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DIGITAL TRANSFORMATION OF THE ECONOMY AND REGIONAL FACTORS OF YOUTH UNEMPLOYMENT IN KAZAKHSTAN

In the context of the accelerated digital transformation of the economy, the problem of youth unemployment is becoming one of the significant challenges to the sustainable socio-economic development of the regions. The spread of digital technologies, the development of online employment platforms and changes in the demand structure for professional competencies are creating new conditions for the integration of young people into the labor market, while increasing interregional differences in the unemployment rate.

The purpose of the study is to identify and quantify regional socio-economic factors influencing the level of youth unemployment in the context of the digitalization of the economy, as well as to substantiate the directions of its reduction, taking into account regional specifics. The methodological basis of the research consists of methods of economic and statistical analysis. The empirical basis was the official data of the Bureau of National Statistics (BNS). The work uses an analysis of the dynamics of labor market indicators, comparative regional analysis, correlation analysis and econometric modeling based on panel data. The results of the study showed that the level of economic activity of young people, the level of socio-economic development of regions, as well as the development of digital infrastructure and the availability of digital services have a statistically significant impact on the level of youth unemployment. It has been established that regions with a more developed digital environment are characterized by lower rates of youth unemployment.

The results obtained expand the scientific understanding of the impact of digitalization on the transformation of regional labor markets and can be used in the development of state youth policy, improvement of regional employment programs and the development of digital competencies of youth.

Keywords: digital transformation of the economy, youth unemployment, regional development, labor market, youth employment.

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Экономиканың цифрлық трансформациясы және Қазақстандағы жастар жұмыссыздығының өңірлік факторлары

Экономиканың жеделдетілген цифрлық трансформациясы жағдайында жастар арасындағы жұмыссыздық проблемасы өңірлердің орнықты әлеуметтік-экономикалық дамуындағы елеулі сын-қатерлердің біріне айналууда. Цифрлық технологиялардың таралуы, онлайн жұмыспен қамту платформаларының дамуы және кәсіби құзыреттерге сұраныс құрылымындағы өзгерістер жұмыссыздық деңгейіндегі өңіраралық айырмашылықтарды күшейте отырып, жастардың еңбек нарығына интеграциялануы үшін жаңа жағдайлар жасайды.

Зерттеудің мақсаты – экономиканың цифрландыру жағдайында жастар арасындағы жұмыссыздық деңгейіне әсер ететін өңірлік әлеуметтік-экономикалық факторларды анықтау және сандық бағалау, сондай-ақ өңірлік ерекшелікті ескере отырып, оны төмендету бағыттарын негіздеу. Зерттеудің әдіснамалық негізі экономикалық және статистикалық талдау әдістері болды. Эмпирикалық база Ұлттық статистика бюросының (ҰСБ) ресми деректері болды. Жұмыста еңбек нарығы көрсеткіштерінің динамикасын талдау, салыстырмалы аймақтық талдау, корреляциялық талдау және панельдік деректерге негізделген эконометрикалық модельдеу қолданылады. Зерттеу нәтижелері жастардың экономикалық белсенділік деңгейі, өңірлердің әлеуметтік-экономикалық даму деңгейі, сондай-ақ цифрлық инфрақұрылымды дамыту және цифрлық қызметтердің қолжетімділігі жастар арасындағы жұмыссыздық деңгейіне статистикалық маңызды әсер ететінін көрсетті. Цифрлық ортасы анағұрлым дамыған өңірлер жастар арасындағы жұмыссыздық көрсеткіштерінің төмендеуімен сипатталатыны анықталды.

Алынған нәтижелер цифрландырудың өңірлік еңбек нарықтарының трансформациясына әсері туралы ғылыми түсінікті кеңейтеді және мемлекеттік жастар саясатын әзірлеу, өңірлік жұмыспен қамту бағдарламаларын жетілдіру және жастардың цифрлық құзыреттерін дамыту кезінде пайдаланылуы мүмкін.

Түйін сөздер: экономиканың цифрлық трансформациясы, жастар арасындағы жұмыссыздық, аймақтық даму, еңбек нарығы, жастарды жұмыспен қамту.

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Цифровая трансформация экономики и региональные факторы молодежной безработицы в Казахстане

В условиях ускоренной цифровой трансформации экономики проблема молодежной безработицы становится одним из существенных вызовов устойчивому социально-экономическому развитию регионов. Распространение цифровых технологий, развитие онлайн-платформ трудоустройства и изменения в структуре спроса на профессиональные компетенции создают новые условия для интеграции молодежи на рынок труда, одновременно усиливая межрегиональные различия в уровне безработицы.

Целью исследования является выявление и количественная оценка региональных социально-экономических факторов, влияющих на уровень молодежной безработицы в условиях цифровизации экономики, а также обоснование направлений ее снижения с учетом региональной специфики. Методологическую основу исследования составили методы экономического и статистического анализа. Эмпирической базой послужили официальные данные Бюро национальной статистики (БНС). В работе используется анализ динамики показателей рынка труда, сравнительный региональный анализ, корреляционный анализ и эконометрическое моделирование на основе панельных данных. Результаты исследования показали, что уровень экономической активности молодежи, уровень социально-экономического развития регионов, а также развитие цифровой инфраструктуры и доступность цифровых услуг оказывают статистически значимое влияние на уровень молодежной безработицы. Установлено, что регионы с более развитой цифровой средой характеризуются более низкими показателями молодежной безработицы.

Полученные результаты расширяют научное понимание влияния цифровизации на трансформацию региональных рынков труда и могут быть использованы при разработке государственной молодежной политики, совершенствовании региональных программ занятости и развитии цифровых компетенций молодежи.

Ключевые слова: цифровая трансформация экономики, молодежная безработица, региональное развитие, рынок труда, занятость молодежи.

Introduction

Unemployment remains one of the key socio-economic problems affecting the economic stability and efficiency of the labor market. In the context of digital transformation, structural changes in the demand for labor and the spread of digital employment platforms significantly affect the employment opportunities of young people.

A special place in the labor market is occupied by youth as a socio-demographic group that is at the stage of initial inclusion in economic activity. The level of youth employment (YE) largely determines the formation of competitive human capital and long-term prospects for economic growth. At the same time, young people remain one of the most vulnerable categories in the labor market due to a lack of professional experience, inadequate edu-

cational training to the requirements of the digital economy, as well as limited employment opportunities in certain regions.

Despite the implementation of government programs to support employment and develop youth entrepreneurship, the problem of youth unemployment (YU) remains relevant. The digitalization of the economy strengthens the regional differentiation of the labor market, which is manifested in differences in the level of youth employment, job availability, the development of digital infrastructure and the level of economic activity of the regions. In this regard, there is an increasing need for a comprehensive analysis of regional socio-economic factors that determine the level of YU.

In Kazakhstan, in 2022, the age category of youth was expanded to 15-34 years, which affects the interpretation of statistical indicators of the labor market.

The object of the research is the youth labor market in the context of the digital transformation of the economy. The subject of the study is regional socio-economic and institutional factors influencing the youth unemployment rate (YUR). The purpose of the study is to identify regional socio-economic factors that determine the level of YU, as well as to assess the possibilities of its reduction based on methods of economic and statistical modeling, taking into account the processes of digitalization of the economy.

To achieve this goal, the following tasks are being solved: theoretical approaches and results of domestic and foreign research on YU are analyzed; the dynamics and regional features of YU in 2020-2024 are investigated; key socio-economic factors affecting the level of YUR are identified; correlation and regression analysis of the dependence of YUR on selected factors is carried out; a forecast scenario is developed and determined directions for improving the regional YE policy.

The methodological basis of the research consists of methods of economic and statistical analysis, including analysis of the dynamics of indicators, comparative regional analysis, correlation analysis and econometric modeling based on panel data.

The scientific novelty of the study is a comprehensive economic and statistical analysis of the impact of socio-economic and digital factors on YU in the regions of Kazakhstan. Unlike previous studies, the article uses panel data on 17 regions and 3 cities of national significance for the period 2020-2024, the econometric model includes indicators of digital development, and scenario modeling of the impact of key factors on YU is applied.

The practical significance of the research lies in the possibility of using the results obtained in the development of regional youth employment programs, the formation of state youth policy, as well as in the development of measures to develop digital competencies and increase youth adaptability to the digital economy.

Literature review

The development of human capital and its impact on the functioning and transformation of the labor market have received fundamental justification in the works of representatives of neoclassical economic theory. Within the framework of this approach, education, vocational training and accumulation of skills are considered as key factors for increasing labor productivity, competitiveness

of workers and their employment (Shults, 1961; Besker, 1987). The theory of human capital suggests that investments in education and the development of professional competencies increase the likelihood of employment and contribute to a more efficient allocation of labor resources in the economy.

In modern conditions of global economic instability and the accelerating digital transformation of the economy, there is a significant transformation of the factors determining the level of employment and unemployment. The development of digital technologies, automation and artificial intelligence tools leads to structural changes in the labor market and the formation of new requirements for the professional competencies of employees. On the one hand, digitalization contributes to the growing demand for young professionals with digital skills, the ability to innovate and high adaptability to technological changes. On the other hand, technological progress and automation of certain types of activities can lead to a reduction in traditional jobs and increased structural unemployment (Autor, 2015; Frey & Osborne, 2017).

Research shows that the impact of technological change on employment is mixed. On the one hand, digital transformation creates new employment opportunities related to the development of digital platforms, remote work and online entrepreneurship. On the other hand, automation and technological changes can reduce the demand for traditional jobs. Modern research highlights that digitalization is significantly transforming the structure of the labor market and employment mechanisms (Acemoglu & Restrepo, 2020). As a result, the importance of digital competencies and continuing education as key factors of youth competitiveness in the labor market is increasing.

A number of research show that digital infrastructure and the level of digital skills of the population are becoming important factors for the competitiveness of workers in the modern labor market and can have a significant impact on the employment rate of young people (Başol *et al.*, 2023; OECD, 2023). At the same time, digitalization leads to structural changes in the demand for labor and increases the importance of human capital, professional skills and adaptability of workers.

In recent years, considerable attention in the scientific literature has been paid to the development of platform employment, which is one of the key forms of employment in the digital economy. Platform services and online platforms create new employment opportunities, allowing employees to offer services

in the global labor market. Research shows that digital platforms can act as an alternative employment channel for young people, providing job flexibility, reducing the transaction costs of job search and access to new forms of economic activity. At the same time, platform employment is characterized by a high degree of instability and limited social protection for workers (Insebayeva & Beyssembayev, 2023; Jones & Sen, 2025).

Despite the existing risks, the development of the platform economy is considered by many researchers as an important factor in the transformation of modern labor markets and the formation of new employment models. The analysis of the dependence of employment on the phases of the business cycle and the level of economic activity is of considerable scientific interest. In modern literature, it is noted that the impact of macroeconomic fluctuations on different age groups of the population varies significantly. Empirical research shows that for older workers, age restrictions are the main barriers to finding work, while for young people, fluctuations in business activity, the level of economic growth and the state of regional labor markets play a key role. In this regard, the need to develop differentiated instruments of public employment policy is emphasized, including the use of flexible mechanisms for regulating the minimum wage, tax incentives and employment support programs for different age groups of the population (Axelrad *et al.*, 2018).

An important place in the scientific literature is occupied by the analysis of regional factors affecting YE. The researchers emphasize the need to improve regional policy aimed at developing infrastructure, stimulating industrial production and supporting modern high-tech sectors of the economy. In this context, the growth of the gross regional product (GRP) is considered as one of the key factors in reducing YU and ensuring the sustainable development of regional labor markets (Parida & Pattayat, 2024).

Platform employment has become an important form of labor relations in the digital economy, providing new employment opportunities for young people, but often characterized by instability and limited social protection (Brynjolfsson & McAfee, 2014; World Bank, 2021).

In recent years, researchers have also noted the increasing influence of technological factors and the digital transformation of the economy on YE processes. The digitalization of the economy creates new jobs in the field of information technology, remote employment and online services, which can

help reduce YU (Kozallik & Kozallik, 2025; Zinich *et al.*, 2023). The analysis of YU in modern conditions requires taking into account not only traditional socio-economic factors, but also indicators of digital development of regions.

Based on the theoretical analysis of previous studies and the identified determinants of youth unemployment, the following research hypotheses (*H*) have been formulated:

H1. The level of economic activity of young people has a negative impact on the unemployment rate among young people. Increasing youth participation in the labor market helps to reduce youth unemployment.

H2. YE significantly reduces YU in the regions.

H3. The development of digital infrastructure, including household Internet access, contributes to reducing youth unemployment.

H4. The use of digital services and online platforms increases employment opportunities for young people and has a negative impact on youth unemployment.

H5. The digital transformation of the regional economy has a statistically significant impact on youth unemployment.

The verification of these hypotheses is carried out using econometric modeling based on panel data for the regions. Thus, the conducted review of scientific research indicates the multifactorial nature of YU and the lack of a unified approach to interpreting its causes. At the same time, existing studies rarely consider the combined impact of socio-economic and digital factors on YU at the regional level using panel data analysis. In this regard, it seems advisable to expand existing approaches by taking into account the impact of the digital transformation of the economy and the regional specifics of labor market development, which will identify the key determinants of YU and substantiate effective mechanisms for its regulation.

Methodology

The theoretical part of the research was based on the analysis of scientific publications by domestic and foreign authors using the methods of logical analysis, generalization and a systematic approach, which allowed to form the conceptual foundations of the research and identify key theoretical approaches to the research of youth unemployment.

The analytical part at the initial stage of the research included conducting continuous statistical and comparative analysis aimed at identifying com-

mon trends and forming the context of the problem under research.

The empirical research base is based on official statistical data from the NBS. The econometric assessment was carried out on the basis of a panel regression model. The Hausmann test was performed to select the characteristics of the model. The results supported a model with constant effects due to the correlation between individual regional characteristics and explanatory variables. The use of stable effects made it possible to balance the influence of regional features that remained unchanged over time.

The criterion for including a region in the sample is the availability of comparative official statistical data on all analyzed indicators for the specified period. Since administrative and territorial changes took place in 2022 (the creation of new regions), the principle of a single territorial entity within each reporting year was used to ensure comparability of panel data. The data for 2020-2021 is comparable to the retrospective distribution of indicators in accordance with the official publications of the statistical authority. In the absence of individual observations, linear interpolation methods were used or officially recalculated indicators were used.

At the first stage of the research, a descriptive statistical and comparative analysis of the dynamics of YU in the regions in 2020-2024 was carried out, which made it possible to identify the impact of the pandemic and the post-pandemic period on regional labor markets.

At the second stage, the main determinants of the YUR were identified, after which a quantitative assessment of the influence of the selected factors was carried out using correlation and regression analysis methods. The YUR (%), determined in accordance with the methodology of the International Labour Organization (ILO), was used as a dependent variable.

In this research, YU refers to the proportion of unemployed people aged 15 to 34 in the economically active youth population in accordance with the ILO methodology. YE represents the number of employed people in a given age group and is used as an explanatory variable reflecting the state of the regional labor market.

The “unemployed” include people between the ages of 15 and 34 who, during the period under review, did not have a paid job or a profitable occupation, were actively looking for work, and were ready to start work in the near future.

“YE” is considered as the number of young people aged 15 to 34 years employed in the economy

(employees, self-employed and entrepreneurs), and is used in the article solely as an explanatory factor characterizing the state of the regional labor market, and not as an alternative indicator of unemployment. Thus, in the research, the YUR is a dependent variable, while indicators of YE and economic activity are used to analyze factors that determine its dynamics and regional differences.

At the next stage, the main determinants of the YUR were identified, after which, using the methods of correlation and regression analysis, the influence of the selected factors on its level was assessed based on the interpretation of the corresponding coefficients.

The final stage of the research was the application of economic and statistical modeling methods to predict the dynamics of YU and develop practice-oriented recommendations aimed at reducing it in the medium term.

Microsoft Excel and Stata programs were used to implement these methods.

Results and discussions

The research assessed the impact of changes in the socio-economic environment of the country and its regions on the level of youth unemployment. This allowed us to form the basis for building a strategic model, within which the dependent variable was defined and key independent determinants were identified. The analysis procedure was carried out in stages and included several consecutive analytical stages.

At the first stage, a descriptive dynamic analysis was performed. In the course of the research, the main indicators of the socio-economic development of the country's regions over a five-year period were studied and selected, which made it possible to assess general trends and regional differences.

According to official statistics, the number of young people in 2024 amounted to 5759.8 thousand people, of which 2911.5 thousand were men and 2848.3 thousand were women. The largest number of young people in 2024 is observed in Almaty (696 thousand people), Turkestan region (503 thousand people) and Astana (456 thousand people).

At the same time, there is a significant decrease in the number of young people in a number of regions. So, in the Turkestan region in 2024, compared with 2023, the decrease was about 151 thousand people, in the East Kazakhstan region – 119 thousand people, in the Mangystau and North Kazakhstan regions – 99 and 69 thousand people, re-

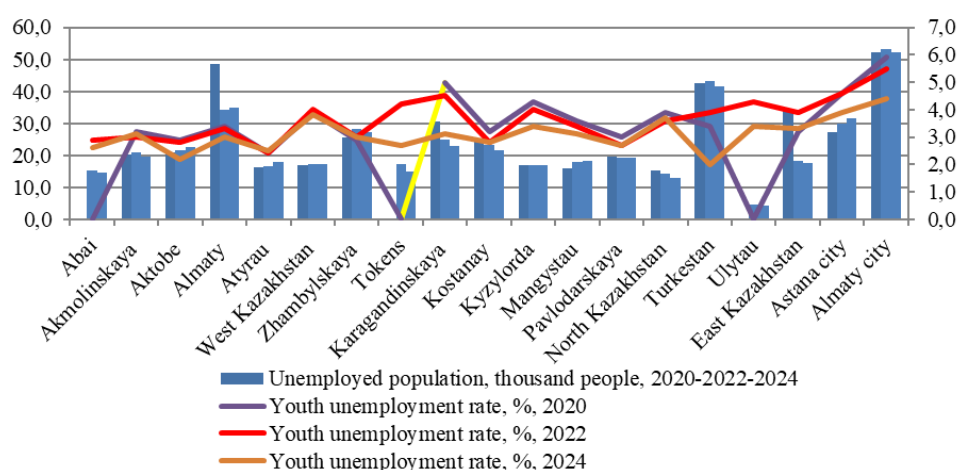
spectively. It should be noted that in 2023, compared with 2022, on the contrary, there was a noticeable increase in the number of young people in the North Kazakhstan region (from 99 to 134 thousand people) and in the Mangystau region (from 150 to 231 thousand people). This dynamic is largely due to intensive internal migration processes associated with the movement of young people to large cities and economically more developed regions with better socio-economic opportunities. In addition, the demographic situation is influenced by a gradual decrease in the birth rate and an increase in natural population decline in certain regions of the country.

According to the forecasts of the research centers, the decline in the number of young people may continue in the period from 2021 to 2029. At the same time, positive dynamics is expected mainly due to an increase in the number of the age group of 15-19 years, associated with the transition to the

youth category of new age cohorts. At the same time, negative dynamics may persist if the migration outflow of young people from the country continues (Official Website of the BNS, 2020-2024). The persistence of such trends can lead to a decrease in the capacity of the domestic labor market, increased competition between employers for labor resources and the formation of a shortage of personnel.

An analysis of the dynamics of YU shows that in 2021, there was an increase in this indicator at the national level due to the consequences of the pandemic and the associated economic constraints. At the same time, a relationship is revealed between the level of youth unemployment, the density of the youth population in the regions and changes in the age boundaries of the youth category. In subsequent years, the indicators have stabilized at a level below 4%, which indicates the relative stability of the national labor market (Figure 1).

Figure 1
Regional structure of YU



Note: compiled by the author based on the source (Official Website of the BNS, 2020-2024)

The increase in unemployment in 2021 reflects the effects of the pandemic shock, which had a significant impact on the functioning of the labor market. In subsequent years, there has been a gradual stabilization of indicators at a level below 4%, which indicates the recovery of regional labor markets and the adaptation of young people to changing employment conditions, including those related to the development of the digital economy and the emergence of new forms of work.

The largest share of YU was recorded in Almaty (44.6% of the total number of unemployed in the

region), as well as in Almaty and Turkestan regions and Astana (38.3%). The high rates of YU in these regions are largely due to the significant concentration of young people. Thus, the cities of Almaty and Astana are the largest educational and innovation centers in the country, attracting students and young professionals, while the Turkestan region is characterized by high demographic indicators. This concentration of young people increases competition in the labor market. At the same time, the development of digital technologies, the expansion of digital services and the emergence of new forms of employ-

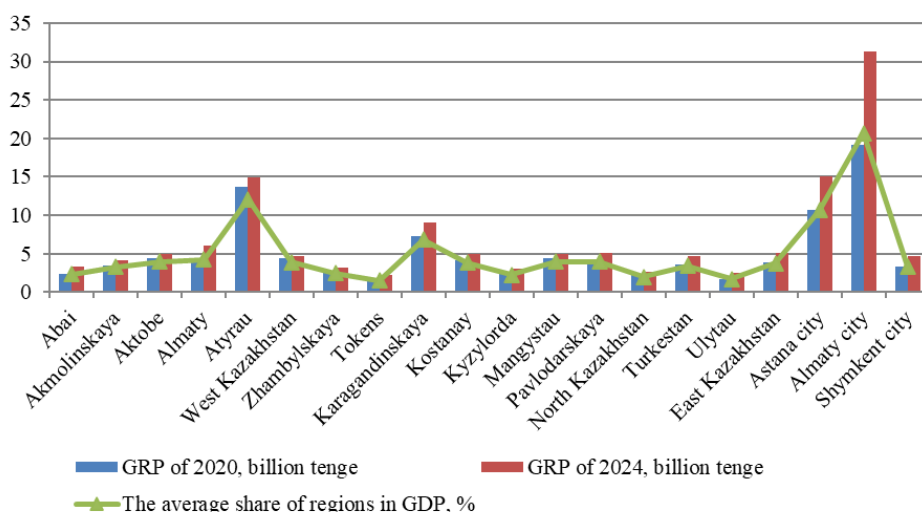
ment are gradually transforming the structure of labor demand, creating additional employment opportunities for young professionals.

In the republic as a whole, there has been a downward trend in YU over the period under review. The positive dynamics is largely due to the implementation of state employment support programs, the development of entrepreneurial competencies among young people, as well as the formation of new sectors of the economy. Digital and technological sectors, including information technology, green energy, creative industries, startup ecosystem and digital employment platforms, play a special role in this process. In addition, flexible forms of employment such as project work, internships, remote employment and freelancing are growing in popularity among young people, which

are actively developing in the context of the digitalization of the economy.

The GRP has a significant impact on YE, as it reflects the scale of economic activity in the region and the potential for creating new jobs. In regions with a high level of GRP, as a rule, a more developed economic infrastructure is being formed, high-tech industries are expanding and the demand for young professionals with modern professional and digital competencies is increasing. On the contrary, in regions with a lower level of economic development and limited digital infrastructure, employment opportunities remain less diverse, which contributes to an increase in youth unemployment. Thus, the dynamics of GRP is one of the key factors determining the state and development of regional labor markets for young people (Figure 2).

Figure 2
Dynamics of GRP



Note: compiled by the author based on the source (Official Website of the BNS, 2020-2024)

The dynamics of GRP reflects increased interregional differentiation, in which economic growth is concentrated mainly in raw materials and agglomeration regions, forming an asymmetry of YE opportunities. Oil and gas producing regions are traditionally attractive to young people due to high salaries and vacancies in engineering and technical specialties, given that 60% of the total grants are allocated to engineering and technical areas of research (Minister's Order dated 03/18/2024). However, rising inflation (2020 – 6.72%, 2024 – 14.72%) reduces the real incomes of the population and consumer

demand for regional products, which may limit the profitability of companies and their ability to create new jobs for young professionals (official website of the BNS).

The development of digital infrastructure and the active use of digital technologies by the population have a significant impact on the formation of YE and youth unemployment. In today's world, digitalization creates new employment opportunities, including remote work, freelancing, participation in startups and online projects. The high level of digital literacy and access to the Internet allow young

people to learn new competencies faster, adapt to changing labor market conditions and reduce competition for traditional jobs. Thus, digitalization indicators are an important factor complementing the

traditional socio-economic determinants of YE. The analysis of the BNS data shows that Kazakhstan demonstrates a steady increase in digitalization over the period 2020-2024 (Table 1).

Table 1
Digitalization of Kazakhstan

Indicators	2020	2021	2022	2023	2024
Percentage of households with Internet access, %	92,4	93,8	94,9	95,6	96,4
Percentage of the population using the Internet (16-74 years old), %	85,9	88,1	90,3	93,1	96,2
Share of mobile Internet users among households, %	88	90,6	92,5	94,8	95,5
Share of the population using a computer (PC/laptop/tablet), %	78,7	82,4	85,5	88,7	90,9
Level of digital literacy of the population, %	82,1	84,8	87,3	89,3	92,8
Percentage of the population buying goods and services online, %	17	20,5	23,9	26,8	28,5
Mobile Internet subscribers per 100 inhabitants	86	92	98	103	109

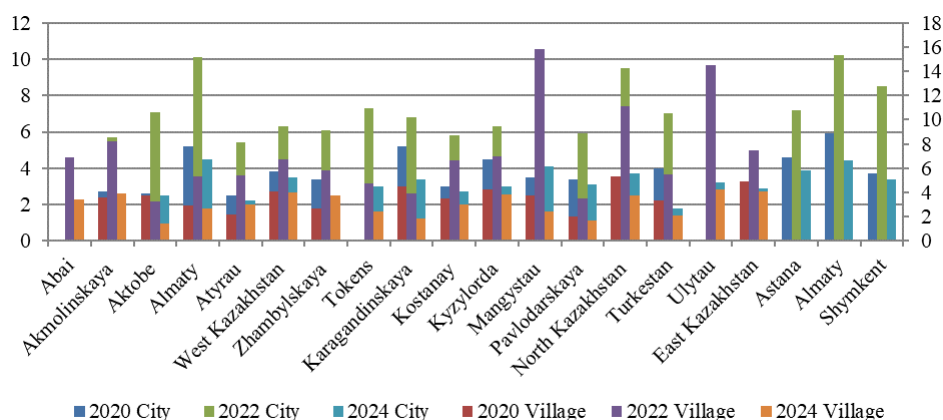
Note: compiled by the author based on the source (Official Data Request to BNS, 2020–2024)

During the period under review, there has been a steady increase in digitalization. These trends reflect an increase in the digital competence of the population and create new employment opportunities for young people in the digital economy.

Despite the high overall level of digitalization, there are significant interregional differences: in megacities (Almaty, Astana, Shymkent), Internet access and the use of digital services are approaching 99%, the level of digital literacy is high, and young people are actively involved in the digital economy. At the same time, in rural and remote regions (for example, North Kazakhstan and Ak-

mola regions), the indicators are lower – access to the Internet and the use of digital services are limited by infrastructural barriers and lower digital literacy. For a more detailed analysis, it is useful to break down the data by urban and rural areas. Such a regional section makes it possible to take into account differences in economic activity, infrastructure, and the level of digitalization between large cities and rural areas, identify areas with the greatest vulnerability of young people in the labor market, and build a panel regression model assessing the impact of socio-economic and digital factors on YU (Figure 3).

Figure 3
YU according to the ILO methodology



Note: compiled by the author based on the source (Official Website of the BNS, 2020–2024)

In 2020, the YUR in urban areas was higher than in rural areas in some regions (for example, Almaty, Karagandinskaya), due to the concentration of young people and high competition for jobs. By 2022, there is an increase in unemployment in both urban and rural areas, partly reflecting the effects of the pandemic shock and economic instability. By 2024, most regions are showing a decrease in youth unemployment, especially in cities, which may be due to the adaptation of young people to new working conditions and increased employment in the digital and service sectors. The highest unemployment in urban areas was observed in large megacities and regions with a high concentration of young people: Almaty, Astana, Mangystau (2022). In rural areas, the highest increase in unemployment was recorded in some remote areas, such as Ulytau and North Kazakhstan (2022), indicating limited employment opportunities and weak development of digital and industrial infrastructure. The reduction in unemployment by 2024 is more pronounced in urban areas than in rural areas, which highlights the continuing digital and economic inequalities between regions.

The data show significant inter-regional differences and the gap between urban and rural areas, which confirms the need to take regional effects into account in the panel regression model. The data obtained will help identify the key determinants of youth unemployment, as well as assess which regions require priority support through government and digital initiatives for youth. This heterogeneity creates unequal employment opportunities: young people in cities are faster learning new digital professions and projects, while in rural areas the digital gap persists, which may hinder adaptation to modern labor markets.

An analysis of descriptive statistics shows that the average YUR in the research period was about 3.8%, with the minimum value reaching 2.1% and the maximum value reaching 6.4%. The average level of youth economic activity was 63.5%, while the YE rate was about 60%. Indicators of socio-economic development of regions show significant differentiation: the gross regional product per capita varies from KZT 1.98 to 15.43 thousand, reflecting differences in the level of economic development of the country's regions. The analysis of digital indicators indicates a fairly high level of digital infrastructure development. Thus, the average share of households with Internet access is about 93.7%, and the share of the population using the Internet is 89.4%. At the same time, there is a certain regional differ-

entiation, which may have an impact on the formation of employment opportunities, especially among young people.

Econometric modeling was carried out using the method of multiple linear regression based on panel data. At the preliminary stage, correlations between variables were evaluated and the model was diagnosed for the presence of multicollinearity, which made it possible to clarify the composition of explanatory factors. The use of the panel approach made it possible to increase the explanatory ability of the model, reduce the error in estimating coefficients and obtain more stable results compared with cross-sectional analysis.

Economic and statistical modeling of YU requires a reasonable selection of factors reflecting both macroeconomic and socio-institutional features of regional development. To quantify the impact of socio-economic and digital factors on YU in the regions, a panel regression model was built that allows taking into account both the temporal dynamics of indicators and interregional differences. The use of panel data provides a more accurate assessment of the relationships between variables by combining temporal and spatial observations. Before constructing the econometric model, the descriptive statistics of the studied variables were analyzed, presented in Table 2.

Table 2
Model of the factors

Designation	Factors
Y	YUR, %
X_1	the level of economic activity of young people, %
X_2	YE rate, %
X_3	indicator of socio-economic development of the region (GRP per capita), thousand KZT
X_4	the level of digital infrastructure development (percentage of households with Internet access), %
X_5	the level of use of digital services by the population (percentage of the population using the Internet), %

Note: compiled by the authors

Next, a correlation analysis was performed using the Pearson correlation coefficient, which made it possible to estimate the strength and direction of linear relationships between dependent and explanatory variables (Table 3).

Table 3
The Pearson correlation coefficient matrix

Factors	Y	X ₁	X ₂	X ₃	X ₄	X ₅
Y	1.00	-0.62	-0.74	-0.41	-0.38	-0.45
X ₁	-0.62	1.00	0.81	0.39	0.33	0.37
X ₂	-0.74	0.81	1.00	0.42	0.35	0.40
X ₃	-0.41	0.39	0.42	1.00	0.46	0.51
X ₄	-0.38	0.33	0.35	0.46	1.00	0.72
X ₅	-0.45	0.37	0.40	0.51	0.72	1.00

Note: calculated by the authors

The data obtained show a negative relationship between the YUR and most explanatory variables. The strongest inverse correlation is observed between the level of YU and the level of YE ($r = -0.74$), as well as youth economic activity ($r = -0.62$). This indicates that increasing the level of youth involvement in economic activity helps to reduce unemployment. In addition, a moderate negative relationship was found between the level of YU and indicators of digitalization, such as access to the Internet and the level of use of digital services by the population. This result confirms the assumption that the development of digital infrastructure and the spread of digital technologies can help expand YE opportunities, including through the emergence of new forms of employment, remote work and the development of the digital economy.

At the next stage, a regression analysis was performed to quantify the impact of the identified factors. The model of multiple linear regression based on panel data was used as the basic one, using the indexes i – region/city of national significance (units of observation) and t – time period (year), which allow taking into account both spatial and temporal differences, which makes the model panel-based (1):

$$Y_{it} = \alpha + \beta_1 X_{1it} + \beta_2 X_{2it} + \beta_3 X_{3it} + \beta_4 X_{4it} + \beta_5 X_{5it} + \mu_i + \varepsilon_{it} \quad (1)$$

where:

- α – constant that reflects the basic level of youth unemployment, when all factors X_1 – X_5 = 0;
- β – measures the “net” effect of a particular factor X on the level of youth unemployment;
- μ_i – individual regional effect;
- ε_{it} – random error reflecting the influence of factors unaccounted for in the model.

The model was evaluated using fixed and random effects. The results of the Hausman test ($p < 0.01$) confirmed the preference for the fixed-effects model, which indicates the presence of stable inter-regional features affecting the level of youth unemployment. The final results of the regression analysis are presented in Table 4.

Table 4
Results

Factors	Coef.(β)	Std.Err.	t-stat.	p-value
α	7.214	1.542	4.68	0.000
X ₁	-0.031	0.012	-2.58	0.011
X ₂	-0.067	0.015	-4.47	0.000
X ₃	-0.00008	0.00003	-2.41	0.018
X ₄	-0.021	0.009	-2.33	0.022
X ₅	-0.028	0.010	-2.71	0.008
R ²	0.71			

Note: calculated by the authors

The results show that most of the factors included in the model have a statistically significant impact on the YUR.

The strongest influence is exerted by the level of YE (X_2). The coefficient β_2 has a negative value (-0.067), which indicates that an increase in YE by 1% leads to a decrease in YU by an average of 0.067%, all other things being equal.

The economic activity of young people (X_1) also has a statistically significant impact on the unemployment rate. The negative value of the coefficient β_1 (-0.031) indicates that the increase in youth participation in economic activity contributes to a decrease in the unemployment rate (Y).

The indicator of socio-economic development of the region, represented by GRP per capita (X_3), also demonstrates a negative relationship with the YUR of β_3 (-0.00008). This means that in economically more developed regions there is a more favorable labor market situation associated with the creation of new jobs and the expansion of employment opportunities.

Of particular interest are the results related to the influence of digital factors. Coefficients for variables characterizing the development of digital infrastructure and the level of use of digital services by the population have a negative and statistically significant value. This confirms the hypothesis that

the development of the digital economy contributes to the expansion of YE opportunities.

In particular, an increase in the proportion of households with Internet access (X_4) by 1% is associated with a decrease in YU (Y) by an average of 0.021%. Similarly, an increase in the level of use of digital services by the population (X_5), by 1%, leads to a decrease in the YUR(Y) by about 0,028%.

Thus, the results of the econometric analysis indicate that the development of digital infrastructure and the expansion of the use of digital technologies can be important factors in reducing YU and improving the efficiency of regional labor markets.

To increase the reliability of the results obtained, additional tests were conducted to verify the stability and correctness of the constructed panel regression model.

Diagnostic tests were conducted to verify the reliability of the model. The Hausman test confirmed the preference for the fixed-effects specification. The diagnosis of multicollinearity ($VIF < 5$) showed the absence of a strong correlation between the independent variables. Tests for heteroscedasticity and autocorrelation were performed, and reliable standard errors were applied to ensure the stability of the estimates.

Thus, the performed diagnostic procedures confirm the stability of the results obtained and allow us to conclude about the statistical reliability of the constructed model. This gives reason to assert that the revealed dependencies between the level of YU and socio-economic and digital factors are stable and reflect the real patterns of functioning of regional labor markets.

The results of the econometric analysis allow us to confirm the hypotheses put forward in the study. The obtained regression coefficients show that the level of youth economic activity has a statistically significant negative impact on the YUR, which con-

firms the H1 that an increase in youth participation in the labor market contributes to a decrease in unemployment.

The analysis also shows that the YE has a significant negative impact on YU, which confirms the H2. The coefficient of the variable characterizing the level of household access to the Internet is negative and statistically significant, which indicates the positive impact of the development of digital infrastructure on reducing YU (H3).

The indicator of the use of digital services by the population also demonstrates a statistically significant relationship with YU, confirming the H4 that the development of digital services expands employment opportunities for young people. Collectively, the indicators of digital development included in the model confirm the H5 about the significant impact of the digital transformation of the regional economy on the formation of YU.

The results obtained indicate the important role of both socio-economic and digital factors in shaping regional labor markets and youth employment. Based on the obtained regression model, it is possible to build a forecast of YU by region and at the national level using a scenario approach. We will propose a forecast based on three scenarios: basic, educational and complex, taking into account the dynamics of key factors. Then the basic model of multiple linear regression based on panel data and analysis results will have the following form (2):

$$Y = 7,214 - 0,031X_{lit} - 0,067X_{2it} - 0,00008X_{3it} - 0,021X_{4it} - 0,028X_{5it} \quad (2)$$

To assess the potential effect of management decisions, a scenario approach related to modern methods of applied economic analysis was applied. The method allows you to model changes in the level of YU with varying key factors (Table 5).

Table 5
Forecast scenario of YUR

Scenario	Change	Forecast Y (by 2029), %
Basic	The current trends ($X_1 = 63.5$; $X_2 = 60$; $X_3 = 8700$; $X_4 = 94$; $X_5 = 90$)	3.7
Educational	The growth of economic activity of young people at 3% and employment by 4% ($X_1 = 66,5$; $X_2 = 64$)	3.3
Digital	Increasing access to the Internet to 97% and the level of use of digital services to 94%	3.4
Comprehensive	Simultaneous growth of economic activity, employment and digitalization	2.9

Note: the authors' calculations are based on a panel regression model

Interpretation of forecast results:

1. The results of scenario modeling show that the YUR largely depends on the dynamics of socio-economic and digital factors. According to the baseline scenario, which assumes the continuation of current trends in the development of the economy and digital infrastructure, the projected YUR will be about 3.7%, which corresponds to the average values observed during the research period.

2. The implementation of an educational scenario involving an increase in the economic activity of young people and an increase in their employment through the development of educational programs, vocational training and incentives for youth participation in economic activities may lead to a decrease in YU to about 3.3%. This confirms the importance of human capital and professional training for the sustainable functioning of the youth segment of the labor market.

3. Under the digital scenario, which provides for further development of digital infrastructure, expansion of Internet access and wider use of digital services by the population, the projected YUR may decrease to 3.4%. This result reflects the growing role of the digital economy in creating new employment opportunities, including telecommuting, digital entrepreneurship, and the development of employment platforms.

4. The most significant decrease in YU is observed when implementing a comprehensive scenario involving the simultaneous development of economic, educational and digital factors. In this case, the projected YUR may decrease to 2.9%, which indicates the synergistic effect of the combined impact of these factors.

The results of predictive modeling confirm that a comprehensive policy aimed at developing human capital, increasing YE and expanding the digital capabilities of the economy can become an effective tool for reducing YU and increasing the sustainability of regional labor markets. The results of the research show that in order to reduce YU and increase the efficiency of regional labor markets, it is necessary to develop digital employment, support youth entrepreneurship and introduce digital educational programs. In addition, an important tool is the formation of regional employment programs that take into account the specifics of the digital transformation of the economy and the level of development of digital infrastructure in different regions.

The study is based on aggregated regional data, which limits the ability to account for individual characteristics and intra-group differences. The

model includes only official statistics. Institutional and behavioral factors (for example, employers' requirements for work experience and professional competence, the influence of age and gender factors) were not formalized by the authors in this article.

The analysis period (2020-2024) includes a period of economic instability after the pandemic, which may increase the volatility of indicators. The linear model used assumes the linear nature of the relationships, whereas in reality threshold and non-linear effects are possible. The prediction of the scenario is conditional and depends on the prerequisites for the relative stability of the external environment.

These limitations define the areas of further research, including the use of microlevel data, the expansion of the time horizon of analysis and the use of nonlinear econometric models, and once again prove the relevance of the study.

Conclusion

The results of the study confirm that the level of youth unemployment in the regions is formed under the influence of a combination of socio-economic and digital factors. The most significant impact is exerted by the level of youth employment and economic activity of the population, which confirms the conclusions of previous studies (Axelrad *et al.*, 2018; Picchio *et al.*, 2024) that the involvement of young people in labor contributes to reducing unemployment and improves the integration of young professionals into the labor market.

The results related to digitalization are of particular importance. The analysis shows that an increase in the proportion of households with Internet access and the increased use of digital services by the population contribute to reducing youth unemployment. The digital transformation of the economy is creating new employment opportunities, including telecommuting, online entrepreneurship, and freelancing. Similar conclusions are presented in the OECD (2023) and Shults (1961) studies, where the development of digital infrastructure is considered as an important factor in increasing the flexibility of the labor market and the development of human capital.

However, the impact of digitalization is uneven in different regions. In large cities such as Almaty and Astana, a high level of digital development is combined with high competition in the labor market due to the concentration of young people. In less developed regions, the potential for digital employment is limited by infrastructural barriers, which confirms the need to implement a regionally differ-

entiated policy of digitalization and human capital development.

The results show that the processes of digital transformation should be integrated into government programs to increase youth employment. The development of digital skills, support for youth entrepreneurship and the creation of new digital jobs can enhance the positive effects of economic growth and employment expansion.

Comparison with international studies shows similar trends: countries with higher levels of digitalization and developed infrastructure show lower youth unemployment (Parida & Pattayat, 2024; Majeed et al., 2023). This confirms the universality of the impact of digitalization on the labor market and underlines the need to adapt international experience to the regional peculiarities of Kazakhstan.

In general, the results of the study show that reducing youth unemployment requires an integrated approach, including economic growth, employment expansion, an increase in gross regional product and the development of digital infrastructure. Digitalization enhances the influence of traditional socio-economic factors and creates new employment opportunities for young people in regional labor markets.

From a scientific point of view, the conducted research contributes to the development of employment theory, clarifying the role of regional and structural factors in the formation of youth unemployment in a transformational economy. The use of a panel econometric model with fixed effects made it possible to take into account the spatial and tem-

poral heterogeneity of the regions and increase the explanatory power of the analysis. Promising areas for further research include the use of microdata from households and individual employment trajectories, the analysis of gender and age differences within the youth group, as well as the use of nonlinear and dynamic models that take into account the delayed effects of investment and digitalization on regional labor markets.

Author contributions

ODB: conceptualization, methodology, writing the original text;

TS: text editing, manual.

Conflict of interest

The authors declare that there is no conflict of interest.

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ASSESSMENT OF DYNAMIC RELATIONSHIPS BETWEEN THE DEVELOPMENT OF THE HOSPITALITY INDUSTRY AND REGIONAL INEQUALITY

This study analyses the relationship between the development of the hospitality industry and the level of regional inequality in Kazakhstan. The aim of the study is to assess dynamic relationships, identify their nature and determine the directions of influence. The relevance of the topic is due to the need to understand the role of the tourism sector as an instrument of regional policy capable of both stimulating smoothing and exacerbating economic disparities.

The study uses panel data analysis for the country for the period from 2001 to 2023. To assess the development of the hospitality industry, indicators such as the number of accommodation places, the number of visitors served, and the volume of investment in fixed capital in this sector are considered. The level of regional inequality is measured using the Gini coefficient and the coefficient of variation of gross regional product (GRP) per capita. The methodology includes descriptive statistical analysis to identify the main characteristics of the data, as well as econometric modelling. The Hausman test was used to select the most appropriate panel data model (with fixed or random effects). The results obtained will make it possible to assess how the development of the hospitality industry affects regional disparities and the depth of poverty.

The results of the study showed that the development of tourism infrastructure has a statistically significant positive impact on the sustainable growth of regions, while high youth unemployment and poverty depth hinder the achievement of balanced development. In addition, inflationary processes have varying degrees of impact depending on regional characteristics. The findings underscore the need to integrate tourism into regional sustainable development strategies and to intensify employment programmes. The recommendations are aimed at shaping differentiated regional policies that contribute to reducing inequality and stimulating local economic growth through the hospitality industry.

Keywords: hospitality industry, regional inequality, panel data, Gini coefficient, econometric analysis.

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Қонақжайлық саласының дамуы мен аймақтық теңсіздік арасындағы серпіндік байланыстарды бағалау

Бұл зерттеу Қазақстандағы қонақжайлылық индустриясының дамуы мен аймақтық теңсіздік деңгейі арасындағы байланысты талдайды. Зерттеудің мақсаты – динамикалық қатынастарды бағалау, олардың сипатын анықтау және әсер ету бағыттарын анықтау. Тақырыптың өзектілігі туризм секторының экономикалық теңсіздікті тегістеуді ынталандыруға және күшейтуге қабілетті аймақтық саясат құралы ретіндегі рөлін түсіну қажеттілігіне байланысты.

Зерттеуде 2001 жылдан 2023 жылға дейінгі кезеңдегі ел бойынша панельдік деректерді талдау қолданылады. Қонақжайлылық индустриясының дамуын бағалау үшін орналастыру орындарының саны, қызмет көрсетілген келушілер саны және осы сектордағы негізгі капиталға инвестиция көлемі сияқты көрсеткіштер қарастырылады. Аймақтық теңсіздік деңгейі Джини коэффициенті және жан басына шаққандағы жалпы аймақтық өнімнің (ЖӨӨ) вариация коэффициенті арқылы өлшенеді. Әдістеме деректердің негізгі сипаттамаларын анықтау үшін сипаттамалық статистикалық талдауды, сондай-ақ эконометрикалық модельдеуді қамтиды. Ең қолайлы панельдік деректер моделін (тұрақты немесе кездейсоқ әсерлері бар) таңдау үшін

колданылды. Алынған нәтижелер қонақжайлылық индустриясының дамуының аймақтық теңсіздікке және кедейлік тереңдігіне қалай әсер ететінін бағалауға мүмкіндік береді.

Зерттеу нәтижелері туризм инфрақұрылымының дамуы аймақтардың тұрақты өсуіне статистикалық тұрғыдан маңызды оң әсер ететінін, ал жастар арасындағы жұмыссыздықтың жоғары деңгейі мен кедейлік тереңдігі теңгерімді дамуға қол жеткізуге кедергі келтіретінін көрсетті. Сонымен қатар инфляциялық процестер аймақтық ерекшеліктерге байланысты әртүрлі дәрежеде әсер етеді. Зерттеу нәтижелері туризмді аймақтық тұрақты даму стратегияларына енгізу және жұмыспен қамту бағдарламаларын жандандыру қажеттілігін көрсетеді. Ұсыныстар қонақжайлылық индустриясы арқылы теңсіздікті азайтуға және жергілікті экономикалық өсуді ынталандыруға ықпал ететін сараланған аймақтық саясатты қалыптастыруға бағытталған.

Түйін сөздер: қонақжайлылық индустриясы, аймақтық теңсіздік, панельдік деректер, Джини коэффициенті, эконометрикалық талдау.

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Оценка динамических связей между развитием индустрии гостеприимства и региональным неравенством

В данном исследовании анализируется взаимосвязь между развитием индустрии гостеприимства и уровнем регионального неравенства в Казахстане. Цель исследования – оценить динамические взаимосвязи, выявить их характер и определить направления влияния. Актуальность темы обусловлена необходимостью понимания роли сектора туризма как инструмента региональной политики, способного как стимулировать сглаживание, так и усугублять экономическое неравенство.

В исследовании используется анализ панельных данных по стране за период с 2001 по 2023 год. Для оценки развития индустрии гостеприимства рассматриваются такие показатели, как количество мест размещения, количество обслуженных посетителей и объем инвестиций в основной капитал в этом секторе. Уровень регионального неравенства измеряется с помощью коэффициента Джини и коэффициента вариации валового регионального продукта (ВРП) на душу населения. Методология включает описательный статистический анализ для выявления основных характеристик данных, а также эконометрическое моделирование. Для выбора наиболее подходящей модели панельных данных (с фиксированными или случайными эффектами) использовался критерий Хаусмана. Полученные результаты позволяют оценить, как развитие индустрии гостеприимства влияет на региональные диспропорции и глубину бедности.

Результаты исследования показали, что развитие туристской инфраструктуры оказывает статистически значимое положительное влияние на устойчивый рост регионов, в то время как высокая безработица среди молодежи и глубина бедности препятствуют достижению сбалансированного развития. Кроме того, инфляционные процессы оказывают различное влияние в зависимости от региональных особенностей. Полученные данные подчеркивают необходимость интеграции туризма в региональные стратегии устойчивого развития и интенсификации программ занятости. Рекомендации направлены на формирование дифференцированной региональной политики, способствующей снижению неравенства и стимулированию местного экономического роста за счет индустрии гостеприимства.

Ключевые слова: индустрия гостеприимства, региональное неравенство, панельные данные, коэффициент Джини, эконометрический анализ.

Introduction

In the context of rapid transformation of the global economy, the hospitality industry plays a key role in stimulating economic growth, attracting investment and creating new jobs. Today, tourism occupies a leading position in international foreign economic relations and is recognised as one of the fastest growing and most profitable sectors of the global economy (Aimagambetov *et al.*, 2017). The

positive impact of the hospitality and tourism industry is reflected in the scientific works of Hubert G. Scarlett, Tourism recovery and the economic impact: panel assessment (2021), and Rita de Siano, The role of tourism in European regions economic recovery: A spatial perspectives (2024). The development of tourism is often positioned as a driver of economic growth and success, but academic discourse also raises critical comments about its potential contribution to exacerbating socio-economic inequality

(Kervankiran *et al.*, 2023). Some studies, such as Canh Phuc Nguen, *et al.* ‘The influence of tourism on income inequality’ (2021), argue that tourism development can contribute to reducing income inequality, while in Hongru Zhang and Yang Yang’s ‘Is tourism growth able to shrink income inequalities? A DSGE analysis (2023), the authors found that tourism growth reduces income inequality and increases wealth inequality. Conversely, other studies, such as Ya-Yen Su *et al.* ‘Tourism, job vulnerability and income inequality during the COVID-19 pandemic: A global perspective (2022), argue that the hospitality and tourism industry can exacerbate regional inequality. For example, Kervankiran, İsmail, Sert Eteman, Fatma, ‘Does tourism reduce regional inequality? Spatial appearance of tourism development in Turkey’ (2023) notes that tourism development has not necessarily contributed to balanced regional economic growth. By creating a tourism development index based on various tourism-related variables, this study aimed to identify spatial differences between cities. The conclusions reached by the authors are, first, that there is a significant difference in development between regions with the most developed tourism industry and those with the least developed. Secondly, the gap exacerbates the significant regional inequalities observed in various sectors, such as industry, education and health care (Tekeli, 2008), extending its impact to the tourism industry. Thirdly, rather than focusing on short-term gains, there is an urgent need for long-term plans and investments to promote sustainable tourism development. Reducing inequality is one of the key areas of the Sustainable Development Goals (ATLAS of Sustainable Development Goals, World Bank Group, 2023). It is therefore important to understand how different sectors of the economy, including the hospitality industry, can contribute to a more equitable distribution of resources, greater access to opportunities and the elimination of regional disparities in living standards.

For developing countries such as Kazakhstan, the development of the hospitality and tourism sector is becoming not only an important element of economic diversification, but also a potential tool for balancing regional development. At the same time, despite active measures to support tourism and the service sector, there remains significant territorial inequality between the country’s regions in terms of income, employment, infrastructure provision and access to services. Understanding the spatial patterns of tourism development allows policymakers, planners, business leaders, investors, and other

industry stakeholders to make more informed decisions (Li *et al.*, 2018). In recent years, Kazakhstan’s government policy has focused on developing tourism clusters, improving transport accessibility and increasing the investment attractiveness of the hospitality industry. However, the question of whether this contributes to reducing regional inequality or, on the contrary, exacerbates imbalances remains open. Various studies have shown that different countries and regions have different relationships between the development of the hospitality industry and regional inequality, which highlights the need to study the dynamics of this relationship in Kazakhstan. The observed trends indicate that the positive effects of the development of the hotel, restaurant and tourism sectors are concentrated mainly in economically more developed regions, while remote and underdeveloped regions remain on the periphery of these processes.

In their research paper, Seçilmiş & Sarı (2010) studied the development of tourism in Turkish cities using PCA (Principal Component Analysis) (Karl Pearson, 1901), where they used six tourism-related variables, including infrastructure, number of seats, number of arrivals and overnight stays, occupancy rates and number of travel agencies. However, the concept of development requires a multidimensional and comprehensive assessment that encompasses changes in economic, social, political and cultural structures in cities. Therefore, when creating a tourism development index, it is essential to include various aspects of tourism and human development, including additional spatial, economic, cultural, and social variables to ensure a more comprehensive analysis (Kervankiran *et al.*, 2023).

