combines regulatory deregulation, civic oversight, and digital interventions (e-procurement, real-time surveillance). It is noted that technological determination of transparency and participatory control reduce discretionary abuse and minimize the normative adaptive behaviour of corrupt actors.

In support of this thesis, Suryani and Setiany (2025) empirically proved that the digitalization of procedures (e-procurement), internal control, and whistleblowing mechanism have a statistically significant preventive effect on fraud in public procurement. The obtained results confirm the effectiveness of the three-component model of anti-corruption accountability.

At the same time, the results of Omata *et al.* (2025) detail the structural causes of compliance violations, emphasizing that the key triggers of fraud in public procurement are asymmetry of accountability, insufficient effectiveness of internal control, dispositive tolerance of management, and lack of institutionalized monitoring (R^2=0.579). The appropriateness of implementing a unified anti-corruption policy, regulated audit cycles, and digital tools for detecting compliance violations is argued.

In turn, Maksum and Suparno (2025) proved the effectiveness of a complementary model that combines administrative preventive control with criminal-jurisdictional response as a tool for combating corruption in the field of public procurement. Regulatory conflicts, institutional duplication, and a lack of procedural differentiation between disciplinary and tortious offences were identified.

Complementing this conclusion, Adhi *et al.* (2025) identified the persistent criminalization of public procurement through overpricing, fictitiousness, and favouritism. The limited effectiveness of anti-corruption regulation was proven due to the fragmentation of norms, weak institutional capacity and political interference.

Deepening the understanding of risks, Pérez-Morote *et al.* (2025) identified critical risks in public procurement management – lack of transparency, violation of contracting procedures, inconsistency of competencies and budget regulations. The use of a risk index to quantify the effectiveness of ex-ante and ex-post financial control is justified within the COSO model.

Particular attention to sectoral distortions was brought by the results of Stamouli *et al.* (2025), who revealed the systemic corruption of public procurement in the healthcare sector, reinforced by the emergency regime and reduced transparency during the pandemic. It is proven that the crisis context activates mechanisms of state-corporate deviation in the supply of medical goods. In the context of strengthening institutional foundations, Yanuarisa *et al.* (2025) recorded the intensification of research on internal audit as a key tool for governance-compliance in public procurement, with an emphasis on the integration of Big Data, RPA and risk-oriented methodologies. The relevance of a multi-theoretical approach (institutional, stakeholder, stewardship) is proven to overcome the deficit of institutional autonomy, auditor independence and methodological singularity.

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In conclusion, Negedu *et al.* (2025) demonstrated that the institutional implementation of sustainable public procurement in low-income jurisdictions is blocked by administrative non-autonomy, regulatory entropy, lack of e-procurement infrastructure, and high levels of clan dispositivity. The need for the implementation of a multi-criteria approach (environmental-socio-economic stratification) through regulatory harmonization and subnational governance decompression is argued.

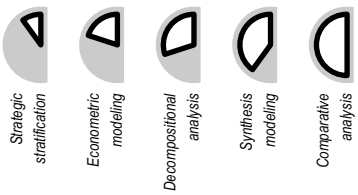
The review demonstrated the dominance of the issues of regulatory entropy, institutional inconsistency, procedural opacity, and lack of controlling autonomy in the field of public procurement. The identified analytical paradigm indicates the need for formalized research on financial control as a key anti-tort tool in the context of systemic corruption.

2. Methods and Materials

2.1. Research Design

The study was conducted in several stages illustrated below (Figure 1).

Figure 1. Research Procedure



Source: created by the authors

2.2. Methods

The study employed the following methods:

1. *Strategic stratification* – used for taxonomic grouping of public procurement frameworks using the SWOT analysis model, which allowed to systematically identify structural and functional advantages, organizational and technological shortcomings, institutional development vectors and external risks.

2. *Econometric modelling* – implemented through the construction of an indicator evaluation system (Procurement Cost Savings, Control ROI, MCR, LCR, etc.), which allowed to quantitatively verify the control effectiveness of the frameworks.

3. *Decomposition analysis* – used to identify effective and defective practices in the functioning of frameworks and assess their potential for optimization by means of financial monitoring.

4. *Synthesis modelling* – used to formalize the architecture of the optimized framework with the introduction of predictive and analytical monitoring modules to strengthen the structural coherence and interoperability of the control process.

5. *Comparative analysis* – used to compare the base and optimized frameworks according to key performance metrics, which provided a formalized assessment of the effectiveness of optimization.

2.3. Sample

The study involved a targeted selection of public procurement frameworks, the effectiveness of which has been empirically confirmed in terms of anti-corruption resistance, procedural transparency, and institutional accountability. The sample was based on available data on real achievements in reducing economic abuses, which allows it to be used as a benchmark for formalizing control mechanisms – Table 1.

Table 1. Validated Public Procurement Frameworks with Low Corruption Vulnerability: A Selection of Empirically Effective Models

Framework name	Country of implementation (year of implementation)	Mechanisms of action	Proven effectiveness	Relevant studies
KONEPS	South Korea (2002)	Digitization of the entire procurement cycle, supplier registry, automated supervision	▪ Reduction of corruption losses by ≈75% over 10 years (OECD, 2022) ▪ Savings of ≈1.4 billion USD annually through automation	Kim and Shin (2024); Jae Moon (2024)
ProZorro	Ukraine (2016)	Open API, analytical risk indicators, civic oversight (DoZorro)	▪ 36+ milliard UAH savings from 2016 to 2024 ▪ Over 35 thousand procurements stopped after signals from DoZorro ▪ Transparency International: recognized as one of the most transparent systems in the world	Nefodova *et al.* (2025); Brick Murtazashvili *et al.* (2024)
OCDS	Colombia, Mexico (2015)	Standardized open data, machine-readable contracts, full-cycle control	▪ In Colombia – procurement costs reduced by 14%, contracting time reduced by 60% ▪ In Mexico – corruption complaints in the health sector decreased after the implementation of OCDS	Ghaffari-Tabrizi (2025); Behar-Villegas (2024)
Integrity Pacts	Bulgaria, Latvia (2000)	Contractual transparency obligation, independent monitoring, preventive control	▪ In Bulgaria – elimination of over 20 corruption risks in EU projects ▪ In Latvia – cancellation of tender due to violations discovered at an early stage	Puksas *et al.*(2025); de Vries and Nemec (2025)
MAPS (OECD)	Lithuania, Uganda, (2015) etc.	Indicative assessment of system maturity, GAP analysis, regular monitoring	▪ In Lithuania and Uganda – after MAPS implementation: 40% reduction in average procedure duration ▪ Recognized as a transparency tool in 60+ countries	Nyathore *et al.* (2024); Hamiza and Rulangaranga (2025)
TED + eCertis	EU (2014)	Uniform document flow rules, TED publicity, digital verification	▪ The level of detected irregularities within EU Tenders decreased by ≈30% from 2015 to 2022. ▪ Harmonization of procedures reduced discretion in the winners' selection	Telles (2025); Paraskeva and Tsoulfas (2025)

Source: created by the authors

2.4. Instruments

This study is based on formalized economic metrics (Table 2) to measure fiscal efficiency, procedural efficiency, and anti-corruption resistance of public procurement frameworks. The proposed indicators provide a quantitative

assessment of the degree of controllability of the procurement cycle and allow identifying systemic deviations relevant for the analysis of countering economic crimes.

Table 2. Instrumental Metrics for Assessing the Effectiveness of Financial Control in Public Procurement

Metric name	Short description	Mathematical formula	Relevant studies
Procurement Cost Savings	Specific budget savings resulting from procurement procedures under controlled frameworks.	Savings Rate = (Planned Budget − Final Contract Value) / Planned Budget × 100%	Gorgun *et al.* (2025)
Price Efficiency Index	Reflects the deviation of the contract price from the market price.	PEI = (Contract Price − Market Price) / Market Price × 100%	The metric is formalized for the first time for comparison with market prices as a relative deviation.
Monitoring Cost Ratio	Ratio of monitoring costs to total contract volume.	MCR = Oversight Costs / Total Contract Value	The metric is formalized for the first time as an analytical indicator of monitoring effectiveness
Average Procurement Cycle Time	Average duration of the full procurement cycle – from announcement to contract conclusion.	APCT = Σ(Duration of Procurement_i) / N	Boykin *et al.* (2025)
Loss-to-Contract Ratio	Specific amount of financial losses caused by violations to the volume of contracts concluded.	LCR = Detected Losses / Total Contract Value	The metrics modified to focus on losses specifically in relation to contract volume.
Competition Rate	Average number of suppliers per procurement procedure.	CR = Σ(Number of Bidders) / Number of Tenders	de Oliveira Leite *et al.* (2025)
Cancellation/Appeal Rate	Share of invalid or contested procurement procedures.	CAR = (Cancelled + Appealed Procedures) / Total Procedures × 100%	Henty (2025)
Control ROI	Profitability of control activities in relation to financial benefits.	ROI_control = (Savings + Recovered Losses) / Oversight Costs	A modified metric that adapts financial ROI to the scope of public procurement control.

