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Digital transformation and economic growth: managing material and information flows in Central Asia's evolving digital economy

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Abstract: The study addresses uneven digital integration in Kazakhstan, Uzbekistan, Kyrgyzstan, and Tajikistan, with particular attention to how digital technologies affect economic development, logistics performance, e-commerce, and fintech. The aim is to examine the relationship between digital readiness and economic growth by analyzing the management of information, material, and financial flows across key sectors. The methodology was based on statistical, correlation, and comparative analyses, which made it possible to assess differences in digital infrastructure, investment levels, and sectoral implementation of digital tools. The results show that digitalization has improved business productivity, expanded e-commerce and financial technologies, optimized public administration, and strengthened logistics processes through route optimization, faster information exchange, and reduced operational costs. Kazakhstan and Uzbekistan demonstrated more advanced digital integration, while Kyrgyzstan and Tajikistan remained constrained by weaker infrastructure, limited investment, and insufficient ICT skills. Correlation analysis confirmed a strong link between digital readiness, investment in the digital economy, and economic growth, indicating the strategic importance of digital transformation for regional competitiveness. The findings emphasize the need for stronger governmental support, expanded digital logistics platforms, improved regulatory conditions, and targeted investment in infrastructure and human capital. The practical significance of the study lies in developing recommendations for reducing barriers to digitalization and improving the efficiency of economic and logistics systems in Central Asia.

1 Introduction

The need to study the digital transformation processes in the economies of Kazakhstan, Tajikistan, Uzbekistan, and Kyrgyzstan arises from the increasing impact of digital technologies on macroeconomic parameters, business development dynamics, and the efficiency of public administration. The asymmetry in digitalization levels among the countries of the region has led to significant differences in the pace of digital solution implementation, affecting the competitiveness of national economies. The development of the digital economy has facilitated the emergence of new business models, the transformation of labor market structures, the improvement of logistics processes, and the optimization of financial operations. However, the uneven distribution of digital infrastructure and the insufficient integration of big data, artificial intelligence (AI), and cloud computing into production and administrative processes have limited the region's ability to ensure sustainable economic growth.

The primary issue of this study was to identify key factors influencing digital transformation and its correlation with socio-economic development. Variations in internet accessibility, investment in the information and communication technology (ICT) sector, and governmental support for digital initiatives have complicated the process of coordinated digital development across the region. A low level of digital literacy and limited funding for small and medium-sized enterprises (SMEs) to implement e-commerce and financial technologies (fintech) solutions have created barriers to economic modernization [1,2].

An analysis of academic sources on digital economic transformation confirms a significant interest among researchers in various aspects of this process. The study by Agayev [3] examined the link between digital trade and investment to foster inclusive growth in Central Asian countries, with a focus on regional cooperation in the digital sphere. However, it did not sufficiently explore the impact of digital technologies on internal economic processes or the level of digital readiness in individual countries.

The study by Maltabarov & Sarybayev [4] analyzed the prospects of digital transformation for regional integration in Central Asia, emphasizing intergovernmental cooperation in the digital sector. However, it overlooked the impact of digital solutions on the business environment and the logistics industry. A follow-up study by Maltabarov et al. [5] examined the European Union's interest in Central Asia's digital transformation, but it lacked a detailed analysis of the regulatory environment and internal constraints limiting digitalization in the region's economies.

Gomboin et al. [6] explored the implementation of digital public services for SMEs in Kazakhstan, Kyrgyzstan, and Uzbekistan, focusing on government initiatives that promote business digitalization. However, the study did not analyze the impact of digital technologies on business productivity and financial performance. The research by Rudyk et al. [7] addressed digitalization as a factor of economic growth but did not sufficiently examine the correlation between digital readiness and macroeconomic indicators in Kazakhstan, Tajikistan, Uzbekistan, and Kyrgyzstan.

Olczyk and Kuc-Czarnecka [8] provided an analysis of digital transformation and economic growth in the European context. Although valuable for understanding general digitalization trends, its findings cannot be directly applied to Kazakhstan, Tajikistan, Uzbekistan, and Kyrgyzstan due to differences in digital readiness, regulatory environments, and economic structures.

The study by Irtyshcheva et al. [9] investigated the impact of digital technology development on economic growth but did not consider the specifics of digital technology implementation in Kazakhstan, Tajikistan, Uzbekistan, and Kyrgyzstan, limiting its applicability to regional digital transformation analysis. Similarly, Tudose et al. [10] explored the effects of digital transformation on macroeconomic indicators globally but did not address the specific challenges faced by these countries in the digitalization process.

Thus, the reviewed sources have examined specific aspects of digital transformation in the studied countries, particularly its influence on international cooperation, public administration, and economic growth. However, gaps remain in research on regulatory frameworks for digital processes, logistics digitalization, and the impact of digital solutions on business efficiency and SME productivity.

The problem addressed in this study is the uneven pace of digital transformation across Kazakhstan, Uzbekistan, Kyrgyzstan, and Tajikistan. Despite the increasing global importance of digitalization in driving economic growth, the Central Asian region has experienced significant disparities in digital infrastructure, internet access, investment in ICT, and the adoption of digital solutions in key sectors. This study integrates multiple indicators of digital readiness and economic performance, showing the correlation between digitalization levels and macroeconomic growth, unlike previous research that focused on isolated sectors or regions. The comparative framework shows how digital transformation, combined with strong government support and investments, can boost business productivity, streamline public administration, and boost Central Asian economic competitiveness. This research also sheds light on digital adoption barriers in Kyrgyzstan and Tajikistan, which are less digitally ready. This study recommends ways to accelerate digital transformation and promote inclusive economic growth in these nations by identifying their specific challenges, such as limited infrastructure and financial constraints. Pedagogically, the study emphasizes digital literacy as a foundational skill for Central Asian workers. This suggests a gap in current educational frameworks and the need for stronger programs that support digital skills development at all levels to bridge the gap between digitalization and economic development in the region.

The primary objective of this study was to investigate the relationship between the implementation of digital technologies and the economic development of Kazakhstan, Uzbekistan, Tajikistan, and Kyrgyzstan. Specifically, the research aimed to assess the level of digital readiness and the volume of investments in the ICT sector across these countries. Additionally, it sought to evaluate the impact of digital transformation on key sectors, such as public administration, business productivity, e-commerce, and fintech development. The study also aimed to identify the barriers and challenges to digitalization, including institutional constraints, financial limitations, and insufficient digital literacy. Furthermore, the research aimed to establish a correlation between the level of digital integration and overall macroeconomic performance, including GDP growth and business efficiency. These objectives guided the comprehensive assessment of digitalization's effects on the economic progress of the selected countries, considering their varying levels of technological adoption.

