



## Assessing the Relationship Between Digital Transformation and Macroeconomic Performance

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### Abstract

Digitalization is becoming a key factor in structural transformation and a source of sustainable economic growth, defining new parameters of productivity, employment and investment. The purpose of the study is to determine the relationship between the level of digital literacy of the population, the use of information and communication technologies (hereinafter - ICT) in organizations and macroeconomic indicators in 2018-2024. The study used seven indicators, of which two characterize digital development (the level of digital literacy of the population and the use of ICT in organizations), and five reflect economic dynamics (GDP, fixed capital investment, real wage index, unemployment rate and gross value added per employee). The results of the analysis showed that the growth of digital literacy of the population has a very strong positive correlation with the main economic indicators: GDP ( $r = 0.934$ ), investments in fixed assets ( $r = 0.909$ ) and gross value added per employed ( $r = 0.947$ ). At the same time, the use of ICT in organizations shows a weak and partially negative correlation with GDP ( $r = -0.205$ ) and investment ( $r = -0.180$ ), reflecting the structural gap between human and technological capital. Thus, for the period 2018-2024. Digitalization has become a stable factor of macroeconomic growth, with human capital playing a key role. To increase the effectiveness of digital transformation, it is necessary to strengthen the integration of ICT into business processes, develop infrastructure and increase the managerial maturity of organizations.

**Keywords:** digitalization, digital development, digital technologies, social capital, labor, social sustainability

# Сандық процестер мен макроэкономикалық көрсеткіштер арасындағы байланысты бағалау

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## Түйін

Цифрландыру құрылымдық өзгерістердің негізгі факторы және тұрақты экономикалық өсудің көзіне айналып, өнімділіктің, жұмыспен қамтудың және инвестицияның жаңа параметрлерін айқындайды. Зерттеудің мақсаты – халықтың цифрлық сауаттылық деңгейі, ұйымдарда ақпараттық-коммуникациялық технологияларды (бұдан әрі – АКТ) пайдалану мен макроэкономикалық көрсеткіштер арасындағы өзара байланысын анықтау. Зерттеу барысында жеті көрсеткіш пайдаланылды, олардың екеуі цифрлық дамуды (халықтың цифрлық сауаттылық деңгейі және ұйымдарда АКТ пайдалану), ал бесеуі экономикалық динамиканы (ЖІӨ, негізгі капиталға инвестициялар, нақты еңбекақы индексі, жұмыссыздық деңгейі және бір жұмыспен қамтылған адамға шаққандағы қосылған құн) сипаттайды. Талдау нәтижелері халықтың цифрлық сауаттылығының өсуі негізгі экономикалық көрсеткіштермен өте жоғары оң корреляцияға ие екенін көрсетті: ЖІӨ-мен ( $r = 0,934$ ), негізгі капиталға инвестициялармен ( $r = 0,909$ ) және бір жұмыспен қамтылған адамға шаққандағы қосылған құнмен ( $r = 0,947$ ). Ал ұйымдарда АКТ пайдалану ЖІӨ ( $r = -0,205$ ) және инвестициялармен ( $r = -0,180$ ) әлсіз және ішінара теріс байланыс көрсетеді, бұл адами және технологиялық капитал арасындағы құрылымдық алшақтықты бейнелейді. Осылайша, 2018–2024 жылдар аралығында цифрландыру макроэкономикалық өсудің тұрақты факторы болып, онда шешуші рөлді адами капитал атқарды. Цифрлық трансформацияның тиімділігін арттыру үшін АКТ-ны бизнес-процестерге тереңірек енгізу, инфрақұрылымды дамыту және ұйымдардың басқарушылық жетілу деңгейін күшейту қажет.

**Түйін сөздер:** цифрландыру, цифрлық даму, цифрлық технологиялар, әлеуметтік капитал, еңбек, әлеуметтік тұрақтылық

# Оценка взаимосвязи между цифровыми процессами и макроэкономическими показателями

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## Аннотация

Цифровизация становится ключевым фактором структурных преобразований и источником устойчивого экономического роста, определяя новые параметры производительности, занятости и инвестиций. Цель исследования – определить взаимосвязь между уровнем цифровой грамотности населения, использованием информационно-коммуникационных технологий (далее – ИКТ) в организациях и макроэкономическими показателями в 2018–2024 гг. В исследовании использованы семь индикаторов, из которых два характеризуют цифровое развитие (уровень цифровой грамотности населения и использование ИКТ в организациях), а пять отражают экономическую динамику (ВВП, инвестиции в основной капитал, индекс реальной заработной платы, уровень безработицы и валовая добавленная стоимость на одного занятого). Результаты анализа показали, что рост цифровой грамотности населения имеет очень сильную положительную корреляцию с основными экономическими показателями: с ВВП ( $r = 0,934$ ), инвестициями в основной капитал ( $r = 0,909$ ) и валовой добавленной стоимостью на одного занятого ( $r = 0,947$ ). В то же время использование ИКТ в организациях демонстрирует слабую и частично отрицательную корреляцию с ВВП ( $r = -0,205$ ) и инвестициями ( $r = -0,180$ ), что отражает структурный разрыв между человеческим и технологическим капиталом. Таким образом, за период 2018–2024 гг. цифровизация стала устойчивым фактором макроэкономического роста, при этом ключевую роль сыграл человеческий капитал. Для повышения эффективности цифровой трансформации требуется усиление интеграции ИКТ в бизнес-процессы, развитие инфраструктуры и повышение управленческой зрелости организаций.