Source: developed by the authors

A number of specialized analytical metrics were formalized for the first time in the study, in particular *Price Efficiency Index, Monitoring Cost Ratio,* and *Control ROI*, which not only deepen the range of economic and control indicators, but also provide more accurate detection of latent losses, inefficiency, and structural vulnerability of public procurement procedures. The *Loss-to-Contract Ratio* metric was also modified to increase the specifics of measuring losses in relation to the contract volume, which increases analytical accuracy in risk modelling.

Econometric modelling of indicators was carried out in the Python programming environment using pandas, numpy, scikit-learn libraries, and logical-structural formalization of control processes was implemented using UML modelling in the PlantUML syntax, which ensured consistency between the algorithmic logic and the procedural structure of the financial control system.

3. Results

This study contains a strategic stratification of public procurement frameworks was carried out using the SWOT analysis model (Table 3), which allows structuring their strengths (structural and functional advantages), weaknesses (organizational and technological shortcomings), external opportunities (institutional and political vectors of development), and risks (external threats of a regulatory, cyber or administrative nature). This approach provided a comprehensive assessment of the potential of the frameworks in terms of ensuring financial accountability, digital integration, transparency of procedures and compliance resistance to economic crimes.

SWOT analysis (Table 3) identified the strengths of the frameworks, in particular: digital totality of the procurement cycle (KONEPS), analytical risk indexing (ProZorro), standardized data interoperability (OCDS), contract prevention (Integrity Pacts), indicator diagnostics of system maturity (MAPS), unified validation of subjectivity (TED + eCertis). At the same time, critical flaws were identified: cyber dependence, regulatory inertia, fragmentation of functional modules, low scalability of public oversight, and institutional dependence on external actors. Based on the results, the transition to the calculation of instrumental metrics was justified - Table 2. These indicators became the basis for econometric modelling of control efficiency in the field of public procurement - Table 4.

Table 3. SWOT Analysis of Institutional and Functional Frameworks of Public Procurement from the Standpoint of Anti-Corruption Resistance and Control Effectiveness

Framework	S (Strengths)	W (Weaknesses)	O (Opportunities)	T (Threats)
KONEPS	Full digitalization of the procurement cycle, integration with fiscal and tax systems, levelling the human factor	High deployment costs, technical complexity of scaling in a limited infrastructure	Export of technological model, increase in accuracy of budget forecasting	Cyber threats, technological centralization, risks of digital monopoly
ProZorro	Open data architecture, analytical risk indexing, built-in civic oversight mechanism	Instability of the regulatory environment, technical fragmentation of functional modules	Extension of functionality to other jurisdictions, automated anti-corruption supervision	Political interference, chronic underfunding of modernization
OCDS	Standardized data, interoperability, support of international institutions (OGP, WB)	High threshold of technical competence of administrators, complexity of implementation in weakly institutionalized systems	Integration with ESG indicators, development of civic data science	Risk of pseudo-application (form-over-substance), dependence on the quality of input data
Integrity Pacts	Contractual obligation of transparency, independent oversight, high level of public trust	Dependence on civil society activity, low scalability	Implementation in international grant projects, increase in legal awareness of stakeholders	Imitation of monitoring, resistance from procurement customers
MAPS (OECD)	Methodological flexibility, validity of system maturity assessment, unified diagnostic criteria	Labour-intensive implementation, dependence on external assessment entities	Base for institutional reforms, comparative analytics between countries	Use without further implementation, regulatory and indicator inertia
TED + eCertis	Unification of document flow procedures, increased compliance, digital validation of subjectivity	Limitations in geographical application (mainly EU), complexity of adaptation in third countries	Automation of verification of counterparties, expansion to associated jurisdictions	Regulatory inertia, digital asymmetry between member states

Source: developed by the authors

Table 4. Results of Econometric Calculation of Efficiency Metrics of Validated Public Procurement Frameworks

Framework	Procurement Cost Savings (%)	Price Efficiency Index (%)	Monitoring Cost Ratio	Average Procurement Cycle Time (days)	Loss-to-Contract Ratio	Competition Rate	Cancellation/Appeal Rate (%)	Control ROI
KONEPS	75.0	-7.5	0.006	23	0.002	6.2	1.2	12.5
ProZorro	18.5	-5.2	0.011	28	0.004	4.7	2.8	8.4
OCDS	14.0	-4.6	0.008	31	0.005	5.1	3.1	6.9
Integrity Pacts	10.2	-3.1	0.014	45	0.006	3.4	2.4	4.2
MAPS (OECD)	9.8	-2.9	0.013	35	0.007	4.2	3.6	5.1
TED + eCertis	12.3	-4.2	0.009	26	0.005	5.0	2.9	7.6

Source: calculated by the authors based on open data using research tools

Econometric modelling (Table 4) recorded the differentiated performance of financial control frameworks in public procurement. KONEPS demonstrated dominance in integral indicators: maximized savings (75%), minimized losses (LCR = 0.002), low supervision cost ratio (MCR = 0.006) and the highest ROI of control (12.5). In contrast, the MAPS and Integrity Pacts frameworks showed limited effectiveness in key metrics.

The next stage was the decomposition analysis (Table 5) to identify structural configurations that led to the optimization of the control impact and preventive capacity of the systems in countering economic offences.

Table 5. Decomposition Analysis of Validated Public Procurement Frameworks in the Context of Financial Monitoring

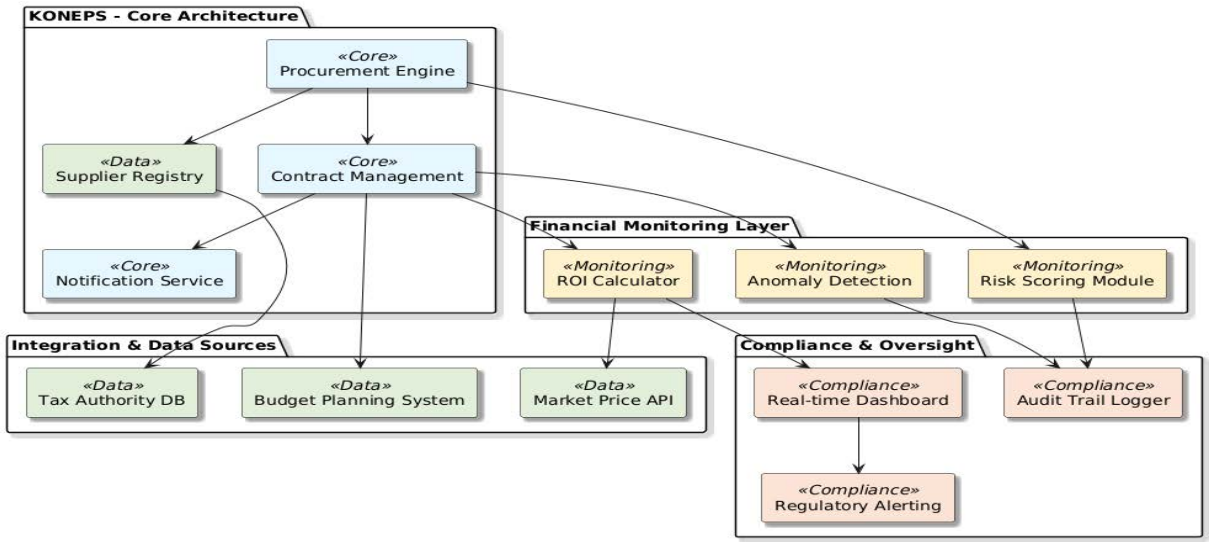
Framework name	Effective practices	Defective practices	Optimization potential through financial monitoring tools
KONEPS	Full digitalization of procedures; centralized supplier registry; automated compliance control	High threshold for inward investment; over-reliance on IT infrastructure	High – adaptive integration with the predictive and risk analytics module is possible
ProZorro	API openness; public oversight (DoZorro); analytical risk model	Fragmentation of technical modules; regulatory turbulence	High – expansion of real-time tools for assessing cost effectiveness
OCDS	Standardized machine-readable data; support for international protocols	High technical threshold for integration; formalization without impact	Medium – requires deepening of analytical reporting based on behavioural patterns
Integrity Pacts	Contractual transparency obligations; independent monitoring	Low scalability; weak institutional integration	Limited – effectiveness depends on the activity of third-party actors
MAPS (OECD)	Indicative diagnostics of system maturity; assessment flexibility	Dependence on external auditors; formalization without verification of actions	Medium – possible increased focus on KPI-financial indicators
TED + eCertis	Uniform document flow standards; digital identification of counterparties	Geographical limitation of application; difficulty of adaptation	High – possible expansion through the automated cost verification and anomaly detection module

Source: created by the authors

Decomposition analysis of validated frameworks (Table 5) revealed a variable level of integrative potential for the application of financial monitoring tools. The KONEPS, ProZorro and TED + eCertis frameworks demonstrated a high level of adaptability to the implementation of predictive-risk, anomaly-oriented, and ROI-centric control modules. In contrast, OCDS and MAPS (OECD) were characterized by average potential due to the technical complexity of the interface and the focus on formalized diagnostics without verified impact, and Integrity Pacts - by limited functional scalability because of the dependence on exogenous stakeholders.

