

The impact of digitalization and ESG factors on sustainable development of the banking sector in Kazakhstan



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ABSTRACT

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This study analyzes the impact of digitalization and the integration of environmental, social, and economic factors on the sustainable development of the Kazakhstani banking sector. The methodological basis of the study is represented by the following methods: statistical analysis, strategic analysis, comparative analysis, and empirical analysis. The results of the study show a significant positive interconnection between the level of digitalization and commercial bank profitability ($R^2 = 0.82$), which indicates the importance of digital transformation for improving the financial efficiency of the banking sector. In addition, the study revealed that the integration of ESG criteria has a positive impact on the sustainability of second-tier banks in the long term, while in the short term, this impact on financial results was not so statistically obvious. The results obtained during the study complement the existing scientific knowledge on the links between digitalization processes and the implementation of ESG principles into the sustainable development of the banking sector in the context of global changes. The results of the study may be useful for the strategic planning of banking activities, as well as for further research in the field of studying the impact of digitalization and environmental, social, and governmental factors on the sustainable development of second-tier banks.

Contribution/ Originality: This study examines the relations between digitalization and ESG factors in the context of the sustainable development of Kazakhstan's banking system, considering the main challenges, prospects, and opportunities for integrating digital solutions into ESG investments.

1. INTRODUCTION

Nowadays, in terms of global economic transformation and the rapid development of digital technologies, sustainable development issues are becoming increasingly important for the banking sector. In Kazakhstan, the banking sector has undergone large-scale changes over the past 20 years, driven by the strengthening of the government's role and the acceleration of digitalization. Digitalization has a comprehensive impact on banking activities, affecting almost all banking processes, from the replacement of banking cards to complex analytical calculations using large amounts of information. In recent years, digitalization has acted as a catalyst for the entire financial system of Kazakhstan, increasing operational efficiency and customer focus. The main drivers of

digitalization in the banking system are mobile banking applications, the use of Big Data technologies and artificial intelligence, the development of blockchain technologies, and ESG principles. These drivers have contributed not only to the growth of transparency and efficiency in the banking sector but also to the favorable overall economic development of the country. At the same time, it is important to note the negative aspects of digitalization in the banking sector. Thus, in recent years, the number of Internet fraud cases, cyber threats, personal data leaks, and increased competition from fintech companies has risen.

The relevance of the study can be confirmed due to a number of factors. The developing economy of Kazakhstan is highly dependent on external influences, such as resource prices, sanctions, and trade restrictions on neighboring countries, structural changes in the global economy, the impact of the COVID-19 pandemic, and the need to integrate ESG criteria. All these factors require the banking sector to be more flexible and adaptable to rapidly changing conditions. In this regard, digitalization is the most important tool for increasing the sustainability and competitiveness of the Kazakhstani banking sector in the context of global instability. The Kazakhstani banking sector is a key element of the country's financial infrastructure, which largely determines the pace and quality of sustainable economic growth. At the same time, the modern global environment poses a number of challenges to banks, such as compliance with international standards of sustainable development, increasing digital risks, changes in digital consumer preferences, strengthening government supervision, etc. Therefore, the introduction of ESG principles and digital technologies can increase the competitiveness of Kazakhstani banks, improve the quality of risk management, and expand opportunities for financing sustainable projects and initiatives.

The purpose of the study is to determine the impact of digitalization and ESG factors on the sustainable development of the Kazakhstan banking industry. This study aims to analyze the relationships between sustainable development and the digitalization of the banking sector, identifying possible problems and promising trends in the integration of digital technologies for the implementation of ESG investments. Digitalization and the integration of ESG principles in the banking sector are key factors in the sustainability and long-term competitiveness of Kazakhstani banks. The practical significance of the study lies in the urgent need for Kazakhstani banks to find solutions to adapt to global standards of sustainable development and the implementation of digital solutions, which are becoming critical in a dynamic and unpredictable external environment. The results of the study can be useful for a wide range of stakeholders, including banks, public authorities, investors, scientists, etc. The obtained results will contribute to making recommendations for the creation of a digital financial infrastructure, improving ESG management methods, and forming an effective banking ecosystem aimed at sustainable economic growth in the long run.

2. MATERIALS AND METHODS OF RESEARCH

To achieve the stated objective of the study, an integrated approach was used, including quantitative and qualitative methods of analysis. The methods of analysis aimed at a systematic study of the impact of digitalization processes and the implementation of ESG principles on the sustainability of the Kazakhstani banking sector:

1. Analysis of the statistical data of Kazakhstani second-tier banks

- Statistical data from the Agency for Regulation and Development of the Financial Market of the Republic of Kazakhstan, the National Bank, and international financial organizations for the period 2013–2024 were utilized. The sampling period from 2013 to 2024 was selected because, during this time, Kazakhstani banks have undergone significant transformations in the face of global challenges.
- A detailed analysis of the dynamics and structure of the main financial indicators of commercial banks was conducted, including an analysis of such indicators as: profit, assets, liabilities, loans to the economy, loan portfolio, loans with overdue payments, operating expenses, ICT costs, and the development of digital technologies. The choice of variables was determined by their direct relation to the objectives of the study - examining the impact of digitalization and ESG factors on banking stability.

2. Assessment of the growth of the studied indicators: - to identify patterns and determine key factors of change in the banking sector, annual growth rates were calculated for all analyzed data, which in turn made it possible to identify stable patterns and determine key drivers of change in banking activities.

3. Conducting a correlation analysis

- To determine the degree and nature of the relationships between independent variables and the resulting indicator (banking sector profit, in millions of tenge), a correlation matrix was constructed;
- The analysis of correlation coefficients made it possible to identify significant relationships between digitalization, ESG factors, and the financial indicators of commercial banks.

4. Conducting a regression analysis

- A multivariate regression model of the dependence of the banking sector's profit on the identified factors was constructed;
- The model used the least squares method (LSM), which allows for assessing the influence of each factor on the resulting indicator;
- Determination coefficients (R^2) were calculated, as well as statistical tests (F-criterion, T-statistics) to verify the significance of the model.

5. Conducting a factor analysis

- An analysis of the main components was conducted, which made it possible to classify the factors under consideration according to the degree of their influence on the financial results of banks.
- The main areas of sustainable development in the banking sector, in the context of digitalization and the integration of ESG approaches, have been identified.

6. Conducting a comparative analysis

- A comparative study of digital transformation and the implementation of ESG principles was conducted;
- The identification of barriers and promising areas for development was conducted.

7. Conducting an empirical analysis

- A detailed analysis of the impact of digitalization processes and ESG factors on the development of the banking industry in Kazakhstan was conducted, based on the methodology of composite indices.

The choice of these scientific methods is justified by the need for a comprehensive analysis of data and the identification of quantitative and qualitative patterns that contribute to a deeper understanding of the mechanisms influencing digitalization and ESG factors on the sustainability of Kazakhstani banks. Thus, the applied methodological approach has made it possible to perform a comprehensive analysis of the impact of digitalization and ESG factors on the sustainable development of Kazakhstani banks, identifying key trends, as well as determining the main risk factors and proposing strategic recommendations for improving the efficiency of banking activities.