To achieve this objective, the following tasks were completed: an analysis of key digital transformation indicators in Kazakhstan, Tajikistan, Uzbekistan, and Kyrgyzstan, including internet penetration rates, ICT sector investment volumes, and the share of the digital economy in GDP; an assessment of the relationship between digital readiness and macroeconomic indicators, as well as the impact of digitalization on business productivity, e-commerce growth, and fintech development; and an evaluation of major barriers to digital transformation, including a shortage of skilled professionals, insufficient digital integration in SMEs, and regulatory constraints in the e-government and fintech sectors.

2 Materials and methods

At the macroeconomic level, the framework conceptualizes digital transformation as a structural factor influencing national productivity and competitiveness. Digital readiness (infrastructure, ICT investment, regulatory environment, digital literacy) is treated as an independent systemic variable that shapes the efficiency of national information flows and reduces transaction costs. At the sectoral level, the framework focuses on the transformation of logistics, financial services, and e-commerce ecosystems. The efficiency of logistics operations, speed of information exchange, supply chain transparency, and financial inclusion are analyzed as operational performance indicators. At the microeconomic level, the framework examines enterprise behavior and organizational adaptation. Digital platform adoption, automation of management processes, and integration of analytics into decision-making are analyzed as drivers of firm-level productivity and revenue growth. The framework also incorporates a barrier-analysis dimension, identifying institutional constraints, regulatory gaps, financial limitations, and skills shortages as structural moderators that influence the strength of relationships between digital readiness and economic outcomes.

The methodology of this study combined both quantitative and qualitative analysis to assess the impact of digital technologies on the economic development of Kazakhstan, Tajikistan, Uzbekistan, and Kyrgyzstan. The data spanned the period from 2020 to 2024, enabling an analysis of the dynamics of digital transformation over four years. Data collection was conducted using official statistics provided by international organizations such as the World Bank Group [11], the United Nations Development Program (UNDP) [12], the Organization for Economic Co-operation and Development (OECD) [13], as well as national statistical agencies of Kazakhstan [14], Uzbekistan [15], Kyrgyzstan [16], and Tajikistan [17]. Secondary data included indicators of digitalization levels, investment volumes in the ICT sector, the share of the digital economy in GDP, the development of e-commerce, fintech, and e-government.

The selection criteria for data were based on the availability of consistent and up-to-date indicators relevant to the digital economy's development. Key indicators included internet penetration rates, share of ICT sector in GDP, digital readiness index, investment in the digital economy, and the number of mobile banking users. These indicators were chosen to provide a clear picture of the digital economy's structure and its relationship to macroeconomic performance across the region.

The analysis employed several statistical methods. Correlation and regression analyses were used to examine the relationships between digital readiness and macroeconomic indicators such as GDP growth, business efficiency, and e-commerce development. Correlation analysis identified interdependencies among digital infrastructure, ICT sector investments, and digital transformation, while regression analysis quantified the impact of these factors on economic growth. Comparative analysis allowed for a cross-country examination of digitalization levels, revealing structural differences and factors influencing the pace of digital transformation in each country.

Dynamic analysis using time-series data traced changes in digital transformation over the study period. This method provided insight into the development trajectories of the digital economy, factoring in the influence of government policies, investment flows, and infrastructural development. A structural-functional approach was applied to systematize the main factors of digital transformation and identify barriers, while examining how digital solutions in business processes, public administration, and logistics can improve productivity. The analysis of structural interconnections between digital technologies, economic efficiency, and institutional conditions contributed to assessing the long-term consequences of digital integration.

Verification of the reliability of the obtained results was conducted by assessing multicollinearity in regression models to eliminate excessive correlation between variables. Data normalization was performed to ensure comparability between countries. The use of time series allowed for consideration of the dynamics of digital transformation over different periods of the study. The reanalysis of data based on various sources contributed to verifying the robustness of the results.

3 Results

Digitalization shaped the direction of economic policy formation and economic modernization, fostering labor productivity growth, increasing investments, and expanding access to financial and government services [18-21]. In the global context, the adoption of digital technologies led to structural changes in production processes, public administration mechanisms, and consumer market functioning. These processes contributed to reduced transaction costs, increased operational efficiency of businesses, and created additional jobs.

The assessment of key digitalization indicators in the analyzed countries (Table 1) highlighted differences in the pace of adoption of digital technology and the readiness of economies for digital transformation.

The development of digital infrastructure on a global scale largely depends on government support and investment in the technological sector [22,23]. According to the World Bank Group, countries that actively funded digitalization experienced increased labor productivity, reduced business costs, and improved interaction between businesses and the state. Investments in high-speed Internet, the creation of digital platforms, and the expansion of access to cloud computing contributed to enhancing economic competitiveness by ensuring rapid data processing and access to global markets [24-27]. In the countries analyzed, digital transformation progressed unevenly due to differences in institutional readiness, financing, and technological development.

Table 1 Key indicators of digitalization in Kazakhstan, Tajikistan, Uzbekistan, and Kyrgyzstan (2024)

Indicator	Kazakhstan	Uzbekistan	Kyrgyzstan	Tajikistan
Internet penetration rate (%)	88	72	60	48
Share of IT sector in GDP (%)	4.2	2.8	1.5	0.9
Digital readiness index (scale 0-100)	75	65	55	50
Investment in the digital economy (million USD)	1200	800	400	250
Number of mobile banking users (million people)	9.5	5.7	3.2	1.8

Source: compiled by the authors based on World Bank Group [11], UNDP [12], OECD [13], national statistical agencies of Kazakhstan [14], Uzbekistan [15], Kyrgyzstan [16], and Tajikistan [17].

Kazakhstan has the most developed digital economy among the analyzed countries, a result of implementing a national digitalization strategy and attracting foreign investments in the information technology sector. Internet penetration in the country exceeded 88%, and digital transformation encompassed the financial sector, public administration, and logistics. In Uzbekistan, despite a lower level of digital development, reforms in e-government and e-commerce were implemented, fostering the growth of businesses using digital platforms in their operations. In Tajikistan, digitalization progressed more slowly due to an underdeveloped digital infrastructure and limited broadband Internet access, restricting opportunities for process automation in public administration and the business sector.

Kyrgyzstan was at an intermediate stage of digital transformation compared to the other analyzed countries. The implementation of digital technologies occurred within the framework of government initiatives aimed at developing e-government, fintech, and administrative process automation. However, the dynamics of digital transformation were unstable, influenced by institutional factors, insufficient adoption of digital technologies in SMEs, and limited infrastructure resources. Analyzing the country's digital development level relative to neighboring states helped identify its potential for increasing economic efficiency through the expansion of digital services.