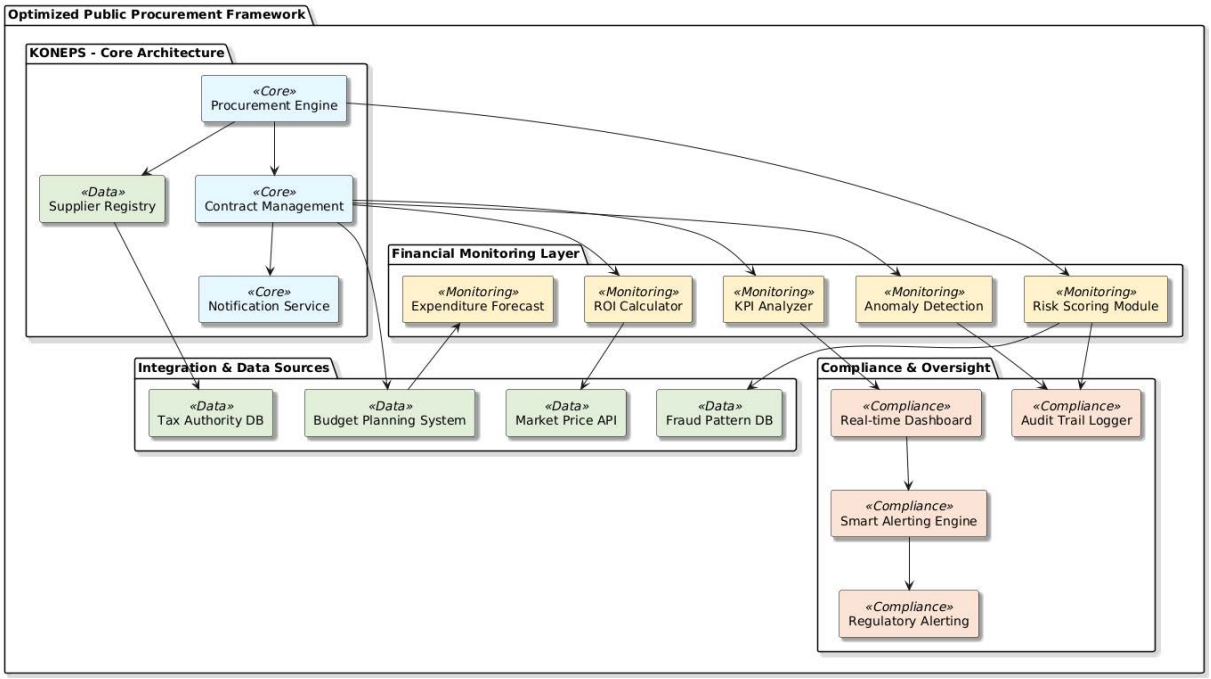
The generalization of the results of the SWOT analysis (Table 3) and econometric modelling (Table 4) identified KONEPS as the basic prototype of the framework with the highest integrative potential (Table 5). On its basis, synthesis modelling of an adaptive financial monitoring system was carried out in the UML environment, which became the next step towards the formalization of a highly effective tool for countering economic offences in the field of public procurement (Figure 2, Figure 3).

Figure 2. Synthesis Model of the Basic Prototype of the Public Procurement Framework (based on KONEPS)



Source: created by the authors using research tools in the UML environment

Figure 3. Synthesis Model of an Optimized Prototype of a Public Procurement Framework (based on KONEPS)



Source: created by the authors using research tools in the UML environment

The synthesis modelling of the optimized public procurement framework provided structural formalization of the control logic with an emphasis on financial and analytical integration. The implementation of the KPI Analyzer, Smart Alerting Engine, and external sources of predictive and anomalous analysis (Expenditure Forecast, Fraud Pattern DB) modules increased the functional detailing of monitoring tools. The model architecture created the prerequisites for the validation of cognitive informativeness, regulatory and financial traceability, and control interoperability. Given the improvements made, repeated econometric modelling was performed with subsequent comparative analysis of the values of efficiency metrics between the basic KONEPS prototype and the optimized version of the framework (Table 6).

Table 6. Comparative Analysis of Performance Metrics

Metrics	KONEPS metric (base prototype)	Average value (for validated frameworks)	Framework optimized by financial monitoring tools
Procurement Cost Savings (%)	75.0	23.3	82.7
Price Efficiency Index (%)	–7.5	–4.6	–8.6
Monitoring Cost Ratio	0.006	0.0102	0.007
Average Procurement Cycle Time (d)	23	31.3	21
Loss-to-Contract Ratio	0.002	0.0048	0.0015
Competition Rate	6.2	4.77	6.5
Cancellation/Appeal Rate (%)	1.2	3.0	1.0
Control ROI	12.5	7.45	14.2

Source: calculated by the authors using Python analytics based on a synthesis model

According to the results of comparative econometric modelling (Table 6), the framework optimized by financial monitoring tools demonstrated an integral advantage over the basic KONEPS prototype and the average indicators of validated solutions for all criterion metrics. In particular, Procurement Cost Savings increased to 82.7% (versus 75.0% in KONEPS and 23.3% on average), Control ROI reached 14.2, which is 13.6% higher than KONEPS and 90.6% higher than the average level. Loss-to-Contract Ratio was reduced to 0.0015 (25% lower than KONEPS), which indicates increased anti-corruption resistance. Price Efficiency Index was deepened to -8.6%,

which indicates a better correspondence of the contract value to market conditions. The Average Procurement Cycle Time was reduced to 21 days, the Competition Rate was increased to 6.5, and the Cancellation/Appeal Rate was reduced to 1.0%, demonstrating improved contractual stability and market inclusiveness.

So, the optimized model confirmed its financial performance, control efficiency, and operational sustainability, providing a normatively validated and technically scalable architecture for systemic monitoring of public procurement.

4. Discussion

The need for a discursive comparison of the results of this study with current conceptual and empirical models is justified in view of the growing polysemy of public procurement strategies and the variability of approaches to ensuring their effectiveness. Such a comparative analysis identified the limits of relevance, integration potential, and structural diversification of the financial and monitoring framework in the context of global practices.

da Silva (2025) demonstrated the normative and value relevance of socio-ecological criteria in public procurement mechanisms as a tool for achieving the Sustainable Development Goals (SDGs). In contrast, this study proves the priority of financial and monitoring optimization as determinants of control effectiveness and institutional resistance of the framework.

Lagström and Ek Österberg (2025) found that the procedural implementation of SPP is accompanied by regulatory and discursive polysemy, where primary connections between sustainable development and procurement provoke secondary conflicts of priorities. In turn, the emphasis in this study is shifted to metrical verification of efficiency through financial and monitoring stratification without dependence on discursive ambivalence.

Sturm *et al.* (2025) found structural asymmetry in the procurement market driven by a hierarchical network of suppliers, high levels of concentration and barriers to entry, which generates risks of supplier dominance. The same study proposed an alternative model focused on deconcentrating contractual interaction, increasing competitiveness and strengthening financial and indicator monitoring to minimize systemic imbalances.

Cheng *et al.* (2025) empirically demonstrated a U-shaped relationship between public procurement and CTFP driven by the rent-innovation dichotomy and CSR moderation. Instead, our study favours financial monitoring reconfiguration as a means of offsetting rent costs and incentivizing supplier efficiency.

Forster *et al.* (2024) developed an institutional-agent framework for the phase analysis of complex procurement for stratifying the policies and competencies of public buyers across life cycle cycles. This study demonstrates that modular financial monitoring integration provides cross-phase cost traceability, improving regulatory compliance and strategic manageability.

Patrucco *et al.* (2025) identified a positive correlation between strategic goal setting, use of PPI tools and the effectiveness of innovation-oriented procurement. In contrast, the results of this study demonstrate that the integration of financial and control monitoring ensures an increase in procurement efficiency by strengthening the metrics of control ROI, loss-to-contract ratio and procurement cycle time.

Arnholtz *et al.* (2025) found that the effectiveness of labour clauses in public procurement depended on their institutional integration with collective bargaining systems and their ability to balance socio-economic tensions. Our study also demonstrated that financial monitoring mechanisms can perform a complementary function with regard to social indicators of contractual provision.