**Ключевые слова:** цифровизация, цифровое развитие, цифровые технологии, социальный капитал, труд, социальная устойчивость

## Introduction

Digitalisation is now recognised as one of the key drivers of global economic transformation. The integration of information and communications technology (hereinafter – ICT) and the enhancement of people's digital skills create new opportunities for innovation, efficient production, and better resource use. In the modern world, digital technology is no longer limited to specific industries and fields; they have become the basic infrastructure that supports economic and social life. The rapid diffusion of digital tools across communication, production, education, and administration indicates that the digital revolution has moved from the technological to the structural and institutional phase. For many economies, digitalization has become not only a tool for recovery but also a mechanism for competitiveness and long-term growth. In Kazakhstan's transition to a digital economy, the digital environment plays a particularly strategic role. The government considers digitalization a national priority and integrates it into broader development programs such as “Digital Kazakhstan,” which aims to increase productivity, transparency and access to services through technology. The digital economy in Kazakhstan is becoming a key driver of modernization, affecting sectors such as finance, logistics, education and public administration. However, as digital technology becomes more widespread, it is becoming clear that not all parts of the economy are growing at the same pace. Disparities in infrastructure, workforce training, and IT adoption across industries result in an uneven digital landscape. Major urban centers and high-tech sectors are adapting quickly, while traditional areas and rural areas are transforming more slowly. Although the proliferation of digital solutions has accelerated over the past decade, the level of digitalization varies significantly between the individual and organizational levels. The increase in digital literacy among the population indicates greater human capital and a greater willingness to adopt new technologies. On the other hand, the level of IT integration in organizations reflects the structural maturity of companies and their ability to translate technological potential into economic results. The distinction between human and institutional digital developments emphasizes the need to analyze how technological changes affect overall economic performance. Understanding this relationship is especially relevant for emerging economies such as Kazakhstan, where digital transformation is expected to support diversification and reduce dependence on extractive industries.

Digitalization affects many aspects of economic activity. It changes production methods, enables automation, improves supply chain efficiency and drives innovation in services. ICT infrastructure enhances market access and facilitates e-commerce growth, while digital platforms create new business models and employment opportunities. At the same time, digitalisation requires significant investments in educational and technological infrastructure, because the success of these transformations depends on individuals' ability to use new tools effectively. For Kazakhstan, a country with a large territory and varying levels of regional development, these challenges are especially important. Ensuring equitable access to digital infrastructure and training opportunities is essential for inclusive growth.

Globally, many studies have confirmed that digital development is strongly correlated with productivity growth and competitiveness. The World Bank (2020) and OECD (2021) highlight that countries that are better digitally prepared recover faster from economic shocks and show more stable long-term growth. In advanced economies, investment in digital infrastructure and education accounts for a significant portion of productivity growth. In developing economies, digitalization is accelerating integration into global value chains and expanding entrepreneurial opportunities. However, in countries where technological progress outpaces institutional reform, digital transformation can increase inequalities between urban and rural areas, between large and small businesses, and between individuals with different levels of access to digital education.

Kazakhstan's experience reflects these global trends. The country has made significant progress in building digital infrastructure and integrating IT into governance, banking and public services. Initiatives such as e-government (eGov.kz), financial technology developments, and digital identity systems have improved efficiency and transparency. However, despite these successes, the country still faces challenges in ensuring equitable access to digital technology and achieving tight integration of ICT into business processes. Small and medium-sized businesses often lack the financial resources and trained professionals to deploy advanced digital solutions. As a result, the benefits of digitalization are unevenly distributed, with large companies and urban areas benefiting the most. The purpose of the article is to determine the relationship between the development of digitalisation (the level of digital literacy of the population and the use of ICT in organisations) and Kazakhstan's economic growth in 2018-2024.

## **Literature Review**

The concept of digitalization as a driver of economic and social change has been widely discussed since the late twentieth century. Nicholas Negroponte (1995) was among the first to conceptualize the transition “from atoms to bits” arguing that the spread of information technologies would fundamentally reshape production, communication, and value creation. Early approaches focused mainly on technological innovation and access to digital infrastructure as the foundation for competitiveness. Castells (1996) expanded this view through his theory of the “network society” describing how information flows and global connectivity form the new architecture of modern economies. In the 2000s, scholars such as Brynjolfsson and Kahin (2002) and Tapscott (2008) emphasized that the digital economy is not only a technological but also an institutional transformation. Their research linked ICT adoption to productivity growth, innovation, and new forms of employment. At the same time, Freeman and Soete (2009) argued that digitalization alters the structure of value chains, shifting economic advantage toward countries that effectively combine technology with human capital. These studies laid the theoretical foundation for understanding digitalisation as a multidimensional process that affects technology, labour, and management. The development of quantitative models in the 2010s enabled more systematic measurement of the digital economy. Van Ark (2016) and OECD (2017) demonstrated that digital adoption explains a substantial share of productivity gains in advanced economies. Similarly, Bukht and

Heeks (2018) proposed a conceptual framework for measuring digital economy indicators across national accounts, highlighting that digitalization's impact depends on institutional quality and workforce skills. More recent studies by Schwab (2019) and the World Bank (2020) linked digital readiness with long-term economic resilience and emphasized the need for inclusive digital transformation policies.