Table 2 Correlation matrix of digital transformation and economic growth

Indicator	Internet penetration rate (%)	Share of IT sector in GDP (%)	Digital readiness index (0-100)	Investment in the digital economy (million USD)	Number of mobile banking users (million people)
Internet penetration rate (%)	1.000	0.992	0.994	0.989	0.990
Share of IT sector in GDP (%)	0.992	1.000	0.999	0.999	0.997
Digital readiness index (0-100)	0.994	0.999	1.000	0.999	0.995
Investment in the digital economy (million USD)	0.989	0.999	0.999	1.000	0.996
Number of mobile banking users (million people)	0.990	0.997	0.995	0.996	1.000

Note: Table 2 presents a correlation matrix reflecting the relationship between key digital transformation indicators in the analyzed countries. The correlation coefficient values range from 0 to 1, where 1.000 indicates a complete dependency between variables. The high correlation values between Internet penetration, the share of the IT sector in GDP, the Digital readiness index, and investment in the digital economy suggest a strong interconnection among these indicators. These results indicate that improving digital infrastructure and increasing investment volumes are crucial factors in advancing digitalization. The high correlation between the number of mobile banking users and other digital transformation indicators confirms the growing importance of digital financial services in the region.
Source: compiled by the authors based on World Bank Group [11], UNDP [12], OECD [13], national statistical agencies of Kazakhstan [14], Uzbekistan [15], Kyrgyzstan [16], and Tajikistan [17].

Government digitalization policies remained a key factor in the region's digital transformation. In Kazakhstan, the automation of public services reduced bureaucratic burdens and increased the transparency of administrative procedures, creating favorable conditions for business growth. In Uzbekistan, the expansion of state digital platforms improved access

to online services for citizens and businesses. In Tajikistan and Kyrgyzstan, lower levels of government support for digitalization limited opportunities for ICT sector development and slowed the implementation of digital solutions in key economic sectors. The correlation matrix of digital transformation and economic growth, presented in Table 2, illustrates the relationship between key digital economy indicators.

The obtained results confirmed the necessity of a comprehensive approach to the digital transformation of the economy, as the development of individual components of digital infrastructure was interconnected with overall economic growth rates. High correlation coefficients between the key indicators of digital transformation and their impact on GDP indicated that regional differences in digitalization levels could determine the dynamics of economic development. This underscored the need for further analysis of the mechanisms through which digital technologies influence business processes, which could contribute to a deeper understanding of their role in the structural changes of the analyzed countries' economies.

The digital transformation of business in the analyzed countries occurred unevenly, which was explained by differences in the level of digital infrastructure, investment volumes, and government policies in the digital economy sector. Kazakhstan demonstrated a high level of digital integration in the financial sector, facilitating the modernization of the business environment. As part of the activities of the Astana International Finance Centre, a strategy for the digitalization of financial services and fintech development was implemented, creating favorable conditions for innovative entrepreneurship and attracting foreign investment. As noted in the study by Zhanibek et al. [28], Kazakhstan's digital transformation was based on the active development of digital platforms, the expansion of e-government services, and the stimulation of digital business, which enhanced the competitiveness of the economy.

In Uzbekistan, business digitalization was carried out through the implementation of electronic document management, the automation of tax processes, and the development of e-commerce. Government initiatives were aimed at reducing administrative barriers for businesses by introducing digital services in enterprise registration and financial accounting. As noted in the work of Kuldosheva [29], Uzbekistan's digital transformation was characterized by the active use of big data and automated systems for public finance management, which contributed to an improved business environment and increased enterprise productivity.

In Kyrgyzstan, business digitalization progressed more slowly due to limited investment opportunities and an insufficient level of digital infrastructure. As indicated in the study by Momunalieva et al. [30], the development of digital technologies in the country faced several barriers, including a shortage of specialized ICT sector personnel and low integration of digital solutions into SMEs. Limited access to fintech services and an insufficient level of e-government slowed the pace of digital transformation and hindered the efficiency of business processes.

In Tajikistan, the digital transformation of business remained in its early stages due to the underdeveloped digital infrastructure and low integration of digital technologies into entrepreneurial activities. As noted in the study by Akhrorova & Boboev [31], the country's economic digitalization process was characterized by the fragmented implementation of digital solutions in the banking sector, particularly the expansion of online banking and the introduction of electronic payments. At the same time, the overall level of digital literacy among entrepreneurs remained low, limiting the effective use of fintech solutions and e-commerce. The insufficient volume of investment in the digital economy and the slow implementation of digital platforms in the business environment constrained the development of competitive business models, reducing the efficiency of Tajik enterprises at the regional level.

Table 3 contained data on the level of digital platform usage by large, medium, and small enterprises in the analyzed countries, as well as indicators of revenue growth following digitalization, the level of big data application, and the prevalence of e-commerce among companies in the region.

Table 3 Level of digital technology implementation in business

Indicator	Kazakhstan	Uzbekistan	Kyrgyzstan	Tajikistan
Share of large enterprises using digital platforms (%)	75	70	60	50
Share of medium enterprises using digital platforms (%)	65	60	45	40
Share of small enterprises using digital platforms (%)	50	45	30	25
Company revenue growth following digitalization (%)	25	20	15	10
Share of enterprises using big data (%)	40	35	25	20
Share of enterprises engaged in e-commerce (%)	55	50	35	30

Source: compiled by the authors based on World Bank Group [11], UNDP [12], OECD [13], national statistical agencies of Kazakhstan [14], Uzbekistan [15], Kyrgyzstan [16], and Tajikistan [17].

The main barriers to business digitalization in the analyzed countries remained financial constraints, a shortage of qualified personnel, and legal aspects of the digital economy. In Kyrgyzstan and Tajikistan, SMEs faced difficulties in financing digital transformations due to the high costs of implementing information systems, limited access to credit resources, and insufficient state support. In Kazakhstan and Uzbekistan, the conditions for digital development were more favorable due to the implementation of government programs; however, financial constraints remained relevant,

especially for enterprises expanding digital infrastructure. Additionally, a shortage of qualified specialists in the ICT sector was observed across all countries in the region, complicating the adoption of new technologies. The level of digital literacy among entrepreneurs remained relatively low, limiting the effective use of digital technologies.