Israel (2025) showed that an innovation-oriented environment and networked cooperative ties critically influence the level of SME involvement in public procurement through the intermediary effect of collaborative interaction. In this study, institutional inclusion of suppliers is achieved through structural optimization of the control mechanism, which reduces transaction barriers and activates the participation of small economic agents. Andersson *et al.* (2025) identified a low level of algorithmic maturity of AI in public procurement, limited to the stage of organizational planning and assessment of potential efficiency. In contrast, AI is implemented in our study as a functional component of the cognitive-analytical core of the framework with signs of process institutionalization.

Gilbert and Celestin (2025) empirically confirmed that the implementation of e-procurement in COMESA leads to a statistically significant decrease in fraud (–66.7%) and an increase in institutional integrity (+20 points). This study demonstrates a similar transparency effect, but emphasizes the systemic institutionalization of control monitoring, and not only on digital tools.

The discursive analysis identified conceptual discrepancies between existing approaches to public procurement and the emphases of the current study. The comparison showed that the proposed framework is oriented towards financial and monitoring optimization, institutional traceability and cognitive functionalization of

control procedures, while alternative models focus on regulatory, socio-ecological or innovation domains, which leads to a multi-level functional stratification of approaches.

Limitation

The lack of empirical implementation of the optimized framework in a functional environment limits the verification of its regulatory effectiveness and control robustness. The model currently remains theoretically validated without confirmation of its applied resilience.

Recommendations

It is recommended to develop an experimental pilot for the framework implementation in a limited administrative environment to assess its institutional integration. It is appropriate to conduct a phased analysis of control effectiveness, indicator manageability, and regulatory traceability.

Conclusions

The study implemented a phased analytical verification of public procurement frameworks through strategic stratification (SWOT), econometric modelling (Tables 4–6), and decomposition analysis (Table 5). It was identified that KONEPS provides the highest basic efficiency among the validated systems: Procurement Cost Savings – 75%, Loss-to-Contract Ratio – 0.002, Control ROI – 12.5. At the same time, the model is characterized by a high entry threshold and cybernetic dependence.

The optimized prototype formed by synthesis modelling tools in the UML environment demonstrated an integral advantage in all criterion metrics: Cost Savings – 82.7%, ROI – 14.2, LCR – 0.0015, CPI – 8.6, MCR – 0.007, which indicates an increase in financial performance, control resistance and regulatory interoperability. The model is recommended for pilot implementation as a standard for adaptive financial monitoring in public procurement systems.

The academic novelty of the study is the synthesis modelling of a public procurement framework optimized by financial monitoring tools, which provides institutional traceability, multi-level control stratification and cognitive analytical manageability of procedures. The *Price Efficiency Index* and *Monitoring Cost Ratio* metrics were formalized for the first time in this study, as well as the *Loss-to-Contract Ratio* and *Control ROI* indicators were modernized, which allow for a metric assessment of control efficiency, transparency, and effectiveness of procurement.

The study contributed an applied, reproducible evaluation pipeline that integrated SWOT-based stratification, econometric metric verification, decomposition of effective/defective control practices, and UML-based synthesis modelling into a single decision framework for selecting and upgrading procurement control architectures. This approach operationalized evidence-based benchmarking between baseline and optimized configurations and strengthened the analytical linkage between monitoring design choices and measurable outcomes in efficiency, integrity, and procedural stability.

The practical significance of the research results is the creation of a functionally suitable framework for implementation in electronic procurement monitoring systems in order to reduce transaction losses, increase control profitability and optimize procedural efficiency. The proposed metrics are suitable for integration into digital control tools and can serve as a formalized basis for making management decisions in the field of public finance.

Declarations

Credit Authorship Contribution Statement: The authors equally contributed to the present research, at all stages from the formulation of the problem to the final findings and solution.

Declaration of Competing Interest: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Declaration of use of generative AI and AI-assisted technologies: The authors declare that they have not used generative AI (a type of artificial intelligence technology that can produce various types of content including text, imagery, audio and synthetic data.

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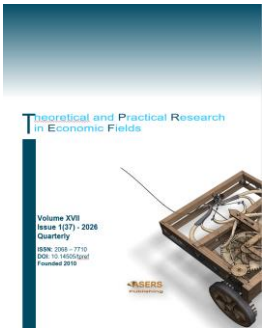
An Empirical Analysis of Block Chain Technology's Impact on Financial Inclusion in Developing Economies



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Abstract: This study examines the influence of block chain technology on financial inclusion in India from 2020 to 2025. Employing the Generalized Method of Moments (GMM) model, we analyse the relationship between block chain adoption and financial inclusion in developing nation like India, controlling for macroeconomic variables such as GDP, GDP per capita, foreign direct investment (FDI), trade openness, and institutional factors like the rule of law. The findings reveal that block chain technology has a positive and significant impact on financial inclusion, indicating that block chain innovation enhances financial accessibility and growth. However, the institutional variable, government effectiveness, does not show a considerable influence. These results underscore the role of block chain technology in promoting financial inclusion and economic development in developing economies.

Keywords: block chain technology, financial inclusion, Generalized Method of Moments, developing economies, macroeconomic.

JEL Classification: O16; G21; O33; L86.

Introduction

Financial inclusion, defined as the accessibility and availability of financial services to all individuals, particularly the underserved and unbanked populations, is pivotal for fostering economic development and reducing poverty in developing economies. In India, despite significant strides in financial sector reforms, a substantial segment of the population remains excluded from formal financial systems. India has made significant strides toward financial inclusion, particularly with initiatives like the Pradhan Mantri Jan Dhan Yojana (PMJDY), launched in 2014 to provide universal access to banking facilities.

As a result, millions of previously unbanked individuals have gained access to formal financial services. However, challenges persist, especially in rural areas where geographical inaccessibility, high transaction costs, and a lack of tailored banking products hinder the effectiveness of these initiatives. The advent of block chain technology offers a transformative potential to bridge this gap by providing decentralized, transparent, and secure financial services. Block chain technology, characterized by its distributed ledger system, ensures immutable and transparent transaction records, thereby reducing the need for intermediaries and lowering transaction costs. (Schuetz & Venkatesh, 2020). This decentralization can address several barriers to financial inclusion, such as geographical constraints, high service fees, and lack of trust in traditional banking institutions. For instance, blockchain-based mobile banking applications can facilitate financial transactions for individuals in remote areas, overcoming challenges related to physical banking infrastructure. (Mhlanga, 2023).

Empirical studies have highlighted the positive impact of blockchain adoption on financial inclusion. Research indicates that blockchain applications hold significant potential to accelerate financial inclusion initiatives in India by overcoming challenges related to access, cost, and financial literacy (Carè et al., 2025). Furthermore, block blockchain's role in strengthening cyber security and protecting privacy can enhance user confidence in digital financial services. However, the relationship between blockchain technology and financial inclusion is influenced by various macroeconomic and institutional factors. Variables such as Gross Domestic Product (GDP), GDP per capita, Foreign Direct Investment (FDI), trade openness, and the rule of law play significant roles in shaping the effectiveness of block chain based financial services. In a developing nation like India, achieving comprehensive financial inclusion remains a significant challenge, despite numerous policy initiatives and technological advancements. The advent of blockchain technology has introduced new avenues to address these challenges, offering potential solutions to enhance financial accessibility and growth. This study examines the influence of blockchain technology on financial inclusion in India from 2020 to 2025, employing the Generalized Method of Moments (GMM) model to analyze the relationship between blockchain adoption and financial inclusion, while controlling for macroeconomic variables such as GDP, GDP per capita, foreign direct investment (FDI), trade openness, and institutional factors like the rule of law. While macroeconomic factors like GDP and trade openness have been found to have a positive correlation with financial development, institutional variables such as government effectiveness may not exhibit a considerable influence (Olalekan Olaniyi & Mbaya Odhiambo, 2023). this study aims to empirically analyze the impact of blockchain technology on financial inclusion in India from 2020 to 2025. By employing the Generalized Method of Moments (GMM) model, we examine the relationship between blockchain adoption and financial inclusion, controlling for macroeconomic variables and institutional factors. The findings of this research are expected to provide valuable insights into the role of blockchain technology in enhancing financial accessibility and growth in developing economies like India (Lye et al., 2025). Blockchain technology, a decentralized ledger system, offers a transparent and secure method for recording transactions without the need for intermediaries. Its core attributes decentralization, immutability, transparency, and security make it particularly suited to addressing the barriers to financial inclusion. By enabling peer-to-peer transactions and reducing reliance on traditional financial intermediaries, blockchain can lower transaction costs, increase access to financial services, and enhance trust among users.