In the post-Soviet context, research has focused on how digitalization interacts with structural and institutional features of transition economies. Verma et al. (2023) studied how the development of information and communication technologies and the financial system affects economic growth in developing countries, and found that both of these areas have a significant and positive impact on the economy. Additionally, Bahrain and Kaffas (2019) conducted research and found that ICT helps developing countries' economies grow by increasing efficiency and productivity. In Central Asia, Shodiev et al. (2021) examined the relationship between ICT and economic growth and concluded that the spread of these technologies has a positive impact on the region's development.

Kireyeva and her co-authors have made a significant contribution to understanding the country's transition toward a digital economy. In her studies (Kireyeva et al., 2022, 2023), she examines the interconnections between digital transformation, innovation, and economic competitiveness. Her findings indicate that higher levels of digital skills and the adoption of information and communication technologies are strongly associated with growth in GDP, capital investment, and productivity. These results confirm that the development of human digital skills is a crucial component of building a digital economy. Kireyeva also emphasises the persistent gap between the availability of technology and its practical implementation.

The research shows that studies on digitalisation have evolved over time, from ideas about how information technology can modernise society to real-world studies that link digital measures to economic performance. Building on the ideas of Negroponte and the regional studies by Kireyeva, this research combines views from around the world with what's happening in Kazakhstan to understand how digital progress is affecting the country's economy from 2018 to 2024.

In recent years, there has been greater digital skill among people and greater use of ICT in businesses. However, the question is how much these changes are helping the economy grow, reducing joblessness, and making workers more productive. To identify these connections, it is essential to compare digital and economic indicators that reflect the labour market and economic activity. The analysis uses data from the Bureau of National Statistics of Kazakhstan (2024) for 2018 to 2024, covering seven leading indicators. Two of these, ICT use in businesses and the level of digital skills among the population, show the country's progress in digitalisation. The other five indicators – gross domestic product (hereinafter – GDP), fixed capital investment, gross value added per employee, absolute wage index, and unemployment rate, reflect the economic situation. Correlation analysis helps determine the strength and direction of the connections between these variables, and how the development of digital skills and the adoption of new technologies relate to critical economic measures. The results of this study help expand our understanding of the impact of digitalisation on Kazakhstan's economy and determine whether digital development contributes to sustainable growth and employment. Understanding these relationships has practical significance for the

formulation of public policy in the areas of digital development and human capital, as well as for developing strategies to increase the efficiency of interaction between the country's technological and economic potential.

Research Methods

This study examines digital development and its relationship with economic growth in Kazakhstan from 2018 to 2024 using a comprehensive quantitative approach, including descriptive and correlational analysis. In developing the methodological approach, particular focus was placed on both the technological and economic aspects of digitalisation, as well as on determining the extent to which macroeconomic conditions influence indicators characterising the utilisation of ICT and the level of digital literacy of the population. A systems approach ensures methodological consistency in the study and enables the transition from data preparation to statistical interpretation. As shown in Table 1, the study relies on a consistent methodological framework, including data acquisition, descriptive analysis, trend assessment, and correlation analysis, which allows for the identification of the direction and strength of relationships between digital and economic indicators. This integrated framework ensures that each analytical stage builds upon the previous one, providing a clear understanding of how digital transformation influences key macroeconomic dynamics.

TABLE 1. Variables indicating units of measurement and data source

Code	Variable	Unit of measurement	Data source
ICT_Use	Indicators of the use of information and communication technologies in organizations	Percent of organizations	Bureau of National Statistics (2024)
DigLit	Digital literacy level of the population	Percent of population	Bureau of National Statistics (2024)
GDP	Gross Domestic Product (GDP)	Million KZT	Bureau of National Statistics (2024)
Unemp	Unemployment rate	Percent of labor force	Bureau of National Statistics (2024)
WageIdx	Real wage index	Percent to the previous year	Bureau of National Statistics (2024)
InvFC	Investment in fixed capital (current prices)	Million KZT	Bureau of National Statistics (2024)
GVA_Emp	Gross value added (GVA) per person employed	Thousand KZT per employed person	Bureau of National Statistics (2024)
Year	Observation period	2018–2024	Bureau of National Statistics (2024)

Note: compiled by the authors based on the Bureau of National Statistics (2024)

The data presents the variables utilized in the study, their symbols (codes), units of measurement, and sources of information. The inclusion of codes ensures transparency in data processing and avoids ambiguity when constructing correlation relationships. The empirical basis of the study is founded on annual observations for the period 2018-2024.