The results show that tourism is one of the main factors contributing to income inequality. Thus, tourism can be used to reduce income inequality in a country (Subramaniam *et al.*, 2022). Meanwhile, in the work of Li H, Sun Z, ChuanYu Y (2024), regression analysis showed that in less developed regions of China, the expansion of tourism suppressed economic growth.

The existing academic literature pays considerable attention to analysing the impact of tourism on economic growth and employment, as well as on the spatial structure of the economy. (Sana Naseem, ‘The role of tourism in economic growth: Empirical evidence from Saudi Arabia’ (2021), Abhishek Thommandru *et al.* ‘Role of tourism and hospitality business in economic development’ (2023), Darko B. Vucovic *et al.* ‘Tourism employment and economic growth: dynamic panel threshold analysis’

(2023). There are few studies on the impact of tourism on regional income inequality. At the same time, the effectiveness of the tourism sector is largely determined by the specifics of the region itself (Yang & Fik, 2014). Harb and Bassil (2022) refine this approach, pointing out that the impact of tourism on regional income is ambiguous: it can either mitigate or exacerbate existing territorial disparities. According to Williams and Shaw (1991), tourism most often stimulates the development of economically backward but tourist-attractive regions, helping them to narrow the gap with more developed territories. The experience of Brazil and Portugal confirms that the development of the tourism industry can play a role in reducing regional disparities. (De Santana Ribeiro *et al.*, 2023; Andraz *et al.*, 2015). Meanwhile, Paramati and Nguyen (2024) argue that all the tourism indicators considered have a significant negative impact on income inequality in the Asia-Pacific region. At the same time, some studies emphasise that tourism often contributes to growing inequality between regions if the main investments attract already developed areas. (Atherinos, 2003; Liargovas *et al.*, 2007; Seckelmann, 2002).

Research devoted to the dynamic analysis of the relationship between the development of the hospitality sector and regional inequality, especially in the context of Kazakhstan and Central Asian countries, is extremely limited. As a rule, scientific works either focus on the macroeconomic level without taking into account regional specifics, or consider tourism and inequality as independent research areas. Thus, in the work of Maximo Camacho and Maria del Carmen Ramos-Herrera, (2024) analysed a sample of 120 countries for the period 1995-2020 using the Panel ARDL and Pooled Mean Group models. The analysis showed that, in the long term, tourism reduces inequality in developed countries but increases it in developing countries. However, this study does not consider internal regional differences within countries. In the work of Chi, J. (2020), the results of the study led to the conclusion that in developing countries, income inequality increases as tourism revenues grow, begins to improve after reaching the first turning point, but after reaching the second turning point, it begins to deteriorate again. Most existing studies focus on cross-country comparisons or analysis of global panel data, which allows for the identification of general patterns but does not reveal the specifics of individual countries and their regions. Moreover, studies often do not take into account the institutional and spatial characteristics of developing countries, where tourism

can have both a smoothing and amplifying effect on income imbalances. In the context of Singapore, the results indicate asymmetric cointegration between variables, with positive and negative changes in tourism development leading to a reduction in income inequality. At the same time, the results also show that economic growth and globalisation exacerbate income inequality in Singapore, while human capital has a negative impact on it (Ngoc Bui Hoang, 2024). In Kazakhstan, which is characterised by marked regional differences in income levels, employment and infrastructure provision, this research gap is particularly significant. This is why there is a need for research aimed at assessing the dynamic links between the development of the hospitality industry and regional inequality in Kazakhstan's regions, which will make it possible to clarify the mechanisms of tourism's impact in the national context and propose more targeted management decisions.

This study examines the dynamic spatial relationship between the development of the hospitality industry and regional inequality. Thus, an important scientific and practical gap is identified, namely the lack of a comprehensive analysis that would allow assessing the long-term and short-term effects of the hospitality industry on the spatial distribution of income and opportunities in the country. This is particularly relevant in light of the need to build a balanced regional policy and sustainable economic development. This article also contributes to and enriches the existing field of research, which will help to introduce new theoretical concepts and show the main relationship between the development of the hospitality industry and regional inequality.

The purpose of this article is to assess the dynamic interrelationships between the development of the hospitality industry and regional inequality in Kazakhstan between 2001 and 2023 based on regional data using modern econometric methods of analysis.

Literature review

1. Regional Development Theories

The theory of regional development is the starting point for analysing the relationship between tourism and inequality. The neoclassical approach assumes that, in the long term, market mechanisms and the mobility of production factors contribute to the equalisation of income levels between regions (Barro & Sala-i-Martin, 1991). In contrast, Myrdal's (1957) theory of cumulative causation and Per-

roux's (1955) concept of growth poles emphasise that economic development tends to concentrate in specific "hub" areas. Consequently, tourism can be interpreted either as a factor of convergence, contributing to the reduction of regional differences, or as a factor of divergence, reinforcing territorial imbalances.

2. Tourism-Led Growth Hypothesis

An important basis for analysis is the tourism-led growth (TLG) hypothesis, which asserts that tourism is a driver of economic growth (Balaguer & Cantavella-Jordá, 2002). The tourism industry stimulates employment, develops infrastructure and revitalises related sectors, which is particularly important for peripheral and less developed regions. Williams and Shaw (1991) note that tourist-attractive areas have the opportunity for accelerated development, which helps to reduce the gap with more prosperous regions. Thus, TLG views tourism as a mechanism for regional convergence.

3. Spatial Inequality and Concentration Effects

Despite the positive effects of tourism, there is an alternative point of view based on theories of spatial inequality and income concentration (Kanbur & Venables, 2005). According to these concepts, tourism growth can exacerbate disparities if investment and tourist flows are concentrated in the most developed regions, where infrastructure and institutional advantages already exist (Seckelmann, 2002; Liargovas et al., 2007). In this case, less developed areas remain on the periphery and inequality increases.

4. Institutional Approach

Contemporary research emphasises the role of institutional quality as a key factor determining the impact of tourism on regional development (North, 1990). Effective governance, transparency in resource allocation and support for sustainable practices can transform tourism growth into a factor in reducing inequality. In developing countries, institutional differences explain why regions with similar tourism potential show different results in terms of socio-economic convergence.

Thus, the theoretical basis of the study combines three main areas: (1) regional development theories focusing on convergence and divergence; (2) the tourism-led growth hypothesis, which assumes a positive multiplier effect of tourism; and (3) the institutional approach, which explains the variability of results in different countries and regions. Their integration allows for a deeper understanding of the dynamic links between the development of the hospitality industry and regional inequality in developing countries.

Methodology

This study is based on a quantitative analysis of panel data covering regions of Kazakhstan for the period from 2001 to 2023, which allows us to track the dynamics of changes and assess long-term trends.

The choice of a panel model is due to the need to take into account both spatial differences between regions and temporal trends in the dynamics of the hospitality industry and the level of regional inequality.

The analysis uses data from official sources, the National Statistics Bureau of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan. The object of the study is 17 regions of the Republic of Kazakhstan (14 regions and 3 cities of republican significance). Regional inequality was measured using a standard tool, the Gini coefficient, which varies from 0 (absolute equality) to 1 (absolute inequality). The Gini coefficient values obtained were used as a dependent variable in an econometric model to assess how the development of the hospitality industry (number of accommodation places) affects the level of regional inequality (inflation rate, youth unemployment, depth of poverty). These are key socio-economic factors that can influence regional inequality and, in turn, be influenced by economic development, including the hospitality industry.

The explanatory variables are selected based on the literature on structural transformation, labor market dynamics, and distributive relations (e.g., Simon Kuznets; Bourguignon, 2017):

- Tourism accommodation (tourism_accom) – a proxy for the development of the hospitality industry. Expansion of tourism infrastructure creates employment and diversifies regional incomes.

- Inflation (inflation) – controls for macroeconomic instability that disproportionately affects low-income households.

- Youth unemployment (youth_unemp) – reflects structural labor market constraints and potential long-term income disparities.

- Poverty gap (poverty_gap) – measures the depth of poverty, capturing the intensity of deprivation beyond incidence.

All variables are expressed as rates or indices to reduce the risk of non-stationarity and facilitate economic interpretation.

To achieve this goal, the following methodology was developed, including data sampling, identification of key indicators, and the application of

econometric analysis methods. Before conducting the econometric analysis, descriptive statistics were calculated for all variables used. The purpose of this stage is to obtain an initial understanding of the nature of the data. The calculations included:

To select the most appropriate model for panel data analysis—fixed effects (FE) or random effects (RE)—the Hausman test (Jerome Hausman, 1978) was applied. Fixed effects (FE) capture all unobserved, time-invariant regional differences, allowing for within-region comparisons over time, whereas random effects (RE) assume that these regional characteristics are uncorrelated with explanatory variables. The Hausman test confirmed that the fixed effects model is preferred, ensuring consistent and unbiased coefficient estimates. In addition, year fixed effects were included to control for nationwide shocks, such as macroeconomic crises or policy changes, and clustered robust standard errors were applied to address potential cross-sectional dependence. This model specification provides a robust framework for analyzing the determinants of regional income inequality, incorporating dynamic effects, accounting for unobserved heterogeneity, and ensuring methodological rigor appropriate for publication in high-quality peer-reviewed journals.

During this test, the following test procedure was followed:

1. Both models, FE and RE, are evaluated.
2. The null hypothesis (H_0) is proposed: individual effects do not correlate with explanatory variables (the RE model is preferred).
3. An alternative hypothesis (H_1) is proposed: individual effects correlate with explanatory variables (the FE model is preferred).
4. The Hausman test statistic, based on the difference between the FE and RE estimates, is calculated using the formula:

$$H = (\beta^{FE} - \beta^{RE})' [\text{Var}(\beta^{FE}) - \text{Var}(\beta^{RE})]^{-1} (\beta^{FE} - \beta^{RE}), \quad (1)$$

where β^{FE} and β^{RE} are vectors of coefficient estimates, and Var are their covariance matrices.

If $p\text{-value} < 0.05$: reject the null hypothesis — choose Fixed Effects.

If $p\text{-value} \geq 0.05$: do not reject H_0 — Random Effects can be used.

The results of the Hausman test allowed us to reasonably select an econometric model that provides the most reliable and unbiased estimates of the relationships between the development of the hospitality industry and regional inequality in Kazakhstan.

Dynamic Lag of the Dependent Variable

Income inequality exhibits temporal persistence; current levels are influenced by past outcomes. To account for this, the model includes the lagged dependent variable (Gini_{it-1}).

Including the lag allows:

- capturing the dynamic effect of previous inequality on current outcomes,
- mitigating potential reverse causality between tourism and inequality,
- enhancing the economic realism of the model.

Lagged explanatory variables are also considered where appropriate to address potential endogeneity, following recommendations for dynamic panel data modeling (Arellano & Bond, 1991; Blundell & Bond, 1998).

Econometric Model Specification

The dynamic panel model is specified as:

$$\text{Gini}_{it} = \alpha \text{Gini}_{it-1} + \beta_1 \text{Tourism}_{it} + \beta_2 \text{Inflation}_{it} + \beta_3 \text{YouthUnemp}_{it} + \beta_4 \text{PovertyGap}_{it} + \mu_i + \lambda_t + \varepsilon_{it}$$

where:

- i denotes the region,
- t denotes the year,
- Gini_{it-1} = lagged dependent variable (lag 1),
- μ_i = region-specific fixed effects,
- λ_t = year fixed effects, controlling for national shocks,
- ε_{it} = idiosyncratic error term.

This specification captures both dynamic persistence and time-invariant regional heterogeneity.

Endogeneity and Methodological Justification

Although dynamic panel estimators such as Arellano–Bond or System GMM are commonly applied to address endogeneity in panels with lagged dependent variables, the relatively small cross-sectional dimension ($N = 17$ regions) limits the efficiency and reliability of such estimators.

To mitigate potential endogeneity concerns, the model includes the lagged dependent variable and lagged explanatory variables where appropriate. Fixed effects control for time-invariant regional heterogeneity, while year fixed effects capture nationwide shocks. Robust standard errors, clustered at the regional level, ensure correct inference in the presence of heteroskedasticity, serial correlation, and potential cross-sectional dependence.

This approach follows standard recommendations in applied panel data econometrics (Wooldridge, 2010; Roodman, 2009) and provides reliable and interpretable estimates for analyzing the dynamic relationships between the development of the hospitality industry and regional inequality.

Cross-Sectional Dependence

Potential correlations across regions (e.g., common macroeconomic shocks, policy changes) are addressed using clustered robust standard errors.

This ensures that coefficient estimates remain valid even in the presence of cross-sectional dependence.

Limitations and Model Scope

1. The relatively small number of regions limits the use of GMM estimators; therefore, fixed effects with robust SE are applied.

2. While lagged variables mitigate endogeneity concerns, full causal identification may require instrumental variables in future research.

3. Cross-sectional dependence is controlled statistically, but unobserved time-varying factors may still influence results.

These considerations are explicitly reported to provide transparency and robustness for policy interpretation.

Interpretation

The model allows for:

- Assessment of persistence in regional income inequality,

- Evaluation of the effects of tourism, inflation, youth unemployment, and poverty gap on inequality,

- Robust inference accounting for potential endogeneity, heteroskedasticity, serial correlation, and cross-sectional dependence.

Results and discussion

Descriptive analysis was performed based on mean values and the calculation of increasing and decreasing deviations from the mean values, identifying patterns and trends in the variability and consistency of the data (Coutinho, 2015).

The analysis of average values provides an insight into regional inequality and its distribution, using the Gini coefficient, inflation, youth unemployment rates, poverty levels, and the relationship with the tourism sector (number of accommodation places). The data covers the period from 2001 to 2023.

Table 1

Descriptive statistics. Sample, mean, standard deviation, minimum and maximum values

VarName	Obs	Mean	SD	Min	Max
Gini	367	0.267	0.042	0.16	0.43
tourism_accom	365	120.819	114.871	3.00	589.00
Infl	382	108.458	3.908	103.20	127.10
youth_UN	408	7.301	5.860	0.00	33.60
poverty_gap	378	3.055	4.792	0.00	24.00

Note: compiled by the authors

The sample size for the Gini coefficient is 367, which provides a reliable analytical basis. The average Gini index value was 0.267, indicating a moderate level of inequality in the distribution of income among residents of different regions. However, in some regions, income inequality reached 0.43, which is higher than the national average. This may indicate structural imbalances in the economies of the regions, including differences in employment, inflation, investment, etc.

Secondly, the sample size for the number of accommodation places in the hospitality industry was 365. The average number of accommodation places was 120,819. Given the maximum value of 589 and the minimum value of 3 for this indicator, the gap between the values is clearly visible. The standard

deviation is 114,871, which indicates the presence of tourist concentration, mainly in economically developed and urbanised regions (Almaty, Astana), while less developed regions lag behind.

Thirdly, the sample for the inflation rate consisted of 382 values. The average inflation rate for the period under review was 108.458, which corresponds to the moderate but unstable inflation dynamics characteristic of developing economies. The high standard deviation (3.908), minimum inflation value (103.2) and maximum value (127.10) indicate significant fluctuations in inflation over the years, especially during periods of economic crisis.

Fourth, the level of youth unemployment is one of the control variables affecting regional inequality, as young people are an important segment of the

labour force. The sample for this indicator consisted of 408 values, with an average value of 7.301, which is low for developing countries. The maximum value (33.60) was recorded in 2001 in the West Kazakhstan region. The standard deviation of 5.860 shows very strong variability in youth unemployment rates between regions and across years. This is evidence of profound inequality in young people's access to employment. Such significant stratification, as well as its regional nature, is closely linked to economic activity, including in the tourism and hospitality sector.

Moreover, the poverty depth index serves as an indicator of inequality in Kazakhstan's regions. The average poverty depth index for the period from 2001 to 2023 was 3.055, with a standard deviation of 4.792, a minimum value of 0, and a maximum value of 24. This means that, on average, poor households are 3.055% below the poverty line. The minimum value indicates that in some regions or years, poverty was either completely absent or all poor people

were on the threshold, i.e. they were almost not lagging behind in terms of income. The maximum value shows that in some regions of Kazakhstan, poor families are significantly below the poverty line, indicating deep poverty and structural disadvantage. The standard deviation value illustrates the high heterogeneity and instability of poverty depth between regions over different years.

The analysis showed that the regions of Kazakhstan differ significantly in terms of the level of development of the hospitality industry, economic activity and the degree of income inequality. The most developed regions accumulate the main flow of tourists and investments, which may contribute to a further deepening of regional differences. These differences justify the use of panel models that take into account spatial and temporal effects for a more accurate assessment of the relationships between variables. The Hausman test will be used to select the most appropriate model for panel data analysis.

Table 2

Results of assessing the impact of factors on the Gini index

VARIABLES	Dependent variable GINI		
	Pooled OLS	FE	RE
tourism_accom	0.000128*** (1.73e-05)	7.60e-05*** (1.64e-05)	8.26e-05*** (1.63e-05)
Infl	0.000587 (0.000450)	0.000916*** (0.000302)	0.000891*** (0.000309)
youth_UN	0.00266*** (0.000553)	0.00140*** (0.000479)	0.00156*** (0.000477)
poverty_gap	0.00139* (0.000812)	0.00320*** (0.000646)	0.00301*** (0.000650)
Constant	0.163*** (0.0487)	0.138*** (0.0326)	0.140*** (0.0337)
Number of regions	17	17	17
Observations	330	330	330
R-squared	0.218	0.302	0.302
Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1			
<i>Note: compiled by the authors</i>			

The table presents the results of a regression analysis assessing the impact of various socio-economic factors on the level of regional inequality, as measured by the Gini index. The model was estimated using three approaches: pooled ordinary least

squares (Pooled OLS), fixed effects (FE) and random effects (RE).

Key results:

- tourism_accom (number of accommodation places in the tourism industry) shows a statistically

significant positive impact on the Gini index in all three models, with the greatest impact observed in the Pooled OLS model (0.000128, $p < 0.01$). This suggests that the expansion of the hospitality sector is associated with increasing income disparities.

- Infl (inflation) shows a significant positive effect on inequality only in the FE model (0.000916, $p < 0.01$), which may indicate the specificity of the perception of inflation in a regional context.

- youth_UN (youth unemployment rate) has a positive and statistically significant effect in all models. In the Pooled OLS model, the coefficient is 0.00266 ($p < 0.01$), confirming the importance of youth employment in reducing inequality.

- poverty_gap (depth of poverty) also has a positive and statistically significant effect, especially in

the FE model (0.00320, $p < 0.01$), highlighting the link between poverty and inequality.

The constant coefficient (Constant) is significant in all models, reflecting the baseline level of inequality, all other things being equal.

Number of observations: 330. The models include 17 regions. The R^2 value is 0.218 for the Pooled OLS model and 0.302 for the FE and RE models, indicating better explanatory power of the models when regional effects are taken into account.

This table presents the results of the Hausman test, used to determine the preference for a fixed effects (FE) or random effects (RE) model in the context of analysing the determinants of regional inequality.

Table 3

Results of assessing the impact of factors on the Gini index (dependent variable)

	Coefficients			
	(b)	(B)	(b-B)	$\sqrt{\text{diag}(V_b - V_B)}$
	FE148	RE148	Difference	Std.err. of Difference
Tourism_ac~m	0.000076	0.0000826	-6.57e-06	2.35e-06
Infl	0.0009158	0.0008905	0.000253	
Youth_UN	0.0013956	0.001556	-0.0001604	0.0000356
Poverty_gap	0.0032033	0.00301	0.0001933	
b=Consistent under H_0 and H_a ; obtained from xtreg.				
B=Inconsistent under H_a and H_0 ; efficient under H_0 ; obtained from xtreg.				
Test of H_0 : Difference in coefficients not systematic				
Chi2(4) = 6.65				
Prob chi 2 = 0.1556 ($V_b - V_B$ is not positive definite)				
<i>Note: compiled by the authors</i>				

The table shows the coefficients of the variables in the FE and RE models, as well as their difference and the standard errors of this difference:

- Tourism_accom: The coefficients are 0.000076 (FE) and 0.0000826 (RE). The difference between them is minimal and amounts to -6.57e-06 with a standard error of 2.35e-06.

- Infl: The difference between the FE and RE coefficients is 0.0002253, which indicates a low sensitivity of the model to the choice of effect.

- Youth_UN: The difference between the estimates is 0.0001604 with a standard error of 0.0000356, which may indicate the potential significance of the differences between the models.

- Poverty_gap: The difference is 0.0001933, which is also a small value.

The bottom of the table shows the results of the test itself:

Test statistic χ^2 (Chi²(4)) = 6.65

p-value = 0.1556

Since the p-value exceeds traditional significance levels (0.01, 0.05, 0.1), there is no reason to reject the null hypothesis. This means that the differences between the FE and RE model coefficients are not systematic, and therefore the random effects (RE) model is preferable, as it is more effective in meeting the relevant assumptions. Thus, the main focus in interpreting the results should be on the RE

model estimates. All key factors – tourism development, youth unemployment, poverty depth, and inflation – have a statistically significant impact on regional inequality. It is particularly important to note the negative role of youth unemployment and poverty, which exacerbate regional income disparities, as well as the positive impact of tourism activity, which acts as a potential tool for mitigating inequality.

The results confirm the relevance of a number of theoretical approaches described in the literature. Thus, the sustained negative impact of tourism infrastructure development on the Gini index is consistent with the tourism-led growth (TLG) hypothesis (Balaguer & Cantavella-Jordá, 2002; Williams & Shaw, 1991), which suggests that the hospitality industry can act as a factor in reducing socio-economic inequality by creating jobs and a multiplier effect for related industries. At the same time, the positive impact of youth unemployment and the depth of poverty on the level of inequality is consistent with the provisions of Myrdal, G. (1957), according to which socio-economic differences tend to intensify under the influence of negative factors that hinder the even distribution of resources. The limited impact of inflation, identified only in the fixed effects model, points to the significance of structural differences between regions, confirming Perroux, F. (1955)'s concept of 'growth poles' and the spatial heterogeneity described by Kanbur and Venables (2005). Thus, empirical analysis demonstrates the dual nature of the impact of tourism and related socio-economic factors on regional inequality, which highlights the importance of the institutional context (North, 1990) and the need for differentiated regional policies.

Conclusion

The study revealed important relationships between the development of the hospitality industry, socio-economic factors and the level of regional inequality in Kazakhstan. Based on a panel analysis of 17 regions using Pooled OLS, fixed effects (FE) and random effects (RE) models, the following key conclusions were drawn:

1. Tourism infrastructure (tourism_accom) demonstrates a stable and statistically significant positive impact on the Gini index. This result confirms the hypothesis that the expansion of the hospitality sector contributes to increasing regional inequality.

2. Youth unemployment (youth_UN) has a positive and statistically significant effect on regional

inequality. Higher levels of youth unemployment intensify social stratification and restrict access to economic opportunities for the younger generation.

3. Poverty gap (poverty_gap) is positively associated with the Gini index. This indicates that regions with deeper poverty experience more unequal income distribution, highlighting the structural nature of inequality.

4. Inflation (infl) is statistically significant only in the fixed effects specification. This suggests that inflationary pressures may operate through region-specific structural characteristics rather than through cross-regional variation.

5. Finally, the Hausman test results ($p = 0.1556$) indicate that the differences between the FE and RE estimators are not statistically significant. Therefore, the random effects model is considered the most appropriate for interpretation.

Based on the results obtained, the following theoretical and practical implications are proposed for public policy and regional development authorities:

1. Hospitality sector development as an inequality-reduction mechanism.

Public investment in tourism infrastructure should be prioritized, particularly in economically lagging regions. Policy instruments such as tax incentives, subsidies, and public-private partnerships can stimulate private investment and expand employment opportunities.

2. Targeted youth employment policies.

Given the strong association between youth unemployment and inequality, vocational training programs, entrepreneurship support, and active labour market policies should be strengthened to facilitate labour market integration.

3. Reducing the depth of poverty.

Policy measures should address not only the incidence but also the intensity of poverty. Targeted social transfers, improved access to education and healthcare, and rural infrastructure development are essential for mitigating structural inequality.

4. Region-specific anti-inflation strategies.

Inflation control policies should account for regional heterogeneity, particularly in areas vulnerable to fluctuations in food and utility prices.

5. Territorially differentiated policy design.

Given substantial regional disparities, a uniform national policy may be insufficient. Instead, territorially adapted strategies should be implemented to reflect structural differences across regions.

Limitations of the study

Despite the significance of the results obtained, the study has a number of limitations that should

be taken into account when interpreting the conclusions.

First, the analysis is limited to data from regions of Kazakhstan. This allows us to identify national characteristics, but does not provide broad cross-country comparability.

Second, the methods used (panel models with fixed and random effects, Hausman test, descriptive statistics) allow us to identify general patterns, but do not take into account spatial dependencies between regions. The impact of tourist activity in one region on neighbouring territories remains outside the scope of the analysis.

Thirdly, the study is based on aggregate indicators (Gini index, youth unemployment rate, poverty depth, inflation), which does not allow for the disclosure of intra-group differences and social aspects of inequality, such as gender or intergenerational differences.

Fourthly, the model does not take into account the impact of external shocks, such as the COVID-19 pandemic or geopolitical crises, which radically change the role of tourism in socio-economic development.

Finally, tourism is treated as a single sector in the study, although its various forms (domestic and inbound, mass and niche, ecotourism, cultural tourism) may have different impacts on regional inequality.

Areas for future research

To further deepen the analysis, it seems appropriate to develop research in several areas.

First, including other developing countries in Central Asia in the sample and conducting a cross-country analysis will allow us to compare the mechanisms of tourism's impact on regional inequality in different institutional and cultural contexts.

Second, the use of spatial panel models and dynamic methods (e.g., panel VAR, GMM) will allow for a more accurate assessment of interregional interactions and time lags in the impact of tourism on household income.

Thirdly, the inclusion of microdata on households and enterprises will make it possible to assess the social consequences of tourism for various population groups, including young people, women and the rural population.

Fourth, studying the resilience of tourism in times of crisis (COVID-19, climate challenges, geopolitical factors) will help identify vulnerabilities and adaptation mechanisms.

Finally, a promising area is the differentiation by type of tourism, which will make it possible to develop more targeted recommendations for regional policy and determine which forms of tourism contribute to reducing regional inequality and which contribute to increasing it.

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Conflicts of Interests

The authors declare no conflict of interest

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Author Contributions

KSS: “Conceptualization, Resources & Data Curation, Writing – Original Draft, Writing – Review & Editing Preparation, Visualization;

SLS: Methodology, Project Administration, Funding Acquisition;

KAR: Software & Formal Analysis;

SLS & KAR: Validation, Supervision.

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ҚАЗАҚСТАННЫҢ АУЫЛ ШАРУАШЫЛЫҒЫ САЛАСЫ ҮШІН КЛИМАТТЫҚ ҚҰБЫЛЫСТАР АУЫТҚУЫНЫҢ МАКРОЭКОНОМИКАЛЫҚ САЛДАРЫ

Соңғы онжылдықтарда температураның өсуі, жауын-шашын режимінің өзгеруі және экстремалды климаттық құбылыстардың жиілеуі ауыл шаруашылығы өндірісінің тұрақтылығына елеулі қатер төндіріп отыр. Бұл жағдайда климаттың өзгеруінің өнімділікке, өндіріс шығындарына және ауыл шаруашылық нарықтарының жұмыс істеу механизмдеріне әсерін ғылыми бағалау өзекті мәселе болып табылады. Бұл зерттеу климаттың өзгеруінің аграрлық секторға макроэкономикалық әсерін жүйелі түрде талдауға бағытталған.

Зерттеудің негізгі мақсаты – климаттық өзгерістердің ауыл шаруашылығының макроэкономикалық көрсеткіштеріне әсер ету арналары мен ауқымын анықтау, сондай-ақ олардың өзара байланысын кешенді түрде талдау. Зерттеудің басты идеясы климаттық факторларды ауыл шаруашылығы дамуының сыртқы экзогенді шоктары ретінде қарастырып, олардың ұзақ мерзімді экономикалық салдарын бағалауға негізделеді. Зерттеу әдістемесі жүйелік, статистикалық, эмпирикалық, салыстырмалы және аналитикалық талдау әдістерін қамтиды. 2001–2024 ж. Қазақстандағы ауыл шаруашылығы өнімдерінің жалпы шығарылымына климаттық және экологиялық факторлардың әсерін бағалау мақсатында корреляция және көптік сызықтық регрессия моделі құрылды. Талдауда ұлттық және халықаралық статистикалық дерекқорлардың мәліметтері пайдаланылды. Зерттеу нәтижелері климаттық өзгерістер мен экологиялық факторлардың Қазақстанның аграрлық секторына айтарлықтай әсер ететінін дәлелдейді. Әсіресе температуралық өзгерістер ауыл шаруашылығы өндірісінің тұрақтылығына қауіп төндіретін негізгі факторлардың бірі болып табылады. Осыған байланысты ауыл шаруашылығы саласында климаттық тәуекелдерді төмендетуге бағытталған бейімделу стратегияларын әзірлеу, су және жер ресурстарын тиімді пайдалану, сондай-ақ экологиялық тұрақтылықты қамтамасыз ету бойынша мемлекеттік саясатты жетілдіру маңызды болып табылады.

Түйін сөздер: климаттың өзгеруі, ауыл шаруашылығы, макроэкономикалық әсер, өнімділік, нарық динамикасы.

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Macroeconomic consequences of climate variability for the agricultural sector of Kazakhstan

This study provides a systematic analysis of the macroeconomic effects of climate change on the agricultural sector. In recent decades, rising temperatures, changes in precipitation patterns, and the increasing frequency of extreme climate events have posed significant threats to the stability of agricultural production. In this case, it is very important to conduct a rigorous scientific assessment of the impact of climate change on productivity, production costs and the functioning of the agricultural market.

The main purpose of the study is to determine the channel and degree of impact of climate change on the macroeconomic indicators of agriculture of Kazakhstan and a comprehensive analysis of their relationship. The main idea of this study is to consider climatic factors as exogenous shocks beyond the development of agriculture and to assess their long-term economic consequences. The research methodology is based on the application of methods of systematic, statistical, comparative, and analytical analysis, as well as methods of dynamic series analysis. The research uses data from national and international

statistical databases. The research methodology includes methods of systematic, statistical, empirical, comparative and analytical analysis. 2001-2024 In order to assess the impact of climatic and environmental factors on the total agricultural output in Kazakhstan, a correlation and multiple linear regression model has been created. The analysis used data from national and international statistical databases. The results of the study indicate a significant impact of climate change and environmental factors on the agricultural sector of Kazakhstan. In particular, temperature changes are one of the main factors threatening the stability of agricultural production. In this regard, it is important in the field of agriculture to develop adaptive strategies aimed at reducing climate risks, improving government policies for the efficient use of water and land resources, as well as ensuring environmental sustainability.

Keywords: climate change, agriculture, macroeconomic impact, productivity, market dynamics.

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Макроэкономические последствия колебаний климатических явлений для сельскохозяйственной отрасли Казахстана

В последние десятилетия повышение температуры, изменение режима осадков и учащение экстремальных климатических явлений создают существенные угрозы устойчивости сельскохозяйственного производства. В этих условиях научная оценка влияния климатических изменений на производительность, производственные издержки и функционирование аграрных рынков приобретает особую актуальность. Данное исследование посвящено системному анализу макроэкономического воздействия изменения климата на сельскохозяйственный сектор.

Основной целью исследования является выявление каналов и масштабов воздействия изменения климата на макроэкономические показатели сельского хозяйства в Казахстане, а также комплексный анализ их взаимосвязи. Ключевая идея работы заключается в рассмотрении климатических факторов в качестве внешних экзогенных шоков развития аграрного сектора и оценке их долгосрочных экономических последствий. Методология исследования основана на применении методов системного, статистического, эмпирического, сравнительного и аналитического анализ. В ходе исследования использованы данные национальных и международных статистических баз. Результаты исследования свидетельствуют о значительном влиянии климатических изменений и экологических факторов на аграрный сектор Казахстана. В частности, температурные изменения являются одним из основных факторов, угрожающих стабильности сельскохозяйственного производства. В этой связи важным в сфере сельского хозяйства является разработка адаптивных стратегий, направленных на снижение климатических рисков, совершенствование государственной политики по эффективному использованию водных и земельных ресурсов, а также обеспечению экологической устойчивости.

Ключевые слова: изменение климата, сельское хозяйство, макроэкономическое воздействие, производительность, динамика рынка.

Кіріспе

Климаттың өзгеруі қазіргі таңда тұрақты жаһандық дамуға төнетін ең өзекті сын-қатерлердің бірі болып табылады. Оның салдары экологиялық өлшемдермен шектелмей, елдердің өндірістік жүйелеріне, азық-түлік қауіпсіздігіне және экономикалық тұрақтылығына елеулі әсерін тигізуде (Masson-Delmotte *et al.*, 2021). Осы тәуекелдердің ауқымын ескере отырып, Біріккен Ұлттар Ұйымы климатқа байланысты қауіп-қатерлерге төзімділікті арттыруға бағытталған Тұрақты даму мақсаттарының 13-мақсаты шеңберінде жаһандық жылынуға қарсы күресті 2030 жылға дейінгі күн тәртібінің негізгі басымдықтарының біріне айналдырды.

XXI ғасырдың соңына қарай орташа жылдық температураның жаһандық орташа көрсеткіштен жоғары қарқынмен өсуі күтілуде, ал жауын-шашын мөлшері 4-27% аралығында төмендеуі мүмкін, бұл құрғақшылық құбылыстарының күшеюіне алып келеді (Gumus *et al.*, 2024; Masson-Delmotte *et al.*, 2018; Woodward *et al.*, 2014). Бұл осалдық аймақтың құрғақ климаттық жағдайларымен, су ресурстарының шектеулілігімен және экономиканың, әсіресе ауыл шаруашылығының, негізінен егіншілікке жоғары тәуелділігімен түсіндіріледі (Abdelfattah, 2021; Masson-Delmotte *et al.*, 2021; OECD/FAO, 2023). Жан басына шаққандағы жаңартылатын су ресурстарының көлемі әлемдегі ең төмен көрсеткіштердің қатарына жатады. Су ресурстарына мұндай жоғары тәуел-

ділік ауыл шаруашылығы өндірісін климаттық өзгергіштікке ерекше сезімтал етеді.

Жаһандық азық-түлік қауіпсіздігі мен экономикалық дамуда маңызды рөл атқаратын ауыл шаруашылығы қазіргі таңда климаттың өзгеруімен байланысты күрделі сын-қатерлерге тап болуда. Бұл сектордың табиғи-климаттық жағдайларға жоғары тәуелділігі оның осалдығын күшейтеді. (Vogel *et al.*, 2019). Температураның жоғарылауы, тұрақсыз жауын-шашын және ауа-райының күрт өзгеруі бүкіл әлемдегі ауылдық жерлерде азық-түлік қауіпсіздігі мен өмір сүруге елеулі қауіп төндіретін ауылшаруашылық өнімділігін төмендетеді (Mirzabaev *et al.*, 2023).

Климаттың өзгеруі ауылшаруашылық өнімділігіне тікелей әсер етеді, топырақ эрозиясын жеделдетеді, зиянкестер мен аурулардың таралуын арттырады, топырақ құнарлылығын төмендетеді және құрғақшылық пен су тасқыны қаупін арттырады (Lavudya & Prabhakar, 2024; Wang *et al.*, 2024; Yang *et al.*, 2024). Бұл сәтсіздіктер азық-түлік өндіру жүйелерін әлсіретіп, дақылдардың өнімділігі мен мал шаруашылығының өнімділігін төмендетеді, бұл өз кезегінде жергілікті және жаһандық деңгейде азық-түлік қауіпсіздігін күшейтеді.

IPCC климаттың өзгеруі жөніндегі үкіметаралық топтың мәліметтері бойынша (IPCC, 2022), климатқа байланысты төтенше жағдайлар ауыл шаруашылығы мен балық шаруашылығының барлық секторларының өнімділігіне әсер етті. Олар ең осал елдер мен халық топтарының азық-түлік қауіпсіздігіне қауіп төндірді. Біріккен Ұлттар Ұйымының Азық-түлік және ауылшаруашылық ұйымы климаттың өзгеруі ауылшаруашылық өндіріс жүйелеріне тікелей немесе жанама әсер ететінін түсіндіреді. Біріншіден, тікелей әсер ету белгілі бір ауылшаруашылық өндіріс жүйелері үшін температура деңгейі және жауын-шашынның таралуы сияқты физикалық сипаттамалардың өзгеруінен болатын салдарды қамтиды (FAO, 2015).

Климаттың өзгеруінің ауылшаруашылық өндірісіне әсері ауылшаруашылық тауарлары мен азық-түлік бағасынан әр түрлі жолдармен көрінеді. Біріншіден, климаттық тәуекелдерге ұшырау ауыл шаруашылығы өндірісі мен азық-түліктің қолжетімділігіндегі күйзелістерге әкелуі мүмкін, бұл нарықтың бұзылуына әкелуі мүмкін. Екіншіден, әлемдік өндіріс көлемінің төмендеуі нарықтағы шиеленісті күшейтіп, сауда құрылымын бұзу арқылы импорт/экспорт ди-

намикасына әсер етуі мүмкін. Мысалы, Үндістан 2022 жылдың наурызында қатты ыстықтан орасан зор шығыннан кейін бидай экспортына тыйым салды. Үшіншіден, экологиялық және климаттық саясат климаттың өзгеруі мен ауылшаруашылық өнімдері мен азық-түлік бағалары арасындағы байланысқа әсер етеді. Мысалы, елдің климаттың өзгеруіне қарсы тұру әрекеттеріне нұқсан келтіретін көміртегі бағасының саясаты (мысалы, көміртегі салығы және шығарындылар квотасының сауда схемалары) өндірушілер үшін қосымша шығындарға әкелуі мүмкін және ауылшаруашылық өнімдерінің саудасы мен азық-түлік бағасына әсер етуі мүмкін. Осылайша, климаттың өзгеруі қолайсыз ауа-райын тудырады, бұл ауылшаруашылық нарығында үлкен белгісіздікке әкеледі.

Ауылшаруашылық өнімдері мен азық-түлік бағасына әсер ету азық-түлік қауіпсіздігінің барлық аспектілеріне, соның ішінде санына, сапасына және қолжетімділігіне әсер етуі мүмкін. Кейбір зерттеулер (Chatzopoulos *et al.*, 2020; Hertel, 2016; Sweileh, 2020) климаттың өзгеруі дақылдардың өнімділігін төмендету, құрғақшылыққа байланысты шығындарды арттыру және азық-түлік бағасын көтеру арқылы жаһандық азық-түлік тұрақсыздығына ықпал ететінін көрсетеді. IPCC мәліметтері бойынша экстремалды климаттық құбылыстардың күшеюі күтілуде. Бұл оқиғалар жаһандық азық-түлік жүйесі мен ауылшаруашылық тауарлар нарығына қысым жасауы мүмкін. Бір қызығы, климаттың өзгеруінің ауыл шаруашылығы секторына және азық-түлік бағасына әсері айтарлықтай зерттелмеген.

Әдебиеттерге шолу

Климаттың өзгеруінің экономиканың негізгі секторларына экономикалық әсері ұзақ уақыт бойы зерттелді. Ауылшаруашылық секторына экономикалық әсерге келетін болсақ, жаһандық экономикалық модельдерді қолданатын зерттеулерге шолу макроэкономикаға емес, азық-түлік бағасы мен азық-түлік қауіпсіздігіне әсері туралы ғана түсінік береді.

Ертеректегі еңбектерде ауыл шаруашылығының ауа райы факторларына жоғары бейімделгіш екені атап өтілген. Кейінгі зерттеулер климаттық өзгерістердің өнімділікке және азық-түлік қауіпсіздігіне теріс ықпал етуі мүмкін екенін көрсетеді. Сонымен қатар, бейімделу шараларының әсерді әлсірету немесе өнімділік-

ті арттыру мүмкіндігі бар екені айтылғанымен, олардың нәтижелілігі әртүрлі жағдайларға байланысты өзгеріп отырады (Blanc & Reilly, 2017; Porter *et al.*, 2014).

Ауыл шаруашылығына климаттың өзгеруінің макроэкономикалық ықпалын талдауға бағытталған зерттеулер де бар. Мысалы, Reilly *et al.* (1994) ішінара тепе-теңдік моделін қолдана отырып, ауылшаруашылық өндірісінің төмендеуінің экономикалық әсерін талдап, әлемнің қай аймақтары климаттың өзгеруінен пайда көретінін немесе ұтылатынын бағалады. Жаһандық ауқымда, Ren *et al.* (2016) есептелетін жалпы тепе-теңдік моделін (CGE) қолдана отырып, ұқсас талдау жүргізді және макроэкономикалық әсер абсолютті түрде аз болады деген қорытындыға келді (жалпы ішкі өнімнің (ЖІӨ) 1%-дан азы). Roson & Damania (2017) су тапшылығы тұрғысынан бірнеше әлеуметтік-экономикалық сценарийлерді қолдана отырып бағалау жүргізді. Тағы бір зерттеу климаттың өзгеруіне байланысты ауыл шаруашылығының әл-ауқатындағы өзгерістерді бағалау үшін ішінара тепе-теңдік үлгісін пайдаланды (Stevanović *et al.*, 2016). Сауданы ырықтандыру сценарийлеріндегі әл-ауқаттың өзгеру ауқымы 0-ден 0,5% -ға дейін болатыны хабарланды. Ciscar *et al.* (2011) Еуропадағы климаттың өзгеруінің экономикалық әсерін зерттеп, жаһандық жылыну сценарийлерінің көпшілігінде CGE моделін қолданған кезде макроэкономикалық шығындар шамамен 0,3% болатынын анықтады. Көріп отырғанымыздай, климаттың өзгеруіне байланысты ауыл шаруашылығының болжамды жаһандық экономикалық шығындарының ауқымы аз (ЖІӨ-нің шамамен 0-1%). Сондықтан климаттың өзгеруінің ауыл шаруашылығы секторына әсерін бағалау кезінде ЖІӨ-нің өзгеруіне емес, азық-түлік бағасын және аштық қаупі бар халық санын көрсеткіш ретінде пайдаланған жөн.

Алайда климаттың өзгеруінің ауылшаруашылық секторындағы ЖІӨ-ге әсерін сандық бағалау маңызды, өйткені ол климаттың өзгеруінің бірнеше секторларға әсерін бірыңғай макроэкономикалық көрсеткішті қолдана отырып салыстыруға мүмкіндік береді. Бұл бізге әдебиетте сипатталғандай жұмсарту мен бейімделудің жалпы шығындарын салыстыруға мүмкіндік береді. Алайда, ауылшаруашылық секторына экономикалық әсерді сандық бағалау кірістілік, CO₂ тыңайтқышының әсеріне, жаһандық жылыну деңгейіне және әлеуметтік-экономикалық

жағдайларға қатысты әртүрлі болжамдарды қолдану сияқты көптеген белгісіз факторлармен байланысты.

Dijk *et al.* (2021) әлеуметтік-экономикалық және климаттың өзгеру сценарийлерінің ұзақ мерзімді әсерін бағалау үшін жаһандық азық-түлік қауіпсіздігін болжау бойынша 57 зерттеуге жүйелі шолу және мета-талдау жүргізді. Олардың тұжырымдары 2050 жылға қарай азық-түлікке әлемдік сұраныс негізінен халықтың өсуі мен экономикалық өсуге байланысты 35-56%-ға өсетінін көрсетеді. Климаттың өзгеруінсіз аштық қаупі бар халық саны 91%-ға қысқаруы мүмкін, дегенмен әлеуметтік-экономикалық теңсіздік кейбір жағдайларда аштықтың 8%-ға өсуіне әкелуі мүмкін. Алайда, климаттың өзгеруіне байланысты аштық деңгейі климаттың өзгеруінен, азық-түлік жеткізу тізбегінің бұзылуынан және ауа-райының күрт өзгеруінен туындаған егіннің жетіспеушілігінен 30%-ға дейін көтерілуі мүмкін.

Lloyd *et al.* (2019) климаттың өзгеруі кірістер мен азық-түлік бағалары арасындағы байланыс арқылы балалардың өсуінің тежелуіне қалай әсер ететінін зерттеу үшін 44 елде статистикалық модельдеуді қолданды. Олардың тұжырымдары климаттың өзгеруінсіз балалардың өсуінің тежелу жағдайлары кедейлік сценарийінде 110 миллионға, ал 2030 жылға қарай өркендеу сценарийінде 83 миллионға жетуі мүмкін екенін көрсетеді. Алайда, климаттың өзгеруі 570 000-нан 1 миллионға дейінгі жағдайлардың көбеюіне әкелуі мүмкін, ал ауылдық жерлер кірістердің айырмашылығы мен азық-түлік бағасына сезімталдыққа байланысты ең көп зардап шегеді.

Komras *et al.* (2024) сондай-ақ әртүрлі климаттық сценарийлерде әлемдік азық-түлік өндірісі 2050 жылға қарай 6%, 10% және 14%-ға қысқаруы мүмкін, бұл азық-түлік қауіпсіздігі мен экономикалық тұрақсыздықты күшейтеді деп болжайды.

Егер климаттың өзгеруін азайту бойынша шаралар қабылданбаса, дақылдардың өнімділігінің төмендеуі азық-түлік бағасының өсуіне әкеледі, бұл ауыл шаруашылығының әл-ауқатына және жаһандық экономикалық тұрақтылыққа теріс әсер етеді. Stevanović *et al.* (2016) 2100 жылға қарай әлемдік экономика климатқа байланысты ауыл шаруашылығының бұзылуына байланысты жыл сайын ЖІӨ-нің 0,3% жоғалтуы мүмкін деп есептеді. Алайда, тиімді жұмсарту

саясатын жүргізу кезінде азық-түлік бағасы мен экономикалық тұрақтылыққа әсер етуді едәуір төмендетуге болады, бұл халықтың осал топтарына жүктемені азайтады.

Эконометриялық тұрғыдан алғанда, климаттық айнымалылар мен ауыл шаруашылығы өнімділігі арасындағы қатынастарды бағалауға бағытталған зерттеулер климаттық факторлардың әртүрлі аймақтардағы егіндік түсіміне теріс әсерін көрсетеді (Roudier *et al.*, 2011; Challinor *et al.*, 2014). Бұл көрсеткіштер ауыл шаруашылығының макроэкономикалық өсу қарқынына тікелей әсер етеді, әсіресе аграрлық сектордың ұлттық ЖІӨ-дегі үлесі жоғары елдер үшін. Challinor *et al.* (2014) еңбегінде климаттық факторлар мен өнімділік арасындағы байланыс әртүрлі дақылдар мен аймақтар бойынша біркелкі емес екені көрсетіледі. Бұл жағдай климаттық әсердің ерекшеліктерін ескере отырып, бейімделу саясатын нақты бағыттау қажеттігін білдіреді. Бұл әсіресе Қазақстан жағдайында маңызды, өйткені ауыл шаруашылығы табиғи ресурстарға тікелей тәуелді.

Schlenker & Roberts (2009) өз зерттеулерінде температура мен дақылдың өнімділігі арасындағы байланысты талдай отырып, климаттық индикаторлар мен ауыл шаруашылығы көрсеткіштері арасындағы жолдық емес (non-linear) тәуелділікті анықтаған. Бұл зерттеу климаттық өзгерістердің егінді дақылдардың өнімділікке әсері тек температураның жоғарылауына ғана байланысты емес, сонымен бірге тәуелді және маусымдық өзгерістерге де тәуелді екенін көрсетеді (Schlenker & Roberts, 2009). Температура белгілі бір шегінен асып кеткенде өнімділіктің кенет төмендеуі байқалады, бұл климаттық экстремумдардың әсерін дәл сипаттайды.

Tebaldi & Lobell (2018) жұмыстары да көрсеткендей, температураның жоғарылауы және жауын-шашынның тұрақсыздығы астық және мал шаруашылығы өндірісіне кері әсер етеді. Олар климаттық факторлар мен ауыл шаруашылығы өнімділігі арасындағы ұзақ мерзімді көрсеткіштерді бағалай отырып, климаттың өзгеруі өнім көлемінің азаюына, өсімдік физиологиясының бұзылуына және өндірістік циклдің қысқаруына алып келетінін көрсетті (Tebaldi & Lobell, 2018).

Әдебиеттерді шолуды қорытындылай келе, авторлармен келесі гипотезалар тексерілетін болады:

H₁: Климаттың ауытқуы ауылшаруашылығы саласындағы өнімдердің жалпы шығарылымын төмендетеді.

H₀: Ауа райының шектен тыс құбылмалығы ауылшаруашылығы саласындағы өнімдердің жалпы шығарылымына статистикалық маңызды әсер етпейді.

Әдіснама

Бұл зерттеу Қазақстан жағдайында климаттың өзгеруінің ауыл шаруашылығына макроэкономикалық әсерін бағалауға негізделген. Зерттеуде пайдаланылған әдістерді бірнеше кезеңге бөліп қарастырамыз. Бірінші кезеңдеториялық-әдіснамалықбазақалыптастырылып, отандық және шетелдік әдебиеттерге шолу жасалды; екінші кезеңде статистикалық деректер жиналып, климаттық өзгерістердің ауыл шаруашылығына әсері бағаланды; үшінші кезеңде климаттың өзгеруіне бейімделу саласындағы міндеттері, климаттық-табиғи апаттардан болатын шығындар мен болжамдар және климаттық тәуекелдерді азайту бағыттары бойынша ұсынымдар әзірленді.

Зерттеу барысында зерттеу нәтижелерін кешенді түрде бағалауға және талдауға мүмкіндік беретін бірнеше әдістер пайдаланылды.

Ең алдымен, теориялық зерттеулер жүргізілді. Отандық және шетелдік ғалымдардың еңбектеріне, халықаралық ұйымдардың баяндамалары, қорытынды есептеріне салыстырмалы, жүйелік талдау әдістерінің көмегімен шолу жасалды. Бұл деректер ауыл шаруашылығы мен климаттық көрсеткіштердің өзара байланысын кеңірек қарастыруға мүмкіндік берді және климаттық факторлардың әсерін жүйелі түрде бағалап, олардың өзгеру үрдістерін анықтауға жағдай жасады.

Эмпирикалық талдау үшін корреляция және көптік регрессиялық модель қолданылды. Зерттеу 2001–2024 жылдар аралығындағы Қазақстан Республикасы бойынша жылдық уақыттық қатарлар деректеріне негізделеді. FAOSTAT дерекқоры, World Development Indicators базасы, «Қазгидромет» ұсынған климаттық деректер, ҚР Ұлттық статистика бюросының мәліметтері пайдаланылды. Осы әдістер жиынтығы климаттық өзгерістердің ауыл шаруашылығының экономикалық нәтижелеріне қалай әсер ететінін уақыттық кескінде көрсетуге мүмкіндік береді.

Модель кіші квадраттар әдісімен төмендегідей бағаланды:

$$\text{AgriOutput}_t = \beta_0 + \beta_1 \text{SoilErosion}_t + \beta_2 \text{MaxTemp}_t + \beta_3 \text{MinTemp}_t + \varepsilon_t \quad (1)$$

Модельде автокорреляция (Durbin–Watson) және гетероскедастика (Breusch–Pagan) диагностикалық тесттері жүргізілді.

Аналитикалық талдау алынған сандық нәтижелерді кең макроэкономикалық және институционалдық контексте түсіндіру үшін қолданылды. Бұл әдіс климаттық өзгерістердің ауыл шаруашылығына әсерін тек сандық көрсеткіштермен шектемей, оларды экономикалық құрылым, мемлекеттік аграрлық саясат, су ресурстарын басқару және нарықтық тетіктермен байланыстыра талдауға мүмкіндік береді.

Нәтижелер және талқылау

Климаттық қауіптерге экстремалды ауа-райы оқиғалары да, адам немесе табиғи жүйелерге теріс әсер етуі мүмкін баяу дамып келе жатқан климаттық процестер де жатады.

Төтенше құбылыстарға мыналар жатады: қалыптан тыс жылу, құрғақшылық кезеңдері, қатты жауын-шашын, дауыл және басқа да жоғары қарқынды ауа-райы құбылыстары.

Баяу дамып келе жатқан процестерге мыналар жатады: орташа температураның жоғарылауы, құрғақтықтың жоғарылауы, табиғи ортаның қышқылдануы, мұздықтардың еруі, теңіз деңгейінің көтерілуі және климаттық жүйенің басқа да ұзақ мерзімді өзгерістері.