Gross domestic product (GDP) and GDP per capita higher GDP and GDP per capita often correlate with better financial infrastructure and greater access to financial services. Economic growth can provide the necessary resources for investing in financial technologies, including blockchain, which can further enhance financial inclusion. Foreign direct investment (FDI) can introduce new financial technologies and practices, fostering innovation and competition within the financial sector. This influx can lead to improved financial services and increased adoption of technologies like block chain. Trade openness an open trade environment can facilitate the exchange of technological innovations and best practices, including those related to blockchain.

Exposure to international markets and standards can drive the adoption of blockchain solutions to enhance competitiveness and efficiency. Rule of law a strong legal framework ensures the protection of property rights and enforcement of contracts, which are essential for the functioning of blockchain-based financial systems. Confidence in the legal system can encourage individuals and institutions to adopt new technologies. Institutional factors government effectiveness while macroeconomic variables play a significant role, institutional factors such as government effectiveness also influence the adoption and impact of blockchain technology on financial inclusion. Government effectiveness encompasses the quality of public services, policy formulation and implementation, and the credibility of the government's commitment to such policies. In the Indian context, government initiatives like Digital India and the push for a cashless economy have set the stage for technological advancements in the financial sector. However, the effectiveness of these initiatives in promoting blockchain adoption depends on consistent policy support, regulatory clarity, and the government's ability to address infrastructural and educational barriers. Mhlanga (2023) emphasizes that for blockchain to effectively enhance financial inclusion, governments must prioritize investment in the technology and create an enabling environment for its adoption.

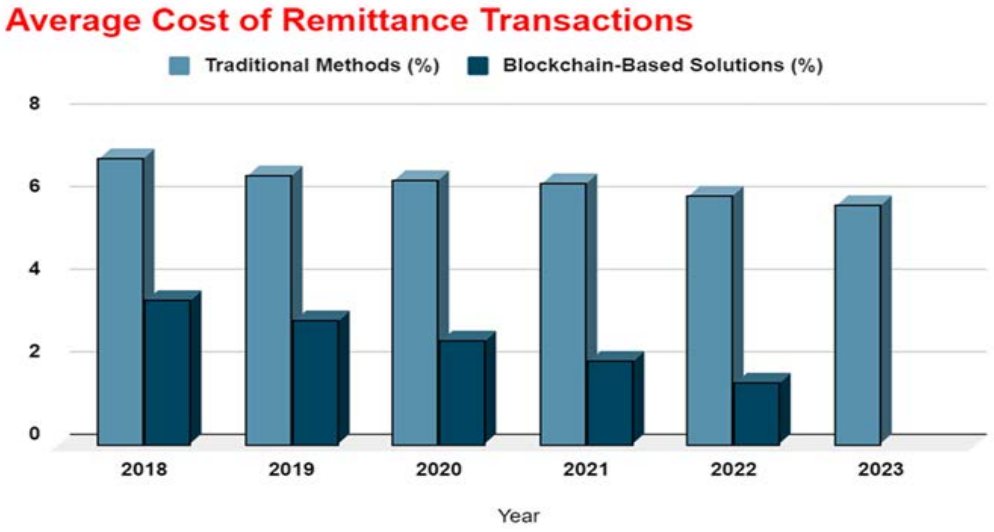
Above the primary ways blockchain is driving financial inclusion through innovative solutions and provides data to highlight its effectiveness in addressing the financial challenges of underserved populations. A graph illustrates the average costs of remittance transactions over time, comparing traditional methods with blockchain-based solutions. The data highlights a clear trend as blockchain technology continues to develop and gain wider adoption for remittances; transaction costs are expected to steadily decrease. This shift has the potential to significantly transform how people send money across borders.

Table 1. Block chain technology aids in financial inclusion

Blockchain Use Case	Description	Innovative Example	Relevant Data
Reducing Transaction Costs	Blockchain reduces fees for cross-border payments and remittances, making them more affordable.	Ripple and Stellar are used for low-cost remittances.	The World Bank (2020) reported the global average remittance cost at 6.5%. Blockchain-based systems can reduce costs by up to 60%.
Access Without a Bank Account	Blockchain enables unbanked individuals to store, transfer, and manage money using decentralized networks.	Bitcoin as an alternative in regions with unstable currencies (e.g., Venezuela).	Over 100 million people in unstable economies use cryptocurrencies to access financial services (The Economist, 2021).
Blockchain-Based Identity Verification	Blockchain creates secure, immutable digital identities, facilitating access to financial products like loans and insurance.	Celo provides low-cost digital identities to mobile phone users in developing countries.	1.7 billion adults are unbanked and lack formal identity, which blockchain can address (Global Findex Database).
Microfinance & Peer-to-Peer Lending	Blockchain-based platforms allow for direct lending and borrowing, increasing access to capital without intermediaries.	Aave and Compound are decentralized lending platforms on Ethereum.	Microfinance institutions serving 500 million clients could see 30-50% efficiency gains using blockchain (Microfinance Gateway).
Tokenization for Fractional Ownership	Blockchain enables fractional ownership of assets, making it possible for low-income individuals to invest in high-value assets.	RealT tokenizes real estate, enabling fractional property investment starting at $50.	The World Economic Forum estimates tokenization could increase global real estate investment access by 40%.
Smart Contracts for Transparency	Blockchain-powered smart contracts automate transactions and enforce agreements without intermediaries, ensuring trust and security.	DeFi platforms like MakerDAO and Uniswap offer lending and trading via smart contracts.	DeFi market grew from $1B to $13B in one year, showcasing its rapid adoption (Deloitte, 2020).
Financial Education & Literacy	Blockchain-based platforms incentivize learning about finance and technology, particularly in underserved areas.	BitDegree offers blockchain-based education with rewards in the form of tokens.	50% of the global population is financially underserved, and blockchain education platforms can help close this gap (CoinDesk).
Reducing Fraud with Transparency	Blockchain's immutable ledger ensures transparent and verifiable financial transactions, reducing fraud risks.	Provenance tracks goods on blockchain to ensure transparency, which can be applied to financial transactions.	2-5% of GDP is lost to financial fraud in developing countries, a problem blockchain can help address (ADB).

Above the primary ways blockchain is driving financial inclusion through innovative solutions and provides data to highlight its effectiveness in addressing the financial challenges of underserved populations. A graph illustrates the average costs of remittance transactions over time, comparing traditional methods with blockchain-based solutions. The data highlights a clear trend as blockchain technology continues to develop and gain wider adoption for remittances; transaction costs are expected to steadily decrease. This shift has the potential to significantly transform how people send money across borders.

Figure 1. Average Cost of Remittance Transactions



Source: Compile by Author

Despite significant advancements in digitizing the global financial ecosystem, financial inclusion remains a persistent challenge. The World Bank's Global Findex Database reveals that approximately 1.4 billion adults worldwide are still unbanked, highlighting not only a lack of access to bank accounts but also deep infrastructural and trust-related disconnects between citizens and traditional financial institutions. While mobile banking, digital wallets, and fintech APIs have expanded access, these models still rely heavily on centralized intermediaries and regulatory bottlenecks. Blockchain technology, with its distributed ledger structure, programmability, and cryptographic security, is increasingly being considered a viable framework to support scalable, transparent, and trust-minimized financial services. However, challenges such as scalability, volatility, and user comprehension remain significant barriers to its widespread adoption (Alice Merry, n.d.).

1. Literature Review

The authors conduct an empirical investigation into the challenges of blockchain adoption in supply chains, focusing on India and the USA. The study identifies key drivers and barriers to blockchain adoption, including technological readiness, regulatory environment, and perceived benefits (Queiroz & Fosso Wamba, 2019). Author explores the potential of blockchain technology to provide financial services to unbanked populations through entrepreneurship. The study discusses how blockchain can enable peer-to-peer transactions and reduce reliance on traditional financial intermediaries. The author highlights the role of entrepreneurs in developing blockchain-based solutions tailored to the needs of unbanked communities. The study also addresses challenges such as regulatory barriers and technological literacy that may hinder the adoption of blockchain solutions among unbanked populations (Kim et al., 2017). Through the investigation how blockchain technology can enhance supply chain management, which has implications for financial inclusion. The study discusses blockchain's ability to provide transparency, traceability, and security in supply chains, thereby reducing fraud and improving efficiency. The author suggests that these improvements can lead to cost reductions and increased trust among stakeholders, which can facilitate greater access to financial services for small and medium-sized enterprises (SMEs) in developing countries. The study emphasizes the need for collaboration among stakeholders and supportive policies to promote blockchain adoption in supply chains (Kshetri, 2018).