It includes two indicators characterising the level of digitalisation ICT use in organisations and digital literacy of the population, as well as five macroeconomic indicators reflecting the development of Kazakhstan's economy: GDP, absolute wage index, unemployment rate, fixed capital investment, and gross value added per employee.

These indicators were selected because they reflect both the technological dynamics and the structural characteristics of the national economy. Before conducting statistical analysis, all variables were checked for accuracy, completeness, and consistency. This helped obtain accurate results for subsequent calculations of relationships and for the interpretation of the received data. Regression analysis was used to determine the relationships between digital and economic indicators, helping to understand the strength and direction of these relationships.

## **Results**

The systems approach ensures a consistent, transparent research process, streamlining the transition from data collection to statistical interpretation. At the first stage, official data of the National Bureau of Statistics of the Republic of Kazakhstan (2024) for the period 2018-2024 were collected, verified and structured for quantitative analysis. This dataset provides empirical evidence on the relationship between a country's digital transformation and its macroeconomic performance. The information covers a seven-year observation period, helping to assess both short-term fluctuations and long-term structural trends in the national economy. The research's empirical basis includes seven leading indicators demonstrating the multidimensional interaction between digitalization and economic development. Two of them – the use of ICT in organisations and the level of digital literacy of the population – constitute the digital component, illustrating the diffusion of technology within companies and the accumulation of human digital capital in the population. These indicators reflect the effectiveness of integrating digital infrastructure and skills into everyday economic, management and communication activities.

The remaining five indicators – gross domestic product (GDP), absolute wages index, unemployment rate, investment in fixed capital and gross value added (GVA) per person employed – make up the economic side of the analysis. They represent essential aspects of Kazakhstan's macroeconomic stability and productivity, reflecting the country's ability to generate income, maintain employment and stimulate investment-led growth. The inclusion of these indicators provides an opportunity to determine whether improvements in digital capabilities directly contribute to higher output, investment efficiency and labor productivity, or whether the relationship is more indirect, mediated by social and institutional factors. All metrics have been standardized and expressed in comparable units of measurement to ensure analytical accuracy and consistency. The use of annual data enables the study to track the evolution of Kazakhstan's economic and digital indicators over time and to identify periods of convergence or divergence between technological and economic developments.

Table 1 shows the dynamics of digital and macroeconomic indicators for Kazakhstan for the period 2018-2024.



**TABLE 1.** Dynamics of digital and macroeconomic indicators in Kazakhstan, 2018–2024

Year	GDP	Indicator of the use of ICT in organisations	Digital literacy level of the population	Unemployment rate	Real wage index	Investment in fixed capital	GVA per person employed
2018	61 819 536,4	75,1	79,6	4,9	101,7	11 179 036	6 173,2
2019	69 532 626,5	80,4	82,1	4,8	109,1	12 576 793	6 869,8
2020	70 649 033,2	81,6	84,1	4,9	106,8	12 270 144	7 111,9
2021	83 951 587,9	78,2	87,3	4,9	108,8	13 242 233	8 423,4
2022	103 765 518,2	79,1	88,3	4,9	107,6	15 251 104	10 083,2
2023	119 442 289,7	79,5	90,2	4,7	102,7	17 649 313	11 354,2
2024	136 693 318,3	76,0	91,2	4,7	102,4	19 461 333	12 886,0

Note: compiled by the authors based on Bureau of National Statistics (2024)

These data demonstrate how the values of digital and economic indicators changed over seven years, allowing us to trace general trends in the country's digital economy. At a later stage, each variable was formalised and coded to ensure standardised and accurate subsequent computations. Coding the variables allowed us to systematise the indicators and use them in a correlation analysis, treating each variable as a separate, autonomous unit of observation. The digital block is represented by the codes ICT\_Use and DigLit, and the economic block by GDP, WageIdx, Unemp, InvFC, and GVA\_Emp. This separation facilitates the building of the correlation matrix and the subsequent interpretation of statistical relationships.

Table 3 shows how closely the two digital measures-the use of ICT and the level of digital literacy-are linked to five economic factors that describe Kazakhstan's economy.