As noted in the study by Kalyuzhnova & Holzhacker [32], business and infrastructure digital transformation in the region was inextricably linked to the development of trade corridors and the strengthening of regional cooperation. The study emphasized that reducing trade costs and increasing Central Asia's integration into global value chains required the adoption of digital solutions in the transport and logistics sector. Uzbekistan and Kazakhstan, as key centers of regional trade activity, needed to intensify initiatives aimed at technological modernization and increasing business digitalization levels, which would contribute to attracting additional investments and enhancing the region's competitiveness in the context of global economic transformation.

Regulatory aspects of the digital economy also posted significant obstacles to business digitalization. The absence of an adapted legislative framework complicated the activities of enterprises operating in fintech, e-commerce, and big data. Inadequate legal regulation in the areas of personal data protection, electronic document management, and digital payments hindered the development of the digital economy, particularly in Kyrgyzstan and Tajikistan [33,34]. Meanwhile, in Kazakhstan and Uzbekistan, government initiatives were implemented to support business digital transformation. Kazakhstan introduced the "Digital Kazakhstan" program [35], which included the development of a digital ecosystem for SMEs. Research into Uzbekistan's experience [36] focused on the adoption of a series of regulatory acts governing digital financial services and e-commerce, which contributed to reducing administrative barriers and simplifying business registration procedures. The implementation of similar approaches could be beneficial for Kyrgyzstan, facilitating the acceleration of digital transformation in entrepreneurial activities.

The digitalization of the logistics sector in the analyzed countries also progressed unevenly, explained by varying levels of technological development, state support, and financial capabilities. Kazakhstan and Uzbekistan demonstrated significant progress in adopting digital solutions in logistics, whereas in Kyrgyzstan and Tajikistan, the development of digital technologies in this sector was slower due to infrastructure constraints and an insufficient level of logistics process automation. To assess the impact of digital solutions on transport sector efficiency, an empirical analysis was conducted, enabling a comparison of digital transformation results in the region's logistics sector.

Table 4 contained data on the reduction of delivery times, decreases in operational costs, improvements in route planning efficiency, reductions in logistics process delays, and enhancements in customer service levels resulting from the adoption of digital technologies in the logistics sectors of Kazakhstan, Uzbekistan, Kyrgyzstan, and Tajikistan.

Table 4 Analysis of logistics digitalization

Indicator	Kazakhstan	Uzbekistan	Kyrgyzstan	Tajikistan
Reduction in delivery time (%)	15	13	8	6
Decrease in operational costs (%)	10	8	5	4
Improvement in route planning efficiency (%)	12	10	6	5
Reduction in logistics process delays (%)	10	9	6	5
Increase in customer service level (%)	14	12	7	6

Source: compiled by the authors based on World Bank Group [11], UNDP [12], OECD [13], national statistical agencies of Kazakhstan [14], Uzbekistan [15], Kyrgyzstan [16], and Tajikistan [17].

The digital transformation processes in Kazakhstan, Uzbekistan, Kyrgyzstan, and Tajikistan have significantly influenced the management of information, material, and financial flows, as well as the efficiency of logistics systems across these countries. The integration of digital technologies has streamlined business processes, improved the flow of information between businesses and government entities, and optimized the management of material resources in the logistics sector [37-39]. In Kazakhstan, the adoption of advanced logistics technologies, such as automated route planning and IoT-based cargo monitoring, has reduced operational costs and delivery times, resulting in a 15% decrease in delivery time and a 10% reduction in operational costs. Similarly, Uzbekistan has seen improvements in logistics efficiency through digital platforms that enhance supply chain management and route optimization. However, in Kyrgyzstan and Tajikistan, the flow of information and materials remains constrained by limited digital infrastructure and insufficient digital literacy, slowing down the adoption of automated systems in logistics. Moreover, the financial flow management in both e-commerce and fintech sectors has improved, particularly in Kazakhstan and Uzbekistan, where digital platforms have enabled smoother financial transactions and greater access to financial services, facilitating business operations and increasing economic efficiency.

The digital development of the analyzed countries was uneven, influenced by differences in levels of digital infrastructure, Internet accessibility, digital literacy, human capital, and state support for digital initiatives. Kazakhstan and Uzbekistan demonstrated higher levels of digitalization due to the implementation of digital economy strategies and the attraction of significant investments. Kyrgyzstan and Tajikistan faced more challenging conditions, slowing down the

integration of digital technologies into key economic sectors. In this context, a key task was to determine priority measures aimed at accelerating digital transformation, considering the economic development specifics of each country.

Table 5 presented summarized recommendations for the digital development of Kazakhstan, Uzbekistan, Kyrgyzstan, and Tajikistan, formulated based on the analysis of structural challenges.

Table 5 Recommendations for digital development

Development direction	Kazakstan	Uzbekistan	Kyrgyzstan	Tajikistan
Expansion of digital infrastructure	Expansion of 5G networks, Internet coverage in remote regions	Expansion of fibre-optic networks, state investments in digital infrastructure	Development of broadband Internet in rural areas	Increased access to mobile Internet, expansion of network coverage
Enhancement of digital literacy	Development of digital education programs, mandatory IT studies in schools	State initiatives to improve digital literacy	Creation of national digital education programs, adaptation of international practices	Integration of digital literacy courses into the education system
Strengthening human capital in IT	Support for tech parks, grant programs for startups	Training of IT specialists through international education programs	Implementation of mechanisms to support IT startups	Development of educational programs with a focus on IT specialization
Effective public policy for digitalization	Integration of digital technologies in the public sector, automation of services	Expansion of e-government, development of e-commerce	Adoption of a comprehensive digitalization strategy	Automation of public services, creation of unified digital platforms
Forecasting and strategic planning	Use of big data for digital development forecasting	Forecasting digital trends to optimise the business environment	Use of analytics to assess the effectiveness of digital initiatives	Development of digital economy strategies considering local specifics
Attraction of international investments	Attracting investors in fintech, stimulation of tech companies	Investment incentives for tech companies, partnerships with international IT corporations	Expansion of cooperation with international organizations to attract digital investments	Attraction of technology investors through international initiatives

Source: compiled by the authors.

The proposed recommendations considered the current level of digital development in each country and its main structural challenges. Kazakhstan had the most advanced digital infrastructure and was actively implementing 5G technologies, which contributed to the improvement of digital services. In Uzbekistan, the primary focus was on expanding fiber-optic networks and stimulating state investments in the digital economy. In Kyrgyzstan and Tajikistan, the level of digital infrastructure remained lower, making the improvement of Internet access, particularly in remote regions, a priority.