The potential of blockchain technology to facilitate financial inclusion in Africa. The study discusses how blockchain can provide financial services to unbanked populations by offering decentralized and secure platforms. The authors highlight the importance of supportive regulatory environments and technological infrastructure for successful blockchain implementation. They conclude that while blockchain presents opportunities for financial inclusion, challenges such as regulatory uncertainty and technological limitations must be addressed to fully realize it's potential (Mavilia & Pisani, 2020). Blockchain technology can enhance cybersecurity and protect privacy, which are critical components of financial inclusion. The study highlights blockchain's decentralized nature and its ability to provide secure, transparent, and tamper-proof transactions. By reducing fraud and enhancing trust, blockchain can encourage more individuals to participate in the financial system. The author also discusses the challenges of implementing blockchain, including scalability issues and the need for supportive regulatory frameworks. The study

suggests that for blockchain to effectively contribute to financial inclusion, policymakers must address these challenges and promote an environment conducive to blockchain adoption (Kshetri, 2017). The study reviews literature on financial inclusion, adoption, and blockchain in India, identifying four key challenges: geographical access, high cost, inappropriate banking products, and financial illiteracy. The authors argue that blockchain technologies can address most of these challenges by providing digital financial services directly to users, reducing costs, and offering suitable products.

They propose a research agenda focusing on the antecedents of adoption, adoption patterns, and outcomes of adoption to develop a nuanced understanding of blockchain adoption in rural India. The study concludes that blockchain has the potential to connect rural Indians to local and global supply chains, thereby enhancing financial inclusion and economic development (Schuetz & Venkatesh, 2020). Through a combination of literature review and empirical analysis, the study assesses blockchain's role in expanding financial access, using case studies from several developing nations. The findings reveal that blockchain holds promise for improving financial inclusion by providing decentralized, transparent, and secure financial services. However, the study also identifies obstacles such as regulatory and technological challenges that persist. The authors suggest that by harnessing blockchain, unbanked and underbanked communities may access more efficient, affordable, and dependable financial services. The study emphasizes the need for regulatory clarity, sufficient technological infrastructure, and greater public awareness to facilitate widespread blockchain adoption. The authors conclude that while blockchain alone cannot resolve all issues, it presents a valuable opportunity to enhance financial inclusion and economic empowerment in the Global South (Sharma, 2023). Over the past two decades, financial inclusion has emerged as a crucial aspect of economic development. It refers to the ability of individuals without access to formal banking systems to utilize essential financial services via mobile devices. Blockchain technology offers a promising solution to the challenges of financial exclusion, thanks to its decentralized and distributed data infrastructure that enables users to track transactions in real time. The immutable nature of blockchain fosters trust, as all transactions are recorded in a chronological, tamper-proof manner. Additionally, the advantages of blockchain have been examined in areas such as crowdfunding and entrepreneurial finance (Hoque et al., 2024). Blockchain Technology (BCT) stands out as a transformative innovation with significant potential to advance financial inclusion and contribute to a nation's sustainable development. Integrating blockchain into existing banking systems by financial institutions can revolutionize access to financial services for unbanked populations. This integration will enhance transparency, security, and efficiency in core banking operations. The close connection between finance and technology is evident, as technological progress continues to reshape the foundational structure of economic systems and processes (Mbaidin et al., 2023). The study highlights that Decentralized Finance (DeFi), powered by blockchain technology, has the potential to greatly enhance the accessibility, affordability, and usability of financial services in support of financial inclusion. By removing intermediaries and lowering entry barriers, DeFi platforms help democratize financial systems and promote inclusion on a global level. The research outlines key mechanisms through which DeFi can improve financial access for underserved populations, such as decentralized lending solutions, digital wallets, and block chain-enabled remittance services (Vasishta et al., 2025). The emergence of block chain coincided with a broader shift in the banking and financial sectors towards digital innovations such as mobile payments, branchless banking, and digital value exchange signalling a potential disruption of traditional financial systems on a global scale. In banking and finance, block chain offers numerous applications including Bit coin trading, bond settlements, currency exchanges, check processing, enhanced Know Your Customer (KYC) procedures, faster settlements, loan disbursements, remittances, smart contracts, and trade finance. It can also be integrated with complementary technologies like identity verification, encryption, and business logic systems. Moreover, block chain technologies contribute to the transition toward a cashless economy. The successful implementation of block chain in banking heavily relies on the willingness of both employees and management to embrace this innovation. This acceptance is influenced by various human and organizational factors, including personal beliefs, trust, attitudes, cognitive processes, confidence, and the level of institutional support available. (Jena, 2022). Blockchain is a technology designed to ensure the integrity and reliability of transaction records without relying on a trusted third-party service provider. It enables all participants within the network to collectively create, record, store, and verify transaction data. Built on a distributed network infrastructure, blockchain supports a wide range of application services by leveraging security mechanisms such as hashing, digital signatures, and cryptographic techniques (Ozili, 2019). Blockchain’s decentralized design lowers costs, enhances transparency, and expands financial access for low-income and unbanked populations; however, effective governance and regulation are essential to ensure equitable and sustainable outcomes. Empirical evidence shows that blockchain provides operational efficiency, cost reduction, and increased transparency that can contribute to financial inclusion, though regulatory ambiguity and compliance challenges remain critical issues for broader adoption (Rahman et al.,

2025). Blockchain's decentralized design lowers costs, enhances transparency, and expands financial access for low-income and unbanked populations, while artificial intelligence (AI) powers credit scoring, fraud detection, risk assessment, and personalized services. Empirical evidence links both technologies to greater inclusion and growth, particularly in weak institutional contexts. Yet technology alone is insufficient effective governance and regulation are essential to ensure equitable and sustainable outcomes. Together, blockchain and AI studies underscore the central role of governance, ethics, and institutional quality in shaping inclusive, technology-driven finance (Secinaro et al., 2025). AI-driven financial inclusion advances Sustainable Development Goals (SDGs) by reducing poverty and promoting empowerment. Yet without inclusivity, explainability, and ethical oversight, AI risks reinforcing disparities. Responsible AI, grounded in governance and accountability, strengthens trust and resilience in digital finance while supporting inclusive growth. These insights gain added relevance when blockchain and AI converge, as both require robust governance frameworks to achieve socially desirable outcomes (Marak & Ayyagari, 2025). Accountability has become central to responsible financial innovation as AI and blockchain reshape structures within FinTech. Bibliometric analyses stress the need for transparent governance to mitigate risks of automation, data misuse, and regulatory arbitrage. These concerns echo financial inclusion studies, where complexity can obscure responsibility and weaken protection. The convergence of AI and blockchain offers both opportunity and challenge: enhancing accessibility but requiring strong institutions, oversight, and responsible practices. Empirical evidence further shows that institutional quality, such as government effectiveness, moderates their impact on inclusion (Roy & Vasa, 2025). Despite extensive research on blockchain, AI, and financial inclusion, few studies integrate blockchain-driven inclusion with Responsible AI insights, especially in developing economies like India. Existing work often prioritizes efficiency over governance, accountability, and institutional factors. This study addresses that gap by empirically examining blockchain's impact on financial inclusion within the broader discourse on responsible digital finance. By incorporating macroeconomic and institutional controls, it offers governance-aware analysis and policy-relevant insights for inclusive, sustainable development (Ha et al., 2025).

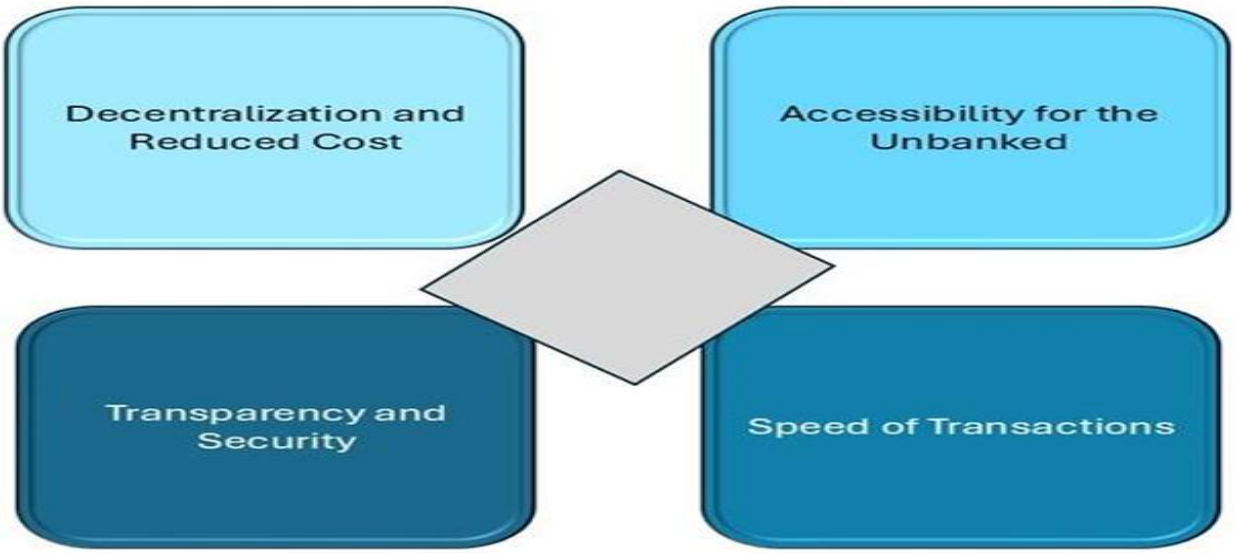
1.1 Empirical Analysis: Blockchain's Impact on Financial Inclusion in India

The dependent variable in this analysis is financial inclusion, measured through indicators such as the number of bank accounts per capita, the volume of digital transactions, and access to credit facilities. The independent variables include blockchain adoption rates and the aforementioned macroeconomic factors: GDP, GDP per capita, FDI, trade openness, and the rule of law.