**Table 3.** Correlation between Digital and Economic Indicators in Kazakhstan, 2018–2024

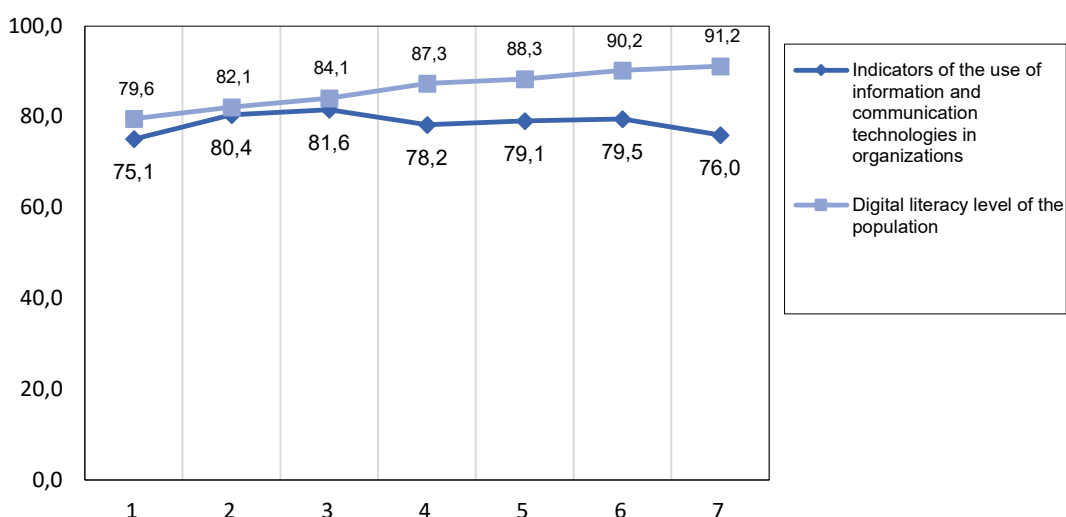
Indicator	Association	Correlation coefficient (r)	Interpretation
Use of ICT in organizations	GDP	-0,205	Weak negative relationship
Use of ICT in organizations	Average wage	0,647	Strong positive relationship
Use of ICT in organizations	Investments in fixed capital	-0,180	Very weak negative relationship
Use of ICT in organizations	Gross value added per employed person	-0,194	Very weak negative relationship
Use of ICT in organizations	Unemployment rate	0,104	Very weak positive relationship
Digital literacy of the population	GDP	0,934	Very strong positive relationship
Digital literacy of the population	Average wage	-0,132	Very weak negative relationship

Digital literacy of the population	Investments in fixed capital	0,909	Very strong positive relationship
Digital literacy of the population	Gross value added per employed person	0,947	Very strong positive relationship
Digital literacy of the population	Unemployment rate	-0,582	Moderate negative relationship

Note: compiled by the authors

The table reveals that digital literacy has a very strong positive connection with GDP ( $r = 0.934$ ), investment ( $r = 0.909$ ), and the value added per worker ( $r = 0.947$ ). However, the use of ICT in organizations has weaker and even slightly negative relationships with these economic factors. This suggests that the human side of digital transformation—the growing ability of people to use digital tools—is advancing more quickly than the use of technology in businesses. This gap shows a key pattern in Kazakhstan's digital economy, where individuals are becoming more digitally skilled, but organizations are not keeping up with the changes. The fact that these connections have remained stable over the time period studied shows that the link between digital change and economic growth is not just a short-term trend. Instead, it is a lasting, long-term relationship. The strong and consistent links for digital literacy show that having skilled and knowledgeable people is now a key part of how Kazakhstan's economy grows and stays strong.

As shown in Figure 1, both lines show different but connected trends.



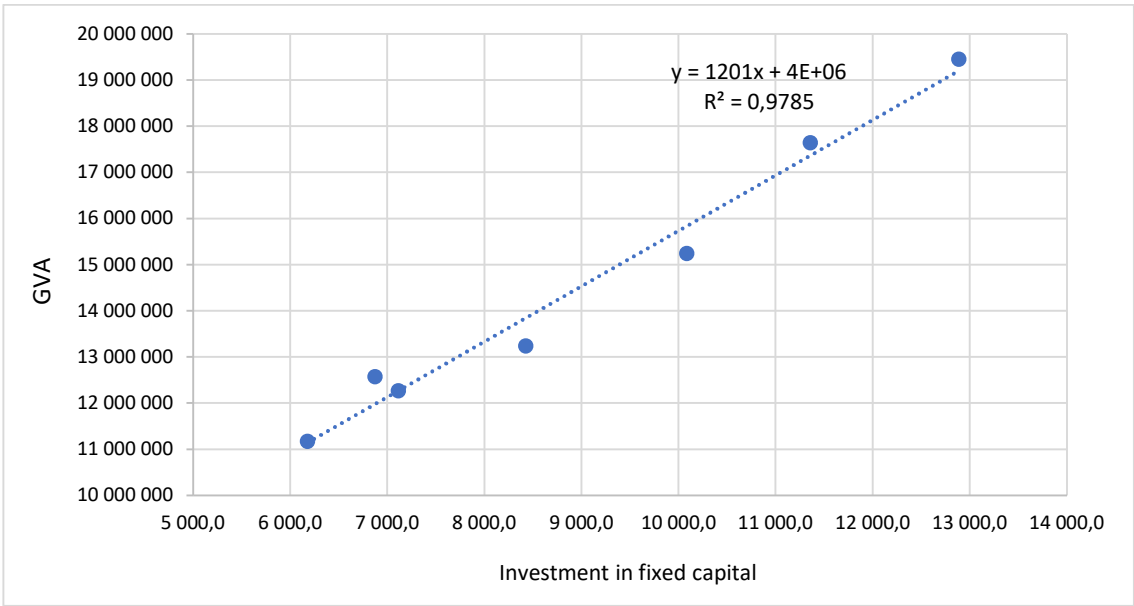
**Figure 1.** Dynamics of ICT use and the level of digital literacy of the population, 2018–2024

Digital literacy among people has been steadily increasing, from 79.6% in 2018 to 91.2% in 2024. This means that more people are becoming familiar with using technology, and a digital culture is starting to form. This trend shows that digitalization in Kazakhstan is affecting not just the economy, but also society, making human skills a vital part of a knowledge-based economy. On the other hand, the number of organisations

using ICT has been changing unpredictably. It increased slowly until 2020, reaching 81.6%, but then dropped to 76.0% in 2024. This change could be due to the coronavirus pandemic, which slowed investment in information systems and prompted companies to shift their spending. It also shows that digital transformation is not happening at the same pace across all areas, especially in small and medium-sized businesses, where adopting technology is slow due to financial constraints and system issues.