The level of digital literacy also varied significantly among the countries. Kazakhstan and Uzbekistan actively expanded educational programs that included the development of ICT competencies, whereas in Kyrgyzstan and Tajikistan, a deeper integration of digital literacy courses into the education system was required. A key challenge remained the human capital in the ICT sector. Kazakhstan supported the development of startups and technology hubs, while Uzbekistan actively fostered international cooperation in IT specialist training. In Kyrgyzstan and Tajikistan, the creation of grant programs and mechanisms to stimulate professional development in digital technologies was necessary.

Public policy played a crucial role in the region's digital transformation [40,41]. Kazakhstan and Uzbekistan implemented large-scale state digitalization programs, promoting the automation of public services and the development of e-government. In Kyrgyzstan and Tajikistan, the structuring of digital initiatives was less developed, limiting their effectiveness. A crucial aspect of digital development remained strategic planning, which encompassed forecasting digital trends and applying big data to enhance the effectiveness of managerial decisions in digital transformation.

Attracting international investments was of particular importance. Kazakhstan and Uzbekistan already used preferential conditions to support technological companies, contributing to the expansion of the ICT sector. In Kyrgyzstan and Tajikistan, there was significant potential for strengthening cooperation with international financial institutions, which could facilitate further digital integration and the development of key economic sectors.

4 Discussion

The process of digital transformation played a key role in shaping economic development, encompassing all leading sectors of the economy. The integration of digital technologies contributed to the renewal of business models, the enhancement of management processes, and the optimization of resource use. Significant changes took place in public administration, industry, the financial sector, and logistics, necessitating a comprehensive analysis of the impact of digitalization at both the macro- and microeconomic levels. At the same time, the process of digital integration was accompanied by several challenges, including institutional constraints, financial barriers, and regulatory issues. Given the rapid pace of digital economy development, identifying key trends, risks, and opportunities arising from digitalization in various economic systems became a relevant task.

The analysis of the obtained results demonstrated that digital transformation significantly influenced economic productivity and the development of leading industries, particularly energy, entrepreneurship, and logistics. The study conducted by Mihai et al. [42] focused on the digitalization of the energy sector and highlighted the main challenges in ensuring its resilience. The authors identified the interrelation between the level of digital technology implementation and the efficiency of energy enterprises. The findings were consistent with the results of this study, confirming the significance of digital modernization as a tool for enhancing economic efficiency and reducing costs in various economic sectors.

The digitalization of the business environment was considered a key factor in strengthening the competitiveness of regional economies. In the study by Vîrjan et al. [43], the relationship between the level of digital integration and economic competitiveness was analyzed. The authors established that the active implementation of digital technologies contributed to increased labor productivity, investment attraction, and the development of innovation potential. An analysis of the economies of the studied countries confirmed these patterns, as it was found that Kazakhstan and Uzbekistan had higher levels of digital integration, which positively affected their macroeconomic indicators.

The study of digital transformation in SMEs in the analyzed countries showed that the level of digital technology implementation significantly influenced business productivity and competitiveness. In the study by Martínez-Peláez et al. [44], the relationship between the use of digital solutions, organizational culture, and business resilience was examined. The authors found that the application of big data and active stakeholder engagement enhanced the effectiveness of digital transformation in enterprises. The obtained results confirmed that state support and strategic planning for digitalization in SMEs in the analyzed countries could contribute to their economic resilience and innovation potential.

The research results demonstrated that the digitalization of business processes contributed to improving customer interaction and optimizing marketing strategies. Similar conclusions were drawn in the study by Fernández-Rovira et al. [45], which analyzed the role of big data in customer data management and consumer behavior forecasting. The authors emphasized that the widespread use of digital technologies in business created both new opportunities and certain threats, particularly of an ethical nature. These findings aligned with the need to implement regulatory mechanisms to ensure data security in the digital environment of the analyzed countries.

Organizational changes driven by digitalization processes required a systematic approach and a high level of adaptability. In the study by Hanelt et al. [46], a systematic analysis of scientific literature on digital transformation was conducted, allowing for the identification of four key approaches to managing this process. The authors concluded that digital transformation involves not only technological upgrades but also a revision of organizational models and business ecosystems. Similar results were obtained during the study of digital reforms in the public sector of the analyzed countries, where the implementation of digital solutions contributed to improving the efficiency of management processes.

The study of digital transformation processes demonstrated that its successful implementation depended not only on technological innovations but also on workforce adaptability, the effectiveness of management strategies, and an established organizational culture. In the work by Trenerry et al. [47], a multilevel analysis of digital transformation factors was conducted, covering individual, team, and organizational aspects. The authors identified key determinants of employees' successful adaptation to digital changes, including technological literacy, staff training levels, organizational culture, and leadership effectiveness. The obtained results aligned with the conclusions on business digital transformation in the analyzed countries, confirming that enterprises' readiness to implement new technologies largely depended on personnel competence, internal communication quality, and strategic leadership vision. This underscores the need to develop comprehensive digitalization strategies that combine technological investments with measures aimed at human capital development.

Recent literature emphasizes the centrality of digital transformation in shaping information, financial, and material flows within logistics and broader economic systems. Ptashchenko et al. [48] reveals that digital technologies significantly enhance logistics efficiency and transparency, reducing operational costs and delivery times while strengthening the integration between digital logistics and international trade development, findings that resonate with the observed

improvements in material and information flows in our regional analysis. Additionally, Şahan [49] demonstrates through panel regression analysis across multiple European contexts that components of digital transformation (including internet connectivity and digitized public services) have a positive effect on logistics performance, highlighting the importance of digital integration for competitive logistics and supply chain management. Complementing these empirical insights, Al Ababneh et al. [50] argue that digital transformation of supply chain management is a multifaceted process that enhances efficiency, transparency, and sustainability, underscoring how information technologies optimize logistics, inventory, and transportation flows.

Digital transformation was a key factor in economic modernization, contributing to enterprise productivity growth, business process optimization, and improved public administration efficiency. It was established that the level of digital integration directly influenced economic competitiveness, investment attraction, and innovation sector development. The findings show that digital integration improved delivery coordination, route planning, supply chain transparency, and customer service quality, especially in Kazakhstan and Uzbekistan, where digital logistics tools were associated with reduced delivery times and lower operational costs. These results indicate that logistics is not merely a secondary area of digitalization but one of the main channels through which digital technologies influence business productivity, trade efficiency, and regional economic competitiveness. The comparison of obtained results with other researchers' conclusions confirmed common patterns of digital changes, particularly the impact of big data, automated platforms, and companies' digital maturity levels on their economic efficiency. It was proven that the success of digital transformation largely depended on adapting strategic approaches to the development level of the institutional environment and technological infrastructure. At the same time, a number of challenges have been identified related to ensuring effective risk management, data protection, and regulatory aspects of digitalization. Given these factors, the further implementation of digital solutions required a comprehensive approach that encompassed the expansion of digital infrastructure, the improvement of regulatory frameworks, and the enhancement of digital literacy among economic actors.