3. STUDY DESIGN

The study was conducted based on a comprehensive methodology using a combination of quantitative and qualitative analytical tools to identify and assess the degree of influence of digitalization processes and the integration of ESG factors into the sustainable development indicators of Kazakhstani banks (Figure 1).

The results of the study have scientific and practical significance and can serve as a basis for developing strategic initiatives in the field of digital transformation and ESG investing. The findings represent an analytical basis for government agencies, financial institutions, and the investment community, ensuring the validity of decisions aimed at the sustainable development of the banking system and its adaptation to modern technological and environmental challenges.

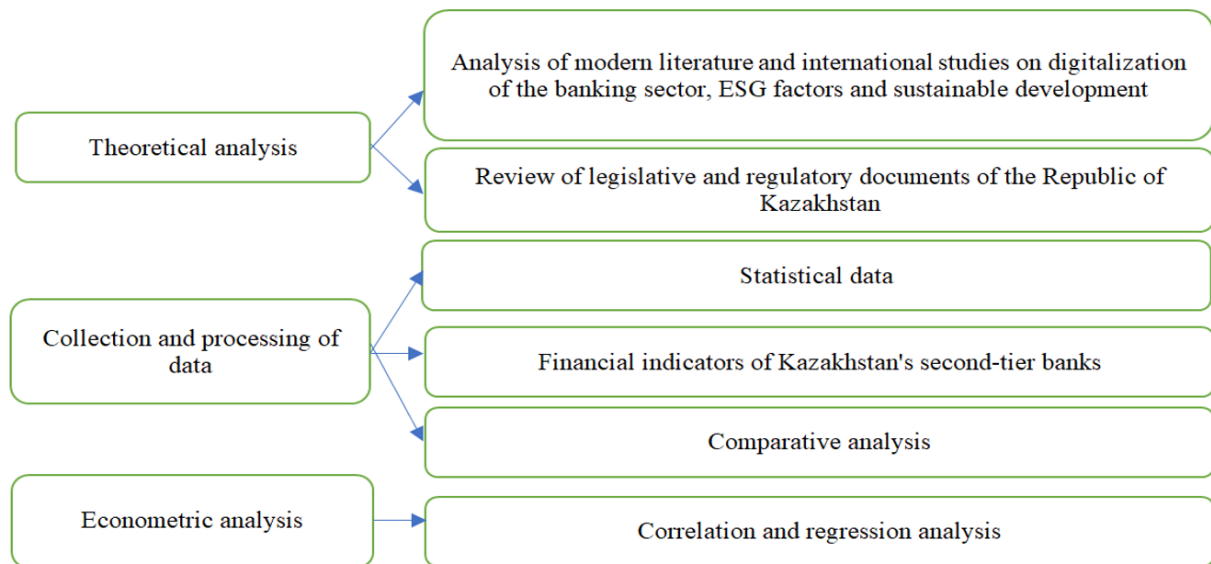


Figure 1. Study design.

4. LITERATURE REVIEW

Current challenges related to climate change and the unstable situation in the investment and business environment encourage companies to consider integrating ESG factors into their development strategies. Digitalization, especially the development of artificial intelligence, is an important tool for solving environmental problems and managing ESG risk issues. In today's realities, investors and society evaluate a company's activities, including the level of digitalization development and sustainability, thereby determining the long-term potential of the company (Mohammad & Wasiuzzaman, 2021). Digitalization expands the possibilities of ESG investing due to higher-quality and more accurate collection of information, as well as more precise processing and analysis of data on environmental, social, and governance issues related to the company's activities. Digitalization also helps to manage a large array of ESG data, which in turn allows companies to make informed and reliable investment decisions. In addition, digitalization helps to expand the possibilities of ESG investing to create sustainable projects and innovations. Moreover, ESG investing can stimulate digitalization processes by directing funding to environmentally significant digital projects and solutions (Fang, Nie, & Shen, 2023).

Companies that adhere to sustainable ESG practices can better manage risks and attract long-term investors. The main goal of most companies is to increase their market share and financial value in the long term (Alsayegh, Abdul Rahman, & Homayoun, 2020; Nasis, Siouziou, & Toudas, 2024). The study of Carnini Pulino, Ciaburri, Magnanelli, and Nasta (2022) shows that the disclosure of information on ESG factors contributes to the improvement of a company's financial performance. A number of empirical studies show that the environmental and social components of ESG have a positive impact on the financial performance of companies, while the governance aspects do not show a significant impact (Mo, Che, & Ning, 2023; Santarius et al., 2023). Research also shows that digitalization and ESG factors are important elements of sustainable development and the formation of open innovation ecosystems (Bouattour, Kalai, & Helali, 2024). However, some studies indicate a possible negative impact of digitalization on the environmental component of sustainable development (Robertson & Lapiņa, 2023).

Modern research in the field of artificial intelligence is devoted to transforming the social and economic environment, solving social problems, and mitigating environmental risks (Baabdullah, Alalwan, Algharabat, Metri, & Rana, 2022; Dubey et al., 2019; Dwivedi, Moktadir, Jabbour, & de Carvalho, 2022; Wamba, Bawack, Guthrie, Queiroz, & Carillo, 2021). The vast majority of scientific literature on artificial intelligence testifies to its interdisciplinary nature and the broad range of research areas. For example, "AI is studied in the context of improving the quality of organizational decisions" (Li, Lin, Ouyang, & Luo, 2022), "the impact of AI on consumer behavior and

decision-making" (Yeo, Tan, Kumar, Tan, & Wong, 2022), "in the personalization of products and services" (Micu et al., 2022), "the application of AI in the public sector" (Di Vaio, Hassan, & Alavoine, 2022), and other key areas.

Making decisions based on big data requires processing significant amounts of information, which makes artificial intelligence and machine learning methods important tools in the banking sector. Therefore, the role of digitalization is increasing every year in Kazakhstan and around the world. In addition, digitalization is developing under the influence of competition in the banking sector, economic growth, and the need for strategic sustainability (Kirdasinova, Omarbekova, Tolysbaev, Utegenova, & Ashimova, 2022). The consequences of the 2008 global economic crisis led to increased government regulation of banking activities in Kazakhstan (Kodasheva, Parusimova, Rispekova, & Uchkampirova, 2017), and the negative consequences of the crisis prompted commercial banks to develop risk management policies using new technologies, including digital ones (Delice & Karadaş, 2022; Sadvokassova, Kodasheva, Khamitkhan, Zhamiyeva, & Sadvokassov, 2020). Given the vast territory of Kazakhstan, digitalization and ESG factors contribute to the improvement of operational decisions and customer interaction (Dang & Ha, 2024; Shustova & Blagoev, 2018). Modern trends in digitalization in the banking sector include reducing cyber threats, developing artificial intelligence, and creating technologies based on remote servicing (Gumar, Imraziyeva, Zhanibekova, Shalbaeva, & Izeyev, 2023). Analysis of the activities of Kaspi Bank and Freedom Bank of Kazakhstan shows that digitalization processes contribute to improving the quality of services and optimizing business processes (Kopbayeva, Nurpeisova, Saimagambetova, & Yesturliyeva, 2024). The level of digitalization in the banking sector determines its competitiveness and has a multiplier effect on the national economy, society, and the state (Buzaubayeva, Orazbayeva, Alina, Baimagambetova, & Kenges, 2024; Omarov & Kobadilov, 2020).