Климаттың өзгеруіне байланысты баяу дамып келе жатқан процестер (1-сурет) тәуелсіз климаттық қауіп болуы мүмкін немесе экстремалды ауа-райының ауқымының, ұзақтығының және жиілігінің өзгеруіне ықпал етуі мүмкін (UNDP, 2025).

Әлемнің көптеген аймақтарында бір уақытта бірнеше қауіптің әсері бар. Мұндай қауіптер қатар пайда болуы мүмкін, бір-бірін каскадты оқиғалар түрінде күшейтеді немесе уақыт өте келе жинақталып, күрделі (аралас) тәуекелдерді қалыптастырады.

Қазақстанның климаты жылынуды жалғастыруда. 1960 жылдардан бастап Қазақстан аумағында әрбір келесі онжылдық алдыңғы онжылдыққа қарағанда жылы болды. 2015-

2024 жылдардағы соңғы онжылдықтағы орташа жылдық ауа температурасы +6,98 °C болды және климаттық нормадан 0,70°C-ге асып түсті. Соңғы бесжылдықта (2020–2024 жж.) ауа температурасының орташа мәні +7,35°C деңгейіне жетіп, бақылау кезеңіндегі ең жылы кезеңдердің бірі ретінде тіркелді. Бұл көрсеткіш климаттық нормадан 1,06°C-ге жоғары. Сонымен қатар ең жылы он жылдың тоғызында дәл осы ХХІ ғасырда байқалғаны климаттың тұрақты түрде жылынуы үрдісін көрсетеді (Казгидромет, 2025).

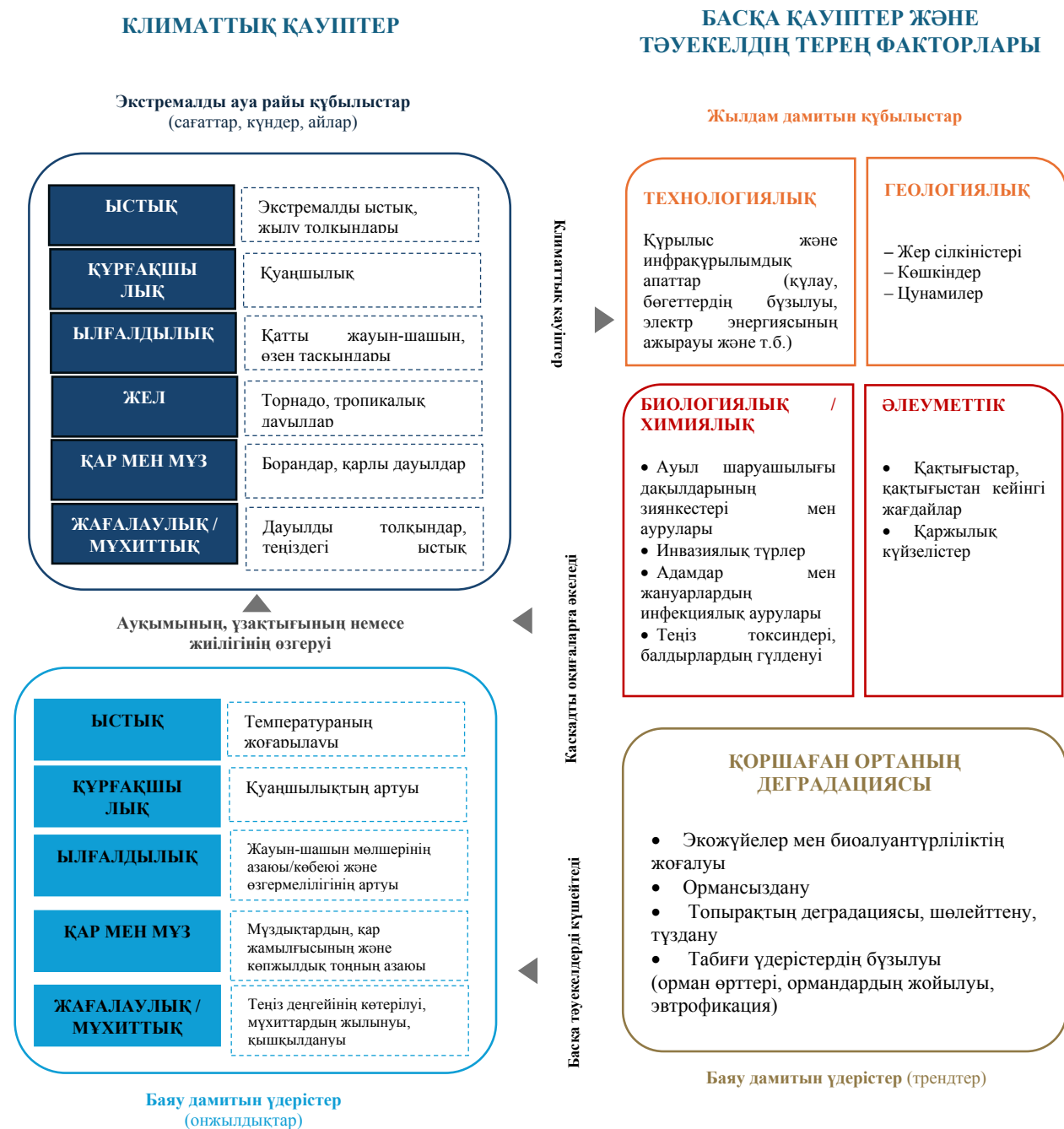
2024 жылы Қазақстан аумағында ауа температурасының аномалиясы +0,87 °C құрады, бұл оны дәрежесі бойынша алтыншы орында және 1941 жылдан бергі барлық бақылау кезеңінде ең жылы жылдардың 10% -ын қамтиды (1-кесте). 2024 жылы Қазақстан аумағы бойынша орташа жылдық орташа температура +7,18 °C құрады, бұл 1991-2020 жылдар кезеңінде климаттық нормадан 0,87 °C асып түсті (MEPR, 2025).

Жылы мезгілде ыстық кезеңдердің жиілігі мен ұзақтығының артуы адамдар мен жануарлардың денсаулығына теріс әсер етеді. Бұдан бөлек, мұндай өзгерістер көлік инфрақұрылымы мен қалалық ортаға, сондай-ақ рекреациялық аймақтардың жағдайына кері ықпалын тигізеді және энергетика саласына түсетін жүктемені арттырады. Жер беті температурасының жоғарылауы суық кезеңдердің қысқаруына әкеледі. Соның нәтижесінде жауын-шашынның сұйық түрі жиілеп, қар жиналу көлемі азаяды, ал қатты жауын-шашынның таралу аймағы мен ұзақтығы да өзгеріске ұшырайды.

ДМУ-ның 2024 жылғы жаһандық климаттың жай-күйі туралы есебі көптеген климаттық рекордтардың қайта жаңартылғанын және кейбір жағдайларда айтарлықтай асып түскенін растайды. Парниктік газдар деңгейі, Жер бетіндегі температура, мұхиттың жылуы мен қышқылдануы, теңіз деңгейінің көтерілуі, теңіз мұз қабатының қысқаруы және мұздықтардың шегінуі жаһандық жылынудың жалғасуын көрсететін бұрын-соңды болмаған өзгерістерді көрсетуді жалғастыруда. ДМУ өз баяндамасында 2024 жыл бақылау тарихындағы ең жылы жылдардың бірі болғанын, орташа жылдық температура бойынша 2023 жылғы алдыңғы рекордтан асып түскенін атап өтті. Эль-Ниньо эффектінің күшеюі және парниктік газдар концентрациясының үздіксіз өсуі климаттық өзгерістердің жеделдеуіне баса назар аудара отырып, жаһандық температураның Жаңа айтарлықтай көтерілуіне ықпал етті.

1-сурет

Негізгі қауіптер және олардың өзара байланысы



Ескерту: (UNDP, 2025) деректері негізінде авторлармен құрастырылды

1-кесте

1941–2024 жылдар кезеңіндегі Қазақстандағы байқаулар тарихындағы ең жылы жылдар және Қазақстан аумағы бойынша орташаланған жер бетіндегі ауаның орташа жылдық температурасының тиісті ауытқулары

Ранг	Ең жылы жылдар	Орташа жылдық температура-ның ауытқулары (қаң.-жел.), °C
1	2023	1.73
2	2020	1.07
3	2013	1.04
4	2022	0.92
5	1983	0.91
6	2024	0.87
7	2015	0.79
8	2021	0.73
9	2002	0.70
10	2004	0.68
Ауытқулар 1991-2020 жылдар аралығында есептелген.		

Ескерту: (MEPR, 2025) деректері негізінде авторлармен құрастырылды

2024 жылы орташа жылдық жаһандық жер бетіндегі температура 1850-1900 жылдардағы орташа деңгейден $1,55^{\circ}\text{C} \pm 0,13^{\circ}\text{C}$ жоғары бол-

ды. 2024 жыл 175 жылдық бақылау тарихындағы ең жылы жыл болды (WMO, 2025).

Қазақстанда жиі кездесетін табиғи гидрометеорологиялық құбылыстар – қатты жел, қатты жаңбыр, қатты боран, қатты қар, бұршақ. «Қазгидромет» РМК бақылау желісінің деректері бойынша 2024 жылы Қазақстан Республикасының аумағында 190 табиғи метеорологиялық құбылыс тіркелген, бұл 2023 жылмен салыстырғанда 13-ке аз. Олардың максималды саны 2003 жылы байқалды – барлығы 218 жағдай (2-кесте).

2024 жылы Қазақстан аумағында 30 м/с және одан жоғары жылдамдықпен қатты желдің 115 жағдайы байқалды. Қатты желдің ең көп саны Жетісу, (45 жағдай), одан кейін Алматы (25 жағдай), Жамбыл (12 жағдай), Павлодар (11 жағдай) облыстарында тіркелді. Қарағанды, Ақмола, Солтүстік Қазақстан, Түркістан, Қызылорда, Маңғыстау облыстары мен Абай облыстарында жағдайлардың саны әрқайсысында 1-ден 7-ге дейін болды. Мұндай қатты жел құбылыстары бірқатар теріс салдарға алып келеді. Атап айтқанда, электр энергиясының үзілуі, автожолдардың уақытша жабылуы, тұрғын үйлердің шатырларының зақымдануы, ағаштардың сынуы, сондай-ақ автокөліктердің бүлінуі байқалады.

2-кесте

2024 жылы Қазақстанның әкімшілік-аумақтық облыстары бойынша қауіпті метеорологиялық құбылыстардың саны

Облыс	Өте қатты жел	Өте қатты боран	Өте қалың тұман	Өте қатты жаңбыр	Өте қатты қар	Ылғалды қардың жабысып қалуы	Өте қатты бұршақ	Жалпы саны
Алматы облысы	25	–	–	14	3	–	–	42
Ақмола облысы	6	4	–	1	–	–	–	11
Ақтөбе облысы	–	13	–	2	–	2	1	18
Атырау облысы	–	–	–	–	–	–	–	0
Абай облысы	1	2	–	1	1	–	–	5
Шығыс Қазақстан облысы	–	–	–	1	–	–	–	1
Жамбыл облысы	12	–	–	–	1	–	–	13
Жетісу облысы	45	–	–	–	1	–	–	46
Батыс Қазақстан облысы	–	2	–	–	–	–	–	2
Қарағанды облысы	7	1	–	1	–	–	–	9
Қостанай облысы	–	4	–	2	–	–	1	7
Қызылорда облысы	1	–	–	–	–	–	–	1
Маңғыстау облысы	1	–	–	–	–	–	–	1
Павлодар облысы	11	1	–	2	–	–	–	14
Солтүстік Қазақстан облысы	3	1	1	3	–	–	2	10

Кестенің жалғасы

Облыс	Өте қатты жел	Өте қатты боран	Өте қалың тұман	Өте қатты жаңбыр	Өте қатты қар	Ылғалды қардың жабысып қалуы	Өте қатты бұршақ	Жалпы саны
Түркістан облысы	3	—	—	5	2	—	—	10
Ұлытау облысы	—	—	—	—	—	—	—	0
Жалпы саны	115	28	1	32	8	2	4	190

Ескерту: (Казгидромет, 2025) деректері негізінде авторлармен құрастырылды

2008-2024 жылдардағы соңғы он жеті жыл ішінде 1991-2007 жылдардағы алдыңғы он жеті жылдық кезеңмен салыстырғанда табиғи метеорологиялық құбылыстардың жиілігі артып отыр. Атап айтқанда, қатты жел мен бұршаққа байланысты оқиғалар шамамен 1,9 есе, ал нөсерлі жауын-шашын жағдайлары 1,5 есе көбейген. Сонымен қатар, кейбір құбылыстардың керісінше азайғаны байқалады: мысалы, қалың тұман жағдайлары 26%-ға, ал борандар шамамен 8%-ға төмендеген (Казгидромет, 2025).

2024 жылғы су тасқыны соңғы бірнеше онжылдықтағы елдегі ең үлкен кезең болды. 2024 жылғы көктемгі су тасқыны метеорологиялық және гидрологиялық факторлар кешенінің әсерінен дамыды. Негізгі триггер наурыздың екінші онкүндігінде жауын-шашынмен бірге жүретін жылдам жылыну болды. Батыс аймақтарда су тасқыны толқыны наурыздың үшінші онкүндігінің басында басталды, ал елдің қалған бөлігінде су тасқыны наурыздың ортасынан сәуірдің басына дейінгі аралықта қалыптасты.

Қазақстан аумағында жалпы саны 2724 мұздық бар. Олардың ішіндегі ең ірілерінің бірі – Тұйықсу мұздығы, ол соңғы 38 жыл ішінде шамамен 1 км-ге қысқарған. Зерттеулерге сәйкес, мұздық жыл сайын орта есеппен 1 млн тоннаға жуық массасын жоғалтып отыр, ал оның жалпы көлемі шамамен 58 млн тоннаны құрайды. Бұл үрдіс 2040 жылға қарай су ресурстарының 20%-дан астам қысқаруына әкелуі мүмкін.

Қазіргі таңда Орталық Азия өңірінде су ресурстарының тапшылығы айқын байқалады. Мұндай жағдай, бір жағынан, су ресурстарын тиімсіз пайдалануымен байланысты болса, екінші жағынан, климаттың өзгеруінің теріс әсерімен күшейіп отыр. Соның нәтижесінде ауыл шаруашылығы, энергетика және суға тәуелді басқа да салалар айтарлықтай қысымға ұшырайды. Бұл өз кезегінде өңір елдерінің азық-түлік және энергетикалық қауіпсіздігіне қауіп төндіріп, баға тұрақсыздығына, атап айтқанда азық-түлік

пен электр энергиясы құнының өсуіне ықпал етуі мүмкін.

Дүниежүзілік банк болжамдарына сәйкес, шамамен 2050 жылға қарай өңірде су ресурстарын тұтыну ең жоғары деңгейіне жетеді, содан кейін өзен ағындарының көлемі айтарлықтай төмендеуі ықтимал. Сонымен қатар, су тасқыны мен құрғақшылық сияқты экстремалды құбылыстардың жиілігі артып, жалпы су тапшылығы мәселесі одан әрі ушыға түсуі мүмкін. Бұл жағдай Қазақстан үшін стратегиялық маңызы бар мәселе болып табылады.

Жалпы, 2024 жыл өткен жылмен салыстырғанда су алмасудың жоғарылауымен және белсенді гидрологиялық процестермен сипатталады, бұл су шаруашылығы жүйелерінің тұрақтылығына айтарлықтай әсер етеді және халықты және инфрақұрылымды су қаупінен қорғау бойынша қосымша шаралар қабылдауды талап етеді.

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH (GIZ, 2025) мәліметтері бойынша ең өзекті климаттық қауіптер су тасқыны, құрғақшылық және жылу толқындары болып табылады.

Орташа алғанда, су тасқыны екі жыл сайын (қауіптің төмен қарқындылығы), төрт жыл (қауіптің орташа қарқындылығы) және 27-40 жыл (қауіптің жоғары қарқындылығы), ал жылу толқындары әр 3, 12 және 50-70 жыл сайын болады. Әр түрлі қарқындылықтағы құрғақшылық сәйкесінше әр 3, 4 және 13-18 жыл сайын күтіледі.

Қазақстанның негізгі астық өндіретін өңірлерінде құрғақшылықтың қайталану жиілігі 20–39% аралығында ауытқиды. Аймақтық ерекшеліктерге байланысты оның байқалу мерзімділігі де әртүрлі. Мысалы, Батыс Қазақстан, Ақтөбе, Қарағанды, Павлодар және Ақмола облыстарында құрғақшылық орта есеппен әр 3 жыл сайын қайталанып отырады. Ал Қостанай мен Шығыс Қазақстан облыстарында бұл көрсеткіш шама-

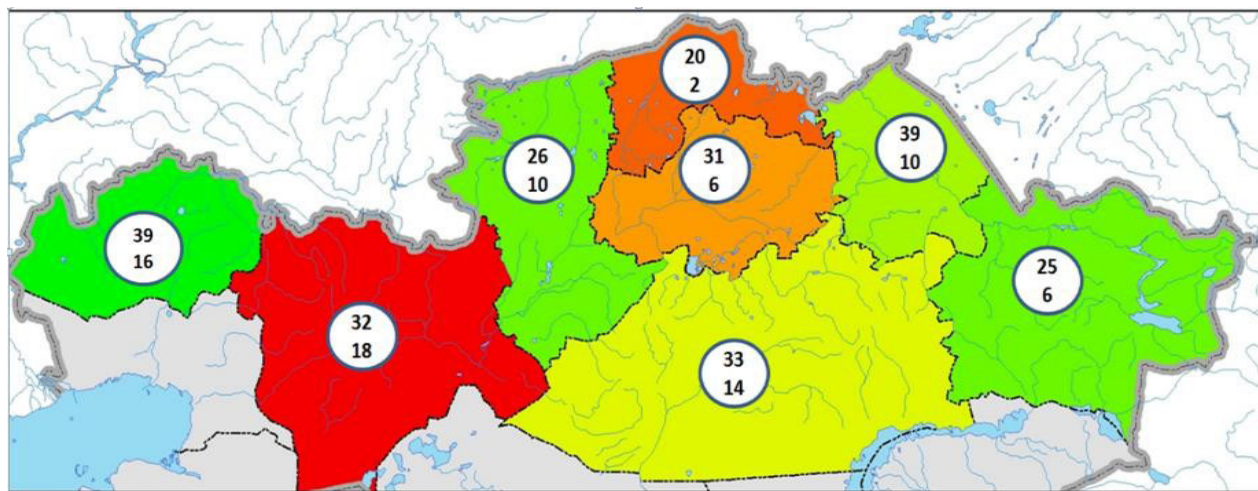
мен 4 жылды құрайды, ал Солтүстік Қазақстан облысында әр 5 жыл сайын байқалады.

Өнімділіктің 50% және одан да көп төмендеуіне әкелетін күшті құрғақшылықтың таралу жиілігі де өңірлер арасында біркелкі емес. Атап айтқанда, Ақтөбе, Батыс Қазақстан, Қарағанды, Қостанай және Павлодар облыстарында оның ықтималдығы салыстырмалы түрде жоғары болып, 10-18% аралығында бағаланады. Ал Солтүстік Қазақстан, Ақмола және Шығыс Қазақстан облыстарында бұл көрсеткіш төменірек, шамамен 2-6% деңгейінде.

Осыған сәйкес, күшті құрғақшылықтың қайталану мерзімі де әртүрлі: батыс және орталық өңірлерде ол орта есеппен 6-7 жыл сайын байқалса, Қостанай мен Павлодар облыстарында шамамен 10 жылда бір рет орын алады. Ақмола және Шығыс Қазақстан облыстарында мұндай құбылыс сирек кездесіп, шамамен 17 жылда бір рет тіркеледі, ал Солтүстік Қазақстан облысында оның қайталануы өте төмен – шамамен 50 жылда бір рет байқалады. Бұл деректер өңірлер арасындағы климаттық тәуекелдердің әркелкі таралғанын көрсетеді.

2-сурет

1966–2016 жылдардағы құрғақшылық/қатты құрғақшылық, қайталануы %



Ескерту: (UNDP, 2022) деректері негізінде авторлармен құрастырылды

Жалпы алғанда, республика аумағының батыс, орталық және солтүстік-шығыс бөліктерінде құрғақшылықтың қайталану жиілігі шамамен әр 3 жыл сайын байқалса, солтүстік және шығыс өңірлерде ол әр 4-5 жыл сайын орын алады. Сонымен қатар, күшті құрғақшылық республикадағы шеткі солтүстік өңірлерде шамамен 50 жылда бір рет, шығыс аймақтарда 17 жылда бір рет, ал батыс өңірлерде орта есеппен 6 жылда бір рет қайталанып отырады (UNDP, 2022).

Құрғақшылық негізінен Қазақстанның солтүстігіндегі ауыл шаруашылығына әсер етеді, онда бидайдың илеу өндірісі басым. Құрғақшылықтың күшіне байланысты егін ішінара немесе тіпті толығымен жоғалады немесе егіннің сапасы нашарлайды, бұл өнімге тек төмен бағаны алуға мүмкіндік береді. Ауыл шаруашылығы-

ның орташа шығыны құрғақшылықтың қарқындылығына байланысты 7-ден 300 млрд теңгеге дейін құрайды.

Осы мәліметтер мен ақпараттар негізінде ауыл шаруашылығына, энергетикаға және инфрақұрылымға әсер ететін негізгі қауіпті климаттық құбылыстар анықталды (3-кесте).

Су тасқыны ғимараттар, жолдар, көпірлер немесе энергетикалық инфрақұрылым сияқты негізгі инфрақұрылымға зиян келтіреді. Жалпы залалдың аз ғана бөлігі ауыл шаруашылығы секторына, зақымдалған автомобильдерге және тұрмыстық техникаға тиесілі. Су тасқынынан жалпы шығын 2024 жылғы су тасқынын қосқанда 468 млн теңгеден 51 млрд теңгеге дейін өзгереді (Astana Times, 2024). Онша ауыр емес оқиғалар өте ауыр оқиғаларға қарағанда жиі болды,

бірақ келтірілген залал аз болды. AQUEDUCT Global Flood Analyzer сияқты Әлемдік Ресурстар Институтының ЖІӨ-ге әсер етуді қарастыратын төмендеу тәсілдерінің нәтижелері ЖІӨ-ге әсер ету кезінде 2,4 миллиард АҚШ долларын немесе 2050 жылға қарай 0,3% құрауы мүмкін екенін көрсетті.

Негізгі құралдардың физикалық зақымдануы электр қуатының үзілуіне, ақауларға және жеткізу тізбегінің кешігуіне байланысты қосымша шығындарға әкелуі мүмкін. Зардап шеккен салаға байланысты бұл импорттың өсуіне немесе экспорттың төмендеуіне әкеледі.

Жылу толқындары көптеген салаларға әсер етеді: энергетика секторы бір уақытта гидроэлектростанциялар мен жылу электр орталықтарында энергия өндірудің шектеулі болуына, сондай-ақ электр энергиясына сұраныстың артуына әсер етеді. Ауыл шаруашылығы секторы жайылым өнімділігінің төмендеуіне байланысты бидай өнімділігінің жоғалуына және мал шаруашылығы өнімінің төмендеуіне тап болады. Керісінше, күнбағыс өнімділігінің өсуі күтілуде (ПРООН, 2020). Халықаралық тәжірибеге сәйкес, сусындарды тұтынудың 3%-ға өсуін күтуге болады.

3-кесте

Қазақстандағы негізгі қауіпті климаттық құбылыстардың әсерін сипаттайтын сандық бақылау көрсеткіштері

Климаттық құбылыс	Ауыл шаруашылығы	Энергетика	Инфрақұрылым	Су ресурстары
Құрғақшылық	•Өткен кезеңдердегі ауыл шаруашылығының орташа шығындары (7-300 млрд теңге)	•Су деңгейінің төмендеуіне байланысты гидроэлектр энергиясын өндірудің қысқаруы (5%-20%) • Салқындату суының жетіспеушілігіне байланысты ЖЭО-ларда энергиямен қамтамасыз етудің шектелуі (3,8%-4,7%)	•Су тасымалдауға кететін шығындардың артуы	•Ауыл шаруашылығында, көмір өндіруде, бу шаруашылығында және ауаны кондициялауда суға сұраныстың өсуі
Жылу толқындары	•Бидай өнімділігінің төмендеуі (2030 ж. дейін – 457 млрд тг, 2050 ж. дейін – 608 млрд тг) • Күнбағыс өнімділігінің артуы (2030 ж. дейін – 1,8 млрд тг, 2050 ж. дейін – 0,9 млрд тг) • Мал шаруашылығы өнімінің қысқаруы (2030 ж. дейін – 170 млрд тг, 2050 ж. дейін – 109 млрд тг)	•Су деңгейінің төмендеуіне байланысты гидроэнергия өндірісінің қысқаруы (5%-20%) • ЖЭО-ларда салқындатуға байланысты шектеулер (3,8%-4,7%) • Әрбір 1°C температураның өсуіне салқындатуға қосымша қажеттілік (0,5%-8,5%)	–	–
Су тасқыны	• Малдың қырылуы, егістік жерлердің су астында қалуы (су тасқынынан келетін жалпы шығынның 2%-ы; 0,5-51 млрд тг)	• Энергетикалық инфрақұрылымның зақымдануы (22-112 млрд тг) • Электрмен жабдықтаудағы үзілістер салдарынан басқа секторлардағы сатылым шығындары (0,5%-7,7%)	• Ғимараттар мен ішкі нысандардың зақымдануы (жалпы шығынның 87%-ы; 0,5-51 млрд тг) • Жол инфрақұрылымы мен автокөліктердің зақымдануы (11%; 0,5-51 млрд тг)	–

Ескерту: (ПРООН, 2020); (World Bank, 2024) деректері негізінде авторлармен құрастырылды

Дүниежүзілік банк 2050 жылға дейінгі аптап ыстық, су арқылы берілетін ауруларға, өсудің тежелуіне және жұқпалы ауруларға байланысты денсаулық сақтау шығындарының бағасын 4,9 миллион АҚШ доллары көлемінде жариялайды (World Bank, 2024).

Жылу толқындары сияқты құрғақшылық энергетика саласына да әсер етеді. Су деңгейінің төмендеуі энергетикалық қауіпсіздік мәселелерін тудыруы мүмкін. Салқындату ресурстарының тапшылығына байланысты су электр станциялары ғана емес, жылу электр станциялары да зардап шегеді.

Кейбір секторларда құрғақшылық кезінде суға сұраныстың артуына байланысты бағаның өсуін күту керек. Бұл аспект Қазақстандағы көшпелі тренинг барысында талқыланып, көмір өндіру, салқындату және ауаны баптау, ауыл шаруашылығы және су көлігі қызметтері үшін іске асырылды. Бағаның өсуі суға деген сұраныстың артуынан немесе су көлігі жағдайында өзен кемелерінің жүктемесінің төмендеуіне байланысты шығындардың өсуінен туындайды (GIZ, 2025).

Опцияларға суды үнемдеу технологияларын пайдалану, ағып кетуді бақылау, су инфрақұрылымын қалпына келтіру және ылғал үнемдейтін дақылдарды өсіру кіреді. Ылғал үнемдейтін технологияларды қолдану (ресурстарды үнем-

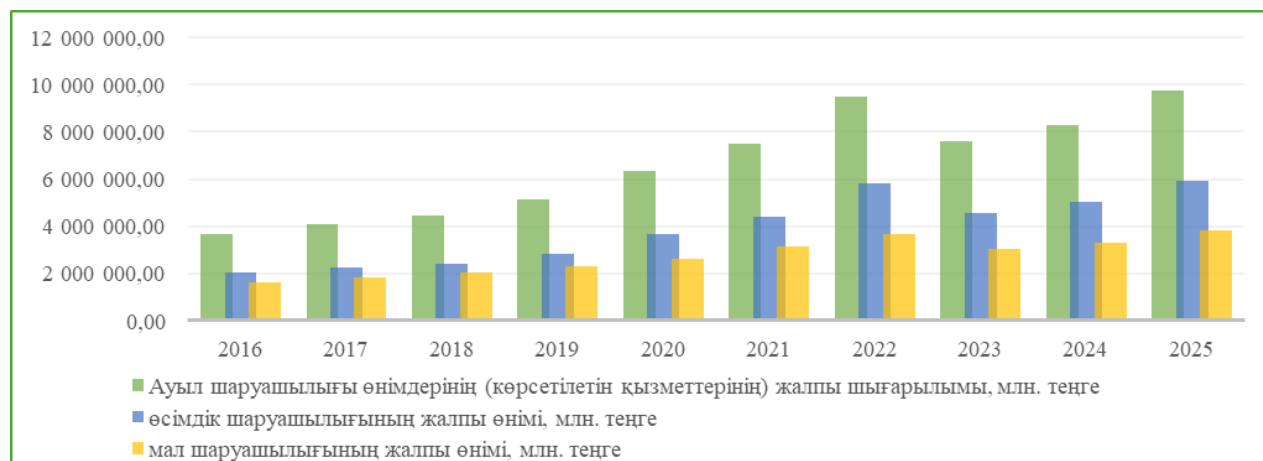
дейтін ауыл шаруашылығы, қалдықсыз егіншілік) топырақтың сақталуына ықпал етуі мүмкін (ПРООН, 2020; Broka *et al.*, 2016). Осы жеке технологиялардың әрқайсысы климаттың өзгеруінен туындаған егін шығынын кем дегенде ішінара өтей алады.

Соңғы он жылда Қазақстандағы ауыл шаруашылығы өнімінің жалпы көлемі екі есеге жуық өсіп, 2016 жылғы 3,7 трлн теңгеден 2025 жылы 9,8 трлн теңгеге жетті. Аграрлық салаға көрсетілген ауқымды қаржылық қолдау да айтарлықтай әсер етті. Көлемі 1 трлн теңгеге жеткен жеңілдетілген несиелердің арқасында ауыл шаруашылығы қатарынан екінші жыл рекордтық көрсеткіштерге қол жеткізіп, аграрлық сектордың тұрақтылығы мен тиімділігін дәлелдеп отыр. Оң өзгерістер ауыл шаруашылығының технологиялық деңгейінің артуы, заманауи агротехнологияларды кеңінен қолдану, сапалы тұқым пайдалану және тыңайтқыш енгізу көлемінің ұлғаюы нәтижесінде қалыптасты.

2025 жылы майлы дақылдардың да рекордтық өнімі алынды – 4,9 млн тонна. Сондай-ақ 1 млн тонна бұршақ тұқымдас дақыл жиналды. Бұдан бөлек 2,8 млн тонна картоп, 3,7 млн тонна көкөніс және 2,5 млн тонна бақша дақылы жиналды. Мақта өнімінің жалпы түсімі гектарына 32 центнер өнімділікпен 466 мың тоннаны құрады. Бұл соңғы 18 жылдағы ең жоғары көрсеткіш.

3-сурет

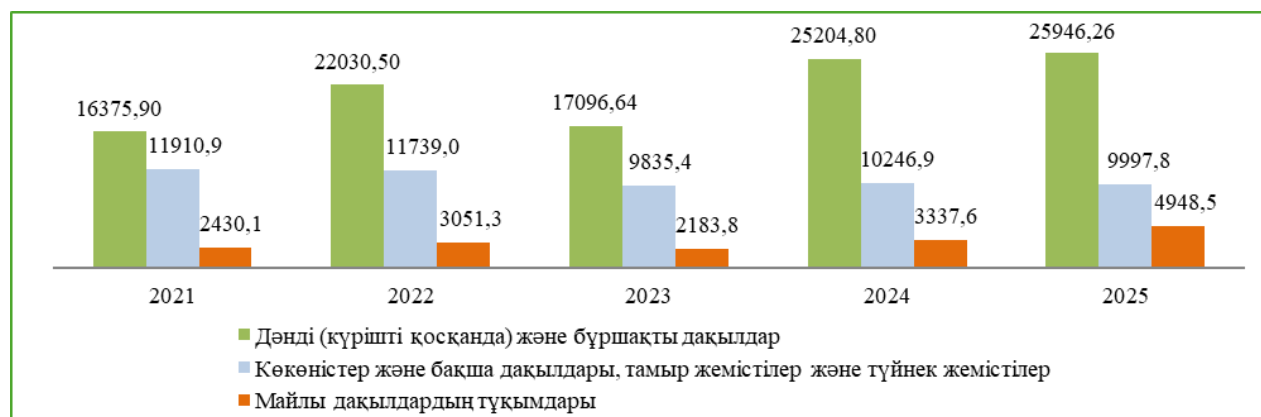
2016–2025 ж. Қазақстан Республикасының ауыл шаруашылығы өнімдерінің динамикасы



Ескерту: (Ұлттық статистика бюросы, 2026) деректері негізінде авторлармен құрастырылды

4-сурет

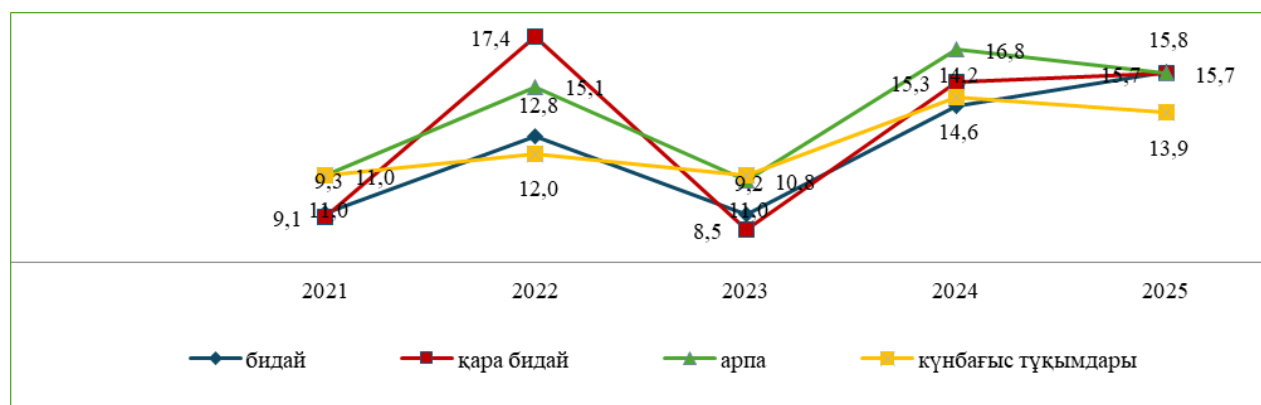
2021–2025 жж. Қазақстандағы негізгі ауыл шаруашылығы дақылдарын жинау динамикасы, мың тонна



Ескерту: (Ұлттық статистика бюросы, 2026) деректері негізінде авторлармен құрастырылды

5-сурет

2021–2025 жж. Қазақстандағы негізгі ауыл шаруашылығы дақылдарының түсімділігі, гектардан центнер

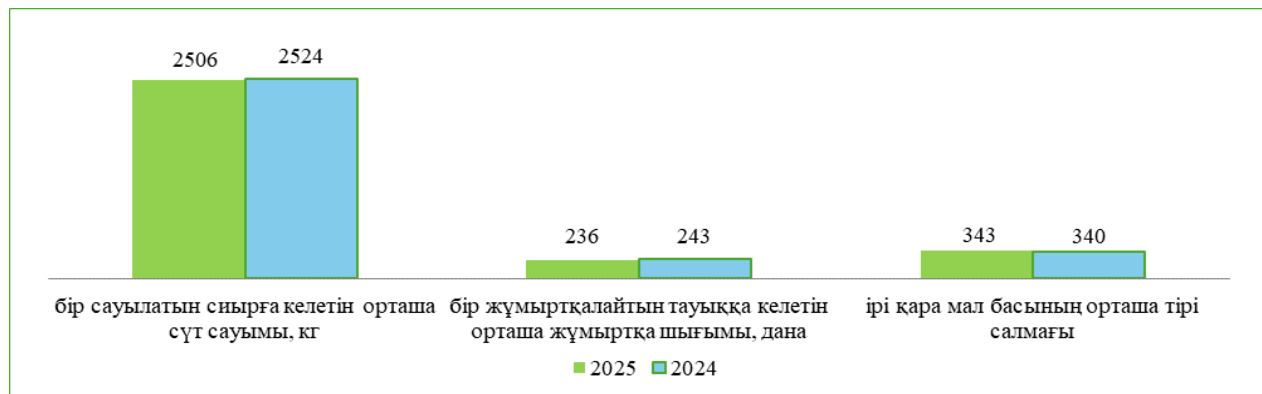


Ескерту: (Ұлттық статистика бюросы, 2026) деректері негізінде авторлармен құрастырылды

4-5 суреттерден көріп отырғанымыздай, 2023 жыл қазақстандық диқандар үшін климат жағдайы тұрғысынан ең сәтсіз маусымдардың бірі болды. Сол жылы көктемнен бастап жауын-шашын аз түсті, ал жазғы аптап пен қуаңшылықта егіс алқаптары қурап кетті. Астық оратын кезде жауын тамыздың екінші жартысы мен қыркүйекте толассыз құйды. Алдымен құрғақшылық, артынша тоқтамай жауған жауын астықтың пісіп-жетілуіне, уақытында жиналуына да кесірін тигізді. Орташа өнімділік гектарына 10 центнерге (2024 ж. 16,1 ц) айналды. Ауа райының бұлай өзгеруі тек маусымдық құбылыс деп бағалау жеткіліксіз. Табиғаттың 2023 жылғы тосын мінезіне жаһандық деңгейдегі екі фактор тікелей

ықпал етті: бірі – Тынық мұхитында басталып, бүкіл әлемге әсерін тигізетін Эль-Ниньо құбылысы болса, екіншісі – атмосферадағы парник газдарының артуынан жүріп жатқан климаттың жылыну процесі.

Мал шаруашылығы ауыл шаруашылығы жалпы өнімінің 39%-ын құрайды. 2025 жылы ірі қара мал басының 2,4%-ға және ұсақ мал басының 1,6%-ға шамалы өсуі байқалады. Сүт өндірісі 5% өсіммен шамамен 3,8 млн тоннаны құрады, ет өндіру көлемі 1,2 млн тоннаға жетті, бұл өткен жылғы деңгейден 2,6%-ға жоғары. Алайда, жалпы өнімнің жыл сайынғы өсімі 2-3% деңгейінде сақталуы саланың әлеуетін толық ашпай отыр.

6-сурет*Қазақстандағы мал шаруашылығы көрсеткіштерінің өнімділігі**Ескерту: (Ұлттық статистика бюросы, 2026) деректері негізінде авторлармен құрастырылды*

Мал басының сақталуы мен өсуінде тұрақты азық-түлік базасын қамтамасыз ету маңызды рөл атқарады, бірақ бұл процесс экономикалық, климаттық және логистикалық факторларға өте сезімтал болып қала береді. Шағын және орта шаруашылықтарда жемшөпті сақтау және қайта өңдеу үшін қуаттардың жеткіліксіз дамуы жемшөптің тұрақты қорларының қалыптасуына кедергі келтіреді. Бұл егіс алқаптарын әртараптандыру және өңірлік жемшөп өндіру желісін дамыту, АӨК салалары арасындағы интеграцияны күшейту қажеттігін көрсетеді. Ішкі бағаны ұстап тұру үшін экспортқа енгізілген шектеулер мен тыйымдар салаға айтарлықтай әсер етеді. Мұндай тыйымдар инфляциямен күресте тиімсіз, өйткені олар ұсыныстың төмендеуіне және бағаның өсуіне әкеледі. Мәселен, 2025 жылғы қарашада ет бағасы 21,7%-ға өсті. 2025 жылғы қаңтар-қазандағы саладағы инвестициялар айтарлықтай төмендегенін көрсетті – 8,0%.

Мемлекеттік қолдау шаралары көбінесе фермерлердің субсидиялар мен дотацияларға тәуелділігін тудыратын саланың бәсекеге қабілеттілігінің өсуін баяулатады. Мемлекет тарапынан одан әрі қолдау түрлі әкімшілік және реттеуші кедергілерді жою жолымен саланы технологиялық жаңғыртуға, инфрақұрылымды жетілдіруге, адами капиталды дамытуға және бизнес-ортаны жақсартуға қайта бағытталуы тиіс.

Дүниежүзілік банк (World Bank, 2022) ұсынған болжамдар климаттың өзгеруі Қазақстан экономикасына қазірдің өзінде теріс ықпал етіп отырғанын көрсетеді. Егер жаһандық деңгейде тиімді шаралар қабылданбаса, бұл әсер алдағы уақытта одан әрі күшеюі мүмкін.

Модельдік есептеулерге сәйкес, климаттың айтарлықтай өзгеруін қарастыратын сценарийлердің бірі – ШРТ 8.5 (шоғырланудың репрезентативті траекториялары) жағдайында, 2050 жылға қарай тауарлар мен қызметтер өндірісі базалық деңгеймен салыстырғанда шамамен 1,6%-ға төмендейді, ал 2100 жылға қарай бұл көрсеткіш 4,3%-ға дейін жетуі ықтимал.

Қазақстан үшін негізгі тәуекелдердің бірі су тасқынымен байланысты. «Қатаң» климаттық сценарий жағдайында су тасқыны салдарынан ЖІӨ көлемі 2050 жылға қарай шамамен 0,9%-ға, ал 2100 жылға қарай 3,3%-ға төмендеуі мүмкін.

Мұндай тәуекелдердің ауқымы мен белгісіздігін азайту үшін бейімделу шараларын уақтылы қаржыландыру маңызды рөл атқарады (4-кесте).

Болжамдарға сәйкес, климаттық катаклизмдер Қазақстандағы еңбек нарығы көрсеткіштерінің нашарлауына алып келеді. Климаттың өзгеруінің макроэкономикалық әсері, ең алдымен, еңбек нарығы көрсеткіштерінің нашарлауы арқылы көрініс табуы мүмкін деп болжанады. Бұл үрдіс жалпы экономика ауқымында өндірістік белсенділіктің төмендеуіне және әлеуметтік-экономикалық тұрақтылыққа қысымның артуына алып келуі ықтимал. Өртүрлі климаттық катаклизмдерді (ауыл шаруашылығы, су тасқыны, қалыптан тыс жылу) көздейтін ШРТ 8.5 максималды шығарындыларының сценарийі шеңберінде нақты жалақының 2060 жылға қарай 2,1 пайызға және 2090 жылға қарай 3,7 пайызға қысқаруы күтілуде. Нәтижесінде 2060 жылға қарай кедейлік деңгейі 3 пайызға жоғары болады, бұл 2060 жылға қарай кедейлер санының 87 000

адамға және 2090 жылға қарай 123 000 адамға артуына сәйкес келеді.

Табиғи апаттар мемлекеттік бюджетке қауіп төндіруі мүмкін. Табиғи апаттарға байланысты

барлық шығындардың үштен екісі құрғақшылық пен су тасқынынан туындайды, климаттың өзгеруі екі құбылыстың да жиілігі мен қарқындылығын арттырады.

4-кесте

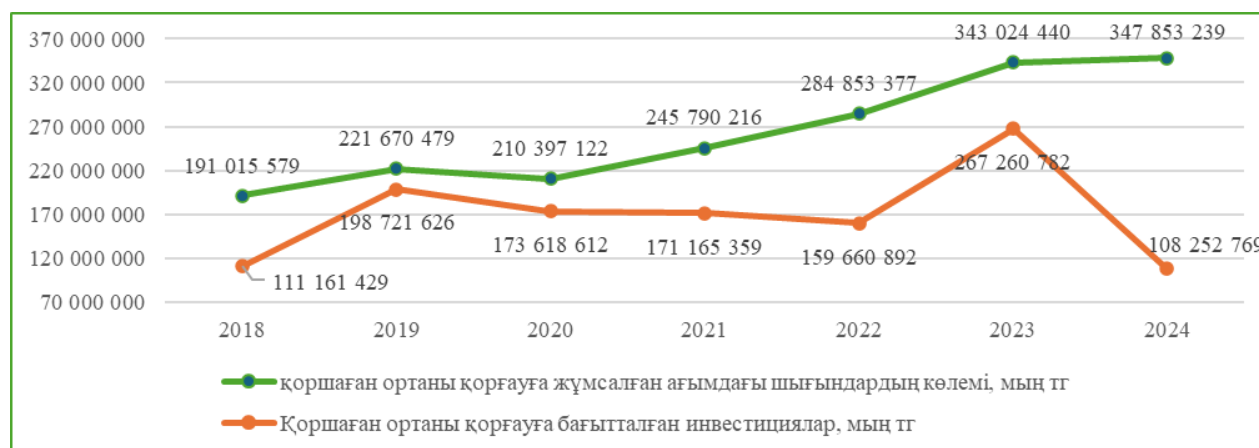
Қазақстан үшін климаттық катаклизмдерге байланысты экономикалық шығындар мен әсерлердің болжамы

Көрсеткіштер	ШРТ 2.6		ШРТ 4.5		ШРТ 8.5	
	2050	2100	2050	2100	2050	2100
Жан басына шаққандағы нақты ЖІӨ (2020 жылғы тұрақты бағамен)	-1.0	-1.3	-1.2	-1.7	-1.6	-4.3
Жан басына шаққандағы үй шаруашылықтарының нақты тұтынуы (2020 жылғы тұрақты бағамен)	-1.0	-1.3	-1.2	-1.7	-1.6	-4.3
Шығындар (% ЖІӨ)						
Ауыл шаруашылығы	-0.5	-0.6	-0.7	-0.7	-0.7	-1.0
Аптап ыстық	0.0	0.0	0.0	0.0	0.0	-0.1
Су тасқыны	-0.5	-0.7	-1.0	-0.9	-0.9	-3.3
Жалпы шығындар көлемі	-1.0	-1.3	-1.2	-1.7	-1.6	-4.3

Ескерту: (World Bank, 2022) деректері негізінде авторлармен құрастырылды

7-сурет

Қазақстандағы қоршаған ортаны қорғау шығындарының динамикасы



Ескерту: (Ұлттық статистика бюросы, 2026) деректері негізінде авторлармен құрастырылды

2024 жылы Қазақстанда қоршаған ортаны қорғауға арналған шығындар 347,8 млрд теңге болды, бұл 2022 жылмен салыстырғанда 22%-ке артық. Қоршаған ортаны қорғаудың шығындары – бұл кәсіпорындардың ластаушы заттардың алдын алуға, азайтуға немесе жоюға бағытталған іс-шараларға, технологиялар мен жабдықтардың жұмысын қолдауға арналған шығындары. Павлодар (16,3%), Атырау (14,5%), Ақтөбе (13,9%)

облыстары табиғат қорғау қызметіне 204,1 млрд теңге бағыттады, бұл қоршаған ортаны қорғауға жұмсалған шығындардың жалпы көлемінің 44,7% құрады. Табиғат қорғау шығындарының едәуір үлесін (95,9%) өнеркәсіп кәсіпорындары жүзеге асырады (7-сурет).

Қазақстанда жинақтаушы егіншілік (ЖЕ) енгізілді (21,3 млн гектардың 2,6-сы), бірақ әлі де жақсартуға мүмкіндік бар (Polo et al., 2022).

ЖЕ минималды немесе нөлдік өңдеуді, дақылдарды әртараптандыруды және топырақты өсімдік қалдықтарымен жабуды білдіреді. Бұл жаңа машиналар мен жабдықтарға, білім мен оқытуға инвестиция салуды талап етеді, бұл белгілі бір шығындармен келеді, бірақ сонымен бірге тиімді (World Bank, 2024).

Эмпирикалық талдау үшін 2001–2024 ж. Қазақстандағы ауыл шаруашылығы өнімдерінің жалпы шығарылымына климаттық және экологиялық факторлардың әсерін бағалау мақсатын-

да көптік сызықтық регрессия моделі құрылды. Модельдегі тәуелді айнымалы ретінде ауыл шаруашылығы өнімдерінің жалпы шығарылымы (AgriOutput) алынды. Тәуелді айнымалылар келесідей:

SoilErosion – топырақ эрозиясына ұшыраған аумақтар;

MaxTemp – ең жоғары орташа айлық температура;

MinTemp – ең төменгі орташа айлық температура.

5-кесте

Ауыл шаруашылығы саласындағы климаттық ауытқулардың әсерін көрсететін корреляциялық матрица

	AgriOutput	SoilErosion	MaxTemp	MinTemp
AgriOutput	1	0.542456	-0.29767	-0.82755
SoilErosion	0.542456	1	0.06354	-0.32778
MaxTemp	-0.29767	0.06354	1	0.259026
MinTemp	-0.82755	-0.32778	0.259026	1

Ескерту: авторлардың есептеулері негізінде құрастырылды

Корреляциялық матрица нәтижелері бойынша (5-кесте) тәуелді және тәуелсіз айнымалылар арасындағы өзара байланыс деңгейі анықталды. 0.542 мәні топырақ эрозиясына ұшыраған аумақтар (SoilErosion) мен ауыл шаруашылығы өндірісі арасында орташа оң байланыс бар екенін көрсетеді. Алынған оң байланыс зерттелетін кезеңдегі ауыл шаруашылығы өндірісінің жалпы өсу тенденциясымен және жер ресурстарын қарқынды пайдаланумен түсіндіріледі.

Ең жоғары орташа айлық температура (MaxTemp) -0.298, бұл әлсіз теріс байланыс. Яғни жоғары температураның артуы ауыл ша-

руашылығы өндірісінің төмендеуіне әсер етуі мүмкін.

-0.828 мәні ең төменгі орташа айлық температураның (MinTemp) өзгеруі ауыл шаруашылығы өндірісіне айтарлықтай кері әсер ететінін көрсетеді. Бұл күшті теріс байланыс.

Тәуелсіз айнымалылар арасындағы корреляциялар: $\text{corr}(x_1, x_2) = 0.064$, $\text{corr}(x_1, x_3) = -0.328$, $\text{corr}(x_2, x_3) = 0.259$. Барлық көрсеткіштер $|r| < 0.7$ деңгейінде болғандықтан, модельде мультиколлинеарлық мәселесі байқалмайды. Бұл модель коэффициенттерінің тұрақтылығын және нәтижелердің сенімділігін көрсетеді.

6-кесте

Регрессиялық талдау нәтижелері

Айнымалылар	Коэффициенттер	Стандартты қате	t мәні	Pr(> t)
Константа	-3E+07	11944959	-2.53847	0.019555 *
SoilErosion	176990	60079.53	2.945928	0.00799 **
MaxTemp	-11170.5	8587.365	-1.30081	0.208112
MinTemp	-158875	26683.37	-5.9541	8.01E-06 ***

Коэффициенттер ***1%, **5%, *10% деңгейінде статистикалық маңызды

Ескерту: авторлардың есептеулері негізінде құрастырылды

Детерминация коэффициенті $R^2 = 0.785$ құрайды. Бұл ауыл шаруашылығы өндірісіндегі өзгерістердің 78.5%-ы модельге енгізілген факторлар арқылы түсіндірілетінін көрсетеді.

Регрессиялық талдау нәтижесінде алынған көптік сызықтық регрессия моделі келесідей:

$$\text{AgriOutput} = -30321925 + 176990\text{SoilErosion} - 11170.5\text{MaxTemp} - 158875\text{MinTemp} + \varepsilon_t \quad (2)$$

Регрессиялық зерттеу нәтижелері бойынша ауыл шаруашылығының жалпы шығарылымына маңызды әсер ететін айнымалылар топырақ эрозиясына ұшыраған аумақтар мен ең төменгі орташа айлық температура болып табылады.

SoilErosion айнымалысы бойынша коэффициент 176990-ге тең (p -мәні = 0.00799) және 5% деңгейінде статистикалық маңызды болып табылады ($p < 0.05$). Бұл, басқа факторлар тең болған жағдайда, топырақ эрозиясына ұшыраған аумақтар 1 га өсуі AgriOutput көрсеткішінің орташа алғанда 176990 тг артуын білдіреді. Яғни, топырақ эрозиясының оң коэффициент көрсетуі зерттелетін кезеңдегі ауыл шаруашылығы өндірісінің жалпы өсу тенденциясымен және жер ресурстарын кеңінен пайдаланумен түсіндіріледі.

MaxTemp айнымалысы бойынша коэффициент -11170.5-ге тең (p -мәні = 0.208112) және статистикалық маңызды болып табылмайды ($p > 0,10$).