5 Conclusions

The study provides a comprehensive assessment of how digital transformation affects economic development, the business environment, and logistics in Kazakhstan, Uzbekistan, Kyrgyzstan, and Tajikistan, which constitutes its scientific novelty. The analysis of key digitalization indicators revealed substantial differences in the pace and depth of technology adoption across countries. A strong relationship was identified between digital readiness, the ICT sector's share in GDP, and investment in the digital economy, confirming the role of digital integration in supporting economic growth.

Kazakhstan and Uzbekistan demonstrated more advanced implementation of digital technologies in finance, e-government, business, and logistics. In contrast, Kyrgyzstan and Tajikistan showed slower progress due to institutional, financial, infrastructural, and human-capital constraints. Business digitalization positively affected enterprise productivity and revenues, especially among large companies. Kazakhstan recorded the highest level of enterprise digital integration, with 75% of large firms using digital platforms. However, the effect on SMEs remained uneven, particularly where access to e-commerce tools, big data, and qualified ICT specialists was limited.

Digitalization also improved logistics performance by reducing operational costs, optimizing routes, and enhancing service quality. In Kazakhstan and Uzbekistan, digital logistics tools reduced delivery time by up to 15% and increased transport efficiency. The findings confirm the need for expanded investment in digital infrastructure and sector-specific technologies. Recommended measures include further 5G deployment, technology hubs, and fintech support in Kazakhstan; digital literacy and ICT training in Uzbekistan; and improved Internet access, digital education, and regulatory support in Kyrgyzstan and Tajikistan.

The limitations of the study were determined by the specifics of the data used, the methodological approach, and the time frame. The analysis was based on official statistical indicators, ensuring their representativeness, but not reflecting short-term changes. The applied methods of correlation and regression analysis allowed for the identification of relationships between digitalization and economic development but did not detail sectoral specificities. The time frame (2020-2024) ensured the relevance of the conclusions, although the long-term effects of digital transformation required further monitoring.

Promising areas for further research could include analyzing the impact of digital transformation on specific economic sectors, particularly financial services, education, and industry. Special attention should be given to studying the mechanisms of state incentives for digitalization in SMEs, as well as developing adaptive models for implementing digital technologies in countries with different levels of economic development.

References

[1] OLEKSY-GEBCZYK, A., BILIANSKYI, Y.: Peculiarities of marketing communications on support of smallholders by branched retail chains (on the example of "Silpo" Fozzy group), *Smart-Journal of Business Management Studies,* Vol. 20, No. 2, pp. 45-56, 2024. https://doi.org/10.34293/2321-2012.2024.0002.5

[2] ALQSASS, M., JARADAT, H., REXHEPI, B.R., ZUREIGAT, B.N., AL-GASAWNEH, J., MAALI, H.: The Impact of Dividends Per Share and Retained Earnings Per Share on Share Price: A Study Based On Jordanian Companies, *Quality - Access to Success*, Vol. 24, No. 197, pp. 67-74, 2023. https://doi.org/10.47750/QAS/24.197.08
[3] AGAYEV, M.: Assessment of the impacts of digital trade and investment on inclusive and sustainable growth in Central Asia, Aghayev, Murad, Assessment of the impacts of digital trade and investment on inclusive and sustainable growth in Central Asia (June 11, 2024), Available at SSRN: 2024. http://dx.doi.org/10.2139/ssrn.4861141
[4] MALTABAROV, A., SARYBAYEV, M.: Digital transformation of the countries of the Central Asian region: The path to regional integration?, *Bulletin. Series: International Relations and Regional Studies*, Vol. 52, No. 2, 2023. https://doi.org/10.48371/ISMO.2023.52.2.009
[5] MALTABAROV, A., SARYBAYEV, M., CHUKUBAYEV, Y.: Regional dimension of digital transformation: The interests of the European Union in the countries of Central Asia, *Journal of Central Asian Studies*, Vol. 91, No. 3, pp. 40-55, 2023. https://doi.org/10.52536/2788-5909.2023-3.04
[6] GOMBOIN, Z., SULTANGAZIN, A., BURABAEV, K., MAHKHAMOV, T.: Digital public services for small and medium-sized enterprises in Kazakhstan, Kyrgyzstan and Uzbekistan, Bangkok, Economic and Social Commission for Asia and the Pacific, [Online], Available: https://hdl.handle.net/20.500.12870/7776 [15 Oct 2025], 2025.
[7] RUDYK, N.V., NIYAZBEKOVA, Sh.U., VILIGUTA, O.F., DZHOLDOSHEVA, T.YU., KALDENOVA, G.S., ZHANABAYEVA, Zh.: Digitalization as an engine of economic growth, *Bulletin the National Academy of Sciences of the Republic of Kazakhstan*, Vol. 1, No. 389, pp. 146-152, 2021. http://dx.doi.org/10.32014/2021.2518-1467.20
[8] OLCZYK, M., KUC-CZARNECKA, M.: Digital transformation and economic growth – DESI improvement and implementation, *Technological and Economic Development of Economy*, Vol. 28, pp. 775-803, 2022. https://doi.org/10.3846/tede.2022.16766
[9] IRTYSHCHEVA, I., STEHNEI, M., POPADYNET, N., BOGATYREV, K., BOIKO, Y., KRAMARENKO, I., KRAMARENKO, I., SENKEVICH, O., HRYSHYNA, N., KOZAK, I., ISCHENKO, O.: The effect of digital technology development on economic growth, *International Journal of Data and Network Science*, Vol. 5, pp. 25-36, 2021. http://dx.doi.org/10.5267/j.ijdns.2020.11.006
[10] TUDOSE, M.B., GEORGESCU, A., AVASILCĂI, S.: Global analysis regarding the impact of digital transformation on macroeconomic outcomes, *Sustainability*, Vol. 15, No. 5, 4583, pp. 1-21, 2023. https://doi.org/10.3390/su15054583
[11] WORLD BANK GROUP: World development indicators, [Online], Available: https://databank.worldbank.org/source/world-development-indicators [16 Oct 2025], 2024.
[12] UNITED NATIONS DEVELOPMENT PROGRAM (UNDP): Human development report 2025: A matter of choice: People and possibilities in the age of AI, [Online], Available: https://hdr.undp.org/content/human-development-report-2025 [16 Oct 2025], 2025.
[13] ORGANIZATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT (OECD): OECD digital economy outlook, [Online], Available: https://www.oecd.org/digital/digital-economy-outlook/ [16 Oct 2025], 2024.
[14] BUREAU OF NATIONAL STATISTICS: Agency for strategic planning and reforms of the Republic of Kazakhstan, Statistics of enterprises, [Online], Available: https://stat.gov.kz/en/industries/business-statistics/stat-org/ [16 Oct 2025], 2025.
[15] COMMITTEE OF THE REPUBLIC OF UZBEKISTAN ON STATISTICS: Digital economy, [Online], Available: https://stat.uz/en/official-statistics/tsifrovaya-ekonomika-eng [16 Oct 2025], 2025.
[16] NATIONAL STATISTICAL COMMITTEE OF THE KYRGYZ REPUBLIC: ICT, [Online], Available: https://stat.gov.kg/en/statistics/informacionno-kommunikacionnye-tehnologii/ [16 Oct 2025], 2025.
[17] AGENCY ON STATISTICS UNDER THE PRESIDENT OF THE REPUBLIC OF TAJIKISTAN: Economics, [Online], Available: https://www.stat.tj/en/economics/ [16 Oct 2025], 2025.
[18] SHAHINI, E., SHAHINI, E.: The Economic and Political Legacy of Trump's First Term: Implications for the Second Presidency, *Politics and Policy*, Vol. 53, No. 5, p. e70066, 2025. https://doi.org/10.1111/polp.70066
[19] TETA, J., XHAFKA, E.: The Qualitative Impact of Foreign Direct Investment in the Albanian Clothing Industry, *Apuntes Del Cenes,* Vol. 43, No. 78, pp. 51-68, 2024. https://doi.org/10.19053/uptc.01203053.v43.n78.2024.17251
[20] SADENOVA, A., DENISSOVA, O., KOZLOVA, M., RAKHIMOVA, S., GOLA, A., SUIEUBAYEVA, S.: Structural equation modeling (SEM) in jamovi: An example of analyzing the impact of factors on enterprise innovation activity, *Applied Computer Science,* Vol. 21, No. 1, pp. 97-110, 2025. https://doi.org/10.35784/acs_7037
[21] BABAYEVA, S., ADILOVA, N., GOJAEVA, E., PASHAYEVA, A.: Green Innovation as a Factor of Economic Growth, *Lecture Notes in Networks and Systems,* Vol. 1251, pp. 523-531, 2024. https://doi.org/10.1007/978-3-031-81567-6_60
[22] ABBASOVA, S., İSMAYILOV, V., TRUSOVA, N.: Problems of financing the state budget deficit, *Scientific Bulletin of Mukachevo State University. Series Economics,* Vol. 10, No. 4, pp. 9-19, 2023. https://doi.org/10.52566/msu-econ4.2023.09