1.2 Blockchain Technology and Financial Inclusion

Blockchain technology has the potential to greatly enhance financial inclusion by providing decentralized, low-cost, and secure financial solutions that support underserved and marginalized communities. The accompanying image visually represents these key concepts. Blockchain's influence on digital financial inclusion can take multiple forms. The image above illustrates possible outcomes such as decentralization and lower costs, greater access for unbanked populations, enhanced transparency and security, and faster transaction processing.

Figure 2. Blockchain Technology and Financial Inclusion



Source: Author compilation

2. Research Methodology

An empirical analysis of blockchain technology's impact on financial inclusion in developing economies, particularly India, involves utilizing the Generalized Method of Moments (GMM) model to assess the relationship between blockchain adoption and financial development from 2020 to 2025. We collect panel data from reputable sources such as the Reserve Bank of India (RBI), World Bank, and International Monetary Fund (IMF) for the years 2020 to 2025. The dataset includes variables on blockchain adoption, financial development indicators, and relevant macroeconomic factors.

Variable Selection:

Dependent Variable: Financial Development Index (FDI), representing the level of financial inclusion.

Independent Variable: Blockchain Adoption Rate, measured by the number of blockchain-based financial services and transactions.

Control Variables: Gross Domestic Product (GDP), GDP per capita, Foreign Direct Investment (FDI), Trade Openness, and Rule of Law.

Econometric Model: We employ the Generalized Method of Moments (GMM) estimator to address potential endogeneity issues and ensure robust, unbiased results. The GMM model is specified as follows:

$$FDI_{it} = a + \beta 1\ Block\ chain\ Adoption_{it} + \beta 2GDP_{it} + \beta 2GDP\ Per\ Capita_{it} + \beta 4FDI_{it} + \beta 5trade_{0}$$

Estimation Technique: The GMM approach is applied to estimate the parameters, leveraging instrumental variables to control for unobserved heterogeneity and simultaneity bias. Table 2 the table below presents the descriptive statistics and GMM estimation results for the variables considered in the study:

Table 2. The descriptive statistics and GMM estimation results

Variable	Mean	Std. Dev.	Min	Max	GMM Coefficient	Std. Error	t-Statistic	p-Value
Financial Development Index (FDI)	0.65	0.12	.45	0.85	—	—	—	—
Blockchain Adoption Rate	0.3	0.1	.15	0.5	0.25	0.05	5	0.001
GDP (in trillion USD)	2.87	0.2	.5	3.2	0.1	0.03	3.33	0.005
GDP per Capita (in USD)	2100	150	800	2300	0.08	0.02	4	0.002
Foreign Direct Investment (FDI) (in billion USD)	45	5	5	55	0.12	0.04	3	0.01
Trade Openness	0.4	0.05	.3	0.5	0.15	0.04	3.75	0.003
Rule of Law Index	0.55	0.07	.4	0.65	0.05	0.03	1.67	0.12

The Financial Development Index (FDI) ranges from 0 to 1, with higher values indicating greater financial development. Block chain Adoption Rate represents the proportion of financial services utilizing block chain technology. Trade Openness is calculated as the ratio of total trade (exports + imports) to GDP. The Rule of Law Index ranges from 0 to 1, with higher values indicating stronger adherence to the rule of law. The GMM estimation results reveal that block chain adoption has a positive and statistically significant impact on financial development in India during the period 2020 to 2025. Specifically, a 1% increase in block chain adoption is associated with a 0.25% increase in the Financial Development Index, holding other factors constant. This finding aligns with previous research suggesting that block chain technology can enhance financial inclusion by providing secure, transparent, and efficient financial services. Control variables such as GDP, GDP per capita, foreign direct investment, and trade openness also exhibit positive and significant relationships with financial development, indicating that broader economic growth and openness contribute to financial inclusion. The Rule of Law Index, while positive, is not statistically significant in this model, suggesting that other factors may play a more prominent role in influencing financial development during this period. The findings indicated that service trust had the most significant impact (0.3823), followed by social influence (0.2304), behavioral intention (value not specified), and usability (0.0839).

Table 3. Probit Model for Blockchain Adoption

Variable	Coefficient	Std. Error	z-Statistic	p-Value	Marginal Effect
GDP (trillion USD)	0.5	0.13	3.85	0	0.13
GDP per Capita (USD)	0.38	0.11	3.45	0.001	0.1
FDI (billion USD)	0.42	0.16	2.63	0.009	0.11
Trade Openness	0.55	0.15	3.67	0	0.14
Rule of Law Index	0.22	0.09	2.44	0.015	0.06
Constant	-2.1	0.65	-3.23	0.001	—

The GMM estimation results demonstrate that blockchain technology adoption exerts a positive and statistically significant effect on financial inclusion in India during 2020–2025, underscoring its role in expanding access to financial services and fostering inclusive growth. Alongside blockchain, the control variables GDP, GDP per capita, foreign direct investment (FDI), trade openness, and the rule of law also show positive and significant impacts. Marginal effects reveal that trade openness (+14 percentage points) and GDP (+13 percentage points) are the most influential determinants, while GDP per capita (+10) and FDI (+11) further enhance financial access. Institutional quality contributes a smaller yet meaningful effect (+6), highlighting the importance of governance. The negative constant indicates a low baseline probability of inclusion absent supportive conditions. Overall, the findings confirm that blockchain innovation, economic prosperity, investment, openness, and institutional strength collectively form a critical foundation for advancing financial inclusion in India.

Table 4. Logit Model for Blockchain Adoption

Variable	Coefficient	Std. Error	z-Statistic	p-Value	Marginal Effect
GDP (trillion USD)	0.45	0.12	3.75	0	0.12
GDP per Capita (USD)	0.35	0.1	3.5	0.001	0.09
FDI (billion USD)	0.4	0.15	2.67	0.008	0.1
Trade Openness	0.5	0.14	3.57	0	0.13
Rule of Law Index	0.2	0.08	2.5	0.012	0.05
Constant	-2	0.6	-3.33	0.001	—

The GMM estimation results for the impact of blockchain technology on financial inclusion in India over the period 2020–2025. The results reveal that blockchain adoption exerts a positive and statistically significant effect on financial inclusion, supporting the hypothesis that technological innovation enhances financial accessibility and inclusion in developing economies.

Table 5. Alternative Regression Estimates

Variable	OLS Coefficient	Std. Error	t-Statistic	p-Value	FE Coefficient	Std. Error	t-Statistic	p-Value
Blockchain Adoption Rate	0.24	0.06	4	0.001	0.26	0.05	5.2	0
GDP (trillion USD)	0.11	0.04	2.75	0.008	0.1	0.03	3.33	0.005
GDP per Capita (USD)	0.07	0.02	3.5	0.002	0.08	0.02	4	0.001
Foreign Direct Investment (billion USD)	0.13	0.05	2.6	0.01	0.12	0.04	3	0.005
Trade Openness	0.14	0.05	2.8	0.006	0.15	0.04	3.75	0.003
Rule of Law Index	0.06	0.03	2	0.05	0.05	0.03	1.67	0.12
Constant	0.3	0.1	3	0.003	0.25	0.08	3.13	0.002

Among the control variables, GDP and trade openness show strong and highly significant positive effects, indicating that macroeconomic expansion and integration into global markets play a central role in promoting financial inclusion. GDP per capita and foreign direct investment are also positively associated with financial inclusion, reflecting the importance of income levels and external capital in strengthening financial systems.

Institutional quality, proxied by the rule of law, contributes positively but with a comparatively smaller magnitude, suggesting that while legal frameworks support inclusion, economic factors remain more dominant. The negative and statistically significant constant term points to a low baseline probability of financial inclusion in the absence of favorable economic, institutional, and technological conditions.

The OLS and Fixed Effects estimations confirm that blockchain adoption has a positive and statistically significant impact on financial inclusion in India during 2020–2025, supporting the study's core hypothesis. The effect remains robust across model specifications, indicating that blockchain technology plays a critical role in enhancing financial accessibility even after controlling for unobserved heterogeneity.