Digitalization of the banking sector remains one of the most studied topics in the world in recent years because digitalization contributes to the accelerated development of the financial sector, effective interaction with clients, improved quality of services, etc. (Al-Dmour, Asfour, Al-Dmour, & Al-Dmour, 2022; Tran, Le, & Hang, 2023; Yang & Masron, 2023). Digital technologies can significantly reduce banks' operating costs and increase efficiency but require a serious approach to managing new types of risks (Zabala Aguayo & Ślusarczyk, 2020). Cocco, Pinna, and Marchesi (2017) also confirm these findings in their study, noting, like other researchers, blockchain technology as one of the factors in reducing costs and increasing security in banking operations (Al Shanti & Elessa, 2023). In addition to digital security, modern banks in the process of digitalization may face other risks, such as operational vulnerabilities, maintaining customer privacy, increasing online fraud, etc. (Chen, Li, Wang, & Wu, 2023; van Zeeland & Pierson, 2024). Globalization, increasing regulation, and the growing role of FinTech companies are prompting the banking sector to pay special attention to reducing barriers to digitalization (Boot, Hoffmann, Laeven, & Ratnovski, 2021; Ulrich-Diener, Dvoutely, & Špaček, 2023).

"Research results show that digitalization helps to reduce systemic risks in banks" (Fan, Zhang, & Zhang, 2024; Hoque, Le, & Le, 2024). The increasing level of digitalization in banks may be accompanied by an increase in systemic risks, the degree of which depends on the characteristics and scale of the bank. For example, regional banks are more vulnerable compared to large state-owned or joint-stock banks (Zhang, Ou, & Chen, 2023). The global COVID-19 pandemic has greatly affected macroeconomic stability, increasing global risks in the banking sector. At the same time, temporary quarantine acted as a catalyst for accelerated banking digitalization, facilitating banks' adaptation to new economic realities (Bueno, Sigahi, Rampasso, Leal Filho, & Anholon, 2024; Doran, Bădîrcea, & Manta, 2022; Huang, Molyneux, Ongena, & Xie, 2023). Macroeconomic instability has a significant impact on the banking sector of ASEAN countries, creating additional risks and affecting the sustainability of financial institutions in the region (Banna & Alam, 2021; Vuong, Nguyen, Nguyen, & Wong, 2024). Using the example of Sub-Saharan African countries, it can be noted that in addition to macroeconomic instability, the following factors affect the efficiency of banks: exchange rate instability, inflation uncertainty, and political instability (Abaidoo & Agyapong, 2023). The results of a study comparing eighty-eight developing and thirty-four developed countries show that regulation and macroeconomic stability play an important role in ensuring financial sustainability (Ullah, Ullah, & Zaman, 2024).

An analysis of the literature shows that digitalization, ESG factors, macroeconomic stability, and risk management are key aspects of the development of the banking sector in the face of global economic challenges (Adam, Sulemana, Sule, & Yussif, 2024; Singh, Chen, Singhania, Nanavati, & Gupta, 2022). Research highlights the need to adapt traditional risk management approaches and implement innovative technologies to improve the resilience of the banking sector, especially considering the increasing prevalence of the Internet and smartphones among the population (Ahuchogu, Sanyaolu, Adeleke, Researcher, & Leenit, 2024; Diener & Špaček, 2021). In the context of digitalization and global challenges, these aspects are becoming particularly relevant and require further study and development of strategies to effectively address them (Kitsios, Giatsidis, & Kamariotou, 2021).

5. DISCUSSION

A review of key indicators of the Kazakhstani banking sector over 12 years allows us to understand how the banking system developed during periods of macroeconomic instability. During the analyzed period, banks were affected by many external and internal macroeconomic factors, including falling oil prices, the pandemic, sanctions restrictions against third countries, and other economic challenges. The following indicators of the banking sector of Kazakhstan were considered: the number of banks, loans to the economy, assets, loan portfolio, overdue loans, liabilities, equity, and ICT costs. The total expenses of the banking sector on the development of digital technology, operating expenses of the banking sector, and profit of the banking sector were also analyzed (National Bank of the Republic of Kazakhstan, 2024). These indicators are presented in Table 1.

Data analysis shows that between 2013 and 2024, the number of banks decreased from 38 to 21. The reduction of banks has occurred due to various reasons, the main one being the tightening of requirements by the Central Bank of Kazakhstan, macroeconomic instability, the consequences of past global economic crises, and sanctions against third countries. Since 2013, the banking sector of Kazakhstan has seen steady growth in lending to the economy, as the number of loans has increased from 11.31 trillion tenge in 2013 to 27.86 trillion tenge in 2023. In October 2024, this figure reached 31.92 trillion tenge. It is worth noting that the growth of loans to the economy began to accelerate after the onset of the COVID-19 pandemic. Bank assets have also shown rapid growth; since 2013, assets have grown from 15.46 trillion tenge to 51.44 trillion tenge in 2023. In 2024, bank assets exceeded 58.45 trillion tenge (National Bank of the Republic of Kazakhstan, 2024).

Table 1. Key absolute and quantitative indicators of the banking sector in Kazakhstan, in millions of tenge.

Indicators	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024. 10.01
Number of banks	38	38	35	34	32	28	27	26	22	21	21	21
Loans to the economy	11314974	12165954	12844824	12519878	12544312	12469986	13673974	14594526	18502803	22774137	27860691	31923204
Assets	15462749	18239256	23784427	25561157	24220516	25240959	26804963	31172379	37622022	44562328	51441097	58 458 813
Loan portfolio	13348171	14184814	15553712	15510812	13590511	13762741	14743023	15792064	20200355	24254661	29853710	33755189
Loans with overdue payments	4 601815	3925558	2117013	1897715	1 989 785	1996417	1806205	1 528 729	1063823	2 996647	3 270 933	4 466 326
Liabilities	13380 304	15879573	21289941	22716298	21129479	22223404	23165493	27217147	33087077	39334637	44579098	50010796
Equity	2082445	2359682	2494486	2844859	3091036	3017554	3639470	3955231	4534944	5227690	6861999	8448016
ICT costs	220 848	237 079	375 600	269 527	349 944	305 217	337 713	388 929	443 121	589 853	918 350	-
Total banking sector expenditure on digital technology development	120 175	145908	126 845	150 904	168 776	156 961	168 146	174 619	206 708	220 607	274 397	259 856
Operating expenses of the banking sector	162 334	192 699	207 036	230 242	230 258	241 390	264 193	287 281	321 064	371 679	471 621	471 334
Banking sector profit	264 871	280 027	227 018	401 846	-18 672	638 389	802 995	726 803	1289327	1466545	2 184 757	1854416

Source: The table was compiled by the authors based on data from the National Bank of the Republic of Kazakhstan.

The loan portfolio of the banking sector of Kazakhstan also showed growth, increasing from 13.34 trillion tenge in 2013 to 29.85 trillion tenge in 2023. However, due to the fall in oil prices and their high volatility, in 2017 there was a decrease in the loan portfolio to 13.59 trillion tenge. Another important indicator, loans with overdue payments, showed a decrease from 4.6 trillion tenge in 2013 to 1.89 trillion tenge in 2016. In 2017 and 2018, this indicator slightly increased to 1.98 trillion tenge and 1.99 trillion tenge, respectively (Figure 2).