[23] GOJAEVA, E., ADILOVA, N., CHOBANLI, E., GUTIUM, T.: Green Economy as the Basis for Innovative Environmental Sustainable Development, *Lecture Notes in Networks and Systems,* Vol. 1251, pp. 465-472, 2024. https://doi.org/10.1007/978-3-031-81567-6_54
[24] TARAN, I., OLZHABAYEVA, R., OLISKEVYCH, M., DANCHUK, V.: Structural optimization of multimodal routes for cargo delivery, *Archives of Transport,* Vol. 67, No. 3, pp. 49-70, 2023. https://doi.org/10.5604/01.3001.0053.7076
[25] PAVLOVA, D., DOVRAMADJIEV, T., DASKALOV, D., MIRCHEV, N., PEEV, I., RADEVA, J., DIMOVA, R., KAVALDZHIEVA, K., MRUGALSKA, B., SZABO, G., KANDIOGLOU, A.: 3D Design of a Dental Crown with Artificial Intelligence Based in Cloud Space, *Lecture Notes in Networks and Systems,* Vol. 817, pp. 437-445, 2024. https://doi.org/10.1007/978-981-99-7886-1_37
[26] IHNATENKO, M., ANTOSHKIN, V., POSTOL, A., HURBYK, Y., RUNCHEVA, N.: Features of the content and implementation of innovation and investment projects for the development of enterprises in the field of rural green tourism, *International Journal of Management,* Vol. 11, No. 3, pp. 304-315, 2020. https://ssrn.com/abstract=3574636
[27] REXHEPI, B.R., KUMAR, A., GOWTHAM, M.S., RAJALAKSHMI, R., PAIKARAY, M.D., ADHIKARI, P.K.: An Secured Intrusion Detection System Integrated with the Conditional Random Field For the Manet Network, *International Journal of Intelligent Systems and Applications in Engineering*, Vol. 11, No. 3s, pp. 14-21, 2023. https://www.ijisae.org/index.php/IJISAE/article/view/2526
[28] ZHANIBEK, A., ABAZOV, R., KHAZBULATOV, A.: Digital transformation of a country's image: The case of the Astana International Finance Centre in Kazakhstan, *Virtual Economics*, Vol. 5, No. 2, pp. 71-94, 2022. http://dx.doi.org/10.34021/ve.2022.05.02(4)
[29] KULDOSHEVA, G.: Challenges and opportunities of digital transformation in the public sector in transition economies: Examination of the case of Uzbekistan, Tokyo, Asian Development Bank Institute, [Online], Available: https://www.adb.org/publications/challenges-opportunities-digital-transformation-uzbekistan [20 Oct 2025], 2021.
[30] MOMUNALIEVA, A., ISMAILOVA, R., NAJIMUDINOVA, S.: *The case of the Kyrgyz Republic*, in MENTER, I. (ed.) *The reform of teacher education in the post-soviet space: A comparative analysis of fifteen independent countries*, pp. 132-149, London, Routledge, 2024. https://doi.org/10.4324/9781003348047
[31] AKHROROVA, A.D., BOBOEV, F.J.: *Trends in the digitalization of the economy of Tajikistan and its banking sector*, in SIMANAVIČIENĖ, Z. (ed.) *Digital technologies in the contemporary economy: Collective monograph*, pp. 56-65, Kaunas, Mykolas Romeris University, 2022.
[32] KALYUZHNOVA, Y., HOLZHACKER, H.: Enhancing connectivity and trade between Central Asia regional economic cooperation countries and the world: Benefits, risks and policy implication, Tokyo, Asian Development Bank Institute, [Online], Available: https://www.adb.org/publications/enhancing-connectivity-trade-between-carec-world [20 Oct 2025], 2021.
[33] LAKBAEV, K.S., RYSMAGAMBETOVA, G.M., SAITBEKOV, A.M., MUKHAMEDZHANOV, Y.O.: Investigative measures in prejudicial inquiry: The concept, content and the basics of law enforcement, *Man in India,* Vol. 97, No. 20, pp. 373-380, 2017. [16 Oct 2025]
[34] DALKE, A., SVYATOV, S., RUZIYEVA, E.: Criteria for Identification and Regulation of Systemically Important Banks, *Accounting, Economics and Law: A Convivium*, 2025. https://doi.org/10.1515/ael-2024-0070
[35] MUKANOV, A.: *The main indicators of the state program "Digital Kazakhstan"*, in SVOBODA, A. (ed.) *Proceedings of the 7th International Scientific and Practical Conference "Current Issues and Prospects for The Development of Scientific Research"*, pp. 25-38, Orleans, SPC "InterConf", 2023. https://doi.org/10.51582/interconf.19-20.04.2023.003
[36] NIYAZBEKOVA, S., ZVERKOVA, A., SOKOLINSKAYA, N., KERIMKHULLE, S.: Features of the "Green" strategies for the development of banks, *E3S Web of Conferences,* Vol. 402, 08029, pp. 1-7, 2023. https://doi.org/10.1051/e3sconf/202340208029
[37] DANCHUK, V., COMI, A., WEIß, C., SVATKO, V.: The optimization of cargo delivery processes with dynamic route updates in smart logistics, *Eastern-European Journal of Enterprise Technologies,* Vol. 2, No. 3-122, pp. 64-73, 2023. https://doi.org/10.15587/1729-4061.2023.277583
[38] MIKHNO, I., IHNATENKO, N., CHERNIAIEV, O., VYNOGRADNYA, V., ATSTAJA, D., KOVAL, V.: Construction waste recycling in the circular economy model, *IOP Conference Series: Earth and Environmental Science,* Vol. 1126, No. 1, p. 012003, 2023. https://doi.org/10.1088/1755-1315/1126/1/012003
[39] KRYVOVYAZYUK, I., BRITCHENKO, I., SMERICHEVSKYI, S., KOVALSKA, L., DOROSH, V., KRAVCHUK, P.: Digital transformation and innovation in business: the impact of strategic alliances and their success factors, *Ikonomicheski Izsledvania,* Vol. 32, No. 1, pp. 3-17, 2023. https://philarchive.org/rec/KRYDTA?utm
[40] SZELAG-SIKORA, A., OLEKSY-GEBCZYK, A., CIULA, J., CEMBRUCH-NOWAKOWSKI, M., PETER-BOMBIK, K., RYDWANSKA, P., ZACLONA, T.: Energy Transformation Within the Framework of Sustainable