Looking at both trends together, it's clear that from 2018 to 2024, digitalization in Kazakhstan has mostly come from the population, not from organizations. Digital literacy is growing faster than the rate at which companies are adopting ICT. This shows there is a gap between people's potential and the country's ability to use technology. This difference could make the digital economy less effective, as improvements in education and skills are not being fully leveraged in the workplace and in management.

As shown in Figure 2, both indicators continue to grow, indicating that the manufacturing sector is strengthening and the economy is becoming more active.

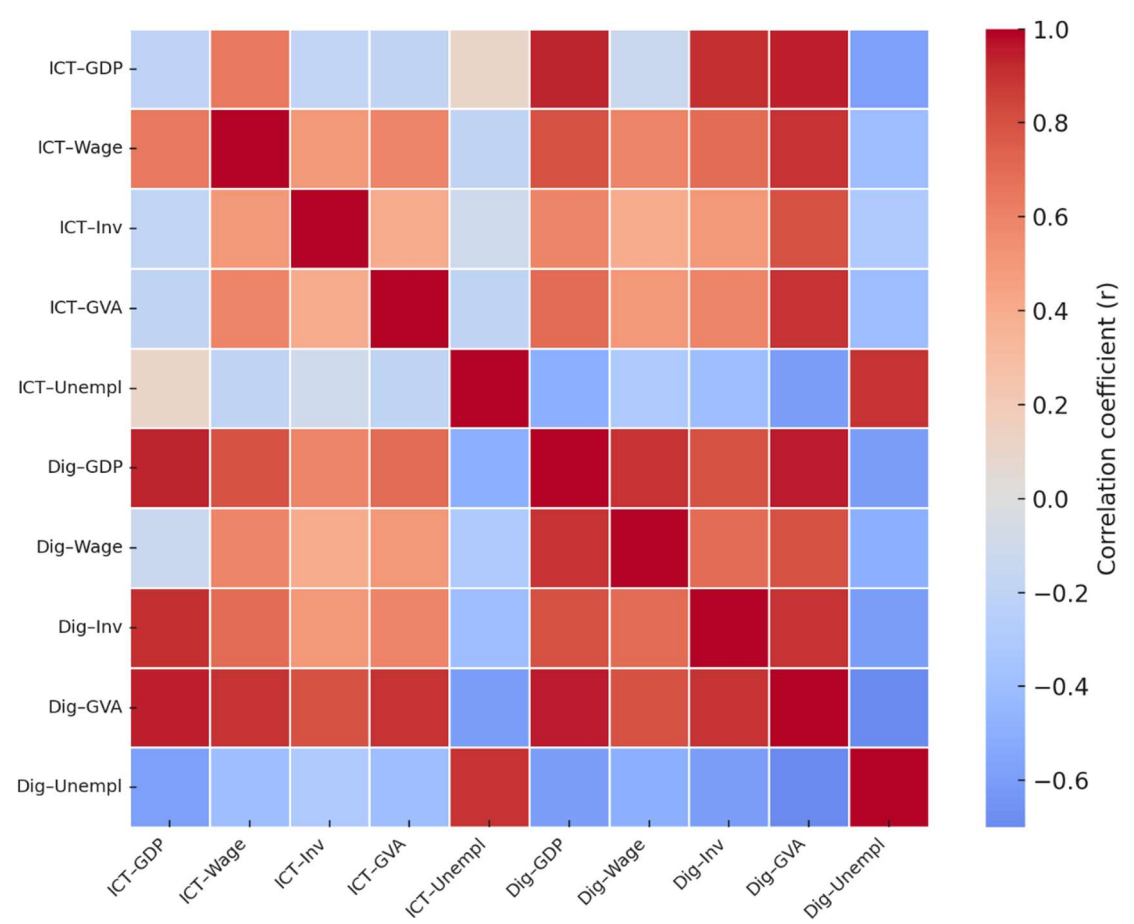


**Figure 2.** Dynamics of investment in fixed capital and gross value added per employee, 2018-2024

Fixed capital investment has more than doubled, increasing from 11.18 trillion tenge in 2018 to 19.46 trillion tenge in 2024. This shows that more money is being invested in infrastructure, industry, and services, indicating that the investment base is growing. Gross value added per employee is also going up, and this increase is even clearer: from 6,170 tenge to 12,890 tenge. This shows not only that workers are being more productive but also that they are working more efficiently. The way these indicators relate to each other shows that as investments grow, so does the value created, which means the fundamental part of the economy is getting stronger. According to the graph, 2020 was a turning point. Even though the economy slowed during that time due to the pandemic and ongoing restrictions, Kazakhstan's economy began to recover in the

investment cycle from 2021 onwards. The rise in investment since 2021 matches the increase in gross value added, showing that business activity is improving and the country's production capacity is growing. Both indicators show that investment activity helps increase productivity and makes economic growth better. When these two things grow together, it shows that Kazakhstan's economy is becoming more stable and moving towards a model that relies more on capital and is more innovative.