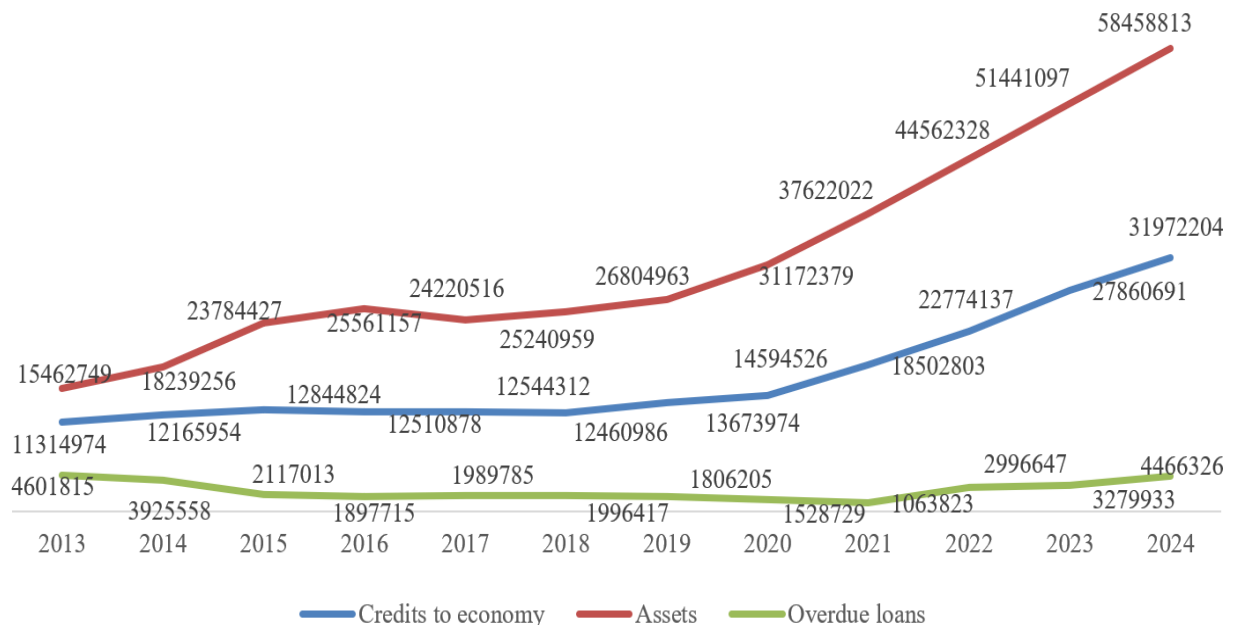


Figure 2. Dynamics of banking sector indicators: loan portfolio, loans to the economy, and overdue loans, in millions of tenge.

In 2019, overdue loans decreased from 1.52 trillion tenge to 1 trillion tenge in 2021. In 2022, this figure increased almost threefold, to 2.99 trillion tenge, and by October 2024, overdue loans increased to 4.46 trillion tenge. An increase in the number of overdue loans may indicate heightened risks and instability in the lending market due to the consequences of COVID-19 and sanctions against third countries. It is also worth noting the increase in other indicators of the banking sector. Banking sector liabilities increased from 13.38 trillion tenge in 2013 to 22.71 trillion tenge in 2016. In 2017, there was a slight decrease in liabilities to KZT 21.12 trillion. Starting from 2018, liabilities increased from KZT 22.2 trillion to KZT 50 trillion as of October 1, 2024. Equity increased from KZT 2.08 trillion in 2013 to KZT 6.8 trillion in 2023. ICT expenses increased by 3.8 times. Total expenses of the banking sector on digital technology development increased from KZT 120 million to KZT 259 million over the analyzed period. Operating expenses of the banking sector also increased from KZT 162 million in 2013 to KZT 471 million in 2023 (National Bank of the Republic of Kazakhstan, 2024).

Continuing the analysis of the indicators in Table 1, it is important to consider the dynamics of banking sector profit. Profit is a crucial indicator of the banking sector, as it enables sustainable growth. Thus, for the period from 2013 to 2024, the profit of the banking sector in Kazakhstan showed significant fluctuations. From 2013 to 2014, profit increased from 264 to 280 billion tenge, but in 2015, the profit of the banking sector decreased to 227 billion tenge. In 2016, profit increased to 401 billion tenge, but already in 2017, the banking sector reported a loss of 18.67 billion tenge (Figure 3).

From 2018 to 2019, profit increased from 638 billion tenge to 802 billion tenge. At the initial stage of COVID-19, profit decreased to 726 billion tenge. From 2021 to 2023, banking sector profit increased from 1,289 to 2,184 trillion tenge. As of October 1, 2024, banking sector profit amounted to 1,854 trillion tenge. The growth in profit since 2013 is due to asset optimization, improvement of loan portfolios, and the active introduction of digital technologies in the banking sector.

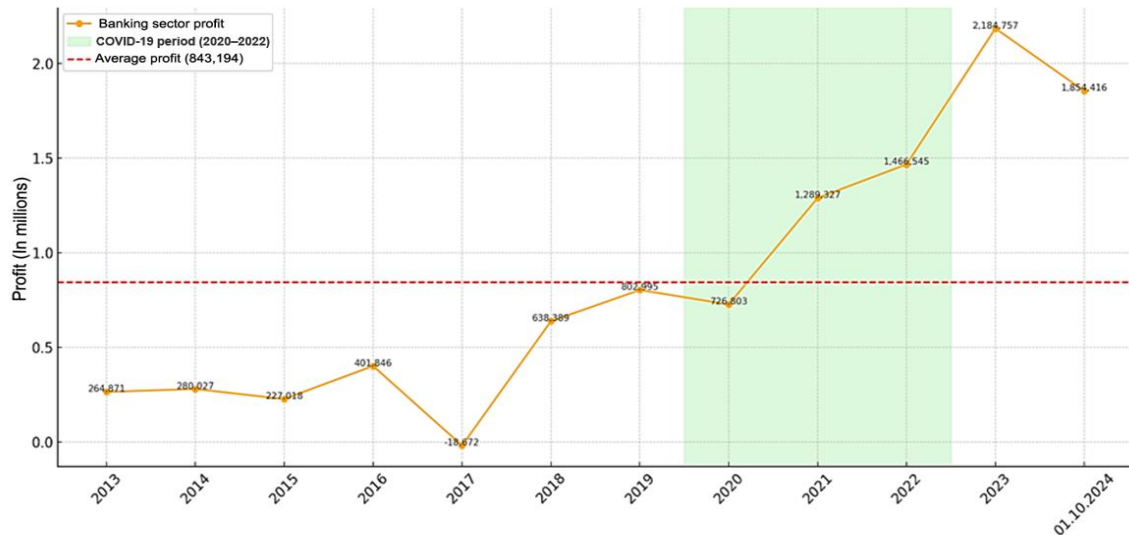


Figure 3. Trends in performance (profit) of the banking sector of Kazakhstan, million tenge.