MinTemp айнымалысы бойынша коэффициент -158875-ге тең (p -мәні = $8.01E-06$) және 1% деңгейінде статистикалық өте маңызды болып табылады ($p < 0.01$). Бұл, басқа факторлар тең болған жағдайда, ең төменгі орташа айлық температура 1°C -қа өсуі AgriOutput көрсеткішінің орташа алғанда 158875 тг төмендеуімен байланысты екенін білдіреді. Ең төменгі температураның төмендеуі ауыл шаруашылығы өндірісіне айтарлықтай теріс әсер етеді.

Фишердің F-критерийін талдау нәтижесінде

$$F_{\text{мәнді}} = 6.8753E-07, F=24.3993934$$

$p < 0.05$ болғандықтан, модель жалпы статистикалық маңызды деп есептеледі. Бұл таңдалған факторлардың ауыл шаруашылығы өндірісіне бірлескен әсері бар екенін дәлелдейді.

Гетероскедастиканың бар немесе жоғын тексеру үшін Breusch–Pagan тестін қолданамыз. $p=0.4389$, $p > 0.05$ болғандықтан гетероскедастика жоқ деп қорытынды жасаймыз.

Автокорреляцияға тексеру үшін Durbin–Watson статистикасын пайдаланамыз. $DW=1.1948$ Бұл қалдықтарда оң автокорреляцияның бар екенін көрсетеді.

Осылайша, зерттеу нәтижесінде көптік регрессиялық модель гипотезалардың эмпирикалық дұрыстығын растады.

H_1 : Климаттың ауытқуы ауылшаруашылығы саласындағы өнімдердің жалпы шығарылымын төмендетеді. Модель арқылы ең төменгі орташа температураның (MinTemp) ауыл шаруашылығы өндірісіне ең күшті теріс әсер етуші фактор ретінде анықталды. Яғни, ең төменгі орташа температураның жоғарылауы ауыл шаруашылығы шығарылымын төмендетеді. Осылайша, H_1 гипотезасы расталды.

H_0 : Ауа райының шектен тыс құбылмалығы ауылшаруашылығы саласындағы өнімдердің жалпы шығарылымына статистикалық маңызды әсер етпейді. Талдау нәтижесінде нөлдік гипотеза қабылданбайды. Себебі, ең төменгі орташа температура (MinTemp) мен топырақ эрозиясына ұшыраған аумақтардың (SoilErosion) ауыл шаруашылығы өндірісіне статистикалық маңызды әсер ететінін растайды.

Дүниежүзілік Банктің мәліметтері бойынша, «суды үнемдейтін» технологияларды немесе TPE (Топырақты қорғау және ресурстарды үнемдейтін егіншілік) технологияларын пайдалану кезінде келесі мақсаттарды анықтауға болады:

- Солтүстік Қазақстан нысаналы аумағын 5 жыл ішінде 25-50% – ға ұлғайта алады;

- Қазақстанның шығыс және батыс аймақтары 5-7 жылдан кейін нысаналы аумағының 50% жетуі мүмкін;

- Қазақстанның оңтүстік-шығыс және оңтүстік аймақтары 5 жыл ішінде нысаналы алаңының 25-30% жетуі мүмкін;

- Осылайша, бес-жеті жылдан кейін тағы 9,6 млн га TPE технологиясын енгізеді деп күтілуде. 7-кестеде ұсынылған TPE-технологияларды қолданудың есептік шығындары мен пайдасы, ауданы 10 000 га болатын гипотетикалық экономика үшін анықталған.

7-кесте

SSP5-8.5 климаттық сценарийі негізінде «үнемдеуші ауыл шаруашылығы» үшін болжамдар

Шығындар (10 000 га АҚШ долларымен)	Пайда (10 000 га АҚШ долларымен)
- Нысаналы аумақ практикасына арналған жаңа жабдыққа инвестициялар (1,2 млн. АҚШ долл); шамамен 10 жылдан кейін ауыстыруға инвестиция - Нысаналы аумақ бойынша фермерлерге арналған ақпараттық науқандар (0,05 млн. АҚШ долл) - Топырақтағы өсімдік қалдықтарын қосымша бөлуге арналған шығындар (0,1 млн. АҚШ долл) - Глифосатты қоса алғанда, гербицидтерді сатып алу (0,3 млн. АҚШ долл)	- Ауыл шаруашылығы дақылдарының өнімділігін арттыру (жылына 0,15 млн. АҚШ долл) - Тыңайған және қосымша егістерді жою (жылына 0,7 млн. АҚШ долл) - Топырақ өңдеу және ілеспе жабдықтарға қызмет көрсететін далалық персоналды қысқарту; отын үнемдеу (жылына 0,3 млн. АҚШ долл) - Топырақты терең өңдеуге арналған техниканы сату (0,6 млн. АҚШ долл)

Ескерту: (World Bank, 2024) деректері негізінде авторлармен құрастырылды

Температураның жоғарылауы және судың қол жетімділігінің төмендеуі жайылымдар үшін өзекті мәселелер болып табылады. Шамамен 27 миллион га немесе барлық жайылымдардың шамамен 15%-ы 2050 жылға қарай деградацияға ұшырайды және олардың алдын алу шаралары қабылданғанға дейін деградацияны жалғастырады. Мал шаруашылығының өнімділігі 5-14% – ға төмендейді деп күтілуде, бұл азық-түлік қауіпсіздігіне әсер етеді (World Bank, 2024; ПРООН, 2020).

Тозған жайылымдарды қалпына келтірудің әртүрлі нұсқалары бар, мысалы, кешенді жайылымды басқару, жайылымдық өсімдіктер, ауыспалы егіс, тұқымдар мен мал денсаулығын жақсарту және инфрақұрылымды қалпына келтіруге инвестициялар (Polo *et al*, 2022).

Бұл сценарий мал басының тығыздығы жоғары жартылай құрғақ және құрғақ экожүйелердегі деградацияланған жайылымдарды жақсарту шараларының жалпы экономикалық салдарына жарық түсіреді. Бұл шараларға, мысалы, шектеулі өңдеу, көпжылдық шөп сорттарын отырғызу және өсімдіктерді қорғау шаралары кіреді.

Алдағы бес-он жылда 27 миллион гектар деградацияланған жердің шамамен екі-үш миллион гектары жақсарады деп күтілуде, негізінен мал басының тығыздығы ең жоғары оңтүстік-шығыс, оңтүстік, батыс және шөлді аймақтарда (World Bank, 2024).

8-кестеде көрсетілген тұрақты жайылымдарды басқару технологияларын енгізудің болжамды шығындары мен пайдасы 10 000 га ферма үшін есептелген.

8-кесте

SSP5-8.5 климаттық сценарийіне негізделген «тұрақты жайылымды басқару» болжамдары

Шығындар (10 000 га АҚШ долларымен)	Пайда (10 000 га АҚШ долларымен)
- Топырақты өңдеу және себу үшін отын қажеттілігі (52,000 АҚШ долл) - Тұқымдар (20 000 АҚШ долл) - Тыңайтқыштар (20,000 АҚШ долл) - Еңбекақы төлеу шығыстары (49 200 АҚШ долл) - Үкіметтің қаржылық қолдауы	Бес жыл ішінде жаңа жайылымдарда жиналған шөптің жалпы құны (5,4 млн. АҚШ долл)

Ескерту: (World Bank, 2024) деректері негізінде авторлармен құрастырылды

Жайылымдарды ұтымды пайдалану кезінде нақты ЖІӨ-нің жылына 0,3%-ға немесе 195 млрд теңгеге дейін ұлғаюы күтілуде. Сүт және басқа да мал шаруашылығы өнімдері сияқты ауылшаруашылық өнімдерінің экспорты же-

делдетіліп, ауылшаруашылық өнімдерінің импорты баяулайды. Пайда уақыт өте келе артады және шара толығымен жүзеге асырылғаннан кейін олар толығымен пайдаланылады деп күтілуде.

Ауыл шаруашылығы секторының бөлігі ретінде мал шаруашылығы сүт пен ет өндірісін ұлғайту арқылы ең көп пайда көреді деп күтілуде. Салааралық байланыстардың арқасында басқа секторлар да пайда көреді. Жобаны іске асыру кезеңінде (2035 жылға дейін) химия өнеркәсібінде (тыңайтқыштар), өңдеу өнеркәсібінде (мұнай өнімдері) және ауыл шаруашылығында (тұқымға сұраныс) қосымша сұраныс байқалуы мүмкін (GIZ, 2025).

Бейімделу және климаттың өзгеруіне төзімділікті арттыру шараларына стратегиялық инвестициялар Қазақстан экономикасы үшін дүлей

зілзалалардың салдарын азайту үшін маңызды болып табылады. Мұндай тәуекелдерді төмендету бюджетке түсетін қосымша жүктемені де жеңілдетуі мүмкін. Сараптамалық бағалауларға сәйкес, климаттық қауіптерге бейімделуге арналған жыл сайынғы шығындар шамамен 610 млн АҚШ долларын немесе ЖІӨ-нің 0,4%-ын құрайды (9-кесте). Бұл сома ЖІӨ-нің 1,9 пайызын құрайтын апаттардың жылдық есептелген шығындарынан аз, сондай-ақ климаттың айтарлықтай өзгеруін қарастыратын сценарий бойынша 2100 жылға қарай болжанған ЖІӨ-нің 4,3 пайызынан аз (World Bank, 2022).

9-кесте

Қазақстанның климаттың өзгеруіне бейімделу саласындағы бірінші кезектегі міндеттері

	Басымдылық дәрежесі (5-тен)	Миллион АҚШ доллары	ЖІӨ %
Жаңа инфрақұрылым объектілерінің климаттың өзгеруіне тұрақтылығын қамтамасыз ету	4	221.8	0.1
Суды басқару жүйесінің климатқа төзімділігін арттыру	3	166.3	0.1
Құрғақ егіншілік жағдайында ауыл шаруашылығы дақылдарының өндірісін жетілдіру	2	110.9	0.1
Ерте ескерту жүйелерін жетілдіру	2	110.9	0.1

Ескерту: (ESCAP, 2022) деректері негізінде авторлармен құрастырылды

Агроөнеркәсіптік кешенді дамытудың 2017-2021 жылдарға арналған мемлекеттік бағдарламасы Қазақстанның 2021 жылдың соңына дейінгі кезеңге арналған ауыл шаруашылығы саясатының негізгі шеңберін айқындады. Алдыңғы негіздемелік бағдарламаның («Агробизнес-2020») қағидаттарын сақтай отырып, 2021 жылға арналған мемлекеттік бағдарламада жеке үй учаскелері мен шағын фермерлік шаруашылықтарды, ауыл шаруашылығы өндірушілерінің кооперативтерін, сондай-ақ ауыл шаруашылығын қолдау қызметтері мен инфрақұрылымын дамытуға және қолдауға көбірек көңіл бөлінеді. Сонымен қатар, шикізатты, соның ішінде тұқымдарды, тыңайтқыштарды және пестицидтерді сатып алуға кейбір субсидиялар ұлғайтылды (Әділет, 2015).

Қазақстанда өндірушілерді қолдау, әдетте, жылдан жылға айтарлықтай өзгеруде. Уақыт өте келе баға интервенциялары арқылы қолдау деңгейі бюджеттік қолдаудың пайдасына төмендеді. Алайда, көптеген жылдар бойы өндірушілерге таза қолдау оң болды, бұл соңғы он жыл ішінде өндірістік ресурстарды, атап

айтқанда несиелерді пайдалануға байланысты қолдаудың артуымен түсіндіріледі. Жалпы, ауыл шаруашылығын бюджеттік қолдаудың жалпы көлемі экономика көлемімен салыстырғанда ұлғайды және қазіргі уақытта фермерлік шаруашылықтардың жалпы түсімдерінің шамамен 2,6% -ын құрайды.

Қазіргі таңда климаттың өзгеруіне бейімделуге бағытталған саясат толыққанды жүйелі түрде қалыптаспағанымен, бұл мәселе мемлекеттік деңгейде ескерілуде. Атап айтқанда, Қазақстан Республикасында 2030 жылға дейінгі ауыл шаруашылығын дамыту тұжырымдамасында климатқа бейімделген, жоғары өнімді және экономикалық тұрғыдан тиімді аграрлық секторды қалыптастыру басым бағыттардың бірі ретінде белгіленген. Үкімет қабылдаған бейімделуге байланысты шараларға суаруды дамытуды қолдау, дақылдарды өртараптандыру және құрғақшылыққа төзімді түрлер бойынша зерттеулер мен әзірлемелер кіреді. Сондай-ақ, ел азық-түлік және ауылшаруашылық ұйымымен (ФАО) шөлейттенуге қарсы ұлттық іс-қимыл жоспарында жұмыс істейді (OECD, 2023).

Осы бағытта 2021 жылы экология, геология және табиғи ресурстар министрлігі климаттың өзгеруіне бейімделу процесін ұйымдастыру мен жүзеге асыру қағидаларын бекітті. Бұл құжат орталық және жергілікті атқарушы органдардың бейімделу шараларын жоспарлау және іске асыру тәртібін айқындайды. Сонымен қатар, онда осалдықтарды бағалау, нақты мақсаттарды белгілеу және тиімділік, орындылық, қаржыландыру мүмкіндіктері мен іске асыру мерзімдерін ескере отырып, бейімделу шараларын басымдыққа қою қажеттілігі атап өтіледі.

Қорытынды

Кешенді талдау нәтижесінде климаттық өзгерістер мен экологиялық факторлардың Қазақстанның аграрлық секторына айтарлықтай әсер ететінін дәлелдейді. Оның ішінде температуралық өзгерістер ауыл шаруашылығы өндірісінің тұрақтылығына қауіп төндіретін негізгі факторлардың бірі болып табылды. Бұл климаттық жағдайлардың нашарлауы, әсіресе температуралық ауытқулардың күшеюі аграрлық сектор өнімділігінің төмендеуіне алып келетінін көрсетеді. Осыған байланысты ауыл шаруашылығы саласында климаттық тәуекелдерді төмендетуге бағытталған бейімделу стратегияларын әзірлеу, су және жер ресурстарын тиімді пайдалану, сондай-ақ экологиялық тұрақтылықты қамтамасыз ету бойынша мемлекеттік саясатты жетілдіру маңызды болып табылады.

Қазақстанның су, ауыл шаруашылығы және жайылымдарды басқару жүйелері климаттың өзгеруіне өте осал және аймақтық айырмашылықтарды ескеретін ведомствоаралық тәсілді қажет етеді. Жер мен экожүйенің деградациясы Қазақстанда қазірдің өзінде теріс салдарға әкеліп соқтыруда, бұл климаттың өзгеруімен күшейе түседі.

Климаттың өзгеруіне бейімделудің негізгі құрамдас бөлігі су ресурстарына әсер етуді шешу болып табылады. Елдің әртүрлі аймақтарындағы судың қолжетімділігі, сұранысы, инфрақұрылым жағдайлары және климаттың өзгеруінің болашақтағы әсерлері арасындағы айтарлықтай айырмашылықтар суды басқаруда экономикалық және әлеуметтік тұрғыдан маңызды қиындықтар туғызады. Елдің артта қалған және су ресурстары ең аз аймақтары бұл қиындықтарға бейімделу және оларды шешу үшін ең аз әлеуетке ие.

Ауыл шаруашылығы саласына климаттық ауытқулардың әсерін зерттей келе бірнеше ұсыныстар беруге болады:

- Су, ауыл және жайылым шаруашылығының өзара байланыстылығына орай климаттық тұрақтылықты арттыруға салааралық тәсілді қолдану қажет;

- Жер және су ресурстарын басқарудың қолданыстағы жоспарларына, сондай-ақ су және жер заңнамасына климаттың өзгеруі мәселелерін жүйелі түрде енгізу қажет. Сонымен қатар, климаттық өзгерістердің су ресурстарының қолжетімділігі мен оған деген сұраныс арасындағы кеңістіктік және уақыттық теңгерімсіздіктерге ықпалын бағалау әдістерін жетілдіру маңызды;

- Қазақстанмен ортақ трансшекаралық өзендер ағып өтетін елдермен деректер алмасу тәжірибесін кеңейту және ынтымақтастықты нығайту маңызды. Ұзақ мерзімді перспективада су ресурстарын бірлесіп пайдалану бойынша ресми келісімдер жасасу және өңірлік институционалдық құрылымдарды күшейту қажет;

- Сумен жабдықтау және ирригациялық жүйелердің тозған нысандарын жаңғырту және модернизациялау қажет. Өнеркәсіп пен ауыл шаруашылығында су үнемдейтін технологияларды қолдану үлесін арттыру, сондай-ақ су қорларын жылдық және көпжылдық реттеуге мүмкіндік беретін көпмақсатты су қоймаларын қалпына келтіру және оңтайландыру маңызды. Болашақта, техникалық мүмкіндіктер болған жағдайда, су айналымы мен ағын суларды қайта өңдеу жүйелеріне инвестиция салу арқылы су пайдаланудың тиімділігін одан әрі арттыру қажет;

- Егіншілік құрылымын суға деген қажеттілігі төмен әрі қосылған құны жоғары дақылдарға қарай әртараптандыру қажет. Климатқа бейімделген ауыл шаруашылығы әдістерін енгізуді жеделдету үшін мақсатты ынталандыру тетіктерін (мысалы, субсидияларды ресурсты үнемдейтін технологияларды қолданумен байланыстыру) қолдану маңызды. Сонымен қатар, фермерлердің әлеуетін арттыруға бағытталған бағдарламаларды іске асыру қажет. Жаңа технологияларды сынақтан өткізу үшін мемлекеттік қаржыландырумен пилоттық жобаларды жүзеге асыру мүмкіндігін қарастыру ұсынылады. Ұзақ мерзімде ауыл шаруашылығында тұрақты әдістерді толық (100%) енгізуге және экстенсивті тәсілден тиімділікке негізделген модельге көшуге ұмтылу қажет;

- Жайылымдардың климатқа төзімділігін қамтамасыз етуде тұрақты жерді пайдалану маңызды рөл атқарады. Жайылымдарды климаттың өзгеруінің әсеріне бейімдеу үшін мал шаруашылығы мен жемшөп өндірісінің бейімделгіш-ландшафт жүйесіне көшуді қоса алғанда, тұрақты жерді пайдалану әдістерін енгізу қажет. Бұл ауысудың әсері субсидия жүйесін түзету арқылы күшейтіледі;

- Табиғи апаттардан қорғаудың табиғи бейімделу шешімдері климаттың өзгеруінен туындаған мәселелерді шешуде де маңызды. Қазақстан қазірдің өзінде су тасқыны мен селден қорғау үшін өзінің оңтүстік таулы аудандарының, әсіресе Алматының айналасындағы инфрақұрылымды дамытуға көп күш пен қаражат жұмсады. Сонымен қатар, су тасқыны қаупі бар аймақтарда су тасқынынан қорғау жөніндегі табиғи шешімдерді, соның ішінде жайылмалы экожүйелер мен сулы-батпақты жерлерді қалпына келтіруді, «жасыл» инфрақұрылым объектілерін (мысалы, қорғау белдеулерін, орман екпелерін, табиғи шалғындарды) құруды және шағын көлдер, тоғандар, буферлік су айдындары немесе су ағындары сияқты «көк» элементтерді пайдалануды жоспарлау қажет. Тозған ландшафттардың құрғақ жерлерінде

сексеуіл екпелерінің аумағын ұлғайту жоспарлары шөлейттенуді шектеуге және шаңды дауылдардың жиілігін азайтуға көмектеседі.

Қаржыландыру

Зерттеу Қазақстан Республикасы Ғылым және жоғары білім министрлігі Ғылым комитетінің ЖТН АР26103913 «Қазақстанның агроөнеркәсіптік кешені тұрақты дамудың жана өсу нүктесі ретінде: климаттың өзгеруінің ұзақ мерзімді макроэкономикалық салдарын талдау» гранттық қаржыландыру бағдарламасы шеңберінде әзірленген.

Алғыс, мүдделер қақтығысы

Авторлар мүдделер қақтығысының жоқтығын мәлімдейді.

Авторлардың қосқан үлесі

БЛА & ЭМШ: Әдістеме, деректерді жинау, тұжырымдамалау, деректерді өңдеу, авторлық қадағалау.

СПН & СДА: Зерттеу, түпнұсқа жобаны жазу, мақаланы түзету

Барлық авторлар қолжазбаның жарияланған нұсқасымен танысып, онымен келісті.

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THE IMPACT OF GOVERNMENT EXPENDITURE AND INFLATION ON ECONOMIC GROWTH: AN ARDL APPROACH WITH STRUCTURAL BREAK ANALYSIS IN NIGERIA

This study examined the impact of government expenditure and inflation on Nigeria's economic growth from 2000 to 2024 using the Autoregressive Distributed Lag (ARDL) model with structural breaks. Both short- and long-term relationships between government spending, inflation, and growth were analyzed using annual time-series data. Results indicate that government expenditure has a negative but statistically insignificant effect on economic growth in both periods, suggesting public spending has not significantly driven growth. Inflation shows a weak positive correlation, indicating minimal direct impact on growth. The model demonstrates strong explanatory power with R^2 values of 0.782 (long run) and 0.679 (short run). Significant F-statistics confirm the joint influence of variables on growth. A structural break was identified with a notable negative effect on economic growth, highlighting the adverse impact of major economic events or policy shifts. While long-run interaction effects between the structural break and explanatory variables are minor, short-run results reveal inflation's positive and significant influence on growth. The error correction term is significant and negative, indicating a stable long-run equilibrium with 68.54% of short-run disequilibrium corrected per period. The findings suggest fiscal policy alone may not sustain long-term growth without efficient expenditure management, sound policy implementation, and macroeconomic stability. The study recommends improved allocation of public spending toward productive sectors, enhanced fiscal oversight, better policy coordination, and incorporating structural break considerations into economic planning and policymaking.

Keywords: Fiscal policy, government expenditure, inflation, economic growth, structural break, ARDL Model, Nigeria.

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Мемлекеттік шығыстар мен инфляцияның экономикалық өсуге әсері: Нигериядағы құрылымдық үзілістерді талдау мен ARDL тәсілі

Бұл зерттеу 2000–2024 жылдар аралығындағы Нигерияның экономикалық өсіміне мемлекеттік шығындар мен инфляцияның әсерін құрылымдық үзілістерді ескеретін авторегрессиялық үлестірілген лаг (ARDL) моделі арқылы талдайды. Жылдық уақыттық қатарлар деректері негізінде мемлекеттік шығындар, инфляция және экономикалық өсім арасындағы қысқа мерзімді және ұзақ мерзімді байланыстар зерттелді.

Нәтижелер мемлекеттік шығындардың экономикалық өсімге теріс, бірақ статистикалық тұрғыдан маңызды емес әсер ететінін көрсетті. Бұл мемлекеттік шығындардың экономикалық өсімді айтарлықтай ынталандырмағанын білдіреді. Инфляция әлсіз оң корреляция көрсетіп, оның экономикалық өсімге тікелей әсері шамалы екенін байқатады.

Модельдің түсіндіру қабілеті жоғары, мұны детерминация коэффициентінің (R^2) 0,782 (ұзақ мерзімде) және 0,679 (қысқа мерзімде) мәндері дәлелдейді. Маңызды F-статистика мәндері айнымалылардың экономикалық өсімге бірлескен ықпалын растайды.

Экономикалық өсімге елеулі теріс әсер еткен құрылымдық үзіліс анықталды, бұл ірі экономикалық оқиғалардың немесе саясаттағы өзгерістердің жағымсыз әсерін көрсетеді. Құрылымдық үзіліс пен түсіндірмелі айнымалылар арасындағы ұзақ мерзімді өзара әсерлер шамалы болғанымен, қысқа мерзімді нәтижелер инфляцияның экономикалық өсімге оң және статистикалық маңызды ықпал ететінін көрсетті.

Қателерді түзету коэффициенті маңызды және теріс мәнге ие, бұл ұзақ мерзімді тұрақты тепе-теңдіктің бар екенін білдіреді. Әр кезең сайын қысқа мерзімді тепе-теңсіздіктің 68,54%-ы түзетіледі.

Зерттеу нәтижелері тиімді шығындарды басқару, саясатты сапалы іске асыру және макроэкономикалық тұрақтылықсыз тек фискалдық саясаттың өзі ұзақ мерзімді экономикалық өсімді қамтамасыз ете алмайтынын көрсетеді. Сондықтан мемлекеттік шығындарды өнімді секторларға тиімді бөлу, бюджеттік бақылауды күшейту, саясаттарды үйлестіруді жақсарту және экономикалық жоспарлау мен саясат қалыптастыру барысында құрылымдық үзілістерді ескеру ұсынылады.

Түйін сөздер: Фискалдық саясат, мемлекеттік шығындар, инфляция, экономикалық өсім, құрылымдық үзіліс, ARDL моделі, Нигерия.

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Влияние государственных расходов и инфляции на экономический рост: подход ARDL с анализом структурных разрывов в Нигерии

Данное исследование изучает влияние государственных расходов и инфляции на экономический рост Нигерии в период с 2000 по 2024 год с использованием модели авторегрессионно-го распределённого лага (ARDL) с учётом структурных разрывов. Были проанализированы как краткосрочные, так и долгосрочные взаимосвязи между государственными расходами, инфляцией и экономическим ростом на основе годовых временных рядов.

Результаты показывают, что государственные расходы оказывают отрицательное, но статистически незначимое влияние на экономический рост как в краткосрочном, так и в долгосрочном периодах, что свидетельствует о том, что государственные расходы не являлись существенным фактором роста экономики. Инфляция демонстрирует слабую положительную корреляцию, указывая на минимальное прямое влияние на экономический рост.

Модель обладает высокой объясняющей способностью, о чём свидетельствуют значения коэффициента детерминации R^2 , равные 0,782 (долгосрочный период) и 0,679 (краткосрочный период). Значимые значения F-статистики подтверждают совместное влияние переменных на экономический рост.

Был выявлен структурный разрыв, оказавший заметное отрицательное влияние на экономический рост, что подчёркивает негативное воздействие крупных экономических событий или изменений экономической политики. Хотя долгосрочные эффекты взаимодействия между структурным разрывом и объясняющими переменными являются незначительными, краткосрочные результаты показывают положительное и статистически значимое влияние инфляции на рост экономики.

Коэффициент корректировки ошибок является значимым и отрицательным, что свидетельствует о наличии устойчивого долгосрочного равновесия: за каждый период корректируется 68,54 % краткосрочного отклонения от равновесия.

Полученные результаты показывают, что одна лишь фискальная политика не способна обеспечить устойчивый долгосрочный экономический рост без эффективного управления государственными расходами, качественной реализации политики и макроэкономической стабильности. Исследование рекомендует улучшить распределение государственных расходов в пользу производительных секторов экономики, усилить бюджетный контроль, повысить координацию экономической политики и учитывать структурные разрывы при экономическом планировании и разработке государственной политики.

Ключевые слова: фискальная политика, государственные расходы, инфляция, экономический рост, структурный разрыв, модель ARDL, Нигерия.

Introduction

The government of Nigeria has persistently pursued various macroeconomic policy options as a means of steering the Nigerian economy towards growth and improving the living standards of its people through the means of different macroeconomic policy options. The concept of tax-and-spend policy (fiscal policy) which is one of the macroeconomic tools is continually in use by the government of Nigeria, as it is one of the major tools used in

achieving economic growth and stability. Fiscal policy as often employed by the government is an intentional action of the Nigeria government to manage its taxations, expenditures and public debts to achieve its macroeconomic aims like stabilizing price, beneficial balance of payment and sustainable economic growth implemented through its agencies. Fiscal policy role in the management of the Nigeria economy has been extensive and dynamic showing the reliance of Nigeria on oil revenue and exposure to global shocks. Over the year in Nige-

ria there have been continues increase in spending by the government to boost productivities without a substantial rise in economic growth (Amadi *et al.*, 2020). Government spending on all sectors of the country's economy are projected to result into economic growth, as these spending on public expenditures will improvement the productive base of the nation's economy, and the outcome of which will result into economic growth (Mohammed & Ibrahim, 2019).

Barro *et al.* (2023) explained public expenditure in growth model and determine the nature and connection between public spending, rate of growth and savings, he is of the opinion that any increase of resources dedicated to non-productive services will result to low production of economic goods and services, which will lead to low per capita growth. Hence, government expenditures should be spent on productive services in order to enhance economic growth. Some economic problem troubled economic growth of Nigeria such as inflation, increasing exchange rate, increasing rate of unemployment, infrastructural deficits, etc. These economic problems called for the government involvement in the controlling the economy through fiscal policy. Between the year 2000 and 2024, there are some changes that have occur in the fiscal environment of Nigeria, such as global financial crisis between 2008 and 2009, fall in oil price between 2014 and 2016, 2020 tax reforms including increase VAT from 5% to 7.5% and the emergence of COVID-19 in the year 2020, all of which have cause some disruption in Nigeria economic growth. These fiscal changes have prompted the Nigeria government to implement emergency fiscal interventions such as debt relief initiatives and social investment programmes to cushion the effect of the economic shocks (Verivafrika, 2025).

In Nigeria, diverse fiscal policies measures have been implemented and the economic growth has been slow and the standard of living of the citizen of the country is not improving and unemployment level is increasing, level of poverty is also increasing day by day and inadequacy of infrastructures. Therefore, the investigation of the effects of some fiscal policy tools on Nigeria economic growth over the years is necessary so as to evaluate their contribution or otherwise. Therefore, it calls for the attention of the researcher to study the impact of fiscal policy on Nigeria economic growth. The current fiscal situation globally due to fluctuation in the oil prices and the removal of fuel subsidy in Nigeria coupled with high inflation rate and increase in exchange rate in the coun-

try which have adversely affected virtually every households and businesses in Nigeria and also affecting the level of production and consumption of economic goods and services in the Nigeria. During the period under review Nigeria economy has experienced multiple disruptions such as financial crisis that occur globally between 2008 and 2009, oil price collapse between 2014 and 2016 and COVID-19 pandemic in the year 2020 that can cause structural breakdown (Verivafrika, 2025). Despite an abundance of natural resources and a youthful population, the country has faced persistent economic challenges characterized by low growth rates, high unemployment, and significant poverty levels. Fiscal policy, which includes tax revenue, government expenditure and public debts, plays a critical role in shaping economic outcomes. However, the effectiveness of Nigeria's fiscal policies in promoting sustainable economic growth remains uncertain.

While there have been various fiscal reforms implemented within the years under study, such as the establishment of debt management office in the year 2000 to centralized the management of Nigeria public debt, oil price based fiscal rule and excess crude account in the year 2000 to manage Nigeria oil revenue volatility, fiscal responsibility act 2007 to enforce fiscal discipline, budget reform act by adopting multi-year budgeting through medium term expenditure framework (MTEF), unification of exchange rates in 2023 and fuel subsidy removal in the year 2023 (Olufemi, 2024). Most of the policy reforms in Nigeria fail as a result of weak public finance management, weak oversight, corruption, political economy challenges, debt accumulation and servicing pressure implementation gaps. Existing studies have documented a range of outcomes, but many have focused on isolated aspects of fiscal policy, overlooked the effect of any structural changes and the broader economic context within which these policies operate. Moreover, the volatility of the naira and the impact of global economic conditions, including fluctuations in oil prices, pose further challenges to the success of fiscal interventions in Nigeria.

There is need to examine how this fiscal policy variable interact with economic growth, considering the unique structural challenges faced by Nigeria. By means of empirical evidence, this research will contribute to the existing literature by revealing the effectiveness of fiscal policy in the contexts of growth and economic stability in Nigeria, thereby informing policymakers about effective strategies to

harness fiscal tools for national development. The main objective of the study is to evaluate the impact of fiscal policy on economic growth in Nigeria.

To achieve this goal, the following objectives are set:

1. To assess the impact of fiscal policy on economic growth in Nigeria?
2. To check if there is significant structural breakdown in the Nigeria economic growth?
3. To assess the effect of structural breakdown on economic growth in Nigeria?

Literature review

Tax-and-spend policy can be define as a deliberate action taken by the government of a country on public spending and tax levying on every citizen of the country with the aim of prompting its macroeconomic variables, like employment level, level of aggregate demand, general price level and level of national income in a desired direction (The Economic Times, 2025). Fiscal policy can also be referring to as the use of expenditure and taxation by the government to stimulate the economy. Fiscal policy is a macroeconomic policy option is crucial for controlling economic performance, inflation and employment. International Monetary Fund (2025) define fiscal policy as a way of influencing the economy through taxation and government spending. Generally, most government use fiscal policy to boost sustainable growth and reduce poverty. According to Mellisya, (2025) sees it as tax policies and expenditure by the government to control economic conditions, particularly macroeconomic conditions, which include economic growth, employment, inflation and aggregate demand. Oguejiofor *et al.* (2024) define fiscal policy as the process of influencing a nation's economic activities through the use of tax and expenditure. Dwivedi (2009) refers to fiscal policy as a government programmes for achieving certain national goals through taxation, government expenditure and other financial operations.

Economic growth can be regarded as an increase in the overall production of goods and services in an economy throughout a certain period that is both positive and continuous. Jiaqi (2024) define it as a raise in economic goods and services in a period or year compared with previous year or period. Cornwall (2025) define economic growth a raise in a country wealth over time. It is a raise in a nation's wealth over an extended time period. It is an improvement in the inflation adjusted economy in a financial year. According to Reserve Bank of Aus-

tralia (2025) define it as arise in the volume of the economy of a nation over a year. GDP is typically used to measure the sizes of the economy. it can be measured in either real term or nominal term. When there is raise in the volume of goods and services only, which takes away the effect of price changing it is refers to real economic growth rate as it is better to reflects how much a country is producing at a given period of time, compared with another points in time. When there is a raise in dollar which leads to changes in both volume produced it is refers to nominal economic growth. There is positive economic growth when there is a raise in the growth of an economy over a specific period of time. While a negative economic growth is connected with economic recession and depression.

Karl (2025) define inflation as the as a general or universal raise in prices or an increase in the money supply, both of which can cause a country's currency purchasing power to decline. Jason (2025) explain that inflation is a continuous or gradual loss of purchasing power that is reflected in a comprehensive rise in price. Inflation is calculated as the average price increase of a chosen goods and services over one year. The root of inflation in any economy is the increase in the money supply, shortage of key goods and supply bottlenecks. Inflation can come in various ways, it may be demand pull inflation which occur as a result of increase in the supply of money and credit stimulates the overall demand for goods and services to rapidly increase than the economy's production capacity, this will increase demand and leads to rice in price. Inflation can also be cost push inflation which is caused as a result of the rise of the inputs employed in the production process.

The theoretical background of this study is centered on "financing and macro stability theory". The theory explains the link between the public expenditure and economic growth. According to this theory, the issue as to whether the government spending will boost the growth of the economy lies not just on the level of expenditure but also on the type of macroeconomic and financing environment within which the expenditure is made. In most nations (Nigeria included), it is only possible for expenditure to lead to growth provided that such expansion in expenditure does not result in a disturbance in the levels of inflation, exchange rate, interest rate and debts. Public spending is mainly funded by one (or any combination) of either tax revenues or borrowing from either internal or external sources, monetizing (printing of money) and aid (mainly through foreign source). This is because according to the

macroeconomic stability theory, when there is a sustainable funding of the expenditure, it will result in economic growth while unsustainable spending leads to economic instability.

The theoretical background of this study is centered on “financing and macro stability theory”. The theory explains the link between the public expenditure and economic growth. According to this theory, the issue as to whether the government spending will boost the growth of the economy lies not just on the level of expenditure but also on the type of macroeconomic and financing environment within which the expenditure is made. In most nations (Nigeria included), it is only possible for expenditure to lead to growth provided that such expansion in expenditure does not result in a disturbance in the levels of inflation, exchange rate, interest rate and debts. Public spending is mainly funded by one (or any combination) of either tax revenues or borrowing from either internal or external sources, monetizing (printing of money) and aid (mainly through foreign source). This is because according to the macroeconomic stability theory, when there is a sustainable funding of the expenditure, it will result in economic growth while unsustainable spending leads to economic instability.

Saputra *et al.* (2025) analyzed local expenditure policies implemented by the Aceh government, using per capita income as a mediating variable. The analysis was conducted using the Random Effects Model (REM) and panel data from 23 districts/cities from 2011 to 2021. Findings revealed capital expenditure and social assistance expenditure negatively impact inclusive growth, whereas grant expenditure and per capita income have a positive effect. Additionally, the findings indicate that per capita income mediates the impact of capital expenditure on inclusive growth but does not mediate the effects of grant expenditure or social assistance on inclusive growth. Therefore, the study proposed improve governance, budgeting policies, and regional expenditures in a more sustainable and targeted manner to promote inclusive growth and achieve more equitable welfare for all people in Aceh Province.

The article by Adesodun and Isaac (2025) discusses the fiscal policy growth nexus in Nigeria. They employed trend analysis, descriptive statistics, and OLS regression to analyze the data. Expo factor design and a quantitative research approach were used. Secondary data was collected from 1986 to 2023 by the FIRS and the National Bureau of Statistics. The findings indicate that government expenditure has a significant and positive effect on

the economic growth of Nigeria whereas tax revenue has a positive correlation with GDP and public debt has a negative but non-statistically significant effect on GDP. It was agreed that, even though the contributions of tax revenue and public debt are still limited for the time being, government spending is the main driver of economic growth in Nigeria. The research results advise the policymakers to adopt the proper fiscal method of public spending to develop the economy of Nigeria in the long term, as efficient public spending is the way to go.

Ele *et al.* (2024) focused on the influence of fiscal policy variables on Nigeria economic prosperity. Data analysis was done using OLS method. Secondary data was employed to draw out information. The result indicate that government expenditure positively and significantly influences Nigeria’s GDP, while taxation drive an adverse significant effect on Nigeria’s GDP. Reduction in spending when tax rate is high was proposed, this will balance effect and normalize growth, government should review the tax rates downward because it is hitting hard on the aggregate economic output.

Ali Saif *et al.* (2024) considered the dynamics between good governance, fiscal policy and economic growth in Oma. Quantitative Research design and secondary sources of data was used. The analysis used to analyze the data was OLS regression and ARDL Model. The analyzed data show that there is bidirectional causal connection, the Regulatory Quality Index, Good Governance Index, and economic growth have established a relationship, whereas the Government Efficiency Index, Fiscal Policy Effectiveness, and Rule of Law Index have demonstrated one-way causality leading to GDP. Budget Balance indicate no causal bond with GDP. According to the study, sustainability of economic growth can be achieved through the improvement of governance practices, the enhancement of fiscal policy effectiveness, and the promotion of digital financial inclusion

Alli-Momoh *et al.* (2024) investigate the relationship between fiscal policy and the economic growth of Nigeria. Secondary data sources were applied for data collection and analysis; the result shows a direct link between recurrent expenditure and economic growth, while there was a reversed link between capital expenditure and economic growth, as well as taxes and economic growth. This has led to improvement in both tax policies and government spending.

Muhammad *et al.* (2024) studied the nature of relationship between public spending and long-run

economic growth depends upon the institutional quality of a country. The techniques of analyses used in the study were. Panel method of data analysis of 113 developed and developing economies was used. The result indicates that the relationship between the public size and growth effects was mostly felt in the country with a poor institutional quality, while the growth inhibiting effects of government size become insignificant.

Ejinkonye *et al.* (2023) studied the influence fiscal policy on Nigeria's economy growth. Secondary sources of data were used and OLS as technique for analysis. The results demonstrate that revenue positively but non-significantly impact GDP, capital expenditure negatively and non-significantly impact, and recurrent expenditure positively and significantly impact. It was suggested that the Nigeria government make sure that its revenue base is increased and varied, monitor and assess spending to prevent waste, and guarantee that recurring expenditures and capital expenditures are properly channeled.

Jane *et al.* (2023) investigated the impact of fiscal policy on the economic growth of Nigeria. Secondary source of data was used and Johansen Co-integration for analysis. The finding shows that the connection between GDP and public debt, tax revenue and expenditure was linear. Total government expenditure is positively related to GDP, while public debt and revenue from taxation were negatively connected with GDP. The recommendation was that Nigeria government to jack-up expenditure on economically feasible investment and that all government expenditures should be well monitored.

Girma *et al.* (2023) analyzed Effect of Public Expenditure on Economic Growth of Ethiopia from the year 1980 to 2018. Secondary sources of data collection were utilized. The johansen cointegration test and VECM are used for analysis. The finding shows that economic growth negatively impacts expenditure on agriculture in the long term. GDP positively and impact by expenditure on education in short run and long run. Investment spending also positively but negligible effect on growth in the long run, however in the short run investment present a negative but huge effect. The study reviewed that government spending on education sector would help assist in having higher labour force which will result to higher economic growth. Thuy *et al.* (2023) examined the relationship between tax revenue and economic growth, including the intermediate role of trade openness, in developing countries. between the year 2000 to 2020. The study used the generalized least squares (GLS) and the fixed effect

model (FEM). The results of the analysis show that in general tax revenue positively affects GDP and trade openness increases the positive connection between GDP and tax revenue. The findings of the study reviewed that increasing tax and trade openness provides an important implication for developing countries.

Ezenwobi *et al.* (2022) examined the resultant impact of government borrowing on economic development from 1990 to 2020. Secondary source of data was used, multiple regression model was used to analyze data. The findings show a positive statistically significant bond between external debt and economic development. Similarly, positive statistically significant relationships have been established among domestic debt and economic development. The study suggests that the government should direct borrowed funds to sectors that promote growth in the economy

Elham (2022) studies the long-term connection between disaggregated government expenditure and economic growth in Jordan from 1990 to 2019. The secondary source of data was used and the Granger cointegration test, fully ordinary least squares (FMOLS) and ARDL was used as techniques for analysis. The findings indicate that recurrent expenditure negatively affects economic growth in the long run, while government capital expenditure has a long-lasting positive effect on economic growth. In order to increase its positive investments and reduce recurrent expenditure it was recommended in the study that government of Jordan should implement some procedures.

The following hypotheses are formulated accordingly:

HO1: There is not significant impact of fiscal policy on economic growth in Nigeria?

HO2: There is no significant structural breakdown in the Nigeria economic growth?

HO3: There is no significant effect of structural breakdown on economic growth in Nigeria?

Methodology

The study utilized quantitative data analysis, employing an Autoregressive Distributed Lag (ARDL) approach to analyze time-series data and examine trends in selected variables over time. It relied on secondary data sources, focusing on existing records from 2000 to 2024. Real GDP growth rate, government spending, and inflation rate were the variables being studied, and they were found in the 2024 CBN Statistical Bulletin. The model is specified as follows:

$$RGDP = f(FP) \quad (1)$$

The functional model including the control variable

$$RGDP = f(GOVE, INF) \quad (2)$$

The econometry model is given below:

ARDL model (short-run form)

$$\begin{aligned} \Delta RGDP_t = & \alpha_0 + \sum_{i=1}^{p} \phi_i \Delta RGDP_{t-i} + \\ & + \sum_{j=0}^{q} \theta_j \Delta GOVE_{t-j} + \\ & + \sum_{k=0}^{r} \psi_k \Delta INF_{t-k} + \\ & + \lambda_1 RGDP_{t-1} + \lambda_2 GOVE_{t-1} + \\ & + \lambda_3 INF_{t-1} + \lambda_4 Dt + \lambda_5 GOVE_{t-1} Dt + \\ & + \lambda_6 INF_{t-1} Dt + \varepsilon_t \end{aligned} \quad (3)$$

ARDL Long-run (cointegrating) relationship

$$RGDP_t = \beta_0 + \beta_1 GOVE_t + \beta_2 INF_t + \beta_3 Dt + \beta_4 GOVE_t Dt + \beta_5 INF_t Dt + u_t \quad (4)$$

Error-Correction Representation (ECM)

$$\begin{aligned} \Delta RGDP_t = & \phi (RGDP_{t-1} - [\beta_0 + \\ & + \beta_1 GOVE_{t-1} + \beta_2 INF_{t-1} + \beta_3 D_{t-1} + \\ & + \beta_4 GOVE_{t-1} D_{t-1} + \beta_5 INF_{t-1} D_{t-1}]) + \\ & + \sum_{i=1}^{p-1} \alpha_i \Delta RGDP_{t-i} + \\ & + \sum_{j=0}^{q-1} \theta_j \Delta GOVE_{t-j} + \\ & + \sum_{k=0}^{r-1} \psi_k \Delta INF_{t-k} + \eta_t \end{aligned} \quad (5)$$

Where:

RGDP = Real Gross Domestic Product growth rate (proxy for economic growth), FP = Fiscal Policy, GOVE = Total Government Expenditure, INF = Inflation Rate (control variable), D = Dummy variable capturing structural breaks, α and β = Regression Parameters, p,q,r = lag orders,

λ = long run equilibrium, ϕ = the speed of adjustment coefficient, ε_t = short-run error term (white noise) and μ_t = long-run disturbance.

RGDP rate is the dependent variable. It is used to measure economic growth. Fiscal policy, which is defined by government expenditures is the study's independent variable. The inflation rate is the control variable.

Results and discussion

Table 1
Descriptive Statistics

	RGDP	GOVE	INF
Mean	5.313200	6395.262	13.85400
Median	5.390000	4210.060	12.90000
Maximum	14.60000	34494.25	31.43000
Minimum	-1.790000	701.0500	5.400000
Std. Dev.	3.845136	7360.887	5.705900
Skewness	0.274151	2.519008	1.238342
Kurtosis	3.064890	9.711922	4.993187
Jarque-Bera	0.317548	73.36616	10.52788
Probability	0.853189	0.000000	0.005175
Sum	132.8300	159881.5	346.3500
Sum Sq. Dev.	354.8417	0.0000000013	781.3752
Observations	25	25	25

Note: authors' computation

Table 1 above. The mean value of RGDP, GOVE, and INF is 5.31%, N6395.26b, and 13.85% respectively, and the median of RGDP, GOVE, and INF is 5.39%, N4210.06b, and 12.9% respectively. According to the standard deviation values, RGDP

varies from the mean by 3.85%, GOVE varies from the mean by N7,360.89b, and INF varies from the mean by N5.71%. The value of skewness of RGDP is positive i.e. 0.274151 with a long right tail. Similarly, the value of skewness of GOVE and INF is

2.519008, and 1.238342 respectively with long right tails. This is a desirable condition for normal distribution. Furthermore, RGDP, GOVE, and INF are leptokurtic, and the value of kurtosis is 3.06, 9.71, and 4.99 respectively, which are greater than three. This is the best distribution. For RGDP, the Jarque-Bera probability is 0.853189 which is higher than 0.05 hence we accept the null hypothesis that RGDP distribution is normally distributed. On the other hand, for the variable GOVE, its Jarque-Bera probability is 0.0000, while INF Jarque-Bera probability is 0.005175; both of them are lower than 0.05. We, therefore, reject the null hypothesis because their probabilities are statistically significant.

The correlation analysis presented in Table 2 was used to examine the relationships among RGDP, GOVE, and INF. Both Government Expenditure (GOVE) and Inflation (INF) exhibit a moderate negative linear relationship with Real GDP growth rate (RGDP), indicating that increases in GOVE and INF are associated with decreases in RGDP. Additionally, there is a strong positive linear relationship between Government Expenditure (GOVE) and In-

flation (INF), suggesting that as GOVE rises, INF tends to increase correspondingly.

Table 2
Correlation matrix

	RGDP	GOVE	INF
RGDP	1		
GOVE	-0.417781	1	
INF	-0.183575	0.768502	1

Note: authors' computation

Unit Root Test

This was tested to check the order to ascertain the order of integration of the variables. (ADF) test was used to establish if the data is stationary (absence of unit root) or non-stationary (present of unit root).

The unit root using the ADF was presented in table 3 shows that RGDP, LGOVE, and INF are all stationary at 1st difference.

Table 3
ADF UNIT ROOT

VARIABLE	ADF T-STAT. VALUE	1% CRITICAL VALUE	5% CRITICAL VALUE	10% CRITICAL VALUE	ORDER REMARKS	T-STAT PROB.
RGDP	-6.2099	-3.7530	-2.9981	-2.6388	I(1) STATIONARY	0.0000
LGOVE	-2.7073	-3.7530	-2.9981	-2.6388	I(1) STATIONARY	0.0880
INF	-5.4890	-3.7530	-2.9981	-2.6388	I(1) STATIONARY	0.0002

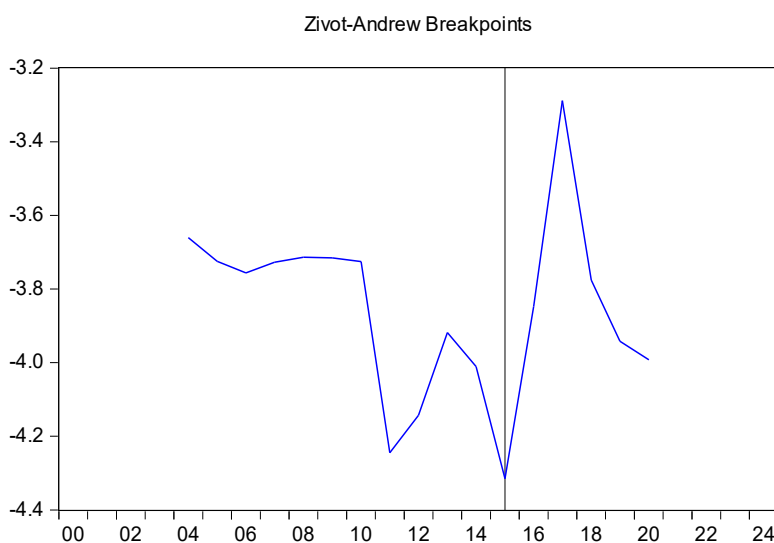
Note: authors' computation

Table 4
Zivot-Andrews Test

Chosen break date: 2015		
	t-Statistic	Prob. *
Zivot-Andrews test statistic	-4.314975	0.040350
1% critical value:	-5.34	
5% critical value:	-5.93	
10% critical value:	-4.58	

Note: authors' computation

Figure 1
Zivot-Andrew Breakpoints Figure



Note: authors' computation

The Zivot-Andrews test identified 2015 as the structural break date in the data series, with a test statistic of -4.315 and a p-value of 0.0404. This test statistic is higher than the 1% and 5% critical values of -5.34 and -5.93, respectively, but slightly lower than the 10% critical value of -4.58. Therefore, the test statistic of -4.315 and corresponding p-value of 0.040 indicate rejection of the null hypothesis of a unit root at the 5% sig-

nificance level. This finding implies that the series is stationary once the structural break is taken into account. As the Zivot-Andrews test shows that there is a structural break in the year 2015, a statistical analysis will be run for all the variables including the dummy variable that represent the structural break using the Auto-regressive Distribution Lag (ARDL) model.

ARDL Regression analysis

Table 5
ARDL Regression analysis

Variable	Coeff	Std. r	t-Stat	Prob
RGDP (-1)	-0.068549	0.210629	-0.325448	0.7493
LGOVE	-2.299992	1.382366	-1.663808	0.1169
INF	0.017099	0.198347	0.086205	0.9324
INF(-1)	0.236688	0.152868	1.548313	0.1424
DUMMY	-42.80167	23.99982	-1.783416	0.0948
LGOVE*DUMMY	4.930689	2.924743	1.675542	0.1145
LGOVE(-1)*DUMMY (-1)	-0.431095	0.349992	-1.231729	0.2370
INF* DUMMY	-0.177069	-0.578028	-0.578028	0.5718
C	23.22741	1.807568	1.807568	0.0908
R ²	0.782027	Mean dependent variable		5.304583
Adjusted R ²	0.665775	S.D. dependent variable		3.927590
F-statistic	6.726994	D-W		1.978908
Prob. (F.Static)	0.000815			

Note: authors' computation

The ARDL Regression model as show in table 5 above shows that Government expenditure (LGOVE) shows a negative coefficient of -2.3000 with a p-value of 0.1169, suggesting that the dependent variable tends to decrease as government spending rises. Nevertheless, at the standard 5% threshold, this effect is not statistically significant. In a similar vein, the current inflation rate (INF) has a p-value of 0.9324 and a positive coefficient of 0.0171, showing a small and statistically insignificant impact on the dependent variable. With a p-value of 0.1424 and a positive coefficient of 0.2367, the lagged inflation rate INF (-1)] is likewise statistically insignificant. With an R^2 value of 0.782, the regression findings show that the model has a significant explanatory power, meaning that the explanatory variables included account for about 78.2% of the variability in the dependent variable. The modified R^2 of 0.666 further indicates that the model explains roughly 66.6% of the variation in the dependent variable after taking the number of regressors into account. The model is statistically significant overall, with an F-statistic of 6.727 and a corresponding probability value of 0.000815, indicating that the explanatory factors jointly affect the dependent variable. Additionally, the Durbin-Watson statistic of 1.979, indicates that there is not any significant autocorrelation in the residuals. The regression model explains approximately 78.2% of the variation in the dependent variable ($R^2 = 0.782$), with an adjusted R^2 of 66.6% indicating strong explanatory power after accounting for the number of predictors. The model is statistically significant overall, supported by an F-statistic of 6.727 ($p = 0.000815$), confirming that the explanatory variables jointly affect the dependent variable. The Durbin-Watson statistic of 1.979 suggests no serious autocorrelation in the residuals. The struc-

tural change over the study period was linked to a decrease in the dependent variable, according to the structural break dummy variable, which has a negative coefficient and is significant at the 10% level. The effects of inflation and government spending may have changed throughout the structural break, according to the interaction terms, but these changes are not statistically significant.