To understand how digitalization indicators relate to key economic factors, Figure 3 shows a correlation matrix.



**Figure 3.** Correlation Matrix

It shows the strength and direction of the correlation between all variables. Colors help clarify these relationships: dark blue indicates a negative correlation, while deep red indicates a positive one. This makes it easier to analyse the relationship between digital and economic indicators. The strongest positive correlations are observed between the population’s digital literacy and indicators such as GDP, investment in fixed capital, and GVA per employee. This suggests that an increase in digital skills is linked to higher economic activity and labor productivity. Additionally, a moderate negative correlation between digital literacy and unemployment indicates that developing digital

competencies may reduce unemployment and enhance labor market efficiency. At the same time, the use of information and communication technologies in companies is correlated with less or even negative associations with key economic indicators. This reflects the uneven adoption of digital technologies, which may stem from differences in the technological maturity of economic sectors and limited opportunities for digital investment, particularly in small and medium-sized enterprises. Overall, digital literacy across the population emerges as a sustainable driver of economic growth, while the process of digitalization within organizations remains underdeveloped and calls for additional structural measures to support the integration of digital technologies into business operations. This diversity highlights a structural gap between human and technological capital in Kazakhstan's digital transformation efforts.

## **Discussion**

The analysis results show a close correlation between digitalization processes and changes in the Kazakhstan economy from 2018 to 2024. When examining indicators reflecting the use of information and communications technology and the level of digital literacy of the population, it can be seen that they impact the economy differently but, together, complement each other. Digital environment indicators have developed linearly.

Digital literacy of the population has grown steadily, while ICT use in organizations has fluctuated. After 2020, business activity declined, likely due to the COVID-19 pandemic, reduced investment, and changes in company spending. However, the growth of digital skills among residents indicates the development of more substantial human capital capable of adapting to the digital economy. This gap between the development levels of individuals and organizations highlights that digitalization in companies is progressing more slowly than among individuals. The growth of indicators such as gross value added per capita and fixed capital investment indicates a solid economic foundation. The high correlation between them confirms that investment plays a significant role in increasing productivity and implementing changes in the Kazakh economy. This means that digitalization is closely linked to investment and infrastructure development, which contribute to improving the value of products. An analysis of the correlations revealed that digital literacy of the population is more strongly associated with GDP growth, investment, and value added, and less strongly associated with unemployment. This confirms that digital skills and training have a significant impact on the economy and employment. Meanwhile, the use of ICT in companies shows weak and sometimes negative correlations, indicating insufficient digital integration in business. This supports the idea that skill development within the population outpaces institutional reforms and companies' adoption of technologies.

The analysis shows a clear connection between digitalization and the change in Kazakhstan's economy from 2018 to 2024. At the start of this period, digitalization was still developing — about 75% of organizations used information and communication technology (ICT), and only around 80% of people had basic digital skills. Digital tools were mostly used for simple tasks like communication and reporting, and they haven't had a significant impact on the economy yet.

By 2020, both of these numbers had increased due to more investment and more online tools becoming available.

But then the COVID-19 pandemic changed things. Companies slowed down their digital efforts because they were trying to save money and put off new technology projects. On the other hand, individuals used this time to improve their digital skills through working from home and online classes. This caused a big difference - people's digital abilities grew much faster than businesses' digital changes.

By 2024, Kazakhstan had a stronger digital base: digital literacy reached 91.2%, while ICT use in companies dropped slightly to 76%.

The economy was also recovering well - GDP almost doubled, investments in equipment went up by over 70%, and each worker contributed more to the economy. These changes show that improving people's digital skills helped the economy grow and adapt, even when companies weren't adopting digital tools as quickly. The results also show this pattern clearly.

Digital literacy has a strong positive link with GDP, investment, and economic value, and a weaker negative link with unemployment. This means better digital skills help the economy grow and keep people employed. But ICT use has a weaker or even negative connection, suggesting that many companies haven't fully used digital tools in their work and management. Overall, between 2018 and 2024, Kazakhstan moved from having scattered digital use to a society with high digital skills but uneven business adoption. The findings show that digital transformation is a key part of modernizing the economy, but to reach its full potential, the gap between people's digital readiness and business innovation needs to be closed. To keep making progress and ensure balanced growth, it's important to increase ICT use in businesses, improve management abilities, and connect education with what industries need.