Thus, when considering the activities of the banking sector, along with other important indicators such as assets, liabilities, and capital, it is important to take into account such an indicator as profit. Bank profit is one of the important indicators of sustainability and development. Despite fluctuations in profits during certain periods, the analysis of key indicators of the banking sector of Kazakhstan showed that the banking sector has demonstrated positive trends over twelve years. Despite the fall in prices for key export resources, sanctions against third countries, the COVID-19 pandemic, and various political factors, the banking sector of Kazakhstan demonstrated sustainable growth and strengthening of the financial system according to key indicators. The growth of assets, lending, and profits shows significant potential and opportunities for further development of the banking sector of Kazakhstan.

6. RESEARCH RESULTS

We have put forward and tested a hypothesis about the existence of a connection between the resulting indicator "Profit of the banking sector, million tenge" and the following factors:

- Loans to the economy, million tenge;
- Assets, million tenge;
- Loan portfolio, million tenge;
- Loans with overdue payments, million tenge;
- Liabilities, million tenge;
- Equity, million tenge;
- ICT costs, million tenge;
- Total expenses of the banking sector on the development of digital technology, million tenge;
- Operating expenses of the banking sector, million tenge.

To test the hypothesis, the following were done:

- 1) Statistical data for the period from 2013 to 2024 were used (Table 2).
- 2) The increases in the indicators were calculated (Table 3).
- 3) The matrix of paired correlation coefficients between them was determined (Table 4).

Table 2. Dynamics of the indicators under consideration for 2013–2024.

Year	Loans to the economy, million tenge	Assets, million tenge	Loan portfolio, million tenge	Loans with overdue payments, million tenge	Liabilities, million tenge	Equity capital, million tenge	ICT costs, million tenge	Total expenses of the banking sector on the development of digital technology, million tenge	Operating expenses of the banking sector, million tenge	Banking sector profit, million tenge
2013	11 314 974	15 462 749	13 348 171	4 601 815	13 380 304	2 082 445	220 848	120 175	162 334	264 871
2014	12 165 954	18 239 256	14 184 814	3 925 558	15 879 573	2 359 682	237 079	145 908	192 699	280 027
2015	12 844 824	23 784 427	15 553 712	2 117 013	21 289 941	2 494 486	375 600	126 845	207 036	227 018
2016	12 519 878	25 561 157	15 510 812	1 897 715	22 716 298	2 844 859	269 527	150 904	230 242	401 846
2017	12 544 312	24 220 516	13 590 511	1 989 785	21 129 479	3 091 036	349 944	168 776	230 258	-18 672
2018	12 469 986	25 240 959	13 762 741	1 996 417	22 223 404	3 017 554	305 217	156 961	241 390	638 389
2019	13 673 974	26 804 963	14 743 023	1 806 205	23 165 493	3 639 470	337 713	168 146	264 193	802 995
2020	14 594 526	31 172 379	15 792 064	1 528 729	27 217 147	3 955 231	388 929	174 619	287 281	726 803
2021	18 502 803	37 622 022	20 200 355	1 063 823	33 087 077	4 534 944	443 121	206 708	321 064	1 289 327
2022	22 774 137	44 562 328	24 254 661	2 996 647	39 334 637	5 227 690	589 853	220 607	371 679	1 466 545
2023	27 860 691	51 441 097	29 853 710	3 270 933	44 579 098	6 861 999	918 350	274 397	471 621	2 184 757
2024	31 923 204	58 458 813	33 755 189	4 466 326	50 010 796	8 448 016	918 350	289 856	471 934	2 854 416

Source: The table was compiled by the authors based on the calculations made.

Table 3. Increases in the indicators under consideration for 2014–2024.

Increase in indicators, %										
Year	Loans to the economy	Assets	Loan portfolio	Loans with overdue payments	Liabilities	Equity	ICT costs	Total banking sector expenditure on digital technology development	Operating expenses of the banking sector	Banking sector profit
2014	7.521	17.956	6.268	-14.695	18.679	13.313	7.349	21.413	18.705	5.722
2015	5.580	30.402	9.650	-46.071	34.071	5.713	58.428	-13.065	7.440	-18.930
2016	-2.530	7.470	-0.276	-10.359	6.700	14.046	-28.241	18.967	11.209	77.011
2017	0.195	-5.245	-12.380	4.852	-6.985	8.653	29.836	11.843	0.007	-104.647
2018	-0.593	4.213	1.267	0.333	5.177	-2.377	-12.781	-7.000	4.835	-3518.964
2019	9.655	6.196	7.123	-9.528	4.239	20.610	10.647	7.126	9.447	25.785
2020	6.732	16.293	7.116	-15.362	17.490	8.676	15.166	3.850	8.739	-9.488
2021	26.779	20.690	27.915	-30.411	21.567	14.657	13.934	18.377	11.760	77.397
2022	23.085	18.447	20.070	181.687	18.882	15.276	33.113	6.724	15.765	13.745
2023	22.335	15.436	23.084	9.153	13.333	31.263	55.691	24.383	26.889	48.973
2024	14.582	13.642	13.069	36.546	12.184	23.113	0	5.634	0.066	30.651

Source: The table was compiled by the authors based on the calculations made.

Table 4. Matrix of paired correlation coefficients between the increases in indicators.

Year	Loans to the economy	Assets	Loan portfolio	Loans with overdue payments	Liabilities	Equity	ICT costs	Total banking sector expenditure on digital technology development	Operating expenses of the banking sector	Banking sector profit
Loans in the economy	1.000	0.490	0.924	0.403	0.417	0.612	0.435	0.339	0.495	0.376
Assets	0.490	1.000	0.688	-0.020	0.993	0.105	0.448	-0.176	0.391	0.327
Loan portfolio	0.924	0.688	1.000	0.247	0.627	0.522	0.344	0.217	0.564	0.264
Loans with overdue payments	0.403	-0.020	0.247	1.000	-0.048	0.198	0.101	0.023	0.143	0.050
Liabilities	0.417	0.993	0.627	-0.048	1.000	-0.014	0.425	-0.252	0.335	0.258
Equity	0.612	0.105	0.522	0.198	-0.014	1.000	0.242	0.635	0.509	0.615
ICT costs	0.435	0.448	0.344	0.101	0.425	0.242	1.000	-0.117	0.332	0.351
Total expenses of the banking sector on the development of digital technology, million tenge	0.339	-0.176	0.217	0.023	-0.252	0.635	-0.117	1.000	0.575	0.467
Operating expenses of the banking sector	0.495	0.391	0.564	0.143	0.335	0.509	0.332	0.575	1.000	0.256
Banking sector profit	0.376	0.327	0.264	0.050	0.258	0.615	0.351	0.467	0.256	1.000

Source: The table was compiled by the authors based on the calculations made.

A statistically significant relationship is observed only between the increase in the resulting indicator and the increase in equity capital. The scatter diagram between the increases in these indicators is shown in Figure 4.