ARDL Bounds Cointegration Test

Table 6
Bounds Test

	VALUE	K
F-stat	4.753060	5
Crit-v		
Signi	I (0)	I (1)
10%	2.26	3.35
5%	2.62	3.79
2.5%	2.96	4.18
1%	3.41	4.68

Note: authors' computation

Table 6 present the result of the bounds test to check if there is a lasting connection in the model. From the result since the value of F-statistics of 4.753060 is larger than the upper critical value I(0) and lower critical value I(1) at 5% critical value of 2.62 and 3.79 respectively, this shows that there is present of co-integration in the bounds test. This suggest a long run connection. As the lower critical value I(1) is less than the F-statistics value, so we run the Error Correction Model (ECM).

Table 7
ARDL Long run Dynamics

VARIABLES	Coff	Stdr	T-stat	Prb
LGOVE	-2.299992	1.319432	-1.631342	0.1169
INF	0.2375506	0.240370	0.988087	0.3388
DUMMY	-42.80167	22.65275	-1.768257	0.0948
LGOVE*DUMMY	4.210940	2.727485	1.543891	0.1434
INF*DUMMY	-0.165710	0.283503	-0.584508	0.5676

Note: authors' computation

According to the regression analysis shown in table 7, LGOVE has a non-significant effect with a negative coefficient of -2.15 (standard error 1.32), a t-statistic of -1.63, and a p-value of 0.12. INF is likewise not significant, with a positive coefficient of 0.24 (standard error of 0.24), a t-statistic of 0.99, and a p-value of 0.34. The DUMMY variable has a t-statistic of -1.77, a marginally significant p-value of 0.10, and a huge

negative coefficient of -42.80 ($p = 0.0948$) and (standard error 22.65). LGOVE*DUMMY with a coefficient of 4.21 (standard error 2.73), t-statistic 1.54, and p-value 0.14 and for the interaction term of INF*DUMMY with -0.17 (standard error 0.28), t-statistic -0.58, and p-value 0.57, neither interaction is statistically significant. All these explains how they affect the structural break in the long run

Table 8
Error Correction Model (Short Run Dynamics)

ECM REGRESSION VARIABLES	Coeff	Stdr	t-sta	Prb
C	23.22741	3.759372	6.178535	0.0000
D(INF)	0.017099	0.089984	0.190018	0.8518
D(DUMMY*LGOVE)	4.930689	5.481703	5.481703	0.001
Coin. Eq. (-1)	-0.685429	0.173286	-6.166400	0.0000
R-Squared	0.679218	F-Statistics		14.11589
Adjusted R ²	0.631101	Prob. (F-Statistics)		0.000036
Durban-W			1.978908	

Note: authors' computation

The short run dynamics as shown in table 8 analyze the immediate fluctuations of the variables in relation to the correction term. It shows, inflation (INF) has a little positive and insignificant effect on RGDP. Indicating that increase in inflation (INF) by 1% in the short run will cause an increase in RGDP by 0.017 units. The interaction of structural break with inflation (INF) shows a positively and statistically significantly impact on RGDP, an increase in inflation (INF) by 1% after interaction with structural break result in 4.93 units increase RGDP. The Co-integration equation (Coin Eq (-1)) is statistically significant and shows that the previous error will be corrected and integrated at a speed of 68.54% from the short run period to long run period. Is that previous errors will adjust back to equilibrium at a speed of 68.54% after shocks. The R-square value of 67.92% indicates a good fit and significant of the model is also very good one with a probability of less than 0.05. The explanatory factors account for 67.92% statistical mean variance of (RGDP) as indicated by R² of 0.679218, the remaining 32.08% was accounted for exogenously but are reflected by the disturbance term. The adjusted R-square (Adj

R²) shows that 63.11% of the change in economic growth (RGDP) in Nigeria can be explained by fiscal policy. This shows that fiscal policy can enhance growth. Also, fiscal policy variables in the model have significant effect on the Nigeria economic growth the value of the exogenous variable is represented by intercept (c), which is 23.22741 when all explanatory factors are zero. The D. W statistic shows no autocorrelation among the variables with a coefficient value of 1.978908, which is within the acceptable range of 1.79 to 2.50.

Diagnostic Test

Serial correlation Test

Table 9
Serial correlation Test

Breusch-G test			
F-statistic	0.438783	Prob. F(2,6)	0.7222
Obs*R ²	1.635526	Prob. Chi(2)	0.5565

Note: authors' computation

The Breusch-Godfrey test results determine whether or not a regression model's residuals contain autocorrelation. The F-statistic value is 0.4388, with a corresponding p-value of 0.7222 (Prob. F(2,6)), suggesting that the null hypothesis of no autocorrelation cannot be rejected at typical significance levels. Similarly, the Obs*R² statistic is

1.6355 with a p-value of 0.5565 (Prob. Chi(2)), indicating no significant autocorrelation in residuals. Overall, both test statistics indicate that the regression model's residuals do not show autocorrelation, meaning that the error terms are independent across observations, validating the model's conclusion.

Heteroskedasticity Test

Table 10

Heteroskedasticity Test

Heteroskedasticity Test: Breusch-Pagan- Null hypothesis: Homoskedasticity			
F-statistic	1.323958	Prb F(15,8)	0.6774
R ²	17.10824	Prob. Chi-2(15)	0.5790
Scales SS	2.789803	Prob. Chi-2(15)	0.9583

Note: authors' computation

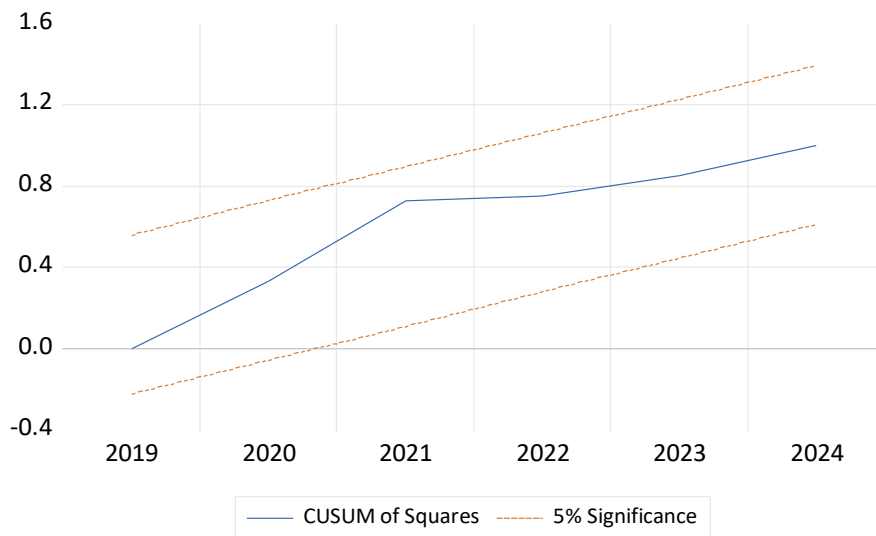
The Breusch-Pagan test results show that the null hypothesis of homoskedasticity is not rejectable. The F-statistic of 1.324 ($p = 0.6774$), R² based statistic of 17.108 ($p = 0.5790$), and Scales SS statistic of 2.790 ($p = 0.9583$) indicate that the residuals'

variance is consistent across data. This means that there is no evidence of heteroskedasticity, verifying the regression model's homoskedasticity assumption and supporting the model's estimate reliability.

Stability diagnostics test

Figure 2

Stability diagnostics



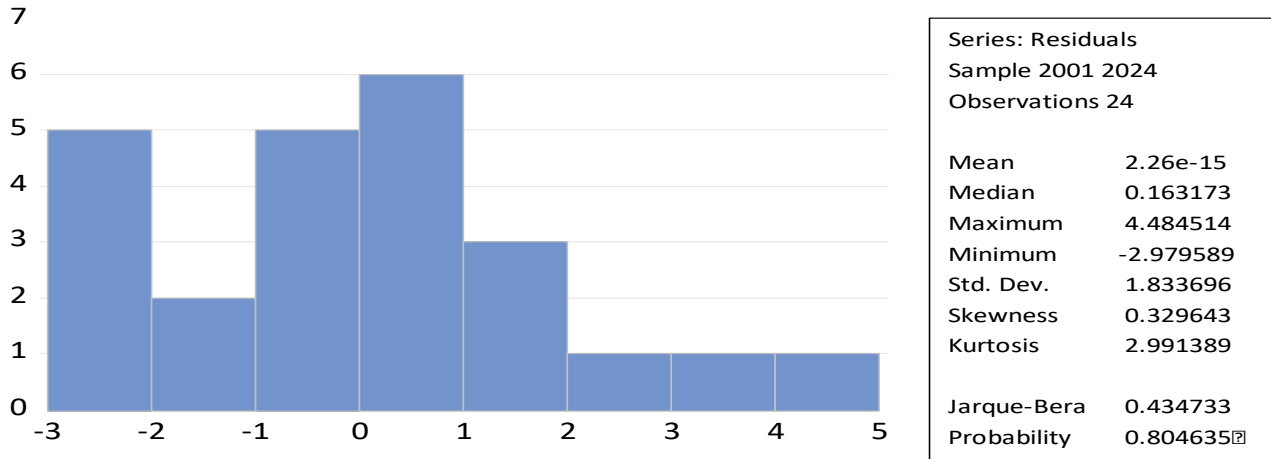
Note: authors' computation

Stability test verifies whether the model's parameters are dependable and consistent, guaranteeing that the model's predictive capability and inference stay valid during the study time. Therefore, the figure 3 above shows that there is stability in the

regression model parameters. It was shown that the model is stable as the blue line is in between the red line, which means that it lays between the 5% significance level.

Normality Test

Figure 4
Normality Test



Note: authors' computation

From figure 4 above the Jarqu-Bera probability of 0.804635 is larger than 0.05, so we accept the normality that residual is normally distributed.

The discoveries of this study are summarized below: It was established in the finding that there is structural breakdown in the time series of the dependent variable. Overlooking structural change in macroeconomic time series relationship can be dangerous as forecast. The finding also established the presence of a co-movement from fiscal policy to growth in Nigeria. The relationship between Total Government Expenditure (GOVE) and Real Gross Domestic Product growth rate (RGDP) is negative and statistically insignificant in the long run this aligns with crowding out effect theory that says public spending displaced private investment, potentially harming growth over time. The relationship between Inflation (INF) and Real Gross Domestic Product growth rate (RGDP) positively but statistically insignificantly. The structural break which is represented by dummy variable also have a large negative effect on growth of Nigeria in the long run but marginally significant at 10% level. Although total government stands as a major determinant of growth in Nigeria and implying insufficient evidence that government expenditure reliably impacts

real GDP rate in the long run and the interaction term shows that fiscal policy impacts are sensitive to structural break represented by dummy.

The study shows that Nigeria economic growth is insignificantly affected by change in fiscal policies, inflation and structural shifts.

In conclusion, the effect of fiscal policy on Nigeria's economic growth is negative and insignificant, and inflation (INF) has a positive but insignificant effect on Nigeria's economic growth, a structural breakdown exists in Nigeria's economic growth in the year 2015 and the impact of the structural break is negative and marginally statistically significant on growth of Nigeria in the long run.

The results of the ARDL analysis show that during the research period, inflation and government spending had no direct impact on Nigeria's economic growth. Despite having a negative coefficient in both the short-run and long-run estimates, government expenditure (LGOVE) has a statistically insignificant impact, indicating that increases in government spending have not resulted in appreciable improvements in economic growth. This result could be the result of ineffective fiscal policy execution, inefficient public expenditure allocation, or the concentration of government expenditures

in unproductive areas. In a similar vein, inflation shows a positive but negligible correlation with economic growth, suggesting that variations in the inflation rate did not significantly impact growth performance throughout the reviewed period. As seen by the R^2 values of 0.782 in the long run and 0.679 in the short run, the regression findings also show that the model has significant explanatory power. It is confirmed by the statistically significant F-statistics that economic growth is jointly influenced by the explanatory variables. The calculated model's reliability is supported by the Durbin-Watson statistics, which are near to 2 and show no serial correlation. The existence of a structural break, indicated by the dummy variable, that has a detrimental and marginally significant impact on economic growth is one of the study's key conclusions. This implies that the selected break period's economic event or policy change had a negative impact on Nigeria's growth trajectory. The link between fiscal policy variables and economic growth may have changed after the structural break, even though the interaction terms coupling government spending and inflation with the break are not statistically significant over the long term. In the medium term, inflation continues to have a slight but favorable impact on economic expansion. Nonetheless, there is a positive and statistically significant interaction between inflation and the structural break, suggesting that inflation had a favorable impact on economic growth during the post-break period. A steady long-term link between the variables is also confirmed by the fact that the error correcting mechanism is statistically significant and negative. With more than two-thirds of disequilibrium adjustments taking place in a single period, the speed of adjustment coefficient of roughly 68.54% shows that deviations from long-run equilibrium are adjusted somewhat quickly.

Conclusions

This study used an ARDL model to evaluate how inflation and fiscal policy affected Nigeria's economic growth while taking structural breaks into consideration. The findings demonstrate that inflation and government spending have no long-term statistically meaningful effects on economic growth. However, the model as a whole shows strong explanatory power and is statistically significant, suggesting that all of the factors have an impact on economic growth. Additionally, the analysis proves that there was a structural rupture that had a detrimental impact on economic growth during the study period. The short-term results

show that inflation positively in-teracted with the structural break to affect economic growth, even if the long-term interaction effects of fiscal policy variables with the structural break are generally negligible. A stable long-run equilibrium relationship between the variables is also confirmed by the considerable error correction term, which also shows a comparatively quick adjustment process af-ter economic shocks. Overall, the results imply that fiscal policy actions by themselves might not be enough to promote long-term economic growth un-less they are combined with macroeconomic stabil-ity, efficient resource allocation, and successful pol-icy implementation. The data also emphasizes how crucial it is to take structural changes into account when developing and accessing Nigeria's economic strategies.

Policy recommendations

Based on the findings of the study, the following policy recommendations are proposed:

1. Government should improve the efficiency and productivity of public expenditure by directing spending toward growth-enhancing sectors such as infrastructure, education, healthcare, agriculture, and technology. This would ensure that public spending contributes more effectively to economic growth.
2. Given the negative effect of the structural break on economic growth, government should develop proactive policy frameworks capable of mitigating the adverse effects of economic shocks, policy changes, and external disturbances on the economy.
3. Economic planning should incorporate structural-break considerations when designing fiscal and monetary policies, as ignoring significant economic shifts may lead to ineffective policy outcomes.

Ajagbe et al: Funding

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Author Contributions

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AOA: literature review, collection of statistical data, interpretation of research results, development of the article structure, and manuscript formatting.

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ECONOMIC POTENTIAL OF GREEN TECHNOLOGIES DIGITALIZATION FOR ACHIEVING CARBON NEUTRALITY IN KAZAKHSTAN

The research problem lies at the intersection of the climate and digital agendas of the Republic of Kazakhstan – a country that simultaneously ranks among the world's twenty largest greenhouse gas emitters and has committed to carbon neutrality by 2060. The purpose of the work is to quantify the synergetic economic effect of the joint deployment of digital and green technologies in Kazakhstan's energy sector. The scientific significance consists in extending the twin-transition concept to the class of resource-dependent economies with coal-dominated generation; the practical significance – in designing an operational framework for national decarbonization programmes. The methodology combines a five-vector effect decomposition through the explicit formula $E = \sum B_i \cdot R_i \cdot k_i \cdot P_i$, three-scenario modeling (business-as-usual, target, breakthrough), and comparative analysis of experience from Germany, China, Denmark, and the United States. Main results: under the target scenario, the direct annual economic effect by 2030 is estimated at USD 615–835 million, rising to USD 3.2–4.1 billion (1.0–1.3% of GDP) when multiplier effects are included; the potential CBAM burden on EU-bound exports is reduced by 32–38% through MRV digitalization. The research value consists in developing a methodology with justified realizability coefficients for Kazakhstan's institutional environment, as well as in constructing a matrix of twelve policy measures with measurable indicators. The practical significance of the results lies in their direct applicability in programmes of the Ministry of Energy and the AIFC, as well as in the transferability of the approach to comparable resource-dependent economies of the CIS and SCO.

Keywords: digitalization, green technologies, carbon neutrality, twin transition, Kazakhstan.

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Қазақстандағы көміртек бейтараптылығына жету үшін жасыл технологияларды цифрландырудың экономикалық әлеуеті

Зерттеу мәселесі Қазақстан Республикасының климаттық және цифрлық күн тәртібінің тоғысында жатыр. Қазақстан бір мезгілде әлемдегі парниктік газдардың ең ірі жиырма эмитентінің қатарына кіретін және 2060 жылға қарай көміртек бейтараптыққа қол жеткізуді мақсат етіп отырған ел болып табылады. Жұмыстың мақсаты – Қазақстанның энергетика секторындағы цифрлық және «жасыл» технологияларды үйлесімді дамыту нәтижесінде туындайтын синергиялық экономикалық әсерді сандық тұрғыдан бағалау. Ғылыми маңыздылығы «қос өтпелі кезең» (twin transition) тұжырымдамасын көмір үстемдігі бар ресурсқа тәуелді экономикалар класына таратуда; практикалық маңыздылығы – декарбонизация бойынша ұлттық бағдарламалар үшін операциялық базаны қалыптастыруда. Әдіснама $E = \sum B^i \cdot R^i \cdot k^i \cdot P^i$ нақты формуласымен бес әсер ету бағыты бойынша декомпозицияны, үш сценарлы модельдеуді (инерциялық, мақсатты, серпінді сценарийлер) және Германия, Қытай, Дания, АҚШ тәжірибесіне салыстырмалы талдауды біріктіреді. Негізгі нәтижелер: мақсатты сценарий шеңберінде 2030 жылға қарай жылдық тікелей әсер 615–835 млн АҚШ долларын, мультипликаторларды ескергендегі жиынтық әсер – 3,2–4,1 млрд долл. (ЖІӨ-нің 1,0–1,3%) құрайды; ЕО-ға экспортқа CBAM-ның ықтимал жүктемесі MRV-ні цифрландыру есебінен 32–38%-ға азаяды. Зерттеудің құндылығы – Қазақстанның институционалдық ортасы үшін негізделген жүзеге асыру коэффициенттерімен әдіснаманы әзірлеуде, сондай-ақ өлшенетін индикаторлары бар он екі саяси шарадан тұратын матрицаны құруда. Нәтижелердің практикалық маңызы – Энергетика министрлігі мен AIFC

кей қолдану және тәсілді ТМД мен ШЫҰ-ның ұқсас ресурсқа тәуелді экономикаларына тарату мүмкіндігі.

Түйін сөздер: цифрландыру, жасыл технологиялар, көміртек бейтараптылығы, қос өтпелі кезең, Қазақстан.

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Экономический потенциал цифровизации зелёных технологий для достижения углеродной нейтральности в Казахстане

Проблематика исследования лежит на стыке климатической и цифровой повесток Республики Казахстан – страны, одновременно входящей в двадцатку крупнейших эмитентов парниковых газов мира и декларирующей углеродную нейтральность к 2060 году. Цель работы – количественно оценить синергетический экономический эффект от сопряжённого развития цифровых и «зелёных» технологий в энергетическом секторе Казахстана. Научная значимость состоит в распространении концепции «двойного перехода» (twin transition) на класс ресурсозависимых экономик с угольной доминантой; практическая значимость – в формировании операциональной рамки для национальных программ декарбонизации. Методология сочетает декомпозицию эффекта по пяти направлениям воздействия с явной формулой $E = \sum B^i \cdot R^i \cdot k^i \cdot P^i$, трёхсценарное моделирование (инерционный, целевой, прорывной сценарии) и сравнительный анализ практики Германии, Китая, Дании и США. Основные результаты: в целевом сценарии прямой годовой экономический эффект к 2030 году оценивается в 615–835 млн долл. США, совокупный с учётом мультипликаторов – в 3,2–4,1 млрд долл. (1,0–1,3 % ВВП); потенциальная нагрузка СВМ на экспорт в ЕС сокращается на 32–38 % за счёт цифровизации MRV. Ценность исследования состоит в разработке методики с обоснованными коэффициентами реализуемости для институциональной среды Казахстана, а также в построении матрицы из двенадцати политических мер с измеримыми индикаторами. Практическое значение результатов – прямое использование в программах Министерства энергетики и AIFC, а также возможность переноса подхода на сопоставимые ресурсозависимые экономики СНГ и ШОС.

Ключевые слова: цифровизация, зелёные технологии, углеродная нейтральность, двойной переход, Казахстан.

Introduction

Climate change has reshaped the architecture of twenty-first century economic policy, dissolving the traditional separation between energy and environmental agendas. Within this reshaped landscape, Kazakhstan occupies a distinctive position: the country simultaneously ranks among the twenty largest global emitters of greenhouse gases and has adopted one of the most ambitious regional commitments – reaching carbon neutrality by 2060 (Decree of the President of RK, 2023). The Carbon Neutrality Strategy envisages a comprehensive restructuring of the national economy, with aggregate investment requirements estimated at approximately USD 610 billion (Resolution of the Government of RK, 2023).

A key, yet often underappreciated, channel for realising this transformation is digitalization. A distinguishing feature of the current phase of the global energy transition is its inseparable link to

digital technologies: the most advanced economies pursue decarbonization and digital modernisation simultaneously – a pattern established in academic literature under the term twin transition (Ajunwa & Nguyen, 2023). Empirical studies consistently show that digital intensification of energy systems reduces the unit operating costs of renewable assets, enhances generation predictability, and lowers non-technical losses. According to the International Energy Agency, intelligent grids and consumer-facing applications alone could save approximately USD 1.8 trillion in global energy investment by 2050 (IEA, 2022).

The object of the research is the process of jointly developing digital and green technologies in Kazakhstan's power sector. The subject – the economic effects arising at the intersection of these two transformational processes.

The Kazakhstani academic debate on decarbonization has developed primarily within engineering and regulatory frames. Existing studies examine ei-

ther renewable energy and its barriers, or the digitalization of energy assets, as separate phenomena, without quantitatively comparing their effects or assessing their synergy. This separation leaves unanswered a practically important question: what is the economic contribution of the joint – rather than sequential – application of digital and green solutions in a resource-dependent economy with dominant coal generation? The present article addresses this question through quantitative assessment.

The objective of the research is to quantify the synergetic economic effect of green technologies digitalization in Kazakhstan and to formulate policy priorities enabling its realisation. Achieving this objective requires solving five tasks: refining the country's carbon profile and the baseline of energy digitalization; systematising relevant international experience; developing a transparent analytical framework for economic assessment; building a three-scenario model of effects through 2030; identifying systemic barriers and proposing a matrix of policy measures with measurable indicators. The research hypothesis states that under Kazakhstani conditions, the synergy of digital and green technologies generates an economic effect sufficient to justify accelerated state investment (at least 1% of GDP annually), if price distortions in the carbon market are addressed in parallel.

This study primarily focuses on the energy sector because it represents one of the most significant sources of greenhouse gas emissions in Kazakhstan and remains central to national decarbonization policy. The energy sector also has a direct impact on the technological modernization of other industries, as the transition to low-carbon energy infrastructure creates systemic conditions for broader green economic transformation.

Other carbon-intensive sectors, including transport, mining, and agriculture, are also important for achieving carbon neutrality. However, they are not included in the main analytical framework of this article to maintain a clear research scope and avoid methodological dispersion. These sectors require separate sector-specific indicators, data structures, and regulatory assumptions, and therefore should be examined in future research.

The scientific novelty of the study comprises three elements. First, a calculation framework is proposed for assessing the economic performance of green technologies digitalization, distinguished by an explicit specification of the realizability coefficient that accounts for Kazakhstan's institutional constraints. Second, for the first time in the Kazakh-

stani context, a three-scenario comparison of direct, indirect, and multiplier effects is conducted across five impact vectors. Third, the barriers to the twin transition are linked, in matrix form, to a concrete set of policy instruments, implementing authorities, and key performance indicators.

Literature review

The theoretical foundation of this research rests at the intersection of three scholarly directions. The twin transition concept has been actively developed in the work of European researchers and international organisations. Ajunwa & Nguyen (2023), using a cross-country sample, show that exceeding the average level of digital readiness by one standard deviation is associated with a 15–20% reduction in GDP carbon intensity, controlling for structural factors. In a related study, the same authors (Ajunwa & Nguyen, 2022) establish a positive relationship between the depth of digitalization and the pace of renewable penetration in the electricity mix. Chien *et al.* (2021), analysing 68 OECD and emerging-market economies, empirically confirm a robust causal link between ICT diffusion and the intensity of the shift towards low-carbon sources.

The applied strand of the literature focuses on specific technological solutions – from intelligent dispatch to AI forecasting of renewable generation. Synthesis reports by the IEA (2022; 2023), IRENA (2023), and the World Bank (2022) converge on the following effect ranges: a 10–25% reduction in the operating costs of renewable assets, a 5–15% reduction in technical grid losses, and a 20–30% improvement in supply reliability. For resource-dependent economies, these ranges require downward adjustment to reflect additional friction arising from infrastructure deterioration and market structure.

The Kazakhstani segment of the literature is represented by studies systematising policy and regulatory barriers to renewable deployment (Karatayev *et al.*, 2016); constructing a spatial model of the national power system (Assembayeva *et al.*, 2020); evaluating energy efficiency potential in thermal generation (Sarbasov *et al.*, 2020). Guliyev (2024) provides a comprehensive assessment of Kazakhstan's energy transition progress and bottlenecks. An adjacent line of work – applied econometrics of decarbonization – is developed in Suiundikov *et al.* (2024), which models the impact of digitalization on the economic efficiency of Kazakhstan's energy industry. Comparable Central Asian studies

highlight the same structural constraints: high coal dependence, deteriorating infrastructure, and under-developed market institutions.

The three streams above have developed in parallel, without meeting in a common analytical frame. Within the twin-transition concept, no quantitative decomposition and verification of effects has been attempted for Kazakhstan. Applied work on power-sector digitalization rarely moves beyond technological description and does not connect these solutions to the 2060 carbon agenda. Strictly decarbonization-focused models do not include an explicit digital component. The present study addresses this gap by integrating the three streams within a single analytical framework and proposing a formalised procedure for linking digital solutions to carbon-policy objectives.

Methodology

Research question. What is the quantitative economic effect that the digitalization of green technologies in Kazakhstan's energy sector could yield by 2030, given existing institutional constraints?

Hypothesis. Under Kazakhstani conditions, the synergy of digital and green technologies generates an economic effect sufficient to justify accelerated state investment (at least 1% of GDP annually), provided that price distortions in the carbon market are addressed in parallel.

Research stages. The work proceeds through six stages: (1) verification of the country's carbon profile using primary sources; (2) systematisation of international practice in green-technology digitalization; (3) formalisation of the effect-decomposition framework; (4) end-to-end calculation of economic effects across five impact vectors; (5) three-scenario uncertainty assessment; (6) construction of the policy-measures matrix linked to barriers, horizons, and indicators.

Research methods. The work combines four approaches: structural-functional analysis (to describe the chain 'digital solution → physical effect → cost saving → contribution to carbon intensity'); comparative study (to identify practices applicable to Kazakhstani conditions); decomposition calculation (for assessment of effects by vector); scenario modelling (for quantification of uncertainty). Triangulation of sources ensures verification of numerical parameters across three independent databases for every key indicator.

The aggregate annual effect was estimated using the following decomposition model:

$$E = \sum B_i \cdot R_i \cdot k_i \cdot P_i \quad (1)$$

Where:

B_i – baseline resource volume;

R_i – technological reduction coefficient;

k_i – realizability coefficient;

P_i – unit price of the resource;

i – digitalization vector (AMI, AI forecasting, BMS, MRV, optimization of TPPs and grids).

The realizability coefficient k_i is adopted in a lower range relative to European practice (which uses 0.8–0.9) based on four factors that sequentially reduce the theoretical potential. The infrastructural factor relates to grid obsolescence, which constrains the integration of new digital solutions without accompanying capital investment. The regulatory factor reflects suppressed tariffs that limit the profitability of modernisation. The human-capital factor relates to the shortage of qualified digital energy engineers. The organisational factor captures inertia in large incumbent energy companies. The upper bound $k_i = 0.8$ applies to vectors with mature regulatory foundations (AMI, MRV); the lower bound $k_i = 0.6$ is reserved for vectors facing the highest regulatory friction (thermal power plant optimization).

End-to-end example (Vector 1 – AMI). The rollout of four million smart meters by 2027 covers approximately 85% of residential and small-commercial consumers. Aggregate non-technical losses in Kazakhstan's distribution grids are estimated at 5.8 TWh per year; the loss-reduction coefficient for automated metering, per World Bank data (World Bank, 2022), is $R = 0.15–0.20$. With realizability coefficient $k = 0.75$ and a weighted average price of lost energy $P = 19$ KZT/kWh (approximately USD 0.042 at the rate of 453 KZT/USD), the calculation yields $E_i = 5.8 \cdot 10_i \cdot 0.175 \cdot 0.75 \cdot 0.042 \approx$ USD 32 million. Additional effects include reduced commercial losses at the retail level, lower costs of meter-reading and billing, and improved payment discipline – together contributing USD 60–75 million. The resulting range of the effect for this vector is USD 95–110 million per year.

The assessment is carried out in three scenarios through 2030 differing in deployment pace and regulatory intensity (parameters in Table 6). Indirect and multiplier effects are tracked separately through three channels: creation of new jobs in the green and IT sectors (following the IRENA & ILO (2024) methodology); induced demand for related services – engineering, information security, consulting; and

additional tax revenues. The overall multiplier m is set at 4.0–5.5 based on comparable country studies.

Data sources. The analysis uses primary data from the International Energy Agency (IEA, 2022; IEA, 2023), IRENA (2023), the World Bank (2022), ICAP (2024), EBRD (2024), UNFCCC (2025), IMF (2023), the Ministry of Energy of the Republic of Kazakhstan, the Bureau of National Statistics of the Republic of Kazakhstan, JSC KEGOC, and the AIFC (2023) for the period 2018–2025. Monetary indicators are converted to USD at the corresponding year's average exchange rate.

The selection of model parameters was based on a combination of theoretical assumptions, available national statistical data, strategic policy documents, and expert interpretation of Kazakhstan's decarbonization priorities. Although the proposed model does not claim to provide a fully econometrically validated forecast, it offers an indicative analytical framework for assessing the economic potential of green technologies digitalization under the conditions of Kazakhstan's transition toward carbon neutrality.

Econometric validation was not the primary objective of this study, as the article is focused on developing a conceptual and scenario-based assessment framework rather than testing causal relationships through time-series or panel data models. Future studies may expand the proposed approach by

applying econometric techniques to validate the relationships between digitalization indicators, green technology adoption, investment intensity, and emission reduction outcomes.

The study does not include Monte Carlo simulation, which may be considered a limitation of the proposed model. Probabilistic simulation could further strengthen the robustness of the findings by estimating the range of possible outcomes under different combinations of uncertain parameters. This approach is recommended for future research.

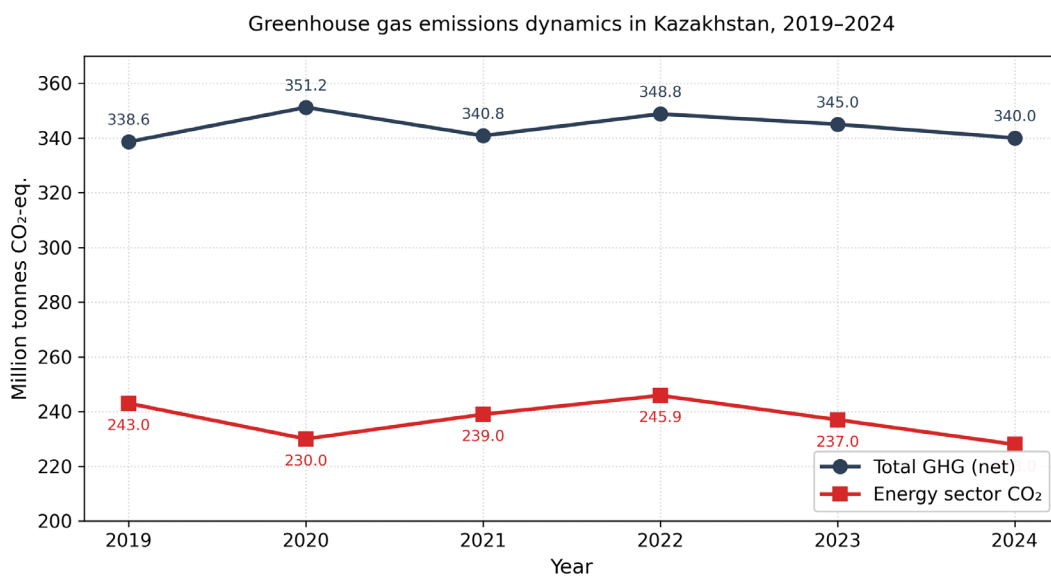
Results and discussion

Carbon profile: initial conditions

According to the First Biennial Transparency Report (UNFCCC, 2025), Kazakhstan's aggregate net greenhouse gas emissions in 2022 amounted to 348.8 million tonnes CO₂-eq., which is 8.5% below the 1990 baseline (385.4 Mt). Preliminary data for 2024, according to Enerdata's early estimates, indicate a moderate downward trend of 1.5–2% year-on-year; however, this trend is not yet sustainable and is sensitive to winter heat-consumption variability (Figure 1).

Aggregated emissions dynamics over the past six years are presented in Table 1. The UNFCCC BTR1 dataset serves as the primary series, cross-checked against IEA and Enerdata.

Figure 1
Greenhouse gas emissions dynamics in Kazakhstan, 2019–2024



Note: compiled by the authors based on sources (UNFCCC, 2025; IEA, 2022)

Table 1*Greenhouse gas emissions dynamics in Kazakhstan, 2019–2024*

Year	Total GHG (net), Mt CO ₂ -eq.	Energy sector, Mt CO ₂	Cross-check with alternative source
2019	338.6	243.0	IEA: 340.1 (+0.4%)
2020	351.2	230.0	IEA: 347.8 (−1.0%)
2021	340.8	239.0	UNCTAD: 342.5 (+0.5%)
2022	348.8	245.9	EDGAR: 350.1 (+0.4%)
2023	≈345.0	237.0	IEA: 343.7 (−0.4%)
2024*	≈340.0	≈228.0	Enerdata: 339.0 (−0.3%)

Note: Preliminary estimate. Compiled by the authors based on sources (UNFCCC, 2025; IEA, 2022)

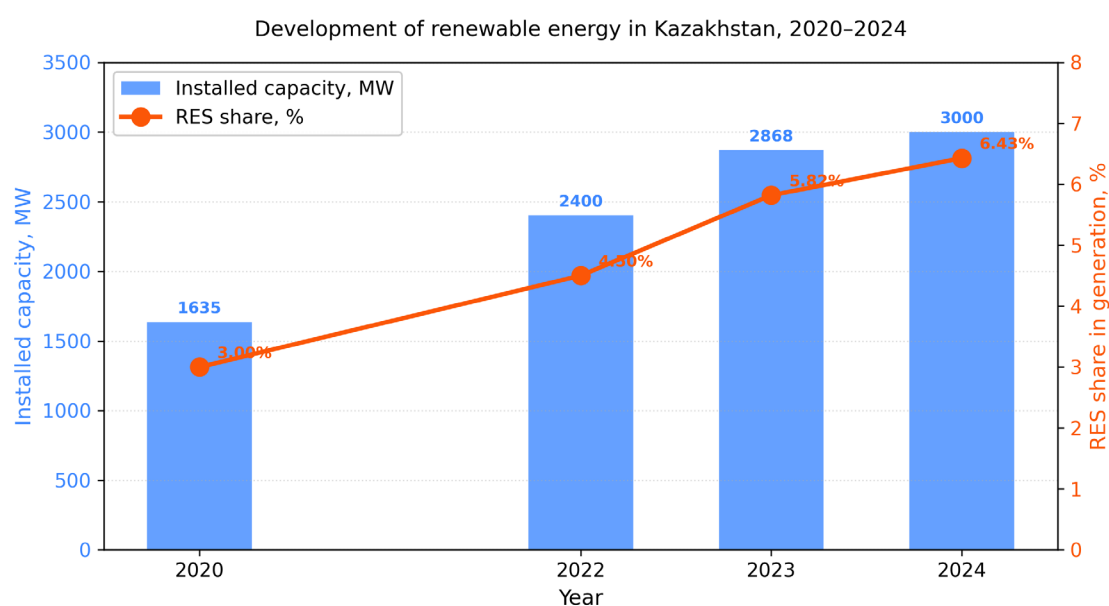
The structure of emissions remains highly unbalanced: the energy sector accounts for 77–82% of total emissions, with coal providing approximately 70% of electricity generation and 99% of district heating, and producing more than 67% of all CO₂ emissions (IEA, 2022). Per capita emissions – 12.3–12.4 t CO₂ per person in 2023 – were roughly twice the global average (Climate Action Tracker, 2024).

The technological context reinforces the case for digitalization: about 65% of generating capacity has been in operation for more than two decades; the average efficiency of thermal power plants is approximately 32%, some 10 percentage points below the European level; and aggregate grid losses reach

15%. These parameters define the upper bound of efficiency gains achievable through digital solutions (Sarbasov et al., 2020).

Renewables and digital infrastructure: the baseline

Despite the dominance of coal, Kazakhstan has shown accelerated growth in installed renewable capacity. According to QazaqGreen (2025) and the Ministry of Energy, the renewable share in electricity generation reached 6.43% in 2024 at an installed capacity of approximately 3 GW (Figure 2, Table 2). The Concept for the Development of the Electricity Industry targets a share of 15% by 2030 and 50% by 2050 (Resolution of the Government of RK, 2023).

Figure 2*Development of renewable energy in Kazakhstan, 2020–2024*

Note: compiled by the authors based on sources (QazaqGreen, 2025; IEA, 2022)

Table 2*Development of renewable energy in Kazakhstan, 2020–2024*

Year	RES share, %	Installed capacity, MW	Generation, GWh	Comment
2020	3.00	1 635	4 600	Launch of incentive auctions
2022	4.50	2 400	5 400	Commissioning of several PV and wind projects
2023	5.82	2 868	6 600	Mega-deals signed with Masdar, TotalEnergies
2024	6.43	3 000	7 600	ACWA Power – 1 GW agreement

Note: compiled by the authors based on sources (QazaqGreen, 2025; IEA, 2022)

The digital layer of energy infrastructure comprises two complementary levels – system (under JSC KEGOC) and distribution. At the system level, an automation project for managing the Unified Electric System has been delivered, incorporating modules for wide-area measurement (WAMS), centralised emergency system control (CESC), and automatic frequency and power regulation (AFPR). Supported by the European Bank for Reconstruction and Development, the 500 kV Karabatan–Ulke line modernisation began in 2024 with total financing of EUR 267 million (EBRD, 2024).

An important institutional development in 2025 was the official launch by the Ministry of Energy of

the national digital platform EnergyTech, built on the QazTech infrastructure. The platform integrates a heating-season readiness module (projected to reduce the accident rate by up to 25%), digital tariff regulation (a 56% reduction in administrative burden), and a renewable-assets registry (Times of Central Asia, 2025). In parallel, a programme is being rolled out to install four million smart meters by 2027.

International experience in green-technology digitalization

To verify calculation parameters and assess the applicability of international practices, four cases with different digitalization foci are reviewed (Table 3).

Table 3*International experience in energy-sector digitalization: key effects*

Country / region	Leading technology	Quantitative effect	Applicability to Kazakhstan
Germany (Energiewende)	Digital asset passports + balancing markets	12–15% reduction in RES integration system costs	High – for asset passports and MRV
China (SGCC, UHV + AI)	AI dispatch for RES and HVDC	28% curtailment reduction; 8% increase in transfer capacity	Medium – requires grid upgrades
Denmark (Energinet)	AI forecasting of wind generation	Forecast error < 4%; up to EUR 150 M/year saved	High – for Masdar, TotalEnergies projects
USA (CAISO, WEIM)	Regional digital balancing market	Cumulative effect of USD 4.6 bn over 2014–2025	High – for a Central Asian regional market

Note: systematised by the authors based on sources (IEA, 2022; IEA, 2023; IRENA, 2023)

The cases reveal a pattern: the economic effect of digitalization grows monotonically with the share of renewables up to a threshold of approximately 30%, beyond which gains decelerate due to saturation of system opportunities. Kazakhstan is at an early phase of this curve, implying a high marginal return on every additional dollar invested in digitalization – an estimated 1.5–2 times higher than in countries with already high renewable shares.

Digital maturity indices and human capital

Kazakhstan's position in international digital-maturity rankings presents a mixed picture (Table 4). The country holds relatively strong positions in

formal e-government and infrastructure-connectivity indices but lags substantially in the deep digitalization of industry and energy.

Human-capital availability remains a critical constraint. According to a recent estimate (Times of Central Asia, 2025), Kazakhstan has about 19,500 IT specialists against a declared demand of 100,000. The gap is concentrated in industrial automation, cybersecurity for critical infrastructure, and data science for the energy sector. Implementing the proposed volume of energy-sector digitalization will require either accelerated training of 6,000–8,000 specialists per year or the contracted engagement of international teams.

Table 4*Digital maturity indices of Kazakhstan (most recent available data)*

Index	Value / rank	Year	Comment
UN E-Government Development Index (EGDI)	28th of 193	2024	Strong segment – e-services
IMD World Digital Competitiveness	35th of 64	2024	Weakest component – knowledge (49th)
Network Readiness Index (NRI)	57th of 134	2024	Regulatory-environment gap

Note: compiled by the authors based on sources (United Nations, 2024; IMD, 2024; Portulans Institute, 2024).

Economic effect: five vectors and their aggregation

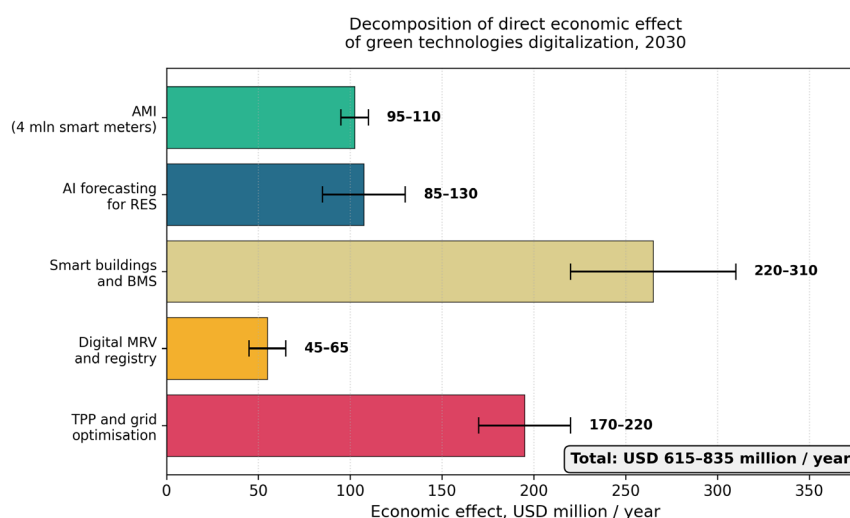
Applying formula (1) to the five priority digitalization vectors yields a detailed decomposition of the

annual economic effect by 2030 (Table 5, Figure 3). Each row presents the baseline volume B_i , the coefficients R_i and k_i , the weighted average price P_i , and the resulting effect range.

Table 5*Decomposition of direct economic effect of green technologies digitalization, 2030*

No	Vector	B_i (baseline)	R_i	k_i	P_i	Effect, USD mn/year
1	AMI (4 mln smart meters)	5.8 TWh losses	0.15–0.20	0.75	0.042 USD/kWh	95–110
2	AI forecasting of RES (3→6 GW)	9.2 TWh	0.08–0.12	0.70	0.055 USD/kWh	85–130
3	Smart buildings and BMS	24 TWh heat consumption	0.10–0.15	0.65	0.063 USD/kWh	220–310
4	Digital MRV (CBAM readiness)	33 Mt exports to EU	–	0.70	CBAM penalties	45–65
5	TPP and grid optimization	OPEX USD 4.5 bn	0.03–0.05	0.60	–	170–220
Total (direct effect)		–	–	–	–	615–835

Note: authors' calculations based on sources (IEA, 2022; IRENA, 2023; World Bank, 2022) and methodology of formula (1)

Figure 3*Decomposition of direct economic effect of green technologies digitalization, 2030*

Note: constructed by the authors based on Table 5

The aggregate direct effect is concentrated primarily in heating and generation optimization – together accounting for about two-thirds of the total. This reflects structural features of the Kazakhstani economy: abnormally high specific heat consumption in buildings (~270 kWh/m² compared with 120–140 kWh/m² in EU countries of similar climate) and a large legacy fleet of thermal power plants, where even incremental optimization yields a substantial monetary effect.

Adding multiplier effects broadens the aggregate estimate to USD 3.2–4.1 billion per year, equivalent to 1.0–1.3% of GDP. New green-economy jobs are estimated at 10,000–12,000 by 2030, of which approximately 40% are in the IT segment, 35% in engineering-installation occupations, and 25% in ancillary services (IRENA & ILO, 2024).

Scenario analysis

To strengthen the robustness of the proposed analytical framework, a simplified scenario-based stress-testing approach was applied. The scenarios reflect different combinations of renewable-energy

deployment, digitalization intensity, regulatory support, and institutional readiness in Kazakhstan's energy sector. Such an approach allows assessment of the sensitivity of the projected economic effect to changes in key policy and technological parameters.

The range USD 615–835 million corresponds to the central target scenario. To quantify uncertainty, two additional scenarios are constructed, differing in the pace of technology deployment and regulatory intensity (Table 6).

The shift from business-as-usual to the target scenario roughly doubles the direct effect at a proportional increase in investment, whereas the move to the breakthrough scenario yields an additional 60% gain at 2.2 times the aggregate investment – indicating diminishing returns. This finding has important practical implications: the optimal strategy concentrates resources on the transition from business-as-usual to the target trajectory, while the breakthrough scenario is justified primarily in flagship projects – in export-oriented industries exposed to CBAM.

Table 6

Scenario range of direct economic effect by 2030

Parameter	Business-as-usual	Target (base)	Breakthrough
Installed RES capacity, GW	4.5	6.0	8.0
AMI coverage, % of consumers	55	85	95
Floor area with BMS, % of stock	3	10	18
KazETS allowance price, USD/t CO ₂	3–5	15–20	35–50
Realizability coefficient k_i	0.5	0.7	0.8
Direct effect, USD mn/year	310–420	615–835	1 050–1 400
Aggregate effect with multiplier, USD bn/year	1.4–1.9	3.2–4.1	5.1–6.8

Note: authors' calculations using formula (1) under the respective scenario parameters

A sensitivity perspective indicates that the results of the model are particularly dependent on three groups of parameters: the rate of green technology adoption, the level of digital infrastructure development, and the volume of investment support. Changes in these parameters may significantly affect the estimated economic potential. Therefore, the results should be interpreted as indicative estimates rather than deterministic forecasts.

The scenario comparison demonstrates that the economic potential of green technologies digitalization depends strongly on the intensity of investment, the pace of digital transformation, and the

consistency of state policy. Under the optimistic (breakthrough) scenario, digital tools may significantly accelerate the transition toward carbon neutrality, while under the business-as-usual scenario their impact remains substantially constrained by institutional and infrastructural barriers. The scenario-based approach therefore serves as a simplified robustness assessment of the proposed model under different transition conditions.

Carbon market, CBAM, and fiscal instruments

The Kazakhstan Emissions Trading System (KazETS) – the first full-fledged ETS in Asia, launched in 2013 – currently covers 212 large installations

(135 companies) with an aggregate cap of 162.1 Mt CO₂ for 2024, providing roughly half of the economy's carbon coverage (ICAP, 2024). However, the price signal remains critically weak: the average allowance price in 2024 was approximately USD 1/t CO₂, about 90 times below the EU ETS level (Figure 4). The NDC roadmap envisages a gradual price increase to USD 16.9/t by 2025 and USD 50.8/t by 2030 (ICAP, 2024).

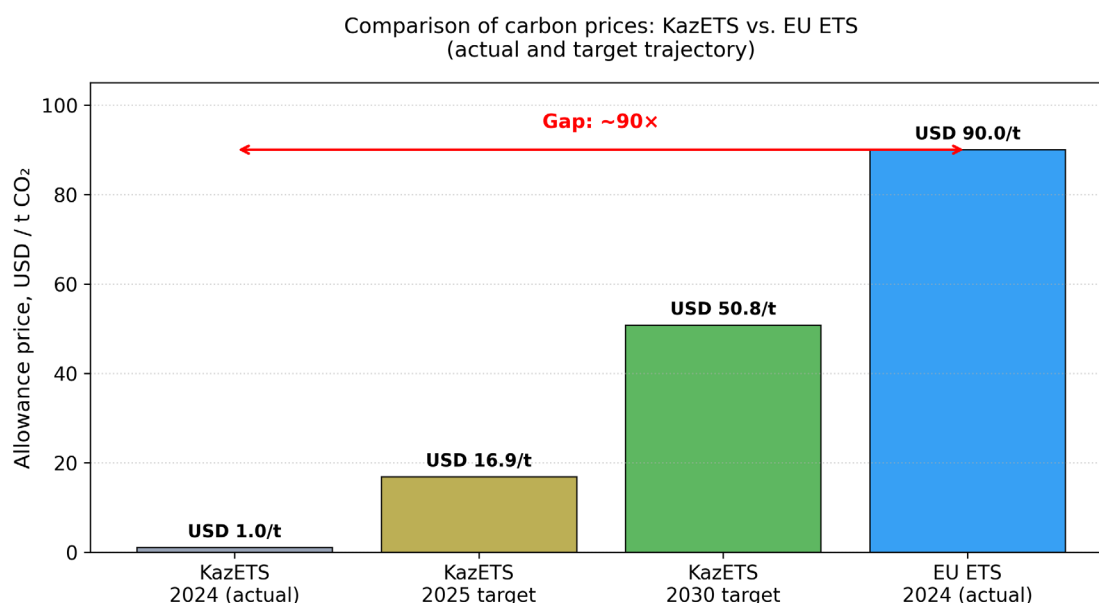
A key external driver of carbon policy is the EU Carbon Border Adjustment Mechanism (CBAM), entering its full charging phase on 1 January 2026. The European Union is the largest destination for Kazakhstani exports (about 39% of deliveries);

however, CBAM exposure is distributed unevenly across product groups (Table 7).

Digitalization reduces the actual CBAM burden through two channels: documentary verification of the real carbon footprint (instead of default values that are typically higher), and the justified deduction of the price already paid under KazETS. Both channels require a digital MRV platform integrated with the EU CBAM registry – precisely the instrument announced within the EnergyTech platform (Times of Central Asia, 2025). MRV digitalization thus ceases to be a 'soft' environmental policy measure and acquires the character of a defensive investment in export competitiveness.