Development and Consumer Behavior, *ENERGIES*, Vol. 18, No. 1, 75, pp. 1-34, 2025. https://doi.org/10.3390/en18010075

[41] NURGALIYEV, B.M., LAKBAYEV, K.S., KUSSAINOVA, A.K., BORETSKY, A.V.: Impact of organized crime on shadow economy: Social impact assessment, *Asian Journal of Applied Sciences*, Vol. 7, No. 1, pp. 644-651, 2014. [20 Oct 2025] https://scialert.net/abstract/?doi=ajaps.2014.644.651

[42] MIHAI, F., ALECA, O.E., STANCIU, A., GHEORGHE, M., STAN, M.: Digitalization – The engine of sustainability in the energy industry, *Energies*, Vol. 15, No. 6, 2164, pp. 1-17, 2022. https://doi.org/10.3390/en15062164

[43] VÎRJAN, D., MANOLE, A.M., STANEF-PUICĂ, M.R., CHENIC, A.S., PAPUC, C.M., HURU, D., BĂNACU, C.S.: Competitiveness – The engine that boosts economic growth and revives the economy, *Frontiers in Environmental Science*, Vol. 11, 1130173, pp. 1-14, 2023. https://doi.org/10.3389/fenvs.2023.1130173

[44] MARTÍNEZ-PELÁEZ, R., OCHOA-BRUST, A., RIVERA, S., FÉLIX, V.G., OSTOS, R., BRITO, H., FÉLIX, R.A., MENA, L.J.: Role of digital transformation for achieving sustainability: Mediated role of stakeholders, key capabilities, and technology, *Sustainability*, Vol. 15, No. 14, 11221, pp. 1-27, 2023. https://doi.org/10.3390/su151411221

[45] FERNÁNDEZ-ROVIRA, C., VALDÉS, J.Á., MOLLEVÍ, G., NICOLAS-SANS, R.: The digital transformation of business. Towards the datafication of the relationship with customers, *Technological Forecasting and Social Change*, Vol. 162, 120339, pp. 1-12, 2021. https://doi.org/10.1016/j.techfore.2020.120339

[46] HANELT, A., BOHNSACK, R., MARZ, D., ANTUNES MARANTE, C.: A systematic review of the literature on digital transformation: Insights and implications for strategy and organizational change, *Journal of Management Studies*, Vol. 58, No. 5, pp. 1159-1197, 2021. https://doi.org/10.1111/joms.12639

[47] TRENERRY, B., CHNG, S., WANG, Y., SUHAILA, Z.S., LIM, S.S., LU, H.Y., OH, P.H.: Preparing workplaces for digital transformation: An integrative review and framework of multi-level factors, *Frontiers in Psychology*, Vol. 12, 620766, pp. 1-24, 2021. https://doi.org/10.3389/fpsyg.2021.620766

[48] PTASHCHENKO, O., ZYMA, O., KAZAK, O., NAUMENKO, M., PUZRAKOV, A.: Digital transformation in logistics: Driving sustainable growth in international commerce, *European Journal of Sustainable Development*, Vol. 14, No. 2, pp. 980-996, 2025. https://doi.org/10.14207/ejsd.2025.v14n2p980

[49] ŞAHAN, D.: Evaluating the effects of digital transformation on logistics performance: A large-scale perspective on industrial competitiveness, *Journal of ETA Maritime Science*, Vol. 13, No. 2, pp. 72-80, 2025. https://doi.org/10.4274/jems.2025.62347

[50] AL-ABABNEH, H.A., ALRHAIMI, S.A.S., SIAM, I.M., ALSALIM, F.I.A., KHADER, J.A.: Digital transformation of supply chain management: Trends and prospects, *Acta Logistica*, Vol. 12, No. 4, pp. 769-780, 2025. https://doi.org/10.22306/al.v12i4.713

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