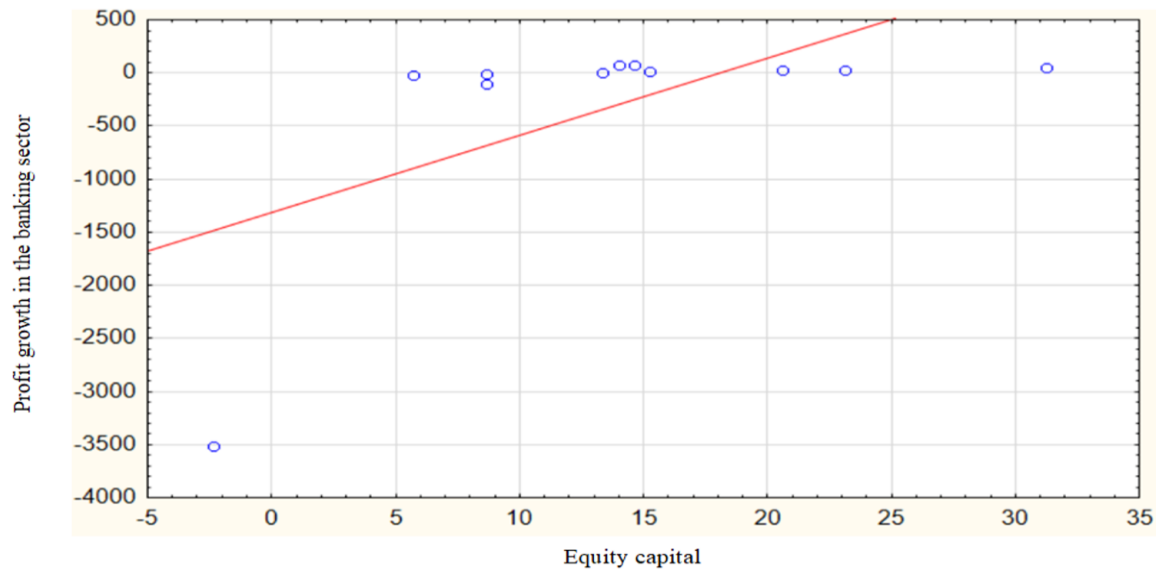


Figure 4. Scatter plot of banking sector profit growth and equity growth.

As a result of approximating statistical data using the least squares method, the following multiple regression equation was obtained.

$$Profit = -1313.200 + 72.396EqCap, \quad R = 0.615, F_{observ} = 5.475 \\ (t_{b_0} = -2.593) (2.340)$$

where:

Profit – Growth in banking sector profits, %.

EqCap – Increase in equity capital, %.

The results of the modeling indicate that the regression equation as a whole and its individual parameters are statistically significant and promising. We can draw the following conclusion: with an increase in equity capital by 1%, the profits of the banking sector increase by an average of 71.396%.

To determine the predicted values of equity capital, a trend model was built with the implementation of certain stages.

- 1) Checking the time series for the presence of abnormal observations (Table 5).

Table 5. Testing for the presence of anomalous observations in a time series using Irwin's test.

Year	Equity capital, million tenge	Observed value of Irwin's criterion	Calculation formulas
2013	2 082 445		Observed value of Irwin's criterion $\lambda_t = \frac{ y_t - y_{t-1} }{\sigma_y}, \quad t = \overline{2, 12}$ Critical value of Irwin's criterion $\lambda_{0,05} = 1.5$
2014	2 359 682	0.143	
2015	2 494 486	0.069	
2016	2 844 859	0.180	
2017	3 091 036	0.127	
2018	3 017 554	0.038	
2019	3 639 470	0.320	
2020	3 955 231	0.162	
2021	4 534 944	0.298	
2022	5 227 690	0.356	
2023	6 861 999	0.840	
2024	8 448 016	0.815	

Source: The table was compiled by the authors based on the calculations made.

The analysis of the time series showed that all observed values of the Irwin criterion are below the critical level, which, with a probability of 95%, indicates the absence of anomalous observations.

2) Additionally, the presence of a trend component in the time series was confirmed using the criterion of "ascending" and "descending" series (Table 6).

Table 6. Checking for a trend.

Critical statistics (For a trend to exist, at least one inequality must be violated)	Calculated values with error probability $0.05 < \alpha < 0.0975$	Critical values
Total number of episodes: $v(n) > \left\lfloor \frac{2n-1}{3} - 1.96 \sqrt{\frac{16n-29}{90}} \right\rfloor$	3	5
Length of the longest series: $K_{max} < [K_0(n)]$	6	5

Source: The table was compiled by the authors based on the calculations made.

3) Using the least squares method, estimates of the growth curve parameters were determined.

$$y_t = 834\,189.909 + 494\,194.014t + \varepsilon_t$$

4) The quality assessment of the obtained model was carried out in two directions: conformity analysis and assessment of the model's accuracy.

To check the model's compliance, a series of residuals were analyzed, including checking the fulfillment of the condition that the mathematical expectation is equal to zero, the coincidence of the residuals' distribution, and their compliance with the normal distribution law. The results of the residuals' analysis are presented in Table 7.

Table 7. Model fit analysis.

Property being tested	Statistics used		Bound	Conclusion
	Name, calculation formula	The resulting value		
Accident	The criterion of "peaks" (turning points) $p > \left\lfloor \frac{2}{3}(n-2) - 1.96 \sqrt{\frac{16n-29}{90}} \right\rfloor$	$5 > 4$	4	Corresponds
Normality	RS-criterion $RS = \frac{e_{\max} - e_{\min}}{S}$	3.22	2.80-3.91	Corresponds
Equality of the mathematical expectation of the levels of a series of residues to zero	Student's t-statistic $t_{\text{набл.}} = \frac{ \bar{e} }{S} \sqrt{n}$	0	2.23	Corresponds

Source: The table was compiled by the authors based on the calculations made.

By calculating the average relative approximation error, a solution was found.

$$E_{rel.} = \frac{1}{n} \sum_{i=1}^n \frac{|e_t|}{y_t} \cdot 100\% = 13.20\%$$

Value indicating a sufficient level of model accuracy.

The developed model has high quality and was used for forecasting.

5) To calculate the timely forecast, the values of the variables are adjusted in accordance with the waiting period in the resulting growth curve model. The confidence interval is set at 95% to ensure forecast accuracy.

The results of modeling and forecasting the amount of equity capital for 2025–2027 are presented graphically in Table 8.

Table 8. Point and interval forecasts of equity capital for 2025–2027 (TENGE in millions).

Year	Point forecast, million tenge	Interval forecast, million tenge	
		Upper bound	Lower bound
2025	7 752 906,105	5 529 159,694	9 976 652,515
2026	8 247 100,119	5 941 060,291	10 553 139,947
2027	8 741 294,133	6 346 051,405	11 136 536,860

Source: The table was compiled by the authors based on the calculations made.

A graphical interpretation of the results of modeling and forecasting the dynamics of equity capital from 2025 to 2027 is presented in Figure 5, which allows us to visualize the expected trends and variations within the established confidence interval.