Figure 4

Comparison of carbon prices: KazETS vs. EU ETS (actual and target trajectory)



Note: compiled by the authors based on source (ICAP, 2024)

Table 7

CBAM exposure by product groups of Kazakhstani exports to the EU

Product group	Exports to EU, USD mn (2023)	Carbon footprint, t CO ₂ /t	CBAM burden at P = USD 90/t, USD mn/year	MRV effect, %
Ferroalloys and ferrous metals	1 450	4.5–5.0	210–240	30–40
Aluminium	380	16–18	95–115	25–35
Mineral fertilisers	290	2.0–3.5	45–65	35–45
Cement and clinker	95	0.8–1.0	15–25	40–50
Total	≈2 215	–	365–445	32–38

Note: authors' calculations based on sources (OECD, 2024; UNFCCC, 2025)

The fiscal imbalance warrants attention: Kazakhstan's fossil fuel subsidies are estimated at around 6% of GDP (IEA, 2022; IMF, 2023). Combined with low allowance prices, this creates a negative price signal that substantially weakens decarbonization incentives for part of producers. A parallel policy of gradual subsidy reduction and upward adjustment of the minimum allowance price is a necessary condition for the economic rationality of digital investment in the green segment.

Risks and limitations of digital transformation

Despite the positive aggregate effect, energy-sector digitalization involves three major categories of risks. Energy consumption of digital infrastructure: data centres and communications networks currently consume approximately 1.5–2.0% of global electricity; Kazakhstan's share remains below 0.5%, but with the implementation of announced programmes it could rise to 3–4% by 2030. In a coal-dominated generation mix, this means that part of the digitalization savings may be neutralised by additional emissions. Mitigation requires mandatory linkage of new data centres to renewable capacity or dedicated green contracts.

Cybersecurity of critical infrastructure. The deployment of WAMS, CESC, and integrated dispatch

systems increases connectivity and, simultaneously, the attack surface. European experience shows that the typical economic damage from a successful attack on critical infrastructure substantially exceeds the annual savings from digitalization. For Kazakhstan, it is advisable to combine the deployment of digital solutions with mandatory categorisation of assets under the critical-information-infrastructure legislation and certification against international standards (ISA, 2023).

Rebound effect (Jevons paradox). Increased efficiency in individual segments, combined with persistently low energy prices, can trigger a rise in aggregate consumption, partially offsetting the environmental benefit. International estimates of the rebound effect in the residential sector range from 10% to 30%. For Kazakhstan, this reinforces the case for parallel strengthening of price signals.

Twin transition barriers and policy matrix

Systemic barriers to the twin transition are classified into four groups: technological, financial/price, institutional, and human-capital. To translate this diagnosis into an operational policy tool, barriers are linked to specific instruments, horizons, and indicators (Table 8).

Table 8
Twin-transition policy matrix

No	Barrier	Policy instrument	Horizon	Key indicator	Responsible authority
1	Generation obsolescence (57% TPPs > 36 years)	TPP modernisation with mandatory IPS/SCADA	2025–2030	TPP efficiency, %; digital-twin share	Ministry of Energy
2	Grid obsolescence (15% losses)	Trunk grid refurbishment + WAMS	2025–2030	Losses, %; SAIDI/SAIFI	JSC KEGOC
3	Fossil-fuel subsidies (~6% of GDP)	Gradual phase-out with compensation	2026–2030	Subsidy share of GDP, %	MoF, MoE
4	Low KazETS allowance price	Floor price USD 5–7/t; USD 50.8/t by 2030	2026–2030	Avg allowance price, USD/t	MoE, Zhasyl Damu
5	Absence of AMI mandate	Legislative mandate with milestones	2025–2027	Smart meter coverage, %	Ministry of Energy
6	Absence of MRV platform	Launch with EU CBAM integration	2025–2027	Exporters with digital passports, %	Ministry of Ecology
7	Institutional fragmentation	Interagency council	2026	Agreed strategic decisions/year	Government of RK
8	Weak regional market	Central Asian balancing platform	2028–2030	Cross-border exchange share, %	JSC KEGOC, MFA
9	Human-capital gap (~80 thousand)	Targeted training programme	2025–2030	Annual profile graduates	MoSHE, MDDAI
10	Cyber risks of critical infrastructure	Mandatory security certification	2026–2028	Certified assets share	NSC, MDDAI

Continuation of the table

№	Barrier	Policy instrument	Horizon	Key indicator	Responsible authority
11	Low building quality	Codes + BMS for new construction	2026–2030	Specific consumption, kWh/m ²	MIID, local authorities
12	Access to green finance	Taxonomy + sovereign green bond	2025–2027	Green bonds volume	MoF, NBK, AIFC

Note: compiled by the authors based on sources (The Concept of Development of the Electric Power Industry of the Republic of Kazakhstan for 2023–2029; IEA, 2022; IRENA, 2023; World Bank, 2022; ICAP, 2024; AIFC, 2023)

The matrix structures the set of measures so that every policy initiative can be traced to a specific barrier and a measurable indicator. Implementation horizons are sequenced: short-term measures (Nos. 4–6, 9) build the regulatory and human-capital foundation; medium-term measures (Nos. 1–3, 7, 10–12) form the investment framework; the long-term measure (No. 8) shapes the institutional architecture at the regional level.

Conclusion

What are the research objectives and methods? The work was devoted to a quantitative assessment of the synergetic economic effect from the joint development of digital and green technologies in Kazakhstan using a transparent calculation framework (formula 1), three-scenario modelling, and comparative analysis of international experience. For the first time, the study formalises the procedure for linking digital solutions to the objectives of the 2060 carbon strategy in Kazakhstani conditions.

What are the results? The economic potential of the twin transition for Kazakhstan is assessed under the target scenario at USD 615–835 million in direct annual effect by 2030 and USD 3.2–4.1 billion including multipliers, equivalent to 1.0–1.3% of GDP. MRV digitalization is shown to reduce the potential CBAM burden on Kazakhstani exports by 32–38%, reclassifying digital investment from environmental to defensive export-oriented.

What conclusions? First, in resource-dependent economies with coal-dominated generation, digitalization and decarbonization should increasingly be treated as mutually reinforcing processes. Second, the greatest economically justified gain is realised in the transition from business-as-usual to the target

trajectory; the breakthrough scenario exhibits diminishing returns and is justified mainly in export-oriented flagship projects. Third, the matrix of twelve policy measures transforms the twin-transition concept from rhetoric into an operational instrument of public management.

What are the prospects and possibilities for application? The resulting parameters can serve as a methodological foundation for the design of green-economy digitalization programmes in comparable CIS and SCO countries. Directions for further research include extending the calculation framework to the transport, mining, and agriculture sectors; regional decomposition of effects across the 17 oblasts of Kazakhstan; application of Monte Carlo simulation and sensitivity testing; and verification of realizability coefficients through panel econometrics as data from 2025–2030 accumulate.

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Author Contributions

GSN: contributed to data analysis and preparation of the manuscript.

GSS: contributed to the development of the study and revision of the manuscript.

RKS: contributed to the interpretation of the results and review of the manuscript.

LZh.A: contributed to the methodological support of the research and revision of the manuscript.

All authors reviewed and approved the final version of the manuscript.

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THE IMPACT OF AFRICAN CONTINENTAL FREE TRADE AGREEMENT (AfCFTA) IMPLEMENTATION ON SMALL AND MEDIUM BUSINESS IN NIGERIA

The study assessed the impact of the implementation of the African Continental Free Trade Agreement (AfCFTA) on Nigerian SMEs. Three goals and research agendas have been formulated to guide the research. The free trade theory proposed by David Ricardo, Adams Smith, and David Hume (1971) has been used to relate the impact of his AfCFTA on small and medium enterprises in Nigeria. The study used a descriptive survey design of 1,766 SMEs registered on the Lagos State Chamber of Commerce platform. Using random sampling, I selected a sample size of 400 respondents (400) from the study area. A thirteen-item (13) structured questionnaire was used to collect data from the respondents. Completed specimens of instruments were pooled and analyzed using the mean and standard deviation. The result among other things states that reduced cost of material and inputs, increase production capacity, reduction in the prices of goods and services and reductions in the cost of machinery are the positive impacts of AfCFTA implementation on SMEs in Nigeria and increase foreign competition with local goods reduction in the demand of goods and services of local goods, and cheaper goods compete with local products. neglect of other important factors affecting SMEs and the promotion of substandard products and dumping is the perceived threat of AfCFTA implementation on SMEs in Nigeria. The study thus recommended that individuals and SMEs in Nigeria should look inwards and try to change the mindset of patronizing products and services from non-African countries and that respective Governments including Nigeria should see to it that policies geared towards effective implementation of the trade agreement should not just be formulated but also be set in motion.

Keywords: AfCFTA, SMEs, Nigeria, international trade, economic development.

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Африка континентальды еркін сауда келісімін (AfCFTA) жүзеге асырудың Нигериядағы шағын және орта бизнеске әсері

Зерттеуде Африка континентіндегі еркін сауда келісімін (AfCFTA) жүзеге асырудың Нигериядағы шағын және орта бизнеске әсері бағаланады. Зерттеулерді осы мақсатқа жетуге бағыттайтын үш мақсат пен зерттеу бағдарламалары тұжырымдалды. Дэвид Рикардо, Адам Смит және Дэвид Юм (1971) ұсынған Еркін сауда теориясы, AfCFTA-ның Нигериядағы шағын және орта бизнеске әсерін сипаттау үшін негіз болды. Зерттеуде Лагос штатының сауда палатасының платформасында тіркелген 1766 шағын және орта бизнес өкілдеріне сауалнама жүргізудің сипаттамалық әдісі қолданылды. Кездейсоқ үлгіні қолдана отырып, зерттелетін аймақтан 400 респонденттен (400 адам) іріктеме негізінде алынды. Респонденттерден деректерді жинау үшін 13 тармақтан тұратын құрылымдық сауалнама пайдаланылды. Дайын құрал үлгілері орташа және стандартты ауытқу арқылы біріктіріліп, талданды. Нәтижесінде, ең бастысы, материалдар мен енгізілетін ресурстар құнының төмендеуі, өндірістік қуаттылықтың ұлғаюы, тауарлар мен қызметтер бағасының төмендеуі және жабдық құнының төмендеуі Нигериядағы ШОБ үшін AfCFTA енгізудің оң салдары болып табылады және жергілікті өндірушілердің тауарлары мен қызметтеріне сұранысты төмендеті отырып, жергілікті тауарлармен шетелдік бәсекелестікті күшейтеді. Жергілікті тауарлар мен арзан тауарлар ШОБ-қа әсер ететін басқа да маңызды факторларды айтпағанда, жергілікті өнімдермен бәсекелестікті күшейтеді, сонымен қатар сапасыз өнімді жылжыту және демпинг – бұл Нигериядағы ШОБ үшін AfCFTA-ны енгізудегі қауіп болмақ. Осылайша, зерттеу Нигериядағы жеке тұлғалар мен шағын және орта бизнеске өздеріне назар аударуды және африкалық емес елдердің тауарлары мен қызметтеріне деген көзқарасты

тиісті үкіметтерге, соның ішінде Нигерияға, сауда келісімін тиімді орындауға бағытталған саясаттың жай ғана тұжырымдалмағанына, сонымен қатар қолданысқа енгізілгеніне көз жеткізуді ұсынды.

Түйін сөздер: AfCFTA, шағын және орта бизнес, Нигерия, халықаралық сауда, экономикалық даму.

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Влияние реализации африканского континентального соглашения о свободной торговле (AfCFTA) на малый и средний бизнес в Нигерии

В исследовании оценивалось влияние реализации Соглашения о свободной торговле на Африканском континенте (AfCFTA) на малые и средние предприятия Нигерии. Были сформулированы три цели и программы исследований, которые направляют исследования на достижение этой цели. Теория свободной торговли, предложенная Дэвидом Рикардо, Адамом Смитом и Дэвидом Юмом (1971), была использована для описания влияния его AfCFTA на малые и средние предприятия в Нигерии. В исследовании использовался описательный метод опроса 1766 малых и средних предприятий, зарегистрированных на платформе Торговой палаты штата Лагос. Используя случайную выборку, были отобраны выборки из 400 респондентов (400 человек) из исследуемой области. Для сбора данных от респондентов была использована структурированная анкета из 13 пунктов. Готовые образцы инструментов были объединены и проанализированы с использованием среднего значения и стандартного отклонения. В результате, надо отметить главное, что снижение стоимости материалов и вводимых ресурсов, увеличение производственных мощностей, снижение цен на товары и услуги и снижение стоимости оборудования являются положительными последствиями внедрения AfCFTA для МСП в Нигерии и усиливают иностранную конкуренцию с местными товарами, снижая спрос на товары и услуги местных производителей. Местные товары и более дешевые товары конкурируют с местными продуктами, игнорируя других важных факторов, влияющих на МСП, а также продвижение некачественной продукции и демпинг – это предполагаемая угроза внедрения AfCFTA для МСП в Нигерии. Таким образом, в исследовании было рекомендовано частным лицам и малым и средним предприятиям в Нигерии обратить внимание на себя и попытаться изменить отношение к товарам и услугам из неафриканских стран, а соответствующим правительствам, включая Нигерию, позаботиться о том, чтобы политика, направленная на эффективное выполнение торгового соглашения, была не просто сформулирована, но и приведена в действие.

Ключевые слова: AfCFTA, малые и средние предприятия, Нигерия, международная торговля, экономическое развитие.

Introduction

The road map for a regionally integrated Africa officially began in June 1991 with the signing of the African Economic Community (AEC), also known as the Abuja Treaty. When the next treaty entered into force in 1994, African countries had to go through six successive stages of regional integration leading to a fully integrated continental market in 34 years. These steps include (i) strengthening intra-regional integration and harmonization among blocs; (ii) the formation of regional blocs (i.e. Regional Economic Community or REC); (iii) the Creation of Free Trade Areas (FTAs) and Customs Unions in all RECs. (iv) Establishment of continental free trade areas and customs unions. (iv) establishment of the African single market; (vi) Establishment of the African Economic and Monetary Union and Par-

liament. However, the process toward a regionally integrated Africa has not been smooth and linear within and among all RECs (Marinov, 2014). FTAs are solid building blocks for regional integration and are known to facilitate trade in goods and investment flows by creating an improved environment that enables cross-border trade. Fofack, 2018). This process can also lead to the diversion of trade and investment away from countries with less favorable business environments. As such, the impact of FTAs varies widely from country to country due to different factors affecting the business environment.

Africa's transcontinental trade is the lowest of any region in the world. This weak commercial activity is both a major cause and an obvious consequence of the region's weak socioeconomic development. Another important factor explaining the weakness of intra-African trade is the trade and non-

trade barriers to the exchange of goods and services. Recent progress in establishing the AfCFTA, adopted by 54 African countries in July 2019, is therefore very encouraging as it has the potential to reduce the existence of trade barriers on the continent. However, the economic impact of a free trade agreement is unlikely to be the same for all participating countries. There will be winners and there will be losers. In this regard, a detailed study by Ubi (2018) concluded that free trade agreements, at least in some cases, have a positive effect on trade growth. However, the picture is not clear, and the estimated impact range varies considerably. Even in countries that have benefited from the ratification of free trade agreements, the benefits are unevenly distributed across industries. This means that while mutual development and trade benefits of AfCFTA are possible, little is known about the cross-sectoral and cross-sectoral benefits in individual countries. For Nigeria, as with any other free trade agreement, the impact of AfCFTA can vary depending on different market opportunities and production constraints.

For example, Marino (2014) applied a gravity model to examine the impact of trade policy reforms and regional integration on exports from the East and West African Economic Community (ECOWAS). The author finds that unilaterally reducing trade barriers and complying with preferential trade agreements in the ECOWAS sub-region is beneficial and beneficial to Nigeria's trade. On the other hand, Tayo (2021) finds that reducing import duties through FTAs will make Nigerian businesses more vulnerable, as it makes domestic producers more sensitive to imported goods at higher prices, higher, lower and/or better in the short term. This is just one example of conflicting evidence that creates uncertainty about the outcome of FTAs in general and the AfCFTA in particular.

Current discussions by several analysts suggest that Nigerian SMEs will benefit from the implementation of the AfCFTA in several ways, including:

- (i) increase the supply of raw materials from the African continent.
- (ii) a broader market for goods and services from Nigeria's SMEs;
- (iii) increase employment for young Nigerians (who can provide services across borders, especially in the technology sector); and
- (iv) increasing the market share of the Nigerian financial services industry (currently dominating the West African market).

However, before the Nigerian government signed the agreement, there was mixed debate about

these potentials, especially regarding the possible negative effects on the country's fragile manufacturing sector., due to the current challenges it is facing. Some of these challenges include high investment costs (loan ratio around 17%), severe infrastructure deficits, high costs, and inadequate access to production inputs (Deloitte, 2018).

In this discussion, the potential impact of AfCFTA on SMEs is least understood. SMEs are an essential component of the Nigerian economy, as they represent approximately 96% of Nigerian businesses and contribute 75% of national employment (SMEDAN, 2019). A major concern is the lack of human and technological capacity of SMEs in Nigeria, which leaves them vulnerable to the negative knock-on effects that may be associated with free trade. and investment trade around the world. continent. However, SMEs can benefit from better access to new markets and the eventual economic transformation that competition can foster. As the discussion surrounding the recent AfCFTA ratification in Nigeria (November 11, 2020) has become increasingly heated, it is therefore imperative to assess the impact of AfCFTA implementation on SMEs. and small. and small from Nigeria.

Statement of the Problem

Overall, trade-related infrastructure is poor and inadequate in Nigeria. For example, the entire road network, including motorways, highways, and local roads, is very poor, many of which are neglected and neglected. These could adversely affect Nigeria's international business opportunities, leading to higher transaction costs and undermining business opportunities available to the economy. In other words, Nigerian SMEs may not seize the opportunities to improve and strengthen business ties on the African continent that the AfCFTA claims to provide. Other countries with better trade-related infrastructure on the African continent could ultimately be those with SMEs that benefit from her AfCFTA agreement. There are also concerns about the dumping of goods from production-oriented countries like South Africa to consumption-oriented countries like Nigeria. For example, production costs in Nigeria are estimated to be higher than in some countries such as South Africa and Egypt (Adejobi, 2019). This means that these low-wage countries can afford to export their goods to Nigeria and sell them at low prices.

As a result, Nigerian SMEs will eventually embrace these cheaper alternatives, thus making it impossible for domestic firms to compete on the cheap.

It has been suggested that Nigeria will remain a net importer of goods and services because of its very low technological capacity and high production costs (among other things), but its highly dense population means that the country would be a dumping ground for services. Services from other African countries (Adebisi and Isiadinso, 2019). The country is flooded with cheap products, which could intensify efforts to revitalize domestic manufacturing, agribusiness, and small and medium enterprises (SMEs). According to Kuwonu (2021), once the AfCFTA comes into force, eligible member states will have to eliminate 90% of their tariffs on imports from other member states, thereby eliminating their ability to generate business. It is levied by the partner country through the imposition of customs duties. and homework. Continental companies now charge higher taxes when exporting to Africa than when exporting abroad and the average tax rate is 6.1%.

The AfCFTA is expected to phase out tariffs on intra-African trade, making it easier for African companies to trade on the continent and unlocking the enormous potential of the vast African market. This doesn't work in Nigeria, which currently has a tax rate of 6% of GDP and is considered the lowest on the continent. Therefore, it is difficult to predict from the above how the AfCFTA agreement will ultimately affect the Nigerian economy, especially small and medium enterprises (SMEs). There is a risk of smuggling and abuse of rules of origin. This could allow traders of SMEs in other countries to disguise their imports from outside the African continent to make them tax-free, ultimately impacting the performance of SMEs. in Nigeria. As the Free Trade Zone spans continents, it is foreseeable that the entry routes for contraband and undeclared goods will extend beyond ECOWAS residential and non-residential borders to include all neighboring countries. This risk is particularly high for Nigerian SMEs, with 92% of Nigeria's imports coming from other parts of the world, so if this threat were to materialize, the government would seek revenue from import tariffs on non-African goods. As a result, the protection of local small businesses is threatened. Second, smuggling, underreporting of imports, and other forms of rule of origin abuse remain major challenges for Nigeria during ECOWAS (Fofack, 2018). Therefore, this study is geared towards assessing the impact of AfCFTA implementation on SMEs in Nigeria.

Aim and Objectives of Study. This study is aimed at assessing the effect of AfCFTA implemen-

tation on SMEs in Nigeria. Its other objectives include: To

1. access the positive impacts of AfCFTA implementation on SMEs in Nigeria.
2. enumerate the perceived threats of AfCFTA implementation on SMEs in Nigeria.
3. preview competitive capacities of SMEs in Nigeria and their capacity to meet the AfCFTA process requirement.

Research Question. The following research question will be used to guide the study

1. what are the positive impacts of AfCFTA implementation on SMEs in Nigeria?
2. what are the perceived threats of AfCFTA implementation on SMEs in Nigeria?
3. what are the competitive capacities of SMEs in Nigeria and their capacity to meet the AfCFTA process requirement?

Significance of Study. This study will be of great benefit to various SME owners in the selected state in Nigeria as it will bring it into the limelight and create better awareness of the impact of AfCFTA implementation on SMEs in Nigeria. The study will correlate the competitive capacities of SMEs and bring out the level of SME owners' awareness of the various implementation policies and the act of AfCFTA and how they can either benefit from it or lose from it. The study narrates the competitive capacities of SMEs in Nigeria and how they can adapt to meet the AfCFTA implementation process requirement. Generally, it will add to the existing literature on the issue of AfCFTA implementation and its effects on the general economy of the country.

Literature review

Brief Overview of the African Continental Free Trade Area (AFCFTA). The first big sign that Africa is taking regional economic integration seriously was the passage of the Tripartite Free Trade Agreement (FTTA) in Egypt in June 2015. This agreement includes a tycoon of 26 countries with a population of 720 million and a GDP of 1.3 trillion USD (Juma & Mangeni, 2018). For years, African leaders have desired a single, single African market with no barriers to trade in goods and services. They want a single market modeled after the European single market across the EU. After many failed attempts due to competing economic and political interests, African leaders finally adopted a resolution to establish a Continental Free Trade Area (CFTA), with a tentative launch date. is 2017. has been included. The African Continental Free Trade Area (AFCFTA) is an

effort to boost intra-African trade, estimated at only 10%. With an estimated population of more than 1.4 billion and a union of 54 countries, the EU will act as a single market for goods and services to become the largest regional economic bloc in the world. by quantity. I'm aiming for the Number of Countries to participate.

It has been the world's largest free trade area since the World Trade Organization was established 1 January 1995. But Nigeria was absent in March 2018 when the leaders of 44 African countries signed an agreement to create a \$2.5 trillion continental free trade area. The Federal Government of Nigeria said the committee was reviewing the treaty and needed input from the private sector and production stakeholders (Amodu and Sibor, 2018). According to Abati (2018), the African Continental Free Trade Agreement is arguably the most historic and important development since the establishment of the Organization of African Unity (OAU) in 2002, which later became the African Union (AU). It is also arguably the largest trade agreement since the founding of the World Trade Organization (WTO) and a tangible and provable culmination of African Renaissance and hedonism goals. This vision of a transformed Africa led to the introduction of policies and structures such as NEPAD, APRM, the New Africa Initiative (NAI), and others. Many of them may have been inspired by developments in this direction in the West, such as the EU. This is associated with the development of Africa's competitiveness, integration, cooperation, and forward-looking future. The AFCFTA is the product of these advances and is perhaps the most important culture (Abati, 2018).

Objectives of AfCFTA. The AfCFTA set out to progressively eliminate 90% of the tariffs on goods within 10 years and more for the remaining 10% (Mutahi and Mudibo, 2021). These tariffs are said to stand at an average of 6.1% which implies that businesses pay more to export within Africa than to export outside Africa (UNECA, 2019). To achieve this, Article 3 of the Agreement outlines the following general objectives:

1. Create a single market for goods, and services, facilitated by the movement of persons to deepen the economic integration of the African continent and by the Pan-African Vision of "An integrated, prosperous and peaceful Africa" enshrined in Agenda 2063

2. Create a liberalized market for goods and services through successive rounds of negotiations;

3. Contribute to the movement of capital and natural people and facilitate investments building on the initiatives and developments in the State Parties and Regional Economic Communities (RECs)

4. Lay the foundation for the establishment of a Continental Customs Union at a later stage.

5. Promote and attain sustainable and inclusive socio-economic development, gender equality, and structural transformation of the State Parties.

6. Enhance the competitiveness of the economies of State Parties within the continent and the global market.

7. Promote industrial development through diversification and regional value chain development, agricultural development, and food security

8. Resolve the challenges of multiple and overlapping memberships and expedite the regional and continental integration processes.

Challenges of the AfCFTA. The AfCFTA is expected to have adverse effects on the African economy. Trade deals are good for economies in the long run, but that's a different short-term story. In the short run, structural change through the movement of labor, capital, and other factors of production entails adjustment costs (Saygili et al., 2018). These adjustment costs will pose more of a challenge for less diverse and more resilient countries than for more diverse countries (Rena,2006; Albert, 2019). Moreover, in the short term, unskilled workers will be negatively affected, possibly leading to social tension. The trade agreement will increase competitive pressure, thereby improving business efficiency. However, small businesses will be negatively affected when facing stiffer competition (Rena and Kefela, 2006; Rena,2009; Saygili et al., 2018). They will incur higher transaction costs and thus face financial challenges when competing with larger companies (Albert, 2019). Trade liberalization will significantly affect the government budget balance/customs income and import tax in some countries. This, in turn, could undermine the government's ability to invest in infrastructure, education, and social programs, which are crucial to achieving sustainable development (Rena,2006; Albert, 2019). Intra-continental trade and exchanges could increase Carbon dioxide (CO₂) emissions which may have negative effects on the environment (Albert, 2019). There are yet some other challenges that have been identified to hinder the full implementation of the trade agreement. Vir (2021) outlined the following challenges of SMEs which indirectly hinder the trade agreement:

1. Deficiency in the human and technological capacity of SMEs making them vulnerable to larger firms

2. Limited access to SME finance and trade finance/high cost of capital

3. Poor/limited access to good infrastructures like steady power supply, good road network, transport system, and digital infrastructure

4. Foreign suppliers are dominating the market, making the local producers lose out

5. Loss of intellectual property to larger corporations due to poorly enforced patent laws.

6. In addition to the, Mutahi and Mudibo (2021) outlined the following challenges that impede the trade agreement

7. Customs systems/delays, security issues, and communication barriers.

8. Some countries are yet to gazette the specific changes in their tariffs and finalize their customs processes, such as the procedures for presentation, identification, and clearance of goods. Tariff reduction has not taken effect in those countries and so prices of goods are still high there.

Overview of SMEs In Nigeria. The criteria for defining SMEs vary from country to country, mainly depending on the size of the economy (Rena and Kefela, 2006; Rena, 2009; Azikiwe., 2018). This implies that a business enterprise may be classified as large in one country, while it may be considered small in another. In Nigeria, most of the business of MSMEs takes place in the informal sector and their operating mechanism is very different from that of the formal sector. These businesses typically require little capital, and minimal technical or professional skills, use local resources, create jobs at a relatively low cost by pooling unskilled and semi-skilled workers, and improved trade links, especially in rural and geographically remote areas. They operate in different sectors of the economy across the country and provide a platform to generate income for poor households. The sectoral and geographic distribution of SMEs in the country. According to a 2019 BNS survey, there are about 41.5 million SME businesses in Nigeria, of which 99% operate at the micro level and the majority are sole proprietors. The survey further highlights the importance of SMEs in Nigeria in terms of employment potential, contribution to GDP, and ability to export, among other factors. SMEs have been shown to play a huge role in the growth and development of many economies around the world (AfDB, 2012).

The Nigerian government recognizes the importance of this sector in achieving greater diver-

sification, industrialization, and a more inclusive growth model for the country. Therefore, to better coordinate, monitor and promote government initiatives related to MSMEs, the Small and Medium Enterprises Development Authority of Nigeria was established in 2004 to work with MSMEs. other stakeholders to strengthen the MSME sector and ensure that SMEs become viable avenues for national economic development. Despite the foregoing progress, Nigeria's SMEs are still not reaching their full potential. For example, SMEs account for 40-60% of exports in China, compared with a contribution of only 7.6% to Nigeria's exports and even less to manufacturing. export (Oyeyinka, 2020). This inefficiency is due to a range of challenges such as macroeconomic policy inconsistent; infrastructure deficit; poor power supply; inappropriate technology; lack of access to credit facilities and inadequate financial education; weak competitive landscape; tax multiple times; the weak link between policy actions and industry activities; inadequate transportation system; bureaucracy in obtaining permits and authorizations; high prices and inflation, etc. (NBS, 2020). Due to these challenges, Nigeria's SMEs often disappear or stagnate, and it is almost impossible to sustainably grow and scale into large enterprises. Therefore, it is urgent to address the peculiarities of the informal economy and difficult business environment to enable SMEs to benefit from regional integration. areas are planned to realize the full potential for national economic growth.

Impact of AfCFTA on Nigerian SMEs. It is no exaggeration to say that SMEs are the engines of the Nigerian economy. SMEs account for about 96% of all businesses in Nigeria and contribute to 75% of national employment (NBS, 2020). Therefore, changes in the country's economic policy model need to be evaluated in terms of their impact on SMEs for the analysis to truly reflect their impact on Nigerian society. There are many studies on the impact of free trade agreements on various parties around the world. For example, FTAs are supposed to affect input prices, industrial production, competitiveness, business productivity, and so on. In general, impacts are heterogeneous across sectors and sectors, so AfCFTA costs and benefits will have different impacts across sectors. This uncertainty reveals little is known about the impact of the AfCFTA on Nigerian SMEs, whose growth and competitiveness are hampered. By many internal and external factors. In this regard, historical considerations of the impact of national policy decisions on his MSME performance show mixed results. Because govern-

ment and central bank policies don't always help small businesses.

One of the biggest challenges in bridging the output gap for SMEs in Nigeria is financing. Lending rates in Nigeria are high (around 17%) compared to other African countries due to the lack of liquidity in the financial sector (Rena, 2006; Deloitte, 2018). The delay is partly due to the Central Bank of Nigeria (CBN) intervening in the foreign exchange market to stabilize the exchange rate. This leads to high-interest rates and discourages small businesses from raising funds to expand their operations, undermining the long-term business prospects of the non-oil sector. Another big challenge for SMEs is the lack of infrastructure (Yadav & Rena, 2025). This inevitably increases operating, or production costs and hinders competitiveness. Nigeria's existing infrastructure appears to be completely inadequate in terms of capacity and quality, and unable to keep up with the expected industrial development. Despite the public investment, Nigeria still suffers from major infrastructure deficits, particularly related to power generation, transport, and drinking water. For example, the current generation capacity is about 3,000 megawatts, corresponding to about 30% of the country's estimated demand. To reap the benefits of trade, a major challenge for governments and the private sector is to build modern, efficient, and effective infrastructure networks. Access to productive resources such as physical space, and public and information infrastructure (a central objective of this project) is also a major challenge for many small businesses in Nigeria.

Regarding the expected impact of the ZLECAf agreement, several existing studies suggest that the potential benefits of the agreement are significant for several reasons. First, the AfCFTA target market is projected to grow from about 1.27 billion to 1.7 billion by 2030, of which about 600 million will be in the middle class (Bramdeo, 2018). Second, gross domestic product (GDP) is between \$2.1 trillion and \$3.4 trillion, or 6.7 \$ trillion at purchasing power parity. Third, in terms of investment and consumer spending, the AfCFTA is expected to attract around \$4 trillion (Azikiwe, 2018). For Nigerian SMEs, some analysts suggest the category could stand to benefit from several opportunities AfCFTA could afford them. For instance, manufacturers should gain access to increased sources of cheaper and higher quality raw materials from the African continent. This will facilitate the production of cheaper and higher-value products which in turn will gain access to a larger continental market. From a gen-

der perspective, "AfCFTA will position women in such a way that they get to understand that trade is a force which, when properly harnessed, can help lift millions of professional and businesswomen out of poverty and bring shared prosperity to them. There are, however, some risks evident as well. For example, while the AfCFTA Agreement may prove beneficial for the already dominant (in the West African context) Nigerian financial services sector by increasing its market share, Nigerian SMEs may face uncompetitive pressure on the currency from the increased demand, thus lowering their ability to export and increasing imports of cheaper continental products. This risk, coupled with the already challenging environment in which SMEs operate in Nigeria detailed above, led various interest groups to argue that AfCFTA will hurt specific sectors such as manufacturing. These debates led to initial hesitation in signing the Agreement.

Theory of Free Trade. This study uses free trade theory as a theoretical approach to clarify the research. Free trade is the unrestricted import and export of goods and services between countries (Longley 2018). Traditional theory, both classical and neoclassical, holds that free trade in goods between different regions is always favorable for each trading country and is therefore best in terms of the welfare of the entire world. commercial rather than regional. Declaration is an agreement. (Kaldor, 1980) The theoretical argument for free trade builds on Adam Smith's argument that the division of labor between countries leads to speculation, greater efficiency, and greater collective output. Since the mid-20th century, countries have gradually removed tariff barriers, currency restrictions on international trade, and other barriers that can impede the efficient flow of goods and services (Dixon, 2022)). Both classical political economy and neoclassical theory favor free trade. They argue that free trade is beneficial because it allows countries to specialize in production with relatively low production factors. Some theorists of free trade theory are David Ricardo, Adams Smith, David Hume (1971), Keynes (1936), Krugman P (1987), Olson M (1982), Robert M (1991), etc.

The link between theory and research is that Nigeria and other member states of the African Union need free trade, free movement of goods and services, and free markets between African nations. The AfCFTA will be a platform to strengthen economic and financial integration with SMEs in Nigeria and SMEs in other African countries. However, free trade agreements have been criticized as means of

violating local or national environmental protection laws, and countries can make their economies eco-friendlier, environment by outsourcing production of polluting goods to other areas instead of changing production and consumption patterns. It has disadvantages as it can be user-friendly. The world imports goods and their products create waste.

Methodology

The study used descriptive survey design and primary data sources using questionnaires. All SMEs in the State of Lagos, where the population is only 1766, have been registered under the foundation of the Lagos State Chamber of Commerce and Industry (LCCI, 2021). The 400 samples for the study were scientifically calculated using Taaro Yamane's sampling method, after which the sample was randomly selected. Responses to the questionnaire were analyzed using the mean and standard deviation from a modified 4-point Likert scale of composite scores Strongly Agree, Agree, Disagree, and Strongly Disagree. Rate the comments for options as follows: Strongly agree (SA) = 4, Agree (A) = 3, Disagree (D) = 2, and strongly disagree (SD) = 1.

Results and discussion

In this section, the data collected for the study was analyzed to provide answers to the research questions that guided the study. Demographic Data Presentation

Demographic Data Presentation

Table 1

Age Range of Respondents

Age of respondent	Number of Respondents	Percentage
20-25	110	30%
26-36	150	37.74%
35-40	140	32.26%
Total	400	100%

Note: primary data

Table 1 above revealed the age range of 26-36 is dominant among the respondents used for the study.

Table 2

Gender of Respondents

Sex of Respondent	Number of Respondents	Percentage
Male	250	67%
Female	150	33%
Total	400	100%

Note: primary data

Table 2. Above shows that there are more male respondents selected for the study.

Table 3

Sector of SMEs

Sector of SMEs	Number of SMEs	Percentage
Agricultural and Food	102	25.5%
Manufacturing	83	20.75%
Wholesale and Retail Trade	110	27.5
Service	105	26.25
Total	400	100%

Note: primary data

Table 3 shows the sector of SMEs from where the selected number of SMEs were taken for the study. The study showed that the wholesale and retail sectors were selected more for the study with 27.5% (110) selected for the study.

Table 4

Size of Business

Work Status	Number of Respondents	Percentage
Small	109	22.26%
Medium	239	60.97%
Large	52	16.77%
Total	400	100%

Note: primary data

Table 4 indicates that there are more small business owners, and respondents, for the study. The

study selected more medium-scale businesses with 239 (60.97%) used for the study.

Research Question One: what are the positive impacts of AfCFTA implementation on SMEs in Nigeria?

Table 5 above shows respondents' views on the positive impact of the AfCFTA implementation on SMEs in Nigeria. Research has shown that lower raw material and input costs, increased production capacity, lower prices for goods and services, and lower costs for machinery are the positive effects of implementing "his AfCFTA for businesses." It has been. SMEs in Nigeria. This is evident from the fact that all items are popular, with one criterion exceeding his 2.5. This result is consistent with a study by Azikiwe (2018), which confirms that in the chain of transcontinental supply within the region, AFCFTA is expected to have an impact by facilitating business connectivity. Small and medium-sized enterprises (SMEs) with large regional enterprises export

both inside and outside the continent. This will contribute to the growth of SMEs and create a larger market for large companies. Continental companies now must consider higher taxes when exporting to Africa than when exporting abroad. The average is 6.1%. AFCFTA is expected to phase out tariffs on intra-African trade, making it easier for African companies to do business on the continent and tap into the vast potential of the broader African market. AFCFTA will help address some of the challenges associated with Africa's many overlapping trade agreements. Facilitate direct capital flows between Africa and African countries by facilitating cooperation in other areas such as technology transfer, investment in innovation, and infrastructure development for SMEs across the continent (Saygili, Peters & Knebel, 2018).

Research Question Two: what are the perceived threats of AfCFTA implementation on SMEs in Nigeria?

Table 5

Mean and standard deviation of respondents on the impacts of AfCFTA implementation on SMEs in Nigeria

S/N	Techniques	SA	A	D	SD	Mean $\bar{x}$	SD	Decision
1	Reduced cost of materials and inputs	221	120	43	16	3.37	0.62	Accepted
2	Increase in production capacity	180	142	48	30	3.18	0.67	Accepted
3	Reduction in the price of goods and service	237	132	21	10	3.49	0.59	Accepted
4	Reduction in the cost of machinery.	145	162	79	14	3.09	0.71	Accepted
5	Increment in the marketing sizes of SMEs.	127	140	94	39	2.78	0.74	Accepted

Note: primary data computation by the authors

Table 6

Mean and Standard deviation of respondents on the perceived threats of AfCFTA implementation on SMEs in Nigeria

S/N	Perceptions	SD	A	D	SD	Mean $\bar{x}$	SD	Decision
1	Increase foreign competition with local goods	187	124	58	42	2.99	0.74	Accepted
2	Reduction in the demand for goods and services of local goods	195	138	45	12	3.09	0.71	Accepted
3	Cheaper goods compete with local products	175	160	30	38	2.87	0.66	Accepted
4	Neglect of other important factors affecting SMEs	191	120	58	32	2.99	0.70	Accepted
5	Promote substandard products and dumping	169	125	46	60	3.00	0.68	Accepted

Note: primary data computation by the authors

Table 6 above shows the responses of respondents to the perceived threats of implementing AfCFTA to Nigerian SMEs. All award categories were accepted

with a mean score of >2.5 . Research shows that foreign competition for local products reduces demand for goods and services from local products, causing

cheaper products to compete with local products. Ignoring other important factors affecting SMEs and promoting shoddy products and dumping are considered threats to the implementation of SME AfCFTA in Nigeria. These results are consistent with the study by Faroe and Abasilim (2018), which shows that Nigerian SMEs end up opting for these cheaper alternatives, so domestic firms cannot compete vigorously. It is believed that Nigeria, with its very large population, will continue to be a net importer of goods and services from other African countries due to its very low technological capacity and high production costs (among other reasons). The country could be flooded

with cheap goods, fueling efforts to revive the local industry, agribusiness, and small and medium-sized enterprises (SMEs) (Azikiwe, 2018). According to Simo (2020), once the AfCFTA comes into force, member countries will be required to reduce duties by 90% on imports from other member countries, thereby allowing partner countries to collect taxes and rates to generate revenue. Companies across the continent are now imposing higher tariffs on exports to Africa than on exports outside Africa.

Research Question Three: what are the competitive capacities of SMEs in Nigeria and their capacity to meet the AfCFTA process requirement?

Table 7

Mean and standard deviation of respondents on the competitive capacities of SMEs in Nigeria and their capacity to meet the AfCFTA process requirement

S/N	Impacts	SD	A	D	SD	Mean $\bar{x}$	SD	Decision
1	Capabilities to defend against all potential competitive threats of AfCFTA	220	119	44	17	3.36	0.61	Accepted
2	Reducing Costs to a Highly Competitive Level	146	124	78	52	2.91	0.78	Accepted
3	Capabilities to Fully Benefit from All Market Opportunities of AfCFTA	165	138	65	32	3.09	0.71	Accepted

Note: primary data computation by the authors

Table 7 shows respondents' responses regarding the competitiveness of Nigerian SMEs and their ability to meet the requirements of the AfCFTA process. With an average criterion of over 2.5, the study finds that protecting Nigerian SMEs from potential competitive threats through AfCFTA reduces costs to a highly competitive level and increases the reach of all markets in the AfCFTA SMEs have a competitive edge to meet the requirements of the AfCFTA process. This correlates with a study by Signe and Van der Ven (2019) that firms must be able to combine assets, resources, and resources to maximize the potential benefits associated with the AfCFTA claims. The power and ability to make the most of that advantage. All market opportunities in trade agreements. Firms are optimistic about the potential to combine complementary assets, financial assets, reputational assets, and structures. This means that Nigerian SMEs seek to leverage intangible organizational and management processes (unique skills, processes, procedures, decision-making rules, in-

novation, etc.) in carrying out their daily activities. It also shows that these companies believe they can seize and maximize the AfCFTA opportunity through corporate structures, processes, design, and incentives.

Conclusion

The study reviewed the impact of AfCFTA implementation on small and medium businesses in Nigeria. From the analysis of the study, the following results were found.

Reduced cost of material and inputs, increase production capacity, reduction in the prices of goods and services, and reductions in the cost of machinery are the positive impacts of AfCFTA implementation on SMEs in Nigeria.

Increase foreign competition with local goods reduction in the demand for goods and services of local goods, and cheaper goods compete with local products. neglect of other important factors affect-

ing SMEs and the promotion of substandard products and dumping is the perceived threat of AfCFTA implementation on SMEs in Nigeria

SMEs in Nigeria by defending against all potential competitive threats of AfCFTA, reducing costs to a highly competitive level, and having the Capabilities to fully benefit from all market opportunities of AfCFTA, SMEs has the competitive capacities to meet the AfCFTA process requirement.

Overall, the impact of AfCFTA has not affected the welfare of SMEs in Nigeria, the prices of goods and services have not yet decreased and tariffs among African countries remain high due to these challenges. It's a long, slow, and complicated process that takes time to fully implement and realize its potential. In summary, Nigeria's SMEs are said to be able to benefit from trade deals, but there is a downturn in the manufacturing sector, growing anxiety, and the tendency of many to be unpatriotic. Nigerians, restrictive trade policies, the undiversified nature of the economy, and weak institutional framework make Nigerian SMEs more likely to lose out on commercial transactions.

Recommendation. As a result of the research, the following recommendations were made:

Nigerians and SMEs should introspect and seek to change their mindset that disrespects the products and services of non-African countries. It will strengthen intra-African trade and complement African leaders' commitment to the success of the AfCFTA.

Governments, including Nigeria, need not only to develop strategies to effectively implement trade agreements but to ensure they are implemented. Mechanisms to implement these policies should be adopted and implemented in a manner that supports

the development of small and medium enterprises in the country.

We strongly recommend addressing the issues plaguing the SME sector and strengthening the industry so that Nigeria can enjoy the comparative advantages of this trade deal. Priority should be given to economic and political structures that promote mutual trust and patriotism among the Nigerian people.

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The authors declare that there are no conflicts of interest that could have influenced the results of the study or their interpretation.

Author Contributions

RR: conceptualization of the study, critical revision of the manuscript for important intellectual content, analysis of the collected data, and approval of the final version of the manuscript for publication.

RR & GED: – literature review, collection of statistical data, interpretation of research results, development of the article structure, and manuscript formatting.

RR & GED: – data analysis, interpretation of statistical calculations, participation in the interpretation of research findings, and reviewing the Russian and English translations of the manuscript.

RR & GED: – collection and systematization of statistical information, participation in data processing, assistance in preparing tables and figures, and editing of the manuscript.

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Авторлар туралы мәлімет:

Равиндер Рена – Азия-Тынық мұхиты аймағында, Африкада және Еуропада 33 жылдан астам педагогикалық және ғылыми-зерттеу тәжірибесі бар экономика саласының аға профессоры. Қазіргі уақытта Оңтүстік Африка Республикасының Дурбан қаласындағы Дурбан технологиялық университетінің Басқару ғылымдары факультеті, Мемлекеттік басқару және экономика кафедрасының экономика профессоры қызметін атқарады. Сонымен қатар, Швейцариядағы Monarch Business School университетінің қосымша профессоры және бірнеше елдерде шақырылған профессор болып табылады. Ол халықаралық академиялық алаңдарда, соның ішінде BRICS зерттеу платформаларында белсенді қызмет атқарады. Профессор Рена 200-ден астам рецензияланатын ғылыми мақала мен 80-нен астам кітап тарауының авторы. Ол 400-ден астам халықаралық конференцияда негізгі баяндамалар жасаған. Ғылыми қызығушылықтары: даму экономикасы, білім экономикасы, мемлекеттік саясат, инклюзивті экономикалық өсу, жаһандану, шағын, микро және орта кәсіпкерлік (SMMEs), микронесиеу және ауылдық кәсіпкерлікті дамыту. Оның Google Scholar профилі бойынша еңбектері 2100-нан астам рет дәйектелген; Хириш индексі (h-index) – 26, i10 индексі – 62 (Дурбан, Оңтүстік Африка Республикасы, e-mail: ravinder.rena@gmail.com).

Джордж Эммануэль Дейнма – Нигериядағы Риверс штаты университетінің Әлеуметтік ғылымдар факультеті, Саясаттану кафедрасының аспиранты. Ол Нигериядағы жастарды ынталандыру және әйелдердің мүмкіндіктерін кеңейту бағдарламалары сияқты көптеген гуманитарлық жобаларға белсенді қатысады. Оның ғылыми қызығушылықтары дәстүрлі жанжалдарды басқару стратегиялары, Нигер дельтасы аймағындағы теңіз қауіпсіздігі, Балтық өңіріндегі ядролық қауіптер, Нигериядағы киберқауіпсіздік қатерлері, сондай-ақ атыс қаруы мен жеңіл қарулардың таралуы мәселелерін қамтиды (Порт-Харкорт, Нигерия, e-mail: ravinder.rena@gmail.com).

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APPLICATION OF ARTIFICIAL INTELLIGENCE-ASSISTED ANALYTICAL TOOLS FOR ASSESSING AND ENHANCING THE EFFECTIVENESS OF GOVERNMENT PROGRAMS IN REGIONAL DEVELOPMENT GOVERNANCE IN THE REPUBLIC OF KAZAKHSTAN

This paper examines the application of AI-assisted analytical tools in evaluating the effectiveness of government regional development programs in the Republic of Kazakhstan. The study addresses the limitations of conventional evaluation practices that focus primarily on budget execution and formal performance indicators, providing limited insight into socio-economic effects under conditions of pronounced interregional heterogeneity.

The objective is to assess the relationship between government program expenditures and gross regional product (GRP) dynamics across regions, as well as to identify differences in program effectiveness associated with regional characteristics. The analytical framework integrates panel econometric methods with AI-assisted decision-support analytics designed to enhance the interpretation and practical relevance of empirical results.

The study employs panel regression models with regional and time fixed effects using official regional statistics for 2018–2024. AI-assisted tools are applied at the post-estimation stage to support scenario-based analysis and explore regional differentiation in program outcomes.

The results indicate a positive but heterogeneous association between government programs and regional economic growth, highlighting the role of institutional conditions, program design, and regional economic structure beyond funding volumes alone. The paper contributes by proposing an integrated econometric–AI evaluation framework that supports differentiated, evidence-based regional policy design under heterogeneous territorial conditions.

Keywords: government programs, regional development, panel data analysis, policy effectiveness, AI-assisted analytics, scenario analysis, regional heterogeneity, Republic of Kazakhstan.

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Қазақстан Республикасында өңірлік дамуды басқару жүйесінде мемлекеттік бағдарламалардың тиімділігін бағалау және арттыру үшін жасанды интеллект көмегімен жүзеге асырылатын аналитикалық құралдарды қолдану

Мақалада Қазақстан Республикасындағы өңірлік дамудың мемлекеттік бағдарламаларының тиімділігін бағалауда жасанды интеллектке негізделген аналитикалық құралдарды қолдану мәселесі қарастырылады. Зерттеудің өзектілігі қолданыстағы бағалау тәжірибелерінің негізінен бюджеттік орындалуды және формальды нәтижелілік көрсеткіштерін бақылаумен шектелуіне байланысты, бұл айқын өңіраралық әркелкілік жағдайында нақты әлеуметтік-экономикалық әсерлерді толық ашуға мүмкіндік бермейді.

Зерттеудің мақсаты – мемлекеттік бағдарламалар шығындары мен өңірлік жалпы өнім (ӨЖӨ) динамикасы арасындағы өзара байланысты бағалау, сондай-ақ өңірлік ерекшеліктерге байланысты бағдарламалардың тиімділігіндегі айырмашылықтарды анықтау. Аналитикалық негіз панельдік эконометриялық әдістерді эмпирикалық нәтижелердің интерпретациясын және

қолданылуын күшейтуге бағытталған жасанды интеллектке негізделген шешім қабылдауды қолдау құралдарымен біріктіреді.

Зерттеуде 2018–2024 жылдар аралығындағы ресми өңірлік статистика деректері негізінде өңірлік және уақыттық тұрақты әсерлері бар панельдік регрессиялық модельдер қолданылады. Жасанды интеллект құралдары постбағалау кезеңінде сценарийлік талдау жүргізу және бағдарламалық әсерлердің өңірлік саралануын зерттеу үшін пайдаланылады.

Нәтижелер мемлекеттік бағдарламалар мен өңірлік экономикалық өсім арасындағы оң, алайда әркімді байланысты көрсетеді және бағдарламалардың тиімділігі қаржыландыру көлемімен қатар институционалдық жағдайларға, бағдарламалардың дизайнына және өңірлік экономиканың құрылымына тәуелді екенін айқындайды. Зерттеудің ғылыми үлесі өңірлік әркімдік жағдайында дәлелді және сараланған өңірлік саясатты қалыптастыруға мүмкіндік беретін эконометриялық және жасанды интеллектке негізделген интеграцияланған бағалау жүйесін ұсыну болып табылады.

Түйін сөздер: мемлекеттік бағдарламалар, өңірлік даму, панельдік деректерді талдау, саясат тиімділігі, жасанды интеллектке негізделген аналитика, сценарийлік талдау, өңірлік әркімдік, Қазақстан Республикасы.

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**Применение аналитических инструментов с использованием
искусственного интеллекта для оценки и повышения эффективности
государственных программ в системе управления региональным развитием
в Республике Казахстан**

В статье рассматривается применение аналитических инструментов на основе искусственного интеллекта для оценки эффективности государственных программ регионального развития в Республике Казахстан. Актуальность исследования обусловлена ограниченностью традиционных практик оценки, которые в основном сосредоточены на контроле исполнения бюджета и формальных показателях результативности и, вследствие этого, дают ограниченное представление о социально-экономических эффектах в условиях выраженной межрегиональной неоднородности.

Цель исследования заключается в оценке взаимосвязи между расходами по государственным программам и динамикой валового регионального продукта (ВРП), а также в выявлении различий в эффективности программ, обусловленных региональными особенностями. Аналитическая рамка интегрирует панельные эконометрические методы с AI-ориентированными инструментами поддержки принятия решений, направленными на повышение интерпретируемости и практической значимости эмпирических результатов.

В исследовании используются панельные регрессионные модели с фиксированными региональными и временными эффектами на основе официальной региональной статистики за период 2018–2024 гг. AI-ассистированные инструменты применяются на постоценочном этапе для проведения сценарного анализа и изучения региональной дифференциации эффектов программ.

Полученные результаты указывают на положительную, но неоднородную связь между государственными программами и региональным экономическим ростом, подчёркивая значение институциональных условий, дизайна программ и структуры региональной экономики наряду с объёмами финансирования. Научный вклад статьи состоит в разработке интегрированной эконометрической и AI-ориентированной модели оценки, способствующей формированию дифференцированной и доказательной региональной политики в условиях территориальной неоднородности.

Ключевые слова: государственные программы, региональное развитие, панельный анализ данных, эффективность политики, аналитика на основе ИИ, сценарный анализ, региональная неоднородность, Республика Казахстан.