## **Conclusion**

The study's analysis shows a significant and multidimensional link between digitalization processes and structural changes in the Kazakh economy from 2018 to 2024. The results confirm that digital transformation has become one of the main drivers of economic growth, employment and productivity. The use of digital technology and the increase in digital literacy among the population not only modernize production and communication systems but also strengthen human capital and support new forms of economic interaction. During this seven year period, Kazakhstan has moved from an early stage of technological adaptation to a more systematic stage of digital maturity, in which digital culture, investment activity and productivity indicators are closely linked. At the start of the research period in 2018, the country's digital landscape was characterized by a moderate level of IT adoption and limited access to advanced technologies in business processes. The use of IT in organizations is about 75%, while the digital literacy level of the population is just under 80%. These indicators reflect the uneven development of digital infrastructure and the lack of awareness among SMEs about the benefits of technology integration. Economic growth at this time was steady but largely resource-driven, with productivity gains driven by extractive industries rather than technological modernization. From 2019 to 2020, Kazakhstan entered a period of

accelerated digital development. The government has launched several national programs to expand broadband access, introduce e-government services, and integrate IT in education and administration. This period also coincided with an increase in GDP and fixed capital investment, reflecting growing confidence in innovation-led growth. However, the 2020 Covid-19 pandemic marked an important turning point. This has forced businesses, organizations and people to go remote, revealing both strengths and weaknesses in the country's digital preparedness. As businesses faced financial and logistical constraints, people quickly improved their digital skills through distance learning, remote working and online communication. This difference has created a structural divide: digital literacy among individuals has progressed faster than digital adoption in the business sector. By 2021-2022, the positive impacts of this workforce-driven transformation have become clearer. The proportion of the population with digital skills has exceeded 88%, while the ICT usage index has stabilized at around 79%. At the same time, GDP and gross value added (GVA) per employed person showed strong growth, a sign that the digitalization of society is starting to generate macroeconomic benefits. Correlation analysis confirmed a strong positive relationship between digital literacy and key economic variables such as GDP ( $r = 0.934$ ), fixed capital investment ( $r = 0.909$ ) and GVA per employee ( $r = 0.947$ ). This trend shows that improving digital skills directly contributes to higher productivity, better employment outcomes and a more dynamic investment environment. The study also found that the correlation between IT use in organizations and economic indicators was much weaker and in some cases negative. For example, the relationship between IT use and GDP ( $r = -0.205$ ) or investment ( $r = -0.180$ ) suggests that technology adoption in business has not yet reached the level of generating tangible macroeconomic returns. This can be explained by several factors: high costs of technology upgrades, lack of qualified IT professionals in regional markets, and uneven distribution of infrastructure across industries. In other words, digitalization in Kazakhstan remains bottom-up – driven by individuals and the public sector rather than private companies. The results also highlight the importance of investment and infrastructure to support digital growth. The observed interdependence between fixed capital investment, GVA and digital indicators demonstrates that economic expansion accelerates as physical and digital infrastructure grow together. Countries that combine technological innovation with ongoing investments in human capital and productive capacity are more likely to achieve long-term competitiveness. For Kazakhstan, this finding highlights the need for an integrated policy framework that links technological progress with education, finance and regional development. Furthermore, the analysis shows that improving digital literacy is strongly associated with lower unemployment rates and higher real wages. As the digital economy grows, the need for skilled professionals in IT, data management and creative industries is increasing. This process contributes to changing the labor market structure, reducing the rate of low-productivity jobs. However, the benefits remain uneven across regions: large cities such as Astana and Almaty attract the majority of digital jobs, while peripheral areas experience slower rates of digital diffusion. This territorial imbalance limits the comprehensive nature of digital transformation and requires targeted policies to support digitalization in rural areas and small towns. Despite the clear progress achieved during the analysis phase, the digitalization process in Kazakhstan is still in a transitional phase.

Correlation patterns indicate that the human factor - reflected in digital culture - has become the catalyst for growth, while the technological factor - the integration of IT within organizations - is lagging behind. The gap between these two components points to a larger institutional challenge: the willingness of businesses and public institutions to adopt and effectively use digital solutions. Meeting this challenge requires not only investment but also management reforms, incentives for innovation and closer links between education systems and the needs of the digital labor market. The findings of this study also have broader implications for understanding Kazakhstan's economic trajectory. The digital economy is no longer a separate sector but a horizontal system that affects production, finance and public administration. From 2018 to 2024, the country demonstrated that even limited technological capacity can produce significant macroeconomic results when combined with human capital development. However, maintaining this momentum depends on how effectively governments and the private sector can institutionalize digital transformation. Providing measures to encourage technological innovation, support startups and expand access to affordable ICT infrastructure will be key to ensuring inclusive digital growth. Overall, the study confirms that digitalization is becoming a cornerstone of Kazakhstan's modernization agenda. It improves productivity, supports economic diversification and opens new opportunities for sustainable development. However, progress remains uneven across sectors and regions. To close the gap between the digital maturity of individuals and that of organizations, Kazakhstan needs to accelerate the adoption of productive technology, develop high-quality infrastructure, stimulate innovation and strengthen the digital culture of society.

### Author Contributions

Conceptualisation and theoretical framework: DA and SA; research design and methodology: DA; data collection and processing: DA, OK and SA; bibliometric analysis and interpretation: SA; case study analysis and visualisation: DA, OK and SA; draft writing and manuscript structure: DA, OK and SA; editing and critical revision: DA, OK and SA; final review and approval: DA, OK and SA. All authors have read and approved the final version of the manuscript and agreed to its publication.

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