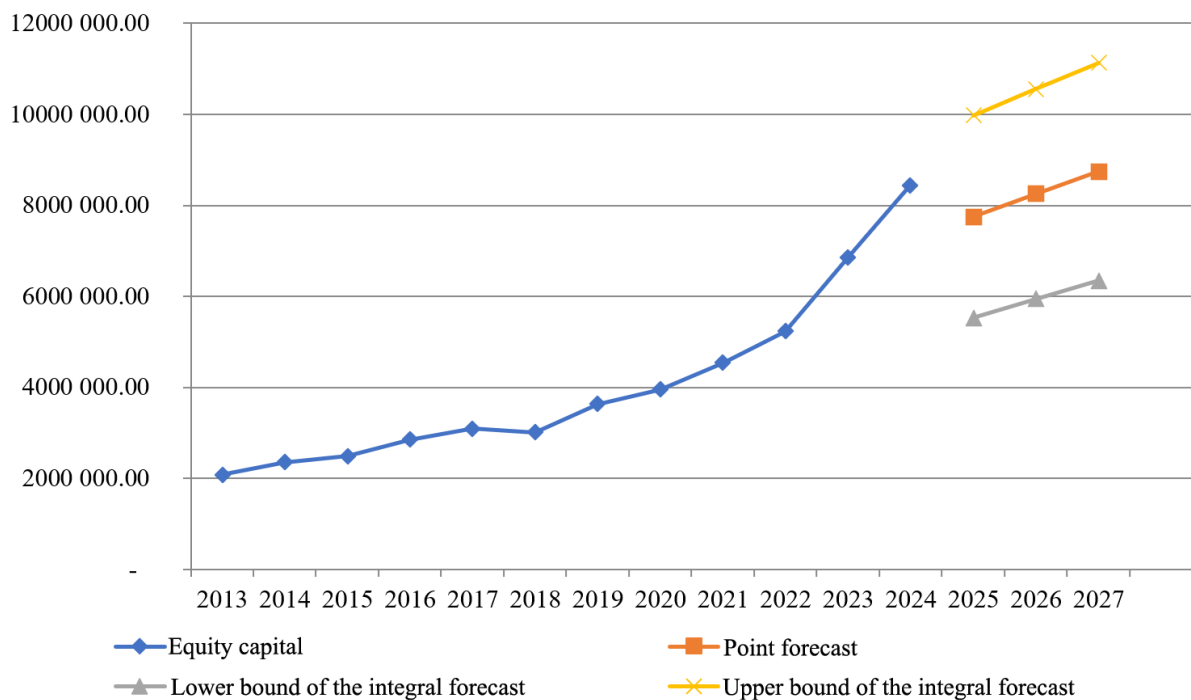


Figure 5. Point and interval forecasts of equity capital for 2025–2027, million tenge.

In the context of digitalization development, the banking sector has undergone significant changes, requiring banks to be highly adaptable to the rapidly changing environment. Global risk factors, including macroeconomic instability, regulatory changes, international conflicts, as well as political and geoeconomic threats, have a significant impact on the stability and profitability of banks. Based on this, the study conducted a comprehensive analysis of banking profit factors, taking into account the external and internal environments affecting financial performance. The study is based on the analysis of data on profit, assets, liabilities, and equity of Kazakhstani banks over the past 12 years. These data provided an idea of the financial stability of banks, their ability to generate income, and manage their resources. Sustainable growth of equity and assets of Kazakhstani banks indicates strengthening financial stability, which contributes to increasing their profitability in the long term.

The empirical model developed to analyze the impact of digitalization and ESG factors on the banking sector of Kazakhstan is based on a system of composite indices. This approach complements the results of the regression

analysis and offers an alternative opportunity to study the issues under consideration based on digitalization and ESG factors data. Table 9 presents the results of the analysis (list of variables, extreme values, index formulas, and conclusions), allowing us to assess how digitalization (H1), sustainability (H2), and key factors (H3) shape bank profitability. Fresh data, including $ICT_{2024} = 678,033$ million tenge, make the analysis relevant and justified.

Table 9. Characteristics of indices and variables of the empirical model of the banking sector of Kazakhstan.

Index/ Variable (Designation)	Minimum and maximum value (Million tenge)	Index formula	Index value boundaries	Conclusions
Level of digital investment (H1)				
DI_t (Digitalization index)	-	$= 0.5 * \frac{ICT_t - ICT_{min}}{ICT_{max} - ICT_{min}} + 0.5 * \frac{DigitalExp_t - DigitalExp_{min}}{DigitalExp_{max} - DigitalExp_{min}}$	0 (2013) – 1.000 (2027)	The growth of DI_t correlates with the increase in profits, confirming the impact of digitalization (H1).
Investments in information and communication technologies				
ICT_t (ICT costs)	220848 (2013) – 918350 (2023)	-	-	The main driver of DI_t , peaks in 2023, then stabilizes.
Total costs of digitalization				
$DigitalExp_t$ (Digital spending)	120175 (2013) – 274397 (2023)	-	-	Strengthens DI_t , showing steady growth in digital investments.
Financial stability and risks (H2, H3)				
SI_t (Sustainability index)	-	$= 0.5 * \frac{Equity_t - Equity_{min}}{Equity_{max} - Equity_{min}} + 0.5 * (1 - \frac{NPL_t - NPL_{min}}{NPL_{max} - NPL_{min}})$	0 (2013) – 0.571 (2027)	The slow growth of SI_t reflects long-term sustainability but limited short-term effect (H2).
Financial stability of banks				
$Equity_t$ (Equity)	2082445 (2013) – 8448016 (2024)	-	-	Key factor SI_t , maintains stability (H3).
Credit risk level				
NPL_t (Overdue loans)	1063823 (2021) – 4601815 (2013)	-	-	The feedback effect on SI_t is that lower NPL_t increases resilience.
Final Performance Indicator				
$Profit_t$ (Profit)	-18672 (2017) – 2184757 (2023)	-	-	Dependent on DI_t and SI_t , confirming H1– H3.

Source: The table was compiled by the authors based on the calculations made.

- ICT , Digital Expert, Equity, NPL, Profit variables are the initial indicators taken from Table 1 of the study and supplemented by ICT_{2024} .
- DI_t , SI_t indices are composite metrics calculated based on normalization to the range $[0, 1]$ using the minimum and maximum values for 2013–2024.
- Formulas determine the contribution of each variable to the indices with equal weights (0.5), which ensures balance.
- Value boundaries and conclusions show the dynamics and significance of the factors.

The final values of the calculated indices, as well as their graphical interpretation, are presented in Table 10, Table 11, and Figure 6. The data obtained clearly demonstrate the dynamics and interrelations of the key factors underlying digitalization and sustainable development in the banking industry.

Table 10. Results of index calculations with forecast data for 2025, 2026 and 2027.

Year	Profit _t (Million tenge)	DI _t	SI _t
2013	264871	0	0
2014	280027	0.073	0.104
2015	227018	0.195	0.264
2016	401846	0.148	0.294
2017	-18672	0.239	0.285
2018	638389	0.184	0.272
2019	802995	0.234	0.349
2020	726803	0.281	0.392
2021	1289327	0.354	0.5
2022	1466545	0.51	0.387
2023	2184757	0.822	0.456
2024	1854416	0.781	0.519
2025	2100000	0.862	0.536
2026	2400000	0.95	0.554
2027	2700000	1	0.571

Source: The table was compiled by the authors based on the calculations made.