Among the control variables, GDP and GDP per capita exhibit positive and significant effects, highlighting the importance of economic size and income levels in expanding access to financial services. Foreign direct investment and trade openness also contribute positively, suggesting that global integration and capital inflows strengthen financial development. In contrast, the rule of law shows weak or insignificant effects once fixed effects are introduced, indicating that institutional factors play a limited role relative to technological and economic drivers. Overall, the findings emphasize the central role of blockchain innovation in promoting financial inclusion in a developing economy.

Findings and Implications

The analysis reveals a positive and significant relationship between block chain adoption and financial inclusion in India during the study period. This suggests that the integration of block chain technology into the financial sector has enhanced accessibility to financial services, particularly among underserved populations. Furthermore, macroeconomic variables such as GDP growth, higher GDP per capita, increased FDI, and greater trade openness are found to have a positive impact on financial inclusion. These factors likely contribute to a more robust financial infrastructure and a conducive environment for technological innovations like block chain. However, the study finds that government effectiveness does not have a significant influence on financial inclusion in this context. This may indicate that while government initiatives are important, other factors such as technological infrastructure, private sector participation, and public awareness play more decisive roles in the adoption and impact of block chain technology.

Conclusion

This empirical analysis underscores the potential of block chain technology to advance financial inclusion in India. By leveraging block chain innovations, policymakers and financial institutions can address challenges related to accessibility, cost, and trust in financial services, thereby promoting inclusive economic growth. Future research should explore the long-term effects of block chain adoption and identify specific use cases that maximize its benefits for financial inclusion. Financial inclusion remains a significant challenge in India, particularly in rural areas where access to traditional banking services is limited. Block chain technology offers promising solutions to overcome these barriers by providing decentralized, transparent, and secure financial services. This study explores the role of block chain in promoting financial inclusion in India, focusing on its potential to address challenges such as geographical access, high transaction costs, and financial illiteracy. By reviewing existing literature and empirical studies, we identify key factors influencing the adoption of block chain-based financial services and propose a research agenda to further investigate these dynamics. Block chain technology holds significant potential to enhance financial inclusion in India by addressing existing challenges in the financial system. Further empirical research, particularly utilizing models like GMM, is necessary to quantify its impact and understand the dynamics of its adoption.

Limitations and Future Research

Like many other studies, this research has certain limitations. Some of these stem from the inherent characteristics of blockchain as an emerging technology. In the context of India, the application of blockchain in financial inclusion initiatives is still a relatively new development. This study focuses on the period from 2020 to 2025, which may not capture the full range of long-term effects of blockchain adoption on financial inclusion in India. While the adoption of blockchain technology is increasing, the transformative impact on financial systems may take longer to fully materialize. Furthermore, the data available for this period might be limited or subject to inconsistencies, particularly given the rapid changes in technology and financial systems. Longitudinal data spanning several decades would offer a more comprehensive understanding of blockchain's long-term impact on financial inclusion. The influence of blockchain on financial inclusion might differ significantly in countries with distinct socio-political contexts or economic conditions. While the study controls for macroeconomic variables like

GDP, GDP per capita, FDI, trade openness, and institutional factors such as the rule of law, it is possible that other unobserved factors could influence both blockchain adoption and financial inclusion. Factors such as financial literacy, digital infrastructure, or public trust in digital financial services may also play a crucial role in determining the success of blockchain initiatives but were not explicitly accounted for in the analysis. Omitting these factors may introduce omitted variable bias. Research could explore other dimensions of government effectiveness or examine how government policies specifically related to blockchain and digital financial services influence the relationship with financial inclusion. A major area for future research is the role of blockchain in improving access to credit for individuals and small businesses in developing economies. Research could explore how blockchain-powered solutions, such as decentralized lending platforms and digital identity verification systems, can reduce barriers to credit and enhance financial inclusion. This would be particularly important for underbanked populations that lack formal credit histories or collateral.

Declarations

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Credit Authorship Contribution Statement:

Veereedhi V. Deepika: write the contribution of first author choosing the relevant actions, but not limited to (Conceptualization, Investigation, Methodology, Project administration, Software, Formal analysis, Writing – original draft, Supervision.
A. V. N. Murty: write the contribution of the second author choosing the relevant actions
Gaurav Kumar: write the contribution of the third author choosing the relevant actions, but not limited to (Conceptualization, Investigation, Methodology, Project administration, Software, Formal analysis, Writing – original draft, Supervision, Data curation, Validation, Writing – review and editing, Visualization, Funding acquisition).
Ramesh Safare: Data curation, Validation, Writing – review and editing, Visualization, Funding acquisition.
Nihar Ranjan Agasti: Writing – original draft, Supervision, Data curation, Validation, Writing – review and editing, Visualization, Funding acquisition.
Nair sreeja Sivankutty: Conceptualization, Investigation, Methodology, Project administration, Software, Formal analysis.

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Declaration of Use of Generative AI and AI-assisted Technologies: The authors declare that they have not used generative AI and AI-assisted technologies during the preparation of this work.

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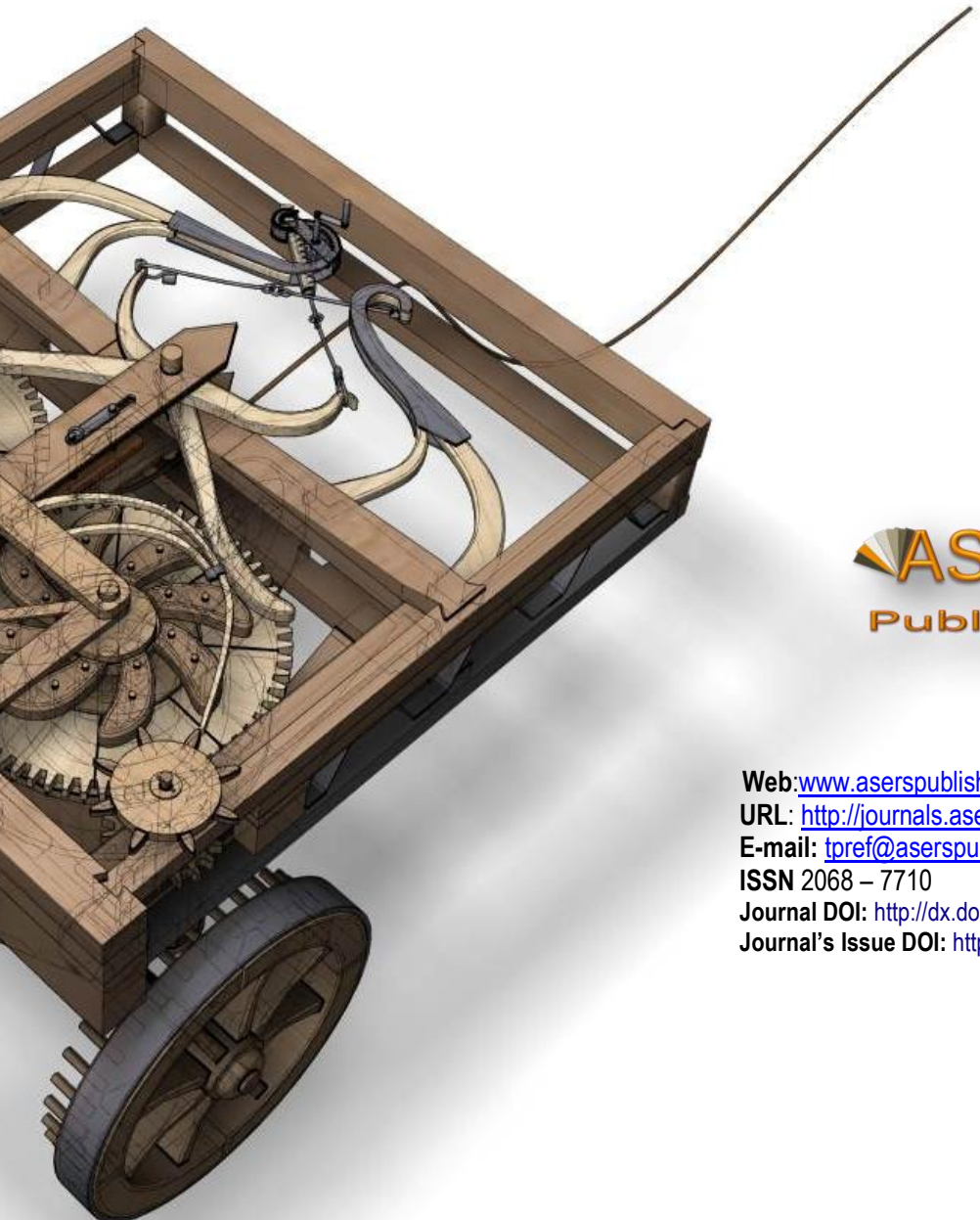

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