Introduction

Government programs for regional development represent a key instrument of public policy in countries characterized by pronounced territorial heterogeneity. The Republic of Kazakhstan exemplifies this challenge, as substantial differences in economic development, investment activity, and employment across regions make policy effectiveness highly dependent on the consideration of regional specificities.

In practice, the evaluation of government programs remains largely focused on monitoring budget execution and formal performance indicators, providing limited insight into actual socio-economic effects and regional variation in policy outcomes. This creates risks of inefficient resource allocation and unsustainable development trajectories.

While advances in panel econometric methods have expanded opportunities for quantitative policy evaluation, their application to regional development programs with explicit consideration of inter-regional heterogeneity remains limited. To address this gap, this study assesses the association between government program expenditures and regional economic development in the Republic of Kazakhstan using fixed-effects panel regression models.

To enhance interpretation and policy relevance, the analysis integrates AI-assisted analytical tools at the post-estimation stage, including scenario-based (“what-if”) analysis commonly used in decision-support systems. Artificial intelligence is treated as a complementary analytical instrument rather than an independent modeling framework, supporting a transition from uniform, expenditure-driven approaches toward more flexible and evidence-based regional development management.

Literature review

Artificial intelligence has become an increasingly important component of analytical decision-support systems in public administration, where it is applied to policy analysis, socio-economic forecasting, and the evaluation of alternative managerial decisions. In regional development policy, data-driven analytical tools are particularly valuable for capturing heterogeneous regional responses and complex interdependencies that are often insufficiently reflected in traditional evaluation approaches.

A substantial body of literature emphasizes the limitations of uniform policy frameworks and supports the transition toward differentiated, place-

based development strategies. The place-based approach argues that public interventions are more effective when aligned with regional socio-economic and institutional conditions rather than applied uniformly across territories (Barca *et al.*, 2012). Empirical evidence further suggests that ignoring regional heterogeneity weakens policy outcomes and may exacerbate spatial inequalities (Rodríguez-Pose, 2018).

Approaches to evaluating government programs have evolved from procedural monitoring toward impact-oriented assessment. International organizations note that reliance on budget execution and formal indicators provides limited information about actual socio-economic effects (European Commission, 2018). The OECD (2020) highlights the importance of evaluation frameworks focused on outcomes and medium-term effects rather than administrative compliance, a view consistent with earlier studies advocating a shift toward measurable results and policy effectiveness.

Recent advances in data analytics have expanded the methodological toolkit available for public policy analysis. Empirical studies show that data-centric approaches improve policy design and evaluation by identifying non-linear relationships and heterogeneous effects (Foster *et al.*, 2021; World Bank, 2021). At the same time, the literature increasingly treats artificial intelligence and machine learning as complementary to econometric methods rather than substitutes. Econometric models remain central for causal inference and interpretability, while AI-based tools enhance exploratory analysis and predictive performance (Athey & Imbens, 2019; Varian, 2019).

The application of artificial intelligence in public sector governance is therefore framed as an augmentation of analytical capacity rather than a replacement of human decision-making. Institutional conditions and governance arrangements play a decisive role in determining the effectiveness of digital tools. The OECD (2024) emphasizes that institutional capacity, organizational coordination, and ethical standards are essential prerequisites for the meaningful integration of AI into public administration. Similar conclusions are drawn in comparative studies of public management reform, which stress the importance of embedding digital innovations within established administrative structures (Pollitt & Bouckaert, 2017).

Research on government programs in Kazakhstan has produced descriptive analyses of regional development outcomes and assessments of specific

policy instruments. However, existing studies lack a unified quantitative framework for systematic cross-regional comparison of program effects (Nekrasov & Sinitsyna, 2017). Moreover, research on the digital transformation of public administration in Kazakhstan has largely focused on information and monitoring systems, including digital models for monitoring national programs, while analytical evaluations of program effectiveness remain limited (Asatova & Mazhiyeva, 2025; Uandykova *et al.*, 2025).

Overall, despite extensive research on regional development and public sector digitalization, a methodological gap persists in studies that combine quantitative program evaluation with AI-oriented analytical tools while explicitly accounting for regional heterogeneity. This study contributes to addressing this gap by integrating panel econometric analysis with AI-assisted scenario modeling applied to the regions of the Republic of Kazakhstan.

Methodology

Research Objective, Question, and Hypothesis

The objective of this study is to assess the impact of government regional development programs on the growth of gross regional product (GRP) across the regions of the Republic of Kazakhstan. The analysis aims to quantify the relationship between public program expenditures and regional economic performance while explicitly accounting for pronounced interregional heterogeneity.

The central research question is as follows: to what extent and with what degree of stability are government program expenditures associated with regional economic growth across heterogeneous regions?

The underlying hypothesis posits that the effectiveness of government programs is not uniform across regions and depends not only on the scale of public financing but also on differences in investment activity, labor market conditions, and institutional capacity. Consequently, identical policy instruments may generate heterogeneous economic outcomes across regions.

Empirical Base and Variables

The empirical analysis is based on a balanced panel dataset covering the regions of the Republic of Kazakhstan for the period 2018–2024. The data are drawn from official statistics published by the Bureau of National Statistics of the Republic of Kazakhstan. The final dataset includes all regions observed consistently over the study period, en-

suring comparability of regional indicators over time.

Administrative and territorial changes that occurred during the analyzed period were addressed through harmonization of regional boundaries, allowing the construction of a consistent panel structure and avoiding artificial structural breaks.

The dependent variable is the growth rate of gross regional product (GRP), which serves as an aggregate indicator of regional economic dynamics. The key explanatory variable is government program expenditures expressed as a share of GRP, reflecting the intensity of public policy intervention at the regional level.

To control for regional economic conditions, the model includes a set of standard control variables. These comprise fixed capital investment as a share of GRP, capturing investment intensity and capital accumulation, and the employment rate, reflecting labor market performance and utilization of human resources.

Econometric Model

To estimate the relationship between government programs and regional economic growth, a panel regression model with regional and time fixed effects is employed. This specification allows for controlling unobserved, time-invariant regional characteristics—such as institutional quality, historical development paths, and structural economic features—as well as common macroeconomic shocks affecting all regions. The baseline econometric model is specified as follows:

$$GRP_growth_{it} = \beta_0 + \beta_1 ProgExp_{it} + \beta_2 Invest_{it} + \beta_3 Employ_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (1)$$

where

GRP_growth_{it} denotes the growth rate of gross regional product in region i at time t ;

$ProgExp_{it}$ represents government program expenditures as a share of GRP;

$Invest_{it}$ denotes fixed capital investment as a share of GRP;

$Employ_{it}$ represents the employment rate;

μ_i captures unobserved region-specific fixed effects;

λ_t denotes time fixed effects controlling for common macroeconomic factors;

ε_{it} is the idiosyncratic error term.

A comparison between fixed effects and random effects specifications was conducted. The results of the Hausman test reject the null hypothesis of no systematic difference between estimators, indicat-

ing correlation between explanatory variables and unobserved regional effects. Accordingly, the fixed effects specification is preferred as it yields consistent estimates under these conditions.

Standard errors are computed using clustering at the regional level to account for potential heteroskedasticity and serial correlation within regions over time.

In an extended specification, total government program expenditures are disaggregated by policy domain to assess potential differences in economic effects across program categories.

Scenario Analysis and AI-Oriented Framework

To explore the potential effects of alternative policy configurations, a scenario-based analytical framework is applied. Scenario outcomes are derived using estimated regression coefficients combined with hypothetical changes in key explanatory variables, expressed as:

$$\Delta GRP = \sum_k \beta_k \Delta X_k \quad (2)$$

where β_k denotes estimated parameters and ΔX_k represents scenario-specific changes in explanatory variables.

AI-assisted analytical tools are employed at the post-estimation stage to support interpretation of scenario results and to identify patterns of regional heterogeneity. In particular, these tools facilitate structured comparison of alternative policy scenarios, grouping of regions according to observed effectiveness patterns, and assessment of differentiated responses to changes in program parameters.

Importantly, artificial intelligence is not applied as an autonomous predictive or machine-learning framework. Instead, it functions as a transparent and interpretable analytical decision-support layer, enhancing the policy relevance and practical usability of econometric findings.

Robustness and Diagnostic Checks

Several diagnostic checks were conducted to assess the reliability of the estimated models. Tests for heteroskedasticity and serial correlation indicate that potential deviations from classical assumptions do not materially affect the estimated coefficients. Sensitivity analyses using alternative model specifications and control variable sets confirm the stability of the main results.

Methodological Limitations

Several methodological limitations should be acknowledged. First, although the fixed-effects framework mitigates bias arising from unobserved time-invariant regional characteristics, it does not

fully eliminate potential endogeneity related to policy allocation decisions. In particular, reverse causality may arise if economically stronger regions are more likely to attract higher levels of public funding.

Second, the analysis relies on aggregated regional data, which limits the ability to capture intra-regional variation and sector-specific dynamics. Third, the scenario-based analysis represents a structured “what-if” exercise based on estimated associations and does not constitute a fully causal framework.

Accordingly, the estimated coefficients should be interpreted as stable empirical associations rather than strict causal effects. Despite these limitations, the proposed methodological framework provides a coherent and empirically grounded approach for assessing heterogeneous impacts of regional development programs and supports evidence-based policy analysis under real-world data constraints.

Results and discussion

Recent studies emphasize that the effectiveness of regional development policies critically depends on institutional quality, governance capacity, and place-specific conditions rather than on funding volumes alone (Crescenzi *et al.*, 2023). Evidence-based evaluation frameworks increasingly combine econometric analysis with structured analytical tools to support differentiated policy design and adaptive program management under heterogeneous regional conditions (OECD, 2023). These approaches are consistent with the analytical strategy adopted in this study.

This section reports the empirical results of the analysis of socio-economic development across the regions of the Republic of Kazakhstan for the period 2018–2024 in the context of state regional development programs. The discussion begins with a descriptive assessment of regional data, which provides the empirical basis for subsequent econometric and AI-assisted analysis.

Table 1 presents descriptive statistics for the key socio-economic indicators. The results indicate a high degree of interregional differentiation. Gross regional product (GRP) and GRP per capita exhibit substantial dispersion, reflecting pronounced differences in both the scale of economic activity and the level of regional development. Similar patterns are observed for investment and employment indicators, suggesting the presence of structurally heterogeneous regional economies with unequal growth potential.

Table 1*Descriptive statistics of socio-economic indicators of the regions of the Republic of Kazakhstan (2018–2024)*

Indicator	Mean	Minimum	Maximum	Standard deviation
GRP, billion KZT	9,840	2,310	29,450	6,120
GRP per capita, thousand KZT	6,540	3,120	14,870	2,980
GRP growth rate, %	4.2	–1.3	9.8	2.6
Fixed capital investment, % of GRP	18.5	9.7	32.4	6.1
Expenditures on state programs, % of GRP	6.1	2.4	11.6	2.3
Employment rate, %	64.3	56.1	72.8	4.1

Note: compiled by the author based on data from the Bureau of National Statistics of the Republic of Kazakhstan

The magnitude of territorial disparities is substantial. The difference between the minimum and maximum values of GRP exceeds KZT 27 trillion, indicating a strong concentration of economic activity in a limited number of regions. GRP per capita varies by more than fourfold, pointing to pronounced differences in productivity and income generation that are not explained by short-term fluctuations.

Regional GRP growth rates range from negative values to nearly 10%, reflecting heterogeneous growth dynamics and differing regional responses to macroeconomic conditions and policy interventions. Under such conditions, identical policy measures are unlikely to produce uniform outcomes across regions.

Investment activity is also highly uneven. The share of fixed capital investment ranges from 9.7% to 32.4% of GRP, indicating unequal access to capital accumulation and development opportunities. Regions with persistently low investment intensity face structural constraints that limit their growth capacity.

Expenditures on state programs account for a significant share of regional output, yet regions with comparable levels of program financing often demonstrate markedly different growth outcomes. This pattern suggests that the relationship between public spending and regional economic performance is not

proportional and depends on regional institutional capacity and economic structure rather than on funding volumes alone.

Employment rates display relatively lower dispersion compared with output and investment indicators, indicating a degree of labor market stability. Nevertheless, remaining differences reflect variation in labor utilization and sectoral composition across regions.

Overall, the descriptive evidence confirms that regional development in the Republic of Kazakhstan is characterized by deep structural heterogeneity. These findings justify the application of panel econometric models that explicitly control for unobserved regional characteristics and support the use of complementary analytical tools aimed at identifying differentiated program effects rather than assuming homogeneous policy impacts.

To further assess the outcomes of state regional development programs, an aggregated program effectiveness index is constructed. Table 2 presents an aggregated effectiveness index of state regional development programs, constructed on the basis of normalized indicators of GRP growth, investment activity, and employment, and intended for interregional comparison rather than as an absolute measure of program performance.

Table 2*Effectiveness index of state regional development programs*

Indicator	Mean	Minimum	Maximum	Standard deviation
Program effectiveness index	0.63	0.28	0.87	0.15
GRP growth rate, %	4.2	–1.3	9.8	2.6
Fixed capital investment, % of GRP	18.5	9.7	32.4	6.1
Employment rate, %	64.3	56.1	72.8	4.1

Note: compiled by the author

The distribution of the program effectiveness index indicates substantial interregional variation. Index values range from 0.28 to 0.87, with a mean of 0.63, suggesting that the outcomes of state programs differ markedly across regions. The magnitude of dispersion implies that program performance cannot be considered uniform, even under a common institutional and policy framework.

Importantly, the presence of regions with medium or low index values despite relatively high levels of program expenditures indicates that financial inputs alone do not determine program success. This pattern suggests differences in regional capacity to translate public resources into economic outcomes, reflecting variations in managerial quality, institutional conditions, and the alignment of program instruments with region-specific socio-economic structures.

The results further indicate that similar values of the underlying indicators—such as investment intensity or employment levels—may correspond to dif-

ferent overall effectiveness scores, underscoring the multidimensional nature of program performance. As a result, the effectiveness index provides additional analytical insight beyond individual indicators and highlights the limitations of evaluation approaches based solely on budget execution or single outcome measures.

Overall, the evidence from Table 2 supports the argument that the effectiveness of regional development programs is conditioned by regional heterogeneity and institutional context. These findings provide a direct empirical motivation for the subsequent econometric analysis, which explicitly controls for unobserved regional characteristics and examines differentiated program effects across regions.

Differences in gross value added (GVA) growth attributable to state regional development programs are assessed using panel regression estimates with regional and time fixed effects. The results are reported in Table 3.

Table 3

Results of the assessment of the impact of state programs on GVA growth rates in the regions of the Republic of Kazakhstan (2018–2024)

Variable	Coefficient (β)	t-statistic	p-value
Expenditures under Program A (“Strong Regions – Drivers of National Development”), % of GRP	0.08	1.21	0.23
Expenditures under Program B (“Business Roadmap–2025”), % of GRP	0.19	2.34	0.02
Fixed capital investment, % of GRP	0.27	3.11	0.01
Employment rate, %	0.14	1.98	0.05
Constant	–1.62	–1.44	0.15
Regional fixed effects	Yes		
Time effects	Yes		
R ² (within)	0.41		
Number of observations	119		

Note: compiled by the author based on data from the Bureau of National Statistics of the Republic of Kazakhstan

The estimated coefficient for expenditures under Program A is positive but not statistically significant. This result indicates the absence of a robust direct relationship between program financing and regional GVA growth within the analyzed period. The finding suggests that the economic effects of Program A are either indirect, delayed, or insufficiently captured by aggregate output dynamics.

In contrast, expenditures under Program B demonstrate a statistically significant positive association with regional GVA growth. The magnitude and

significance of the coefficient indicate a more effective transmission of program resources into economic outcomes. This result is consistent with the program’s emphasis on entrepreneurship support, business activity, and investment stimulation, which are more directly linked to short- and medium-term growth dynamics.

Among the control variables, fixed capital investment exhibits a stable and statistically significant positive effect on GVA growth, confirming its central role in regional economic expansion. The

employment rate shows a positive effect at the conventional significance threshold, suggesting that labor market conditions contribute to growth, although their impact appears less pronounced than that of investment.

Overall, the regression results indicate that the effectiveness of state regional development programs varies across policy instruments. Program outcomes depend not only on the volume of public expenditures but also on the design of program mechanisms and their alignment with regional economic structures. These findings are consistent with the place-based development perspective, which emphasizes the importance of institutional and structural context in determining policy effectiveness.

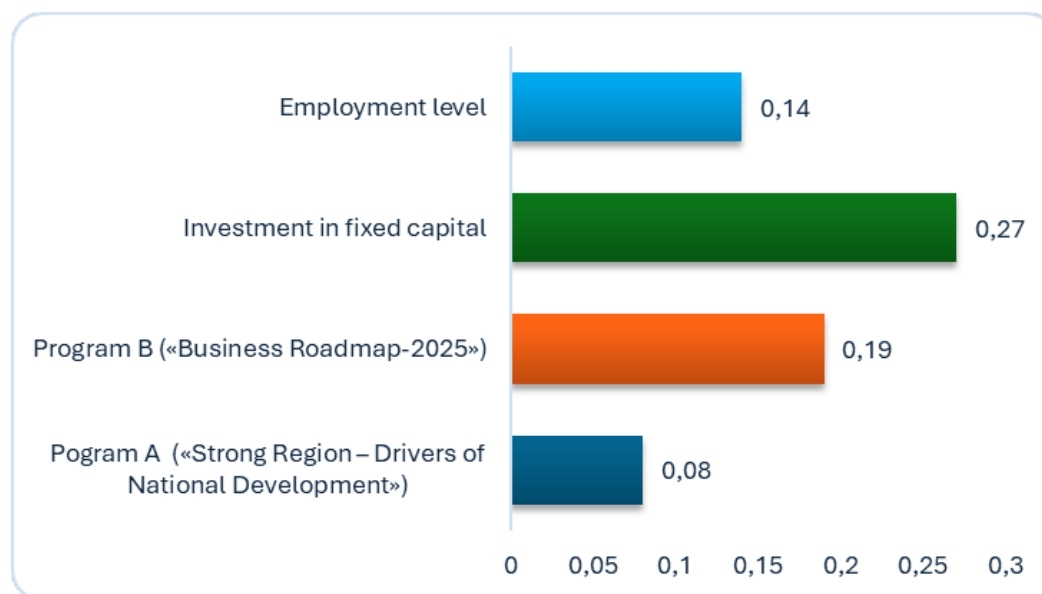
To enhance economic interpretation of the estimated coefficients, it is important to clarify the practical meaning of changes in program expenditures.

A one-percentage-point increase in government program expenditures corresponds to an increase in spending equivalent to 1% of regional GRP. For a region with an average GRP of approximately 10 trillion KZT, this implies an additional allocation of about 100 billion KZT. Within this context, a coefficient of 0.19 indicates that such an increase in program expenditures is associated with an increase in regional GVA growth of approximately 0.19 percentage points, holding other factors constant. This magnitude is economically meaningful when evaluated against average regional growth rates and the scale of public spending involved.

For clearer interpretation of the estimated coefficients, the regression results are summarized in Figure 1, which visualizes the relative effects of state programs and control variables on regional GRP growth.

Figure 1

Estimated effects of state programs and control factors on GRP growth rates of the regions of the Republic of Kazakhstan



Note: compiled by the author based on data from the Bureau of National Statistics of the Republic of Kazakhstan

The visualization confirms the patterns identified in Table 3. Program B demonstrates a noticeably stronger and statistically meaningful association with GRP growth compared to Program A, whose estimated effect remains weak and statistically insignificant. This contrast highlights differences in

the economic transmission mechanisms embedded in the two programs.

Control variables exhibit stable and economically interpretable effects. Fixed capital investment shows the largest positive contribution to regional growth, while the employment rate dis-

plays a more moderate influence. The relative positioning of coefficients in the figure underscores that growth outcomes are driven by a combination of investment dynamics, labor market conditions, and program design rather than by public expenditures alone.

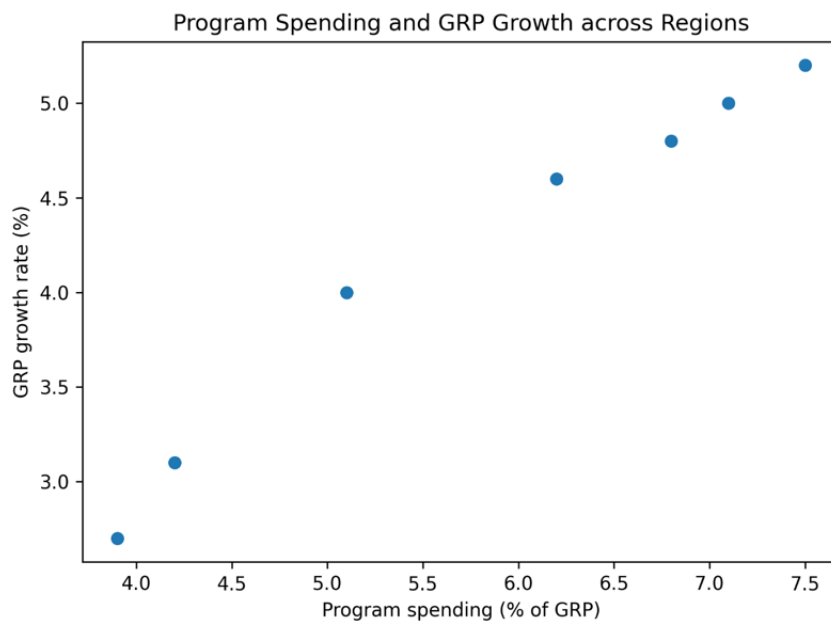
Overall, Figure 1 reinforces the conclusion that the effectiveness of state regional development programs cannot be inferred from funding volumes in isolation. Instead, program outcomes depend on the alignment of policy instruments with regional

economic structures and implementation mechanisms, providing a visual justification for differentiated and context-sensitive regional policy approaches.

The relationship between the share of expenditures on state programs and regional GRP growth rates is illustrated in Figure 2. The figure complements the econometric results by providing a direct visual assessment of how variations in program financing are associated with regional economic dynamics.

Figure 2

Relationship between GRP growth rates and the share of expenditures on state programs in the regions of the Republic of Kazakhstan



Note: compiled by the author based on data from the Bureau of National Statistics of the Republic of Kazakhstan using the Python software environment (Matplotlib library)

The distribution of observations in Figure 2 reveals substantial interregional dispersion of GRP growth rates across comparable levels of program expenditures. Regions with similar shares of state program financing demonstrate markedly different growth outcomes, indicating the absence of a stable linear relationship between funding intensity and economic performance.

To quantify this relationship, a linear correlation coefficient was calculated. The estimated value ($r \approx 0.35$) indicates a moderately positive but weak association between the share of program expenditures

and GRP growth rates. This result suggests that variations in program financing explain only a limited portion of regional growth differences, while the majority of variation is driven by factors beyond expenditure volumes.

The observed pattern is consistent with the panel regression results and reinforces the conclusion that program effectiveness is conditioned by regional heterogeneity. Institutional quality, economic structure, and governance capacity appear to play a more decisive role in shaping growth outcomes than funding levels alone.

Building on these findings, regions were classified according to their levels of program effectiveness, which enabled the implementation of AI-oriented scenario modeling explicitly accounting for regional differences. The scenario analysis indicates that identical changes in program expenditures generate heterogeneous economic effects. Regions with high program effectiveness exhibit a pronounced growth response when increased funding is combined with investment activity. Regions with moderate effectiveness show weaker responses and require complementary institutional or investment measures. In regions with low effectiveness, isolated increases in program expenditures produce only marginal growth effects.

Overall, the analysis presented in Figure 2 highlights the context-dependent nature of state program impacts. Program effectiveness is determined not solely by the scale of public financing, but by the capacity of regional economies and institutional environments to transform program resources into measurable economic outcomes.

Within the AI-assisted analytical framework, regions are compared based on their estimated program effectiveness and structural characteristics. This enables identification of heterogeneous response patterns and supports differentiation of scenario outcomes across groups of regions with similar economic profiles. Such analytical structuring improves the practical usability of econometric results for policy design and program adjustment.

Within the scenario analysis framework, three conditional scenarios of state program implementation are considered: baseline, moderately optimistic, and constrained. The scenarios are designed to examine how alternative combinations of program expenditures, investment activity, and employment conditions affect regional GRP growth. The results of the AI-oriented scenario modeling are presented in Table 4.

The baseline scenario serves as a reference point and reflects unchanged policy and economic conditions. Under this scenario, no additional contribution to GRP growth is observed.

Table 4

Results of AI-oriented scenario modeling of the impact of state programs on GRP growth rates in the regions of the Republic of Kazakhstan

Scenario	Change in Program B expenditures, p.p. of GRP	Change in investment, p.p. of GRP	Change in employment rate, p.p.	Estimated effect on GRP growth rates, p.p.
Baseline	0.0	0.0	0.0	0.00
Moderately optimistic	+1.0	+1.0	+0.5	+0.53
Constrained	+1.0	0.0	0.0	+0.19

Note: Scenario-based estimates are calculated using the coefficients of the panel regression model (see Table 3). Estimated effects represent linear combinations of regression coefficients under hypothetical changes in scenario parameters. The AI-oriented nature of the analysis reflects the application of “what-if” scenario logic to compare alternative development trajectories

The moderately optimistic scenario generates an increase in GRP growth rates of 0.53 percentage points. The largest contribution is associated with higher investment activity, which accounts for 0.27 percentage points of the total effect. Program expenditures and employment improvements contribute 0.19 and 0.07 percentage points, respectively. In relative terms, this corresponds to an increase in average annual GRP growth of approximately 12–13% compared to the mean growth rate over the analyzed period. The result indicates that program financing yields substantially stronger effects when accompa-

nied by favorable investment and labor market dynamics.

In contrast, the constrained scenario produces a markedly smaller effect of 0.19 percentage points. Despite an identical increase in program expenditures, the absence of complementary investment and employment responses limits the overall growth impact. This outcome highlights the restricted effectiveness of isolated increases in program funding and underscores the role of the broader economic environment in shaping policy outcomes.

Overall, the scenario analysis confirms the con-

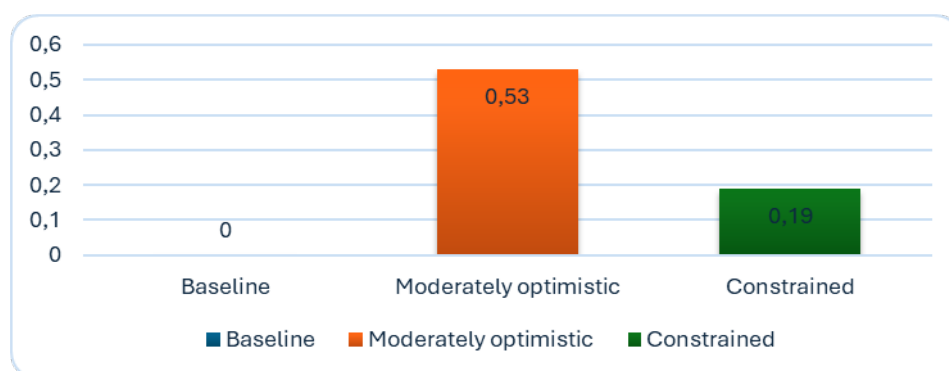
text-dependent nature of state program impacts. The effectiveness of regional development programs is determined not only by changes in funding volumes but also by the capacity of regional economies to support investment expansion and labor market adjustment. These findings reinforce the conclusion

that differentiated and coordinated policy measures are required to achieve устойчивые экономические эффекты across regions.

To facilitate interpretation of the scenario-based estimates, the results of the AI-oriented modeling are summarized graphically in Figure 3.

Figure 3

Scenario effects of state regional development programs (AI-oriented modeling)



Note: The figure presents estimated changes in GRP growth rates under alternative scenarios, calculated as linear combinations of the panel regression coefficients (see Table 3) within a “what-if” analysis framework

The visualization highlights the differences in growth effects across scenarios and confirms the non-linear response of regional economies to changes in program parameters. The moderately optimistic scenario produces a substantially larger increase in GRP growth compared with the constrained scenario, despite identical increases in program expenditures. This contrast illustrates the role of complementary factors—particularly investment activity and labor market conditions—in amplifying the economic effects of state programs.

Within this study, artificial intelligence functions as an analytical layer linking econometric estimates with managerial decision-making. AI-oriented analysis is used to structure and compare alternative scenarios, assess regional heterogeneity, and support the interpretation of model results. Importantly, AI is not employed as a substitute for econometric modeling but as an instrument for extending its analytical and practical applicability within decision support systems.

The results demonstrate that identical policy interventions may generate substantially different outcomes depending on regional conditions. This finding supports a transition from uniform program implementation toward an adaptive model

of regional development management, in which program parameters are adjusted according to regional characteristics and expected response patterns.

Several limitations should be considered when interpreting the results.

First, the panel regression framework with regional and time fixed effects controls for time-invariant regional characteristics and common macroeconomic shocks but does not fully eliminate potential endogeneity of program expenditures. In particular, reverse causality cannot be excluded, as economically stronger regions may be more capable of attracting budgetary resources. Accordingly, the estimated coefficients should be interpreted as stable empirical associations rather than strict causal effects.

Second, the model specification does not employ instrumental variables or quasi-experimental identification strategies, such as difference-in-differences or regression discontinuity designs. This choice is обусловлен by data availability and the primary objective of the study, which is comparative evaluation and identification of heterogeneous program effects rather than causal identification in a narrow methodological sense.

Third, the AI-oriented scenario analysis is implemented as a “what-if” exercise based on estimated coefficients. While this approach allows for systematic comparison of alternative trajectories, it does not constitute a forecast and does not account for potential structural or institutional shifts beyond the scope of the considered scenarios.

In addition, the use of aggregated regional data limits the ability to capture intra-regional variation and sector-specific dynamics. Further research based on more disaggregated data and causal methods could provide a more detailed assessment of program effectiveness.

The results have direct implications for the design and adjustment of state regional development policy in the Republic of Kazakhstan. Empirical evidence consistently indicates that a uniform approach to program implementation does not yield comparable socio-economic outcomes across regions.

For regions with high program effectiveness, an intensification strategy is appropriate. Scaling up well-performing program mechanisms, particularly those supporting investment and entrepreneurial activity, can generate sustained growth without substantial institutional restructuring.

Regions with moderate program effectiveness require a combined policy approach. In these regions, increases in program funding should be complemented by measures aimed at improving institutional capacity, investment conditions, and labor market performance. Coordinated policy packages yield higher returns than isolated budgetary expansion.

In regions with low program effectiveness, standard program instruments demonstrate limited impact in the absence of supportive structural conditions. Policy priorities should focus on institutional development, human capital formation, and improvements in regional governance. Program financing is more likely to generate meaningful economic effects once foundational institutional conditions are strengthened.

Overall, the integration of econometric analysis with AI-oriented scenario modeling enables a shift from *ex post* program evaluation toward proactive and differentiated policy management. This approach strengthens the analytical basis for decision-making, supports targeted budget allocation, and reduces the risk of inefficient use of public resources. The proposed framework may be applied by public authorities and analytical units in the

evaluation and adjustment of regional development programs and can serve as a foundation for the development of decision support systems in regional policy.

The econometric results and AI-oriented scenario modeling consistently indicate that government programs in the Republic of Kazakhstan are positively associated with regional economic growth, while the magnitude of this association varies substantially across regions. Program effectiveness is shaped not only by the scale of public financing but also by program design, investment transmission mechanisms, labor market conditions, and regional institutional capacity.

These findings challenge the effectiveness of uniform, resource-based regional policy approaches. Structural and institutional heterogeneity implies that identical policy instruments may generate differentiated outcomes even within a common national framework.

In this context, AI-oriented scenario analysis complements econometric evidence by providing a structured framework for assessing alternative policy configurations under heterogeneous regional conditions. Although the analysis does not aim at strict causal identification, it supports evidence-based decision-making by explicitly incorporating regional diversity into the evaluation of state development programs.

Building on the limitations of the present analysis, future research may extend the proposed framework through instrumental variable approaches or quasi-experimental designs, such as difference-in-differences, as well as through the use of more disaggregated data and machine learning techniques to explore non-linear and interaction effects.

Conclusion

This study provides an empirical assessment of the relationship between government regional development programs and socio-economic dynamics across the regions of the Republic of Kazakhstan during 2018–2024. The results demonstrate that program effectiveness is heterogeneous and cannot be explained by funding volumes alone, but depends on program design and regional economic and institutional conditions.

Taken together, the findings indicate that uniform, one-size-fits-all approaches to regional development policy are insufficient under conditions of

pronounced territorial heterogeneity. More effective policy design requires differentiated program instruments and adaptive implementation strategies aligned with region-specific contexts.

From a methodological perspective, the integration of panel econometric analysis with AI-assisted scenario modeling enhances the assessment of regional diversity and supports informed managerial decision-making. Overall, this study introduces an integrated econometric–AI decision-support framework that advances evidence-based and regionally differentiated management of government development programs.

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Conflict of Interest

The authors declare that there are no conflicts of interest that could have influenced the results of the study or their interpretation.

Author Contributions

GZh.D: contributed to the development of the research concept, the substantiation of the methodological approach, the supervision of the scientific logic of the article, and the critical revision of the manuscript.

AOO: developed the research design, systematized the statistical materials, prepared the main analytical part of the article, interpreted the empirical results, and coordinated the preparation of the final manuscript.

AKB: conducted the literature review, participated in data processing, prepared tables and graphical materials, and contributed to the interpretation of regional development indicators and econometric results.

VNS: contributed to the analysis of the managerial and applied implications of the study, refined the discussion and conclusion sections, checked the coherence of the theoretical and empirical arguments, and participated in the final editing of the article.

All authors discussed the research results, reviewed the final version of the manuscript, and approved its submission to the journal.

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ДЕТЕРМИНАНТЫ ФИНАНСОВОЙ УСТОЙЧИВОСТИ БАНКОВСКОГО СЕКТОРА КАЗАХСТАНА: ПОДХОД НА ОСНОВЕ ИЕРАРХИЧЕСКОЙ РЕГРЕССИИ

Финансовая устойчивость банковского сектора является ключевым условием макроэкономической стабильности, особенно в ситуациях роста кредитных рисков. Цель исследования – количественно оценить влияние ликвидных активов (FSLT), структуры процентных доходов (FSEIM) и рентабельности активов (FSERA) на уровень неработающих кредитов (FSANL). Научная новизна работы заключается в применении иерархического регрессионного анализа для оценки устойчивости банков Казахстана, что позволило выявить скрытую значимость структуры доходов, не очевидную при простом корреляционном анализе.

Методология исследования базируется на данных 65 наблюдений. Проверка нормальности распределений по критерию Шапиро–Уилка подтвердила статистически значимое отклонение всех переменных от нормального закона ($p < 0.05$), что обосновало применение иерархического моделирования (модели M_0 – M_3).

Основные результаты показали, что итоговая модель M_3 объясняет 62.7% вариации показателя FSANL. Вопреки результатам парных корреляций, где наиболее сильная связь наблюдалась у ликвидности ($r = -0.468$), в комплексной многофакторной модели доминирующим предиктором устойчивости стала структура процентных доходов ($\beta = -0.781$), за которой следуют ликвидность ($\beta = -0.761$) и рентабельность ($\beta = -0.560$). Отрицательный знак коэффициентов подтверждает, что укрепление внутренней финансовой базы банков ведет к снижению кредитных рисков. Показатели валютной позиции (FSSNO) и расширенной ликвидности (FSLs) признаны статистически избыточными для данной модели.

Практическая значимость работы состоит в возможности использования модели M_3 регуляторами для мониторинга системных рисков и совершенствования надзорных практик. Ценность исследования заключается в эмпирическом доказательстве того, что для банковской системы Казахстана стабильность потока процентных доходов является более критичным фактором устойчивости, чем объем ликвидных активов в краткосрочном периоде.

Ключевые слова: банки второго уровня, финансовая устойчивость, регрессионное моделирование, банковский сектор Казахстана, банковский надзор, ликвидность, структура доходов, неработающие кредиты (NPL).

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Determinants of financial stability in Kazakhstan's banking sector: a hierarchical regression approach

Financial stability in the banking sector is a critical prerequisite for macroeconomic stability, particularly in the context of rising credit risks. The study aims to quantitatively assess the impact of liquid assets (FSLT), interest income structure (FSEIM), and return on assets (FSERA) on the level of non-performing loans (FSANL). The scientific novelty of the research lies in the application of hierarchical regression analysis to evaluate the stability of Kazakhstan's banks, which revealed the hidden significance of the income structure that was not evident through simple correlation analysis.

The research methodology is based on 65 observations. Normality testing using the Shapiro–Wilk test confirmed a statistically significant deviation of all variables from the normal distribution ($p < 0.05$), justifying the use of hierarchical modeling (models M_0 – M_3).

Key results demonstrated that the final model M_3 explains 62.7% of the variation in the FSANL indicator. Contrary to the results of pairwise correlations, where the strongest relationship was observed for liquidity ($r = -0.468$), the dominant predictor of stability in the complex multifactorial model was interest income structure ($\beta = -0.781$), followed by liquidity ($\beta = -0.761$) and profitability ($\beta = -0.560$). The

negative sign of the coefficients confirms that strengthening the internal financial base of banks leads to a reduction in credit risks. Foreign exchange position (FSSNO) and extended liquidity (FSLs) indicators were found to be statistically redundant for this model.

The practical significance of the work lies in the possibility for regulators to use the M_3 model to monitor systemic risks and improve supervisory practices. The value of the study consists in the empirical evidence that for the banking system of Kazakhstan, the stability of interest income flow is a more critical factor for resilience than the volume of liquid assets in the short term.

Keywords: second-tier banks, financial stability, regression modeling, banking sector of Kazakhstan, banking supervision, liquidity, income structure, non-performing loans (NPL).

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Қазақстанның банк секторындағы қаржылық тұрақтылық детерминанттары: иерархиялық регрессия негізіндегі тәсіл

Банк секторының қаржылық тұрақтылығы, әсіресе кредиттік тәуекелдердің өсуі жағдайында макроэкономикалық тұрақтылықтың негізгі шарты болып табылады. Зерттеудің мақсаты – өтімді активтердің (FSLT), пайыздық кірістер құрылымының (FSEIM) және активтер рентабельділігінің (FSERA) жұмыс істемейтін кредиттер деңгейіне (FSANL) әсерін сандық тұрғыдан бағалау. Жұмыстың ғылыми жаңалығы Қазақстан банктерінің тұрақтылығын бағалау үшін иерархиялық регрессиялық талдауды қолдануда болып табылады, бұл қарапайым корреляциялық талдау кезінде айқын көрінбеген кірістер құрылымының жасырын маңыздылығын анықтауға мүмкіндік берді.

Зерттеу әдіснамасы 65 бақылау деректеріне негізделген. Шапиро–Уилк критерийі бойынша үлестірімдердің қалыптылығын тексеру барлық айнымалылардың қалыпты заңнан статистикалық маңызды ауытқуын растады ($p < 0.05$), бұл иерархиялық модельдеуді (M_0 – M_3 модельдері) қолдануды негіздеді.

Негізгі нәтижелер қорытынды M_3 моделі FSANL көрсеткіші вариациясының 62.7%-ын түсіндіретінін көрсетті. Ең күшті байланыс өтімділікте ($r = -0.468$) байқалған жұптық корреляция нәтижелеріне қайшы, кешенді көпфакторлы модельде тұрақтылықтың басым предикторы пайыздық кірістер құрылымы ($\beta = -0.781$) болды, одан кейін өтімділік ($\beta = -0.761$) және рентабельділік ($\beta = -0.560$) тұр. Коэффициенттердің теріс таңбасы банктердің ішкі қаржылық базасының нығаюы кредиттік тәуекелдердің төмендеуіне әкелетінін растайды. Валюталық позиция (FSSNO) және кеңейтілген өтімділік (FSLs) көрсеткіштері осы модель үшін статистикалық тұрғыдан артық деп танылды.

Практикалық маңыздылығы реттеушілердің жүйелік тәуекелдерді мониторингілеу және қадағалау тәжірибесін жетілдіру үшін M_3 моделін пайдалану мүмкіндігімен айқындалады. Зерттеудің құндылығы Қазақстанның банк жүйесі үшін пайыздық кірістер ағынының тұрақтылығы қысқа мерзімді кезеңдегі өтімді активтер көлеміне қарағанда тұрақтылықтың неғұрлым маңызды факторы болып табылатынын эмпирикалық дәлелдеуінде.

Түйін сөздер: екінші деңгейлі банктер, қаржылық тұрақтылық, регрессиялық модельдеу, Қазақстанның банк секторы, банктік бақылау, өтімділік, кірістер құрылымы, жұмыс істемейтін кредиттер (NPL).

Введение

Финансовая устойчивость банковского сектора является ключевым условием макроэкономической стабильности, особенно в ситуациях роста кредитных рисков, волатильности финансовых рынков и внешних экономических шоков. В последние годы банковская система Казахстана функционирует в условиях повышенной неопределенности, что актуализирует поиск внутренних рычагов поддержания стабильности. Показатель FSANL (доля неработающих кредитов к валовому портфелю) выступает в данной работе основным индикатором кредитного

риска. Рост этого показателя не только сигнализирует об ухудшении качества активов, но и является опережающим индикатором снижения общей устойчивости банковской системы.

Актуальность темы обусловлена необходимостью глубокого анализа внутренних детерминант кредитного риска. Несмотря на обилие международных исследований, эмпирические работы по банковскому сектору Казахстана часто ограничиваются анализом парных корреляций. Однако, как показало данное исследование, простые взаимосвязи могут маскировать реальную силу влияния факторов. Использование иерархического подхода позволяет воспол-

нить этот исследовательский пробел, определив вклад ликвидности (FSLT), структуры процентных доходов (FSEIM) и рентабельности активов (FSERA) в динамику неработающих кредитов.

Объект исследования – банковский сектор Республики Казахстан, рассматриваемый в разрезе внутренних финансовых детерминант кредитного риска: показателей ликвидности, структуры процентных доходов и рентабельности активов, обуславливающих динамику доли неработающих кредитов (FSANL). Цель исследования – на основе иерархического моделирования выявить и количественно измерить вклад ключевых финансовых детерминант в обеспечение устойчивости банков второго уровня РК.

Для достижения цели были решены следующие задачи:

1. Проведен анализ статистических свойств переменных на выборке из 65 отчетных периодов (с учетом 5 пропущенных значений по показателю FSERA).

2. Проведена проверка данных на нормальность распределения с использованием критерия Шапиро–Уилка, подтвердившая непараметрический характер данных ($p < 0.05$).

3. Оценены парные взаимосвязи между переменными, выявившие значимую внутреннюю зависимость между рентабельностью и структурой доходов ($r = -0.770$).

4. Построены и верифицированы три регрессионные модели (M_1 – M_3), объясняющие до 62.7% вариации целевого показателя.

5. Определена иерархия влияния предикторов на основе стандартизированных коэффициентов.

Гипотеза исследования заключается в том, что в условиях казахстанского рынка структура доходов и ликвидность оказывают более выраженное влияние на уровень неработающих кредитов, чем показатели чистой рентабельности, а включение этих факторов в иерархическую модель существенно повышает её предсказательную силу.

Научная новизна работы заключается в обосновании иерархической значимости внутренних детерминант устойчивости банковского сектора Казахстана. В отличие от существующих работ, ограничивающихся анализом парных корреляций, в данном исследовании доказано, что:

1. Выявлен эффект «статистического замещения» приоритетов: установлено, что при переходе от простых моделей к многофакторной

иерархической модели M_3 , доминирующим фактором снижения доли неработающих кредитов становится не объем ликвидных активов (FSLT), а структура процентных доходов (FSEIM, $\beta = -0.781$). Это опровергает поверхностные выводы о первостепенности ликвидности, полученные на этапе корреляционного анализа ($r = -0.468$).

2. Определен синергетический вклад рентабельности: количественно доказано, что включение фактора рентабельности (FSERA) в комплексную модель повышает её объяснительную способность на 12.8% (рост R^2 с 0.499 до 0.627), что позволяет более точно прогнозировать кредитные риски в условиях волатильности казахстанского рынка.

3. Эмпирически подтверждена избыточность валютных факторов: выявлено, что для текущей структуры банковского сектора РК влияние валютной позиции (FSSNO) и расширенной ликвидности (FSLS) полностью поглощается основными предикторами (ликвидностью и качеством дохода), что позволяет оптимизировать количество индикаторов в прогнозных моделях устойчивости.

Практическая значимость заключается в возможности применения итоговой модели M_3 регуляторами (Национальным Банком РК и АРРФР) для мониторинга системных рисков. Результаты позволяют более точно калибровать надзорные требования, акцентируя внимание не только на объемах ликвидных активов, но и на качестве структуры операционных доходов банков второго уровня.

Обзор литературы

Исследования детерминант банковской устойчивости и качества кредитного портфеля охватывают широкий спектр факторов, которые традиционно классифицируются на макроэкономические, институциональные и специфические (внутренние) банковские показатели.

Макроэкономические и институциональные факторы. В международной литературе значительное внимание уделяется влиянию внешней среды на уровень неработающих кредитов (NPL). Так, Shahzad *et al.* (2019) доказывают, что динамика ВВП, инфляция и уровень безработицы являются фундаментальными предикторами способности заемщиков обслуживать долг. Cicchiello *et al.* (2022) дополняют этот тезис, подчеркивая выраженную цикличность

кредитного риска: в периоды экономической активности качество портфелей растет, тогда как в периоды стагнации наблюдается резкий рост показателя доли проблемных кредитов.

Параллельно развивается направление анализа институциональной среды. Vermpei *et al.* (2018) и Ullah *et al.* (2024) демонстрируют, что верховенство закона и эффективность государственного контроля над коррупцией напрямую снижают уровень кредитного риска. Mawardi *et al.* (2024) отмечают, что институциональные дефекты (например, слабость судебной системы) препятствуют эффективному взысканию задолженности, что критично для стран с формирующимися рынками.

Внутренние детерминанты банков. Особое значение для данного исследования имеют специфические факторы банковской деятельности. Рентабельность активов (ROA) рассматривается как индикатор операционной эффективности: Kil *et al.* (2020) и Bhowmik & Sarker (2024) подтверждают, что высокоприбыльные банки обладают более качественными кредитными портфелями. Важным фактором выступает и структура процентных доходов: Shahriar *et al.* (2022) отмечают, что стабильная процентная маржа служит буфером против накопления проблемных активов.

Ликвидность традиционно интерпретируется как «защитный механизм». Cicchiello *et al.* (2022) и Saliba *et al.* (2023) подтверждают, что достаточный запас ликвидных активов позволяет банкам амортизировать краткосрочные шоки, не допуская деградации кредитного портфеля. Эти параметры закреплены в методологических стандартах МВФ (International Monetary Fund, 2019), что подчеркивает их универсальную значимость для анализа финансовой устойчивости.

Методологические подходы. Современная литература демонстрирует переход от классической статистики к более сложным методам. Wahab *et al.* (2024) указывают на преимущества машинного обучения в прогнозировании дефолтов. Однако, как отмечают Beltman *et al.* (2024), применение таких методов в развивающихся экономиках часто ограничено качеством данных, что сохраняет актуальность надежных эконометрических методов, таких как иерархический регрессионный анализ.

Исследовательский пробел. Несмотря на обширность глобальных исследований, специфика банковского сектора Казахстана остается недостаточно изученной с точки

зрения взаимовлияния внутренних финансовых факторов. Большинство локальных работ фокусируются на внешних шоках (ценах на нефть, курсе тенге), оставляя без внимания глубокий анализ иерархии внутренних детерминант – ликвидности, структуры доходов и рентабельности. Настоящее исследование восполняет этот пробел, используя иерархический подход для выявления чистого вклада каждого из указанных факторов в динамику неработающих кредитов.

Методология

Материалы исследования

Эмпирической базой исследования являются данные по ключевым показателям финансовой устойчивости банковского сектора Казахстана за 65 отчетных периодов. Выбор переменных (FSANL, FSLT, FSEIM, FSERA) обусловлен их соответствием международному стандарту «Индикаторов финансовой устойчивости» (Financial Soundness Indicators, FSI), разработанному Международным валютным фондом (IMF, 2019). Использование данной методологии обеспечивает международную сопоставимость результатов и позволяет рассматривать внутренние детерминанты устойчивости ББУ РК в контексте глобальных стандартов банковского надзора. Данные показатели являются репрезентативными для оценки системных рисков в странах с формирующимися рынками.

Исследуемый материал включает следующие переменные:

FSANL – доля неработающих кредитов в совокупном валовом кредитном портфеле (зависимая переменная, индикатор кредитного риска);

FSLT – отношение ликвидных активов к совокупным активам;

FSEIM – отношение процентного дохода к валовому доходу (структура доходов);

FSERA – рентабельность активов (ROA);

FSLS – отношение ликвидных активов к краткосрочным обязательствам;

FSSNO – отношение нетто-открытой позиции в иностранной валюте к капиталу (валютный риск).

Характеристика материала подтверждает его пригодность для статистического анализа: данные являются сопоставимыми и однородными. В выборке по показателю FSERA имеется 5 пропущенных значений (Valid N = 61), что было учтено при построении итоговых моделей.

Описательная статистика и характеристики распределения переменных. Для оценки свойств переменных проведена описательная статистика (Таблица 1). Ключевой особенностью данных явля-

ется высокая вариативность показателя рентабельности (коэффициент вариации $FSERA = 1.571$), что указывает на значительную неоднородность прибыльности в банковском секторе.

Таблица 1

Описательная статистика и характеристики распределения переменных

Показатель	FSANL	FSERA	FSEIM	FSLT	FSLS	FSSNO
Valid (N)	65	61	65	65	65	65
Missing	1	5	1	1	1	1
Median	8.980	2.030	63.110	22.610	69.950	0.470
Mean	11.459	2.127	62.821	25.031	73.599	-3.665
Std. Deviation	6.669	3.341	16.118	7.513	17.902	18.517
Coeff. of variation	0.582	1.571	0.257	0.300	0.243	-5.052
Shapiro-Wilk (W)	0.872	0.784	0.959	0.942	0.933	0.522
P-value	<.001	<.001	0.031	0.004	0.002	<.001

Примечание: расчеты выполнены авторами

Значения p -уровня критерия Шапиро–Уилка для всех переменных ниже 0.05, что свидетельствует о статистически значимом отклонении распределений от нормального. Данный факт обосновывает применение иерархического регрессионного анализа, который позволяет оценить устойчивость связей даже при нарушении нормальности.

Исследовательский вопрос и гипотеза

Вопрос: Какова иерархия влияния внутренних финансовых факторов на уровень неработающих кредитов (FSANL) в банковском секторе Казахстана?

Гипотеза (H_1): Структура процентных доходов и ликвидность являются более сильными детерминантами устойчивости, чем чистая рентабельность, а их совместное включение в модель значимо повышает точность прогноза кредитного риска.

Методы и этапы исследования

Исследование проводилось в семь этапов: от сбора данных до верификации итоговой модели. Основным методом выступил иерархический регрессионный анализ, обеспечивающий поэтапное включение предикторов:

1. Модель M_0 : Базовая (intercept-only) модель для оценки общей вариативности.

2. Модель M_1 : Оценка вклада ликвидности (FSLT).

3. Модель M_2 : Добавление фактора структуры доходов (FSEIM).

4. Модель M_3 : Итоговая модель, включающая рентабельность (FSERA).

Новизна методологии

Новизна подхода заключается в переходе от простых корреляционных оценок к оценке «чистого вклада» каждого фактора через иерархию моделей. Это позволило выявить, что переменные FSSNO (валютный риск) и FSLS (отношение ликвидности к обязательствам) являются избыточными при наличии основных предикторов, что упрощает и уточняет итоговую прогностическую модель финансовой устойчивости БВУ РК.

Результаты и обсуждение

Результаты оценки качества регрессионных моделей представлены в Таблице 2. Последовательное включение независимых переменных в иерархическом порядке приводит к существенному улучшению объяснительной способности моделей. Итоговая модель M_3 демонстрирует наилучшие показатели качества ($R^2 = 0.627$; $AdjustedR^2 = 0.607$) и наименьшее значение стандартной ошибки прогноза ($RMSE = 4.182$), что подтверждает высокую точность моделирования уровня неработающих кредитов.