Table 10 shows volatile profit dynamics from 2013 to 2017. Since 2018, Profit_t has begun to grow steadily, reaching its peak by 2023 (2,184,757 million tenge). The Digitalization Index (DI_t) starts from zero and gradually grows, exceeding 0.8 in 2023. According to the forecast, it will reach 1.0 by 2027, which indicates the highest possible level of digital development. The Sustainability Index (SI_t) increases more smoothly and reaches 0.571 by 2027, which shows strengthening stability, despite lagging behind the pace of digitalization. Figure 6 shows a graphical visualization of the relationships between digitalization (DI_t), sustainability (SI_t), and profit (Profit).

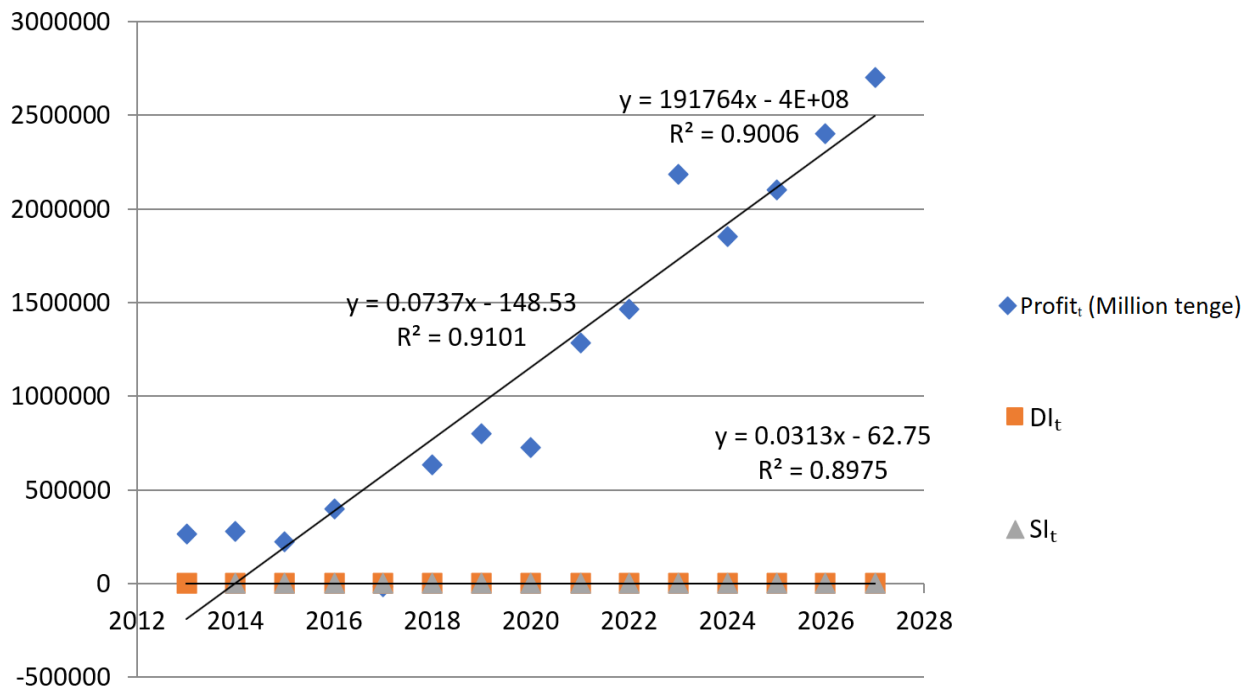
**Figure 6.** Scatter plot of indices and profits with forecast data for 2025–2027, million tenge.

Table 11 presents the modeling of trend dependencies of indices and profit with a forecast for 2025–2027. Thus, all models have a fairly high $R^2 \geq 0.89$, which indicates a strong linear dependence of the variables under consideration. Profit (0.9006) indicates a pronounced trend of profit growth with time advancement, DI_t (0.9101) confirms the confident growth of the digitalization index, and SI_t (0.8975) shows a gradual increase in the sustainability index; however, its growth is smoother compared to DI_t.

Table 11. Modeling trend dependencies of indices and profits with a forecast for 2025–2027.

Trend line	Equation	The magnitude of the approximation confidence (R^2)	Profit forecast, million tenge
Profit	$y = 191764x - 4E+08$	$R^2 = 0.9006$	2100000
DI_t	$y = 0.0737x - 148.53$	$R^2 = 0.9101$	2400000
SI_t	$y = 0.0313x - 62.75$	$R^2 = 0.8975$	2700000

Source: The table was compiled by the authors based on the calculations made.

Thus, a comprehensive empirical model is considered, where composite indices (DI_t and SI_t) are used in conjunction with key financial indicators to assess the impact of digitalization and ESG factors on Kazakhstani banks. The analysis demonstrates that the growth of digital investments (DI_t) closely correlates with an increase in profit ($Profit_t$). The sustainability index (SI_t) has smoother growth and also has a positive effect on financial indicators. Calculations show a high value of digitalization in the long term; ESG parameters (through sustainability indicators) also have positive significance, strengthening the stability of banks. Consequently, digitalization and ESG factors ensure an increase in profits and contribute to the formation of sustainable business models in the Kazakhstani banking system.

Based on this, the approaches under consideration are consistent with each other and indicate a general trend that digitalization and ESG factors contribute to the profitability and sustainable development of the banking system. The first approach (point analysis) reveals the contribution of individual variables, while the second approach (integrated analysis) clearly demonstrates the systemic nature of changes. The synthesis of the two approaches indicates that consistent digitalization and strengthening of sustainability, including through the growth of equity capital and the reduction of problem loans, contribute to increased efficiency and long-term competitiveness of the Kazakhstani banking system.

7. CONCLUSION

Thus, the digitalization of the banking system ensures the following:

- The increased efficiency of credit operations due to the automation of the risk assessment and management system reduces the level of problem loans;
- Optimization of operating costs;
- The use of digital services, online banking, chatbots, CRM, and ERP systems is reducing customer service costs.
- Expansion of the customer base - the online service allows commercial banks to work with clients throughout the country.

Regression analysis allows us to quantitatively assess the impact of digitalization costs (ICT costs, operating costs) on bank profitability, identifying key growth drivers. The use of correlation and regression analysis in the study provides an in-depth assessment of the impact of digitalization and ESG factors on the sustainable development of the Kazakhstani banking system. The empirical analysis confirmed the hypotheses, demonstrating that the impact of digitalization and ESG factors is revealed through an empirical approach based on a system of composite indices. This method made it possible to assess the degree of impact of the aforementioned factors on the banking sector.

The obtained results can serve as a basis for strategic planning in the field of digitalization, risk management, and ESG initiatives, ensuring their practical implementation in the following spheres:

- Optimization of digital methods and determination of the most successful areas of investment in information and telecommunication technologies and digital solutions;
- Increasing financial stability and identifying factors that ensure stable growth of banks in the context of digitalization;
- Development of ESG investing through analysis of the impact of environmental and social factors on the financial performance of banks;

- Development of regulatory policy by forming recommendations for the National Bank of Kazakhstan on the regulation of digitalization and ESG initiatives.

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Data Availability Statement: Upon a reasonable request, the supporting data of this study can be provided by the corresponding author.

Competing Interests: The authors declare that they have no competing interests.

Authors' Contributions: All authors contributed equally to the conception and design of the study. All authors have read and agreed to the published version of the manuscript.

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