Таблица 2*Сводные показатели регрессионных моделей*

Model	R	R ²	Adjusted R ²	RMSE
M ₀	0.000	0.000	0.000	6.671
M ₁	0.627	0.394	0.383	5.238
M ₂	0.706	0.499	0.482	4.802
M ₃	0.792	0.627	0.607	4.182

Примечание: расчеты выполнены авторами

Анализ описательных характеристик (см. Таблицу 1 в Методологии) выявил значительную неоднородность банковского сектора Казахстана. Проверка распределений критерием Шапиро–Уилка ($p < 0.05$ для всех переменных) обосновала отказ от простых линейных оценок в пользу иерархического анализа.

Корреляционный анализ показал, что наиболее сильная статистическая связь наблюдается между независимыми факторами – рентабельностью (FSERA) и структурой доходов (FSEIM)

($r = -0.770$). Что касается зависимости FSANL, выявлены умеренные отрицательные связи с ликвидностью (FSLT, $r = -0.468$) и рентабельностью (FSERA, $r = -0.235$). Связь с FSEIM на этапе парных корреляций была статистически незначимой, однако она проявилась как ключевой драйвер в многофакторных моделях.

Результаты регрессионного моделирования
Для оценки статистической значимости моделей проведен дисперсионный анализ (ANOVA).

Таблица 3*Результаты дисперсионного анализа (ANOVA) для иерархических моделей*

Модель	Источник вариации	Сумма квадратов (SS)	Ст. свободы (df)	Средний квадрат (MS)	F-критерий	p-значение
M ₁	Регрессия	1051.447	1	1051.447	38.320	<.001
	Остаток	1618.879	59	27.439		
M ₂	Регрессия	1332.742	2	666.371	28.895	<.001
	Остаток	1337.584	58	23.062		
M ₃	Регрессия	1673.456	3	557.819	31.896	<.001
	Остаток	996.870	57	17.489		
Итого	Total	2670.326	60			

*Примечание: расчеты выполнены авторами**Примечание: Модель M₀ (константа) исключена из таблицы, так как не несет значимой объяснительной информации.*

Результаты ANOVA (Таблица 3) показывают, что все три модели являются высоко значимыми ($p < 0.001$). Это означает, что выбранные предикторы – ликвидность, структура доходов и рентабельность – в совокупности объясняют существенную долю дисперсии уровня неработающих кредитов (FSANL)».

По мере усложнения модели от M₁ к M₃ наблюдается закономерное увеличение суммы

квадратов регрессии с 1051.4 до 1673.5 и соответствующее сокращение остаточной (необъясненной) суммы квадратов с 1618.9 до 996.9. Наивысшее значение F-критерия для модели M₃ ($F = 31.896$) при минимальном значении среднего квадрата остатков ($MS_{\text{Residual}} = 17.489$) подтверждает, что итоговая спецификация является наиболее адекватной для анализа устойчивости банковского сектора РК».

Все модели статистически значимы ($p < 0.001$). Переход от M_1 к M_3 сопровождается ростом объясненной суммы квадратов и снижением остаточной

вариации, что доказывает целесообразность включения FSEIM и FSERA в итоговое уравнение. Оценки параметров моделей представлены в Таблице 4.

Таблица 4

Оценки коэффициентов иерархических регрессионных моделей

Модель	Предиктор	B (Нестанд.)	Std. Error	β (Станд.)	t	p
M_1	(Intercept)	26.931	2.523		10.673	<.001
	FSLT (Ликвидность)	-0.584	0.094	-0.627	-6.190	<.001
M_2	(Intercept)	39.888	4.372		9.123	<.001
	FSLT (Ликвидность)	-0.729	0.096	-0.783	-7.598	<.001
	FSEIM (Структура доходов)	-0.150	0.043	-0.360	-3.492	<.001
M_3	(Intercept)	52.571	4.770		11.021	<.001
	FSLT (Ликвидность)	-0.709	0.084	-0.761	-8.469	<.001
	FSEIM (Структура доходов)	-0.325	0.055	-0.781	-5.963	<.001
	FSERA (Рентабельность)	-1.119	0.253	-0.560	-4.414	<.001

Примечание: расчеты выполнены авторами

Значимость: все предикторы во всех моделях имеют уровень значимости $p < 0.001$. Это говорит о крайне высокой надежности полученных результатов.

Смена лидера (β): В модели M_2 доминировала ликвидность (-0.783). Однако в финальной модели M_3 на первое место по силе влияния вышла структура доходов (FSEIM) с коэффициентом -0.781, немного опередив ликвидность (-0.761).

Вес рентабельности (B): несмотря на меньший стандартизированный коэффициент ($\beta = -0.560$), переменная FSERA имеет самый большой нестандартизированный коэффициент ($B = -1.119$). Это означает, что рост ROA на 1% сокращает долю плохих кредитов более чем на 1.1%.

На основании полученных статистически значимых коэффициентов в модели M_3 (см. Таблицу 4), итоговое уравнение иерархической регрессии для прогнозирования уровня неработающих кредитов в банковском секторе Казахстана приняло следующий вид:

$$FSANL = 52.571 - 0.709 \cdot FSLT - 0.325 \cdot FSEIM - 1.119 \cdot FSERA \quad (1)$$

Свободный член уравнения (52.571) отражает теоретически ожидаемый уровень неработающих кредитов (FSANL) в ситуации, когда все включенные в модель предикторы (ликвид-

ность, структура доходов и рентабельность) были бы равны нулю. Несмотря на то, что такая ситуация экономически невозможна, высокое значение константы подчеркивает критическую зависимость стабильности кредитного портфеля от внутренних финансовых факторов: при отсутствии ликвидности и доходов риск неконтролируемого роста NPL становится чрезвычайно высоким.

Коэффициент -0.709 при FSLT показывает, что при увеличении доли ликвидных активов на 1%, уровень FSANL снижается в среднем на 0.709 процентных пункта.

Коэффициент -0.325 при FSEIM указывает на защитную роль процентных доходов: их рост в структуре выручки на 1% сокращает объем проблемных кредитов на 0.325 процентных пункта.

Коэффициент -1.119 при FSERA демонстрирует наибольшую чувствительность: каждый процент прироста рентабельности активов (ROA) способствует снижению кредитного риска на 1.119 процентных пункта.

Данное уравнение позволяет количественно оценить вклад каждого фактора. Отрицательные знаки перед коэффициентами подтверждают, что рост ликвидности, улучшение структуры доходов и повышение рентабельности активов ведут к снижению кредитных рисков (FSANL)

Результаты и обсуждение

Итоговая модель M_3 подтверждает гипотезу об отрицательном влиянии финансовой устойчивости на уровень кредитного риска. Однако иерархический анализ выявил важные особенности:

1. Доминирование структуры доходов по результатам корреляционного анализа, где лидером была ликвидность, в финальной модели M_3 наибольшее влияние на FSNL оказывает структура процентных доходов (FSEIM, $\beta = -0.781$). Это означает, что стабильность потока процентных доходов является более значимым барьером для роста неработающих кредитов, чем простое накопление ликвидных активов.

2. Роль ликвидности, где коэффициент ликвидности (FSLT, $\beta = -0.761$) остается критически важным. Снижение доли ликвидных активов на 1% при прочих равных условиях ведет к росту FSNL на 0.709 единиц (коэффициент $\$B\$$).

3. Эффект рентабельности несмотря на самую низкую силу влияния в тройке ($\beta = -0.560$), переменная FSERA обладает наибольшим абсолютным весом ($B = -1.119$). Это указывает на высокую чувствительность кредитного риска к операционной эффективности банка.

Использование иерархического подхода позволило выявить «скрытую» значимость структуры доходов, которая маскировалась ликвидностью на этапе простых тестов. Показатели валютного риска (FSSNO) и расширенной ликвидности (FSLS) были исключены из итоговой модели как статистически избыточные. Данное решение имеет не только статистическое, но и содержательное экономическое обоснование. Исключение FSSNO объясняется специфической институциональной средой казахстанского банковского сектора: последовательная политика дедолларизации, проводимая Национальным банком РК с 2016 года, привела к существенному сокращению доли иностранной валюты в активах и обязательствах банков второго уровня. Жесткое пруденциальное регулирование открытой валютной позиции фактически нейтрализует валютный риск как самостоятельный драйвер роста неработающих кредитов – его влияние оказывается поглощенным показателем ликвидности FSLT, отражающим общую способность банков управлять разрывами между активами и пассивами. Исключение FSLS (отношения ликвидных активов к краткосрочным обязательствам) объясняется концептуальной близостью

данного индикатора к FSLT: оба показателя измеряют способность банка покрывать обязательства за счёт ликвидных резервов, различаясь лишь знаменателем. В условиях относительно стабильной структуры фондирования казахстанских банков, где значительная доля обязательств имеет долгосрочный характер, дополнительная объяснительная способность FSLS сверх FSLT оказывается минимальной. Таким образом, итоговая модель M_3 фокусирует внимание регулятора на трёх фундаментальных и экономически самостоятельных факторах: структуре процентных доходов, ликвидности и рентабельности активов.

Заключение

В рамках проведенного исследования была решена задача количественной оценки детерминант финансовой устойчивости банковского сектора Казахстана. Применение иерархического регрессионного анализа позволило не только подтвердить статистическую значимость ключевых финансовых индикаторов, но и выявить их реальную иерархию влияния на уровень кредитного риска.

Основные выводы исследования:

1. Разработанная иерархическая модель M_3 обладает высокой объяснительной способностью ($R^2 = 0.627$), что позволяет интерпретировать более 62% вариации уровня неработающих кредитов (FSNL) через показатели ликвидности, структуры доходов и рентабельности. Снижение среднеквадратичной ошибки (RMSE) до 4.18 подтверждает адекватность модели для практического применения.

2. В ходе анализа была опровергнута гипотеза о первостепенной роли ликвидности как единственного защитного барьера. Выявлено, что структура процентных доходов (FSEIM) является наиболее сильным предиктором $\beta = -0.781$. Это доказывает, что для стабильности банков Казахстана качественный состав операционного дохода (доминирование процентных поступлений) важнее, чем объем накопленных ликвидных активов.

3. Ликвидность (FSLT) сохраняет статус фундаментального фактора ($\beta = -0.761$), в то время как рентабельность активов (FSERA) демонстрирует значительный потенциал влияния на устойчивость: рост ROA на 1% способствует сокращению доли проблемных займов на 1.119% (согласно коэффициенту B).

4. Использование иерархического подхода доказало свою преимущество перед простым корреляционным анализом, позволив очистить влияние факторов от статистических шумов и выявить избыточность валютных индикаторов (FSSNO) в текущих рыночных условиях.

Рекомендации и практическая ценность:

Результаты исследования имеют прямое значение для совершенствования макропруденциальной политики в Казахстане. Регулятору (Национальному банку РК и АРРФР) рекомендуется:

Сместить фокус надзорных процедур с простого мониторинга нормативов ликвидности на анализ устойчивости процентных доходов банков.

Использовать коэффициенты модели M_3 для проведения стресс-тестирования качества активов при различных сценариях изменения прибыльности сектора.

Работа вносит вклад в понимание внутренних механизмов устойчивости банков в странах с развивающейся экономикой и может служить базой для дальнейших исследований, учитывающих внешние макроэкономические шоки и институциональные факторы.

Ограничения исследования. Необходимо учитывать ряд ограничений, обусловленных дизайном настоящего исследования. Во-первых, выборка объемом 65 наблюдений, хотя и достаточная для получения статистически значимых результатов, ограничивает возможности обобщения выводов на более широкие временные горизонты и различные фазы экономического цикла. Расширение временного периода анали-

за позволит верифицировать устойчивость выявленных зависимостей в условиях кризисных шоков и структурных изменений в банковском секторе. Во-вторых, исследование намеренно сосредоточено на внутренних финансовых детерминантах, тогда как ряд значимых макроэкономических переменных – динамика ВВП, уровень инфляции, обменный курс тенге и уровень безработицы – остался за рамками анализа. Как показано в обзоре литературы (Shahzad *et al.*, 2019; Cicchiello *et al.*, 2022), данные факторы способны существенно модифицировать уровень кредитного риска через механизм платёжеспособности заёмщиков. Включение макроэкономических переменных в расширенную спецификацию модели представляется перспективным направлением для последующих исследований, способных обеспечить более полную картину детерминант финансовой устойчивости банков Казахстана.

Благодарность и конфликт интересов

Авторы заявляют, что с данным исследованием отсутствуют конфликты интересов.

Вклад авторов

АШР: Концептуализация, Исследование, Сбор данных, Написание – Подготовка оригинального проекта.

ЗНК: Разработка концепции, Написание – Рецензирование и редактирование, Авторский надзор.

ЕЖЖ: Методология, формальный анализ.

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THE EFFECTIVENESS OF INDICATORS FOR ASSESSING THE FINANCIAL STABILITY OF ENTERPRISES

This study aims to present specific criteria for assessing corporate financial stability that influence key strategic decisions, and to examine their relationship with capital market returns, asset conditions, and market trends, as well as to conduct a comprehensive comparison of new models for assessing corporate financial performance.

Financial stability is generally underrepresented in both research and practice in the fields of stability management and reporting.

The actions proposed in the article are important because they are at the crossroads of overall stability management, risk management, and dependence on external sources. The research suggested in the article reduces financing and insolvency risks.

An importance of determining the overall financial stability properly lies in its ability to identify the degree and extent of a company's dependence on external financing sources and to prevent the company from going bankrupt.

Key findings of the study include an analysis of financial stability indicators divided by period and by profit level, a comparison of common enterprise liquidity and solvency ratios, a comparison of equity-to-debt ratios, and an assessment of sufficiency and risk-return profiles. Specific features of assessing the effectiveness in evaluating the current and absolute liquidity of assets, as well as the company's equity capital with and without depreciation of fixed assets, are reflected in determining the indicators considered by investors when selecting enterprises and in evaluating the effectiveness of new methods for assessing the volume of raised funds.

Recommendations for proper assessment of financial stability and maintaining liquidity within an enterprise will be aimed at stabilizing cash flow in the enterprise's operations, improving financial reporting methods, and implementing sustainable financial strategic plans into the enterprise's operations.

Keywords: corporate financial stability, ratio analysis, cash flow, financial indicators, dependence on external debt sources, EBIT, EBITDA.

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Кәсіпорындардың қаржылық тұрақтылығын бағалау көрсеткіштерінің тиімділігі

Бұл зерттеудің мақсаты – компаниялардың қаржылық тұрақтылығын бағалаудың маңызды стратегиялық шешімдер қабылдауға әсер ететін тұжырымдамалық негізделген критерийлерін ұсыну, сондай-ақ олардың капитал нарығының табыстылығымен, активтердің жай-күйімен және нарықтық факторлармен өзара байланысын зерттеу. Сонымен қатар зерттеу компаниялардың қаржылық көрсеткіштерін бағалаудың заманауи модельдерінің тиімділігін жан-жақты салыстырмалы талдауға бағытталған.

Қаржылық тұрақтылық мәселесі қазіргі уақытта тұрақты дамуды басқару және корпоративтік есептілік салаларындағы ғылыми зерттеулерде де, практикалық қызметте де жеткілікті деңгейде қарастырылмаған.

Мақалада ұсынылған көрсеткіштер тұрақты дамуды басқару, тәуекелдерді басқару және кәсіпорынның сыртқы қаржыландыру көздеріне тәуелділігін бағалау бағыттарының тоғысында орналасқан. Зерттеу нәтижелері қаржыландыру тәуекелдері мен төлем қабілетсіздігі қаупін төмендетуге мүмкіндік береді.

Кәсіпорынның жалпы қаржылық тұрақтылығын дұрыс бағалау оның сыртқы қаржыландыру көздеріне тәуелділік дәрежесін анықтауға, ықтимал қаржылық қауіптерді уақтылы айқындауға және банкроттық тәуекелін азайтуға мүмкіндік береді.

Зерттеудің негізгі нәтижелері қаржылық тұрақтылық көрсеткіштерін кезеңдер бойынша талдауды, олардың пайда көлемімен өзара байланысын бағалауды, өтімділік пен төлем қабілеттілігінің кеңінен қолданылатын коэффициенттерін салыстыруды, сондай-ақ меншікті және қарыз капиталының арақатынасын зерттеуді қамтиды. Ерекше назар қаржы ресурстарының жеткіліктілігіне, тәуекел мен табыстылық арақатынасына, активтердің ағымдағы және абсолюттік өтімділігін бағалауға аударылған.

Зерттеуде негізгі құралдардың амортизациясын ескере отырып және ескермей меншікті капитал көлемін бағалау ерекшеліктері, сондай-ақ осы көрсеткіштердің кәсіпорындардың инвестициялық тартымдылығына әсері қарастырылған. Сонымен қатар тартылған қаржы ресурстарының көлемін бағалаудың заманауи әдістерінің тиімділігі зерттелген.

Зерттеу нәтижелері негізінде әзірленген практикалық ұсынымдар кәсіпорындардың қаржылық тұрақтылығын бағалау сапасын арттыруға және өтімділігін сақтауға бағытталған. Оларды енгізу ақша ағындарын тұрақтандыруға, қаржылық есептілік жүйесін жетілдіруге және ұзақ мерзімді тұрақты қаржылық стратегияларды іске асыруға ықпал етеді.

Түйін сөздер: кәсіпорынның қаржылық тұрақтылығы, қаржылық талдау, коэффициенттік бағалау әдісі, өтімділік, төлем қабілеттілігі, ақша ағыны, қарыз капиталы, сыртқы қаржыландыру көздері, EBIT, EBITDA.

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Эффективность показателей оценки финансовой устойчивости предприятий

Целью данного исследования является разработка и представление концептуально обоснованных критериев финансовой устойчивости компаний, оказывающих влияние на принятие важных стратегических решений, а также изучение их взаимосвязи с доходностью капитала, состоянием активов и рыночными факторами. Кроме того, исследование направлено на всесторонний сравнительный анализ эффективности современных моделей оценки финансового состояния предприятий.

Проблематика финансовой устойчивости в настоящее время недостаточно представлена как в научных исследованиях, так и в практической деятельности в области устойчивого управления и корпоративной отчетности.

Предложенные в статье показатели находятся на пересечении таких направлений, как управление устойчивым развитием, риск-менеджмент и оценка зависимости предприятия от внешних источников финансирования. Результаты исследования способствуют снижению рисков финансовой несостоятельности и неплатежеспособности предприятий.

Корректная оценка общего уровня финансовой устойчивости позволяет определить степень зависимости предприятия от внешних источников финансирования, своевременно выявить потенциальные финансовые угрозы и снизить вероятность банкротства.

Основные результаты исследования включают анализ показателей финансовой устойчивости в динамике по отдельным периодам, оценку их взаимосвязи с величиной прибыли, сравнительный анализ наиболее распространенных коэффициентов ликвидности и платежеспособности, а также исследование соотношения собственного и заемного капитала. Особое внимание уделено вопросам достаточности финансовых ресурсов, соотношению риска и доходности, а также оценке текущей и абсолютной ликвидности активов.

В работе рассмотрены особенности оценки объема собственного капитала с учетом и без учета амортизации основных средств, а также влияние данных показателей на инвестиционную привлекательность предприятий. Кроме того, исследуется эффективность современных методов оценки объема привлеченных финансовых ресурсов.

Практические рекомендации, разработанные по результатам исследования, направлены на повышение качества оценки финансовой устойчивости и поддержание ликвидности предприятий. Их внедрение будет способствовать стабилизации денежных потоков, совершенствованию системы финансовой отчетности и реализации долгосрочных устойчивых финансовых стратегий.

Ключевые слова: финансовая устойчивость предприятия, финансовый анализ, коэффициентный метод оценки, ликвидность, платежеспособность, денежный поток, заемный капитал, внешние источники финансирования, EBIT, EBITDA.

Introduction

This article is intended to highlight the importance of assessing financial stability and to identify effective methods for obtaining rapid financial results in determining the financial stability of companies, considering complex market phenomena at the present stage, rapid price changes, the growth of global economic relations, and risks arising from adverse events, the actions outlined here are focused on developing a conceptual framework for financial stability.

Defining financial stability in business is broader than the concept of generating substantial profits solely through sales. It demonstrates the continued effective strategic financial growth of the enterprise, while costs remain largely unchanged or show only slight growth. And high expenses sometimes open up new sources of income for company owners.

Financially stable enterprises do not depend solely on externally raised funds or investments; they use their assets effectively and own the margin on product sales. Many enterprises set up various funds that can be used during unprofitable periods, though their scale and volume may vary.

If the research on financial stability has been identified on general concepts and absolute indicators till now, we propose sophisticated, multifaceted, and comprehensive concepts to measuring financial stability.

We study how a long-term commitment to sustainable development, balanced risks, properly valued assets, and a high level of financial stability capable of responding to market conditions influence a company's profitability and strategically maintain its financial performance.

Based on the balance sheet and key capital market indicators, we propose the conditions necessary for implementing comprehensive financial assessment concepts.

Our proposed basic rules will help you achieve the overall goals of "comprehensive sustainable development."

We propose the following rules to improve the effectiveness of financial stability assessments in more detail:

(1) a company's ability, focused on the long term, to maintain financial stability and cover various expenses as they arise;

(2) to determine the relationship between a gradual reduction in the company's reliance on external debt sources and its investment opportunities;

(3) To determine the most effective indicators for assessing a company's property, assets, and securities, and to justify their use during favorable times and periods;

(4) To determine an acceptable risk-return level for owners of the company;

Key provisions and models presented by us complement internal and external approaches to risk management within the company, as they align with existing approaches to risk ranking, risk management, modeling, corporate valuation, and management oversight, while also accounting for new market developments.

For this reason, we establish and develop a link between sustainability and cost management.

The insights presented in this article require a relevant assessment based on various models and the search for effective ways to achieve financial results.

At present, it is important to evaluate companies' financial indicators using generally accepted international methods, as global political, economic, financial, and other connections ensure companies' entry into the international market, and the principles of international accounting, financial, tax, and other reporting are mandatory for companies.

Numerous studies indicate that the country employs methods for assessing the equity capital of many enterprises, analyzing profitability and liquidity, inventory turnover, and evaluating cash flow—methods that still tend to be inadequate or overly risky, rather than strategic and focused solely on the short term.

The correct assessment of a company's financial condition and financial stability allows for increased profitability, the prompt and full settlement of obligations to partners, the avoidance of cash flow gaps and bankruptcy, and the more efficient use of both internal and external funding sources.

In the strategic analysis of enterprises' financial indicators as a whole, it is necessary to determine which values or factors most effectively influence their profitability.

Literature review

It is important to enhance long-term financial stability so that a business owner can continue to operate even in the face of financial difficulties and a deteriorating market situation. If a firm's sales slow down during an economic downturn, it is necessary to consider the entrepreneur's ability to use other sources for paying unpaid bills, which makes it pos-

sible to avoid a cash flow gap until sales improve – provided, of course, that the firm’s finances, assets, and property are properly assessed.

The financial stability requires a continuous analysis of company’s assets and capital structure – that is, the quality of assets, the proportion of borrowed funds, the adequacy of equity, compliance with liquidity limits, and so on, and continuous management is of paramount importance. Analysing a company’s financial statements – including the balance sheet, income statement, and cash flow statements – provides a clear picture of its financial position.

In this regard, market participants must respond promptly to market instability. Their main task is to develop a financial stability strategy. The rapid pace of business growth and intensified competition in domestic and global markets contribute to an increase in corporations’ dependence on external of financing.

The more a company’s profitability grows, the more the seller can expand the range and volume of its products and services; therefore, financial stability is important for banks, lenders, and investors. For instance, should a company require additional funds, they analyze the financial stability report, which demonstrates that the company possesses sufficient cash flow and turnover, as well as the extent to which it is independent of external sources.

The presence of a high proportion of accounts receivable in a company’s assets can lead to a loss of solvency for any company. In such cases, first of all, it is necessary to determine which solvency and liquidity conditions affect the company’s financial condition. Such conditions can be general economic factors (inflation, unemployment, etc.), government-related factors (instability of the tax system, political instability, etc.), and market-related factors (lack of government support, decline in demand for products, financial crises, etc.) (Yerdavletova *et al.*, 2020).

The solvency of companies can be improved by increasing permanent sources of financing and reducing short-term sources of financing. By liquidating unproductive assets and increasing the turnover of short-term funds, the need for temporary sources of financing can be reduced.

It is also necessary to increase equity capital using undistributed profits, which can be achieved by raising voluntary contributions from new shareholders and other parties. An alternative way to improve the company’s solvency could involve restructuring its obligations by transferring the company’s debt to its owners, with necessary payments.

In the opinion of authors such as Sarkambayeva & Sailaubekov, financial stability is an important indicator of a company’s financial condition. Key indicators in assessing the financial condition of banks include liquidity risks, market risks, interest rate risks, currency risks, and credit risks. Nevertheless, there is no single indicator for assessing liquidity, for example, across different banks depending on their financial conditions (Sarkambayeva & Sailaubekov, 2023).

The majority of analyses are conducted over several periods or over several years, using data obtained from companies in similar industries, such as a company’s income statement, which accurately describes changes in operating income and expenses over a specific period. Detailed information can be obtained from certain financial statement items to calculate some key ratios reflecting the dependence of a company’s operations on efficiency, profitability, and financial leverage.

For instance, B.G.Bondar shows that debt-to-total-assets ratio – the extent to which the total amount of a company’s liabilities, divided by its total assets, is financed by borrowed funds. Return on equity shows the amount of profit generated by a company’s equity (Bondar, 2016).

For a deeper understanding of the structure and calculation methods of the ratios used in each organization, it is necessary to compare the ratio values across different companies. Most of the time, the same ratio includes different components. In this case, for a meaningful analysis and comparison, it is essential to consider specific data, trends, and influencing factors.

There are several selected methods for evaluating equity; return on equity (ROE) is an important financial indicator in a company, serving as a leading metric for investors and analysts to assess whether the company is generating a return on its shareholders’ equity and how effectively it utilizes those funds – essentially describing whether the company is using shareholders’ capital efficiently.

An advanced approach is to determine return on investment (ROI), but ROI can be applied to everything from complex projects to marketing initiatives, whereas return on equity refers only to the returns generated from shareholders’ equity. A comparison of ROE with other financial performance indicators will be studied.

Moreover, in today’s environment, the debt capital market plays a significant role in a company’s financial stability.

A. Chepulyanis and others consider that in order to form a comprehensive picture of a company's financial condition, it is necessary to provide reliable and complete information on its assets and sources of financing, along with indicators of the company's operational efficiency (Chepulyanis, *et al.*, 2021).

The more funds a company raises from outside sources, the greater its financial capacity; however, its financial risk also increases, meaning that problems may arise regarding the company's ability to make timely payments to its creditors.

The researcher V. M. Rodionova defines the following key indicators for assessing financial stability (Rodionova *et al.*, 1995):

Financial independence ratio reflects the share of equity in the total volume of funding sources, i.e., the degree of the organization's financial independence (optimal value 0.7–0.8). Financial dependence ratio indicates the degree of the organization's financial dependence on borrowed funds (optimal value 0.2–0.3).

Financial leverage ratio reflects “the organization's activity in raising borrowed capital” (optimal value ≤ 1).

Financing ratio “reflects the ratio of equity to debt capital and, if necessary, indicates the ability to settle liabilities using the company's assets” (optimal value ≥ 1).

Equity turnover ratio clearly shows “what portion of equity is used to finance non-current assets.” If the ratio is greater than one, it indicates that “long-term assets are partially financed by debt, while current assets are financed solely by debt.”

Nevertheless, maintaining a high level of liquidity in accordance with regulatory requirements reduces the ability of assets to generate profits, so by financial stability, we mean that a company's financial position minimizes the impact of adverse factors through effective resource management and creates conditions for further growth and stable operations.

But in conditions of high inflation and financial volatility, maintaining a high level of financial stability is not so simple. At a time of economic change, particularly during periods of inflation, it is crucial for companies to maintain their solvency and liquidity. The assessment of an organization's financial condition is a critical element of financial management (Ilyasov *et al.*, 2020). Financial management is not only the readiness of the regulator to comply with prudential standards, but also the readiness to adapt to changes in the economy.

It is advisable for many enterprises to develop their own investment strategy; when implementing

this strategy, however, it is important to consider both internal factors and external factors, which have no less of an impact on the enterprise.

External factors encompass market, natural, climatic, and other factors; therefore, it is necessary to consider an investment strategy based on all risks that may arise. One more important external factor is the company's level of competitiveness in the market, meaning that the company or the products it manufactures may compete with similar products from other manufacturers (Prigarina *et al.*, 2023).

Market conditions make it difficult for companies to provide their services due to constant changes (prices, taxes, monetary policy). Irrespective of its organizational and legal form, every company seeks to accelerate capital turnover in order to increase profits. Under competitive conditions, it is difficult for companies to maintain financial stability.

If no significant changes occur in the amount of fixed (charter) and additional capital at a specific enterprise during the period under review, this indicates the enterprise's stability.

The reserve capital is a key component of a company's capital and is intended to cover anticipated losses. It states that the main source of capital formation is profit.

In general, positive changes identified through analysis or this process contribute to strengthening the company's financial position and increasing its business activity.

Methodology

An empirical analysis of methodologies has been conducted using financial indicators from Kazakhstani banks and companies for 2023–2025, supplemented by an additional sample to compare data with methods such as EBIT, EBITDA and OIBDA – including depreciation costs.

Key data sets are collected by combining several sources of tax and financial reporting at company level. Base data consists of financial indicators based on a firm's assets, profitability, regions and liquidity.

Up-to-date research covers a number of important areas:

- integrated financial reporting models combining financial, social, economic, and political directions;
- when determining the financial condition of enterprises, it is necessary to divide the factors affecting them and the associated risks into groups

and sectors, and to examine separately the conditions that hinder development;

- digital transformation, improving financial reporting, requires the study of new methods and indicators;

- justification of international standards for auditing and financial control capable of responding to risks and changes.

In this way, it should be revealed that financing a company's operations is not always effective using only the company's own funds, and that borrowing, seeking other sources of financing, and attracting investors are important depending on the level of development of relations between countries.

In the course of the study, statistical data were collected from companies and commercial banks, and the dynamics of changes in these statistical data were analyzed.

In the course of the study, literature reviews on the topic of maintaining financial stability were conducted, and the impact of economic and financial changes on companies was systematically and logically substantiated. Statistical data trends in companies were forecasted using predictive and mathematical methods.

1. Financial indicator analysis. Internal audit reports and annual financial statements of enterprises and commercial banks for 2021–2025 were analyzed and evaluated. Particular attention was paid to the reliability, accuracy, and compliance of the data.

2. It was established that the changes in the financial situation of companies (commercial banks) are in line with the current regulations of the National Bank of Kazakhstan and correspond to the level of the country's economic development.

3. Regression analysis.

The following auxiliary methods were obtained:

1. A comparative assessment of indicators that determine the financial stability of enterprises

2. Analysis and comparison of banks' and enterprises' annual and quarterly reports

3. Review of scientific studies and articles on how to maintain an enterprise's financial stability

4. Study of regulatory decrees and standards governing the preparation of companies' financial statements.

The structure and dynamics of assets should be examined in depth to study the indicators characterizing a company's financial stability.

It strengthens businesses' interest in external sources of funding and boosts economic activity in specific regions. Nevertheless, advanced methods for rapid and correct assessment of their cred-

itworthiness and solvency have not yet been fully improved.

We have therefore studied the effectiveness, at this new stage, of the main existing methods used to analyse the financial condition of companies, introduction of experience from developed countries, and progress in applying and using the new advanced financial methods.

The basis for strategic financial management of a company is considered to be strategic financial planning. Its use improves the company's financial position and defines and refines the path of economic development, ensuring the necessary level of profitability and other financial indicators.

An assessment of financial risks in a company makes it possible to conduct a stress analysis of the company's financial indicators, such as profitability, financial stability, and liquidity. Some authors (Satymbekova *et al.*, 2021) consider that if the calculated indicators exceed a critical level, the level of financial risk is deemed risky.

Users of financial statements and financial accounting information can be either external or internal, and the latter consist of employees and specialists.

Scientific and theoretical aspects of developing a financial stability strategy in companies were examined during the study; methods for organizing the monitoring of financial stability and comparative analysis of the current state of financial strategies were widely applied in the practice of foreign companies; extensive theoretical literature on the topic; logical thinking based on empirical research; and a systematic approach to scientific observation.

This means that using effective ratios in enterprises is the basis for determining financial stability.

An analysis of the depreciation ratio is of particular importance for Kazakhstan, as the structure of fixed assets differs by a high proportion of equipment and buildings acquired at different stages of the investment cycle.

Schündeln's theories suggest that this accounts for variations in the rates of physical and moral depreciation of assets and the impact of investment activity on macroeconomic conditions (Schündeln, 2013).

Evolution of capital assets is described by the equation:

$$K_t = (1 - \delta)K_{t-1} + I_t \quad (1)$$

here K_t – t basic capital fund of the period, I_t – investment in fixed capital, δ – depreciation rate.

According to the method by Schündeln (2013), equation is converted to logarithmic form for econometric estimation:

$$\log(Kt - It) - \log(Kt-1) = \log(1 - \delta) + \varepsilon t: \quad (2)$$

As a result, depreciation rates for medium-sized and large enterprises are significantly lower: depending on the sector, they ranged from 7% to 15% (Schündeln, 2013).

Financial statements provide a basis for calculating comparative performance indicators. Among the most important are EBIT, EBITDA, and OIBDA. A number of calculation formulas exist for companies: classical, IFRS. They differ from one another. The indicators can be represented as follows:

$$EBIT = \text{Income} + \text{Income Tax} + \text{Interest} \quad (3)$$

$$EBITDA = \text{Income} + \text{Income Tax} + \text{Interest} + \text{Depreciation} \quad (4)$$

Financial stability is a key metric at different times and is considered a primary indicator of a company's financial condition. An EBITDA indicator defines well a company's stability, as it defines the company's ability to service its debt, usually, there can be significant differences in the value (cost) of companies with identical net profit figures (Mukhambetov *et al.*, 2020). An EBITDA indicator allows for accurate assessment of a company's financial position, consid-

ering all financial indicators. It is particularly important for lenders.

EBITDA presents a number of advantages and opportunities for analyzing a company's performance. The ratio allows for a more objective assessment of a business's sustainability. EBITDA reflects a higher level of actual profit, which tends to be underestimated in traditional calculations due to the significant proportion of non-cash expenses in the cost structure.

A comparison of a company's market value and book value provides a more accurate and objective assessment of its financial position than metrics based on a comparison of sales and profits.

Both EBITDA and EBIT are widely used by analysts and investors to analyze a company's financial position and determine its market value. The initial purpose of these metrics is to assess a company's attractiveness and sustainability, particularly in the context of a potential leveraged buyout. EBITDA is also used to calculate ROI and evaluate a company's operating performance.

When companies pay off debts to other companies and bank loans, settlements are made promptly, assets are liquid, and profits are sufficient; such companies can be considered financially stable because their shares are liquid, profits are stable, contributions to funds are made periodically, tax revenue increases.

We use the example of these companies to demonstrate an assessment of their financial stability based on financial indicators (Table 1).

Table 1

Comparative Assessment of Financial Indicators for Companies Altyn-Dg and Nurlu-tay

Indicators	Company Altyn-Dg	Compane Nurlu-tay
Total Liabilities	325,8	302,75
Equity	235,5	198,65
Capital Total	436,00	285,25
Profit from Sales	450,00	395,65
Cost of Goods Sold	350,00	280,00
Depreciation and Depreciation Costs	18,75	7,50
General and Administrative Expenses	28,75	32,50
Operating Profit	52,50	47,50
Remuneration Costs	20,00	20,25
Profit Before Tax	26,50	22,00
Tax	8,20	6,50
Net Profit	16,25	14,50

Note: compiled by the authors on the basis of the company's financial reports

When assessing the calculations using the approved formula based on a standard fixed-cost coverage ratio, both companies are exposed to a risk equal to multiplier ratios of 2.1 and 2.03, respectively. A fixed-cost coverage ratio is calculated by Formula (3):

$$EBIT = \text{Income} + \text{Income Tax} + \text{Interest} \quad (3)$$

Companies determine the financial health of a business using EBITDA. If the indicator is negative, the business is considered to be close to bankruptcy. If EBITDA is above zero, it means that the business is profitable and is considered capable to cover its loan and tax obligations.

It is beneficial for business managers and owners to analyze and evaluate the EBITDA indicator, businesspeople analyze their company's financial condition, compare their performance against competitors, and analyze partners to implement joint projects.

If the data provided in accordance with these metrics is calculated using the data provided by the companies, the companies will have the following indicators:

Company Altyn-Dg provides the following indicators: $16,25 + 8,20 + 22,00 / 22,00 = 2,11$

Company Nurlu-tay provides the following indicators: $14,50 + 6,50 + 20,25 / 20,25 = 2,03$

$$\frac{16,25 + 8,20 + 22,00}{22,00} = 2,1$$

Company Nurlu-tay provides the following indicators: $14,50 + 6,50 + 20,25 / 20,25 = 2,03$

$$\frac{14,50 + 6,50 + 20,25}{20,25} = 2,03$$

Company Altyn-Dg and Company Nurlu-tay's indicators are ideal for use as financial leverage; one other such indicator is the standard credit risk ratio, calculated as total debt divided by total capital.

$$\text{Total Debt} / (\text{Total Debt} + \text{Equity}) * 100 \% \quad (5)$$

The coverage ratio for interest on borrowed funds then shows that:

«Altyn-Dg» company $325,8 / 325,8 + 235,5 = 0,5804$ or close to 58 %

«Nurlu-tay» company $302,75 / 302,75 + 198,65 = 0,603809$ or close to 60 %.

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In the assessment based on the standard fixed-cost coverage ratio calculated using the formula, both companies are equally exposed to risk, with coverage ratios of 2.1 and 2.03 respectively.

The figures for summing up non-tax charges show that 2 companies are stable, covered by a difference of 0.08. this, of course, shows that 2 companies are also in good financial condition.

For the purposes of this study, the indicator is referred to as the EBIT-based coverage ratio. To make things easier, we will refer to the standard creditworthiness indicator as the EBIT-based coverage ratio. The net profit, tax expenses and remuneration payments of a number of companies do not coincide with the EBIT figure, as the latter reflects the impact of factors such as extraordinary items and minority interest income arising below the level of gross profit before tax.

By these criteria, lending to Altyn-Dg can be considered safe, as can lending to Nurlu-Tau.

But the EBITDA figure shows that Altyn Dg is more resilient, as it is better able to meet its remuneration obligations during a crisis.

It confirms that, when assessing a company's stability, it is advisable to calculate the fixed cost coverage ratio, which ensures comparability between organisations with different depreciation policies. Another factor to consider is EBIT, or *Earnings Before Interest and Taxes*, which describes income before taxes and interest payments on debt. Due to depreciation, it can accurately reflect actual cash flow - "unadjusted" income – rather than merely the company's operating results.

EBIT and EBITDA indicators differ only in one cost item – depreciation, it describes the wear and tear and decrease in the value of assets. In the case of a large amount of equipment and expensive assets owned by a bank or company, the company's depreciation costs are higher.

The multipliers show profit without accounting for these costs and lots of banks and company analysts use EBITDA indicators.

Production costs included in the period under review for the RK enterprise material costs accounted for 52.6% of production expenses, while labor costs and depreciation amounted to 13.9% and 15.6%, respectively.

Regarding the profitability of large and medium-sized enterprises, this indicator by region was 11.7% for Shymkent, 24.2% for Turkistan, and 14.3% for Almaty. Akmola showed the highest figure in Kazakhstan at 51.5%.

When comparing figures for similar periods, the overall state of the enterprise is clearly reflected; for example, in Table 2, the overall performance indicators of a small enterprise were compared with those for similar periods (Table 2).

Table 2

Key performance indicators of small enterprises for comparable periods (billion dollars in KZT)

Indicators	I quarter of 2023	I quarter of 2024	I quarter of 2025
1. Average monthly wage per employee, KZT	246 951	302 363	333 157
2. Output of manufactured goods, completed work, and services rendered, billion KZT	9 363,5	9 918,9	10 000,0
3. Income from sales of goods and services	18 947,3	18 353,1	19 070,0
4. Cost of goods sold and services rendered	12 820,1	11 698,1	12 299,2
5. Gross profit	6 127,3	6 655,0	6 770,9

Note: compiled by the author based on the source (Official Website of the BNS, 2025)

Based on the data, the debt on liabilities in the first quarter of 2025 amounted to 81,312.0 billion KZT, of which overdue debt accounted for 0.6%. Based on the study results, the net financial result of economic entities amounted to 4,191.0 billion KZT, defined as profit in KZT, with a return on production (loss) of 18.3%.

The average monthly wage across the Republic of Kazakhstan in the III quarter of 2025 increased by 10.0% compared with the corresponding quarter of 2024, amounting to 429,368 tenge.

The survey results showed that the net financial result of economic entities was a profit of 5,673.4 billion KZT, with a profitability (loss) ratio of 17.9%.

The gross profit at the end of 2024 was 16,821.8 billion KZT, and at the end of 2025 it was 19,340.4

billion KZT, a total increase of 2,518.6 billion KZT. Revenue from enterprises' services and output for the fourth quarter of 2025 amounted to 63,718.8 billion KZT, an increase of 9,415 billion KZT compared to the same period in 2024 (54,303.8 billion KZT). Assessment of the depreciation ratio of fixed assets in these small enterprises in Kazakhstan made it possible to quantify the level of physical wear and tear of capital and to identify its structural characteristics.

The following Table 3 provides an overview of the liquidity of commercial banks' assets. Bank assets are classified depending on their liquidity, income-generating capacity, and maturity. Certain financial ratios of banks were analyzed using financial stability methods (Table 3).

Table 3

Quick (immediate, fast) liquidity ratios of commercial banks in the Republic of Kazakhstan (calculated as of September 1, 2025)

Names of banks	Quick ratio (κ4-1)	Quick ratio (κ4-2)	Quick ratio (κ4-3)
Otbasy bank	169,3	42,1	23,2
VTB	135,8	38,8	11,6
BNK bank	55.8	32.4	10.8
JSC Shinhan Bank Kazakhstan	29.7	17.9	11.6
Zaman bank	28.4	27.1	29.8
Eurasian bank	21.7	5.0	2.0

Note: compiled by the authors

According to the analysis, the Otbasys bank (family bank) has the highest quick (immediate) liquidity ratios among second-tier banks in the Republic of Kazakhstan: (k4-1) – 169.3, (k4-2) – 42.1, (k4-3) – 23.2. this result reflects the population's demand in the housing and construction sector and the effectiveness of lending to the industry; furthermore, since the majority of these loans are long-term and stable, the financial institution does not face a sudden inflow of funds.

Among all second-tier banks in Kazakhstan, Otbasys Bank has the highest short-term liquidity ratios: (k4-1) – 169.3, (k4-2) – 42.1, (k4-3) – 23.2. This result is explained by the bank's unique housing and construction savings scheme: the majority of deposits are long-term and stable, so the financial institution does not face a sudden outflow of funds. Otbasys Bank also maintains a high volume of liquid assets and pursues a conservative lending policy.

Consequently, a high liquidity ratio indicates the bank's stability and reliability, as well as its ability to meet its obligations to clients even in stressful situations.

High short-term liquidity ratios are also observed in the following second-tier banks:

VTB Bank Kazakhstan: (k4-1) – 135,8, (k4-2) – 35,8, (k4-3) – 11,6.

BNK Commercial Bank: (k4-1) – 55,8, (k4-2) – 32,4, (k4-3) – 10,8.

Shinhan Bank Kazakhstan: (k4-1) – 29,7, (k4-2) – 17,9, (k4-3) – 11,6.

Zaman Bank Islam Nank: (k4 – 1)-28,4, (k4 – 2)-27,1, (k4 – 3) – 29,8.

Unlike enterprises, commercial banks have been actively engaged in the use of state funds. An assessment of a bank's asset quality is a process based on internal control systems and prudential standards, while the financial regulator's prudential decisions are grounded in existing financial accounting and risk assessment practices.

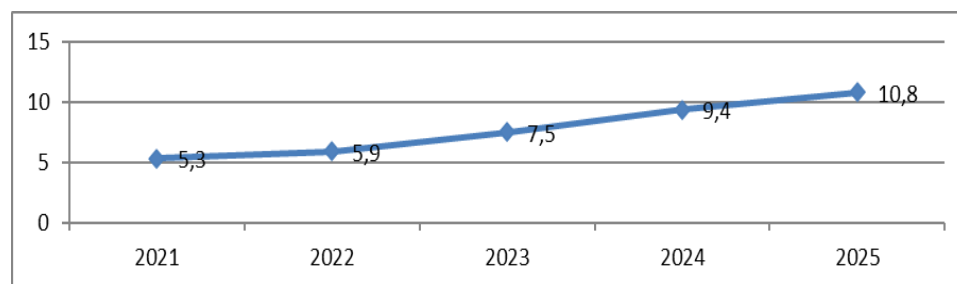
Adilkhanova & Andrus Studies show that over an 8-year period, an analysis of financial indicators at 18 banks and their audit reports revealed that, despite the banking sector's significant share in the country's economy, country ratings regarding the application of standards and bank reliability have not improved. It demonstrates the need for the further full-scale implementation of all international auditing standards and related guidelines, as well as the analysis of available information resources (Adilkhanova *et al.*, 2025).

All the provided information describes the financial condition of enterprises in their accounting and financial statements.

Over the period under review, regulatory capital is considered one of the key indicators of a bank's reliability and effective performance and is used by the regulatory authority to assess the bank's stability and its ability to absorb losses.

The banks' assets increased by 25.8% over the year, reaching 5.2 trillion KZT as of January 1, 2026 (Fig. 1).

Figure 1
Commercial banks' regulatory capital in Kazakhstan (trillion KZT)



Note: compiled by the authors

Financial stability and confidence are key, and if we look at which financial institutions are leading the way in terms of asset growth and increased lending volumes, the one with the highest annual growth rate is one of the country's largest banks:

ForteBank. A financial institution's regulatory capital grew by 41.1% (or 225 billion tenge), reaching 773.2 billion KZT.

On 1 February 2026, the regulatory capital of Kazakhstani banks reached 10.7 trillion KZT, an

increase of 11.6% compared with the same period in 2025. In general, a steady increase in this indicator has been observed in recent years. Over the past five years, the equity capital of commercial banks in Kazakhstan has grown by an average of 17.2% annually, indicating a fairly rapid strengthening of the banking sector's capital base.

ForteBank showed the highest growth in equity capital among all commercial banks in Kazakhstan: a 44% increase (or an increase of 240 billion KZT) over the year.

The following factors were cited as contributing to this growth:

- asset growth without a sharp increase in risks;
- capital strengthening through profits without external support;

- the acquisition of Home Credit Bank using own funds.

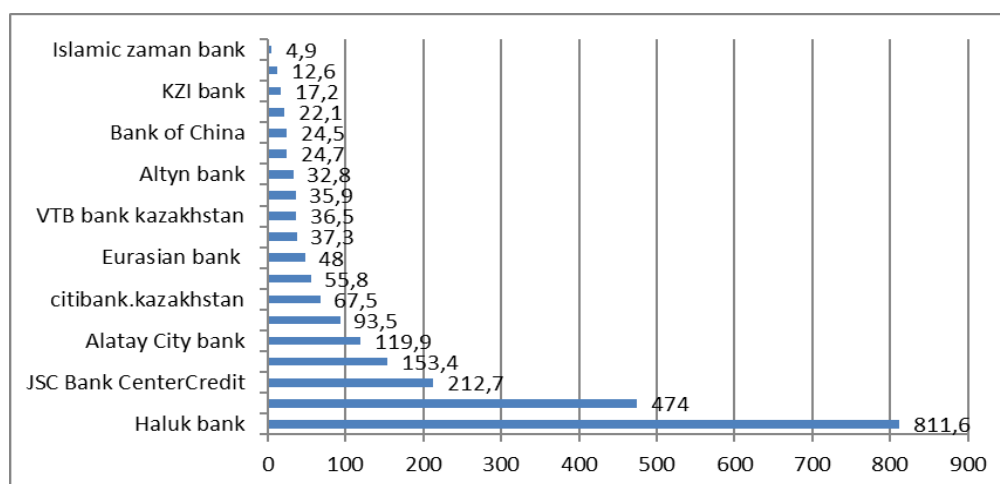
- Retained earnings, subordinated loans, share capital and share premium – these factors influence the financial stability of banks, their ability to withstand shocks, expand their operations and maintain client confidence.

A bank's regulatory capital shows how financially stable it is and its ability to withstand stress; an increase in equity capital expands opportunities for growth and asset financing.

If we compare banks' net profit figures, the following changes occurred by the end of 2025 (Fig. 2).

As shown in Figure 2, Halyk Bank led all banks in net profit growth: over the year, it recorded an increase of 122.4 billion KZT, or 17.8%.

Figure 2
Bank indicators by net profit (in billions KZT)



Note: compiled by the authors

Basically, as per company statistics, accounts receivable in the first quarter of 2025 amounted to 20,769.3 billion KZT, of which 3.1% was past-due. Total assets at enterprises amount to 163,239.7 billion KZT. Long-term assets account for the largest share at 63.3%.

Financial leverage ratio showed an optimal value for “the organization's activity in raising debt capital” (≤ 1).

By the end of 2025, the net profit of Kazakhstani banks had reached 2.7 trillion KZT, an increase of almost 7% compared with 2024. Return on assets (ROA) on 1 January 2026 stood at 4.2%, while return on equity (ROE) was 28.4%.

Moreover, equity on the balance sheet of Kazakhstan's commercial banks reached 10.6 trillion tenge, an increase of 19.1% over the year. Such a result is due to the effective diversification of business lines and the development of the product range: the financial institution actively works with both individuals and the corporate sector. For example, some banks are developing digital, credit and deposit products.

In December 2025, the international rating agency Fitch Ratings affirmed Home Credit Bank's credit ratings at 'BB-' with a 'Stable' outlook.

Ratings confirmation reflects the strength of Home Credit Bank's financial profile, adequate

capitalization and liquidity levels, as well as the maintenance of operational stability during a period of ownership restructuring. These indicators all contribute to improving the banks' financial position and financial stability.

Accordingly, studies conducted using proposed methods can fully characterise banks' ability to raise investment and their lending potential and help identify areas of financial growth for firms.

The proposed methodology provides a reliable basis for accurately determining depreciation expenses and assessing the relationship between risk and profitability.

When evaluating the assets of enterprises and banks, a clear definition of the volume of risks and the distribution of liquidity by type is provided. An EBITDA indicator clearly defines assets and information on companies' property, including all financial indicators. It is especially important for creditors.

Mainly for companies, by correctly valuing their assets and shares, the regulatory capital of leading Kazakhstani banks, a bank's ability to withstand internal and external risks, and the liquidity of assets are compared.

Based on the example of banks, the liquidity ratios of the largest banks in the top ten were compared by period and financially with one another.

This was done by analysing companies' financial indicators, assessing the level of credit availability, determining credit intensity, analysing capital investments from additional sources, firms' investment opportunities, comparative financial indicators, and determining the effectiveness of the methods under study.

Evaluation of internal and external risks' impact on companies' financial condition, the firm's permanent effects and permanent effects within the sector, and strategic models within the firm for innovation and past results highlight the importance of assessing and determining the financial stability of any company.

Results and discussion

By analyzing international experience in improving the effectiveness of analyzing and assessing corporate financial stability, we observe that comparative reviews reveal differences in the level of financial management reflected in financial statements between banks and other enterprises. The requirements for financial reporting and auditing, standardized models, and reporting on social responsibility in developed and developing countries vary significantly; in developing countries, there is a trend toward transitioning to digital models.

The identification and comparison of financial indicators for banks and manufacturing enterprises do not always yield positive results, as there is sometimes a discrepancy between the actual assessment of financial stability and actual indicators.

Measures aimed at meeting international requirements and maintaining financial stability play an important role in ensuring sustainable business development.

This can be achieved through a proper analysis of the company's financial statements and an accurate assessment of the risks arising from external and internal factors.

Table 4
Company financial stability factor and values

Criteria for attractiveness	Quantitative and qualitative assessment	Share of relative dependence (projected)
Investment efficiency	Profitability and quantitative analysis of stocks and bonds, currencies, and financial ratios	60-80 %
Advantages of internal competitiveness	Share of the market; quality; life cycle; brand; capacity; innovation	60-70 %
Strategic Potential	Return on investment; employee professionalism level; diversification; risk; technological capability; equipment modernity	40-60 %
Industry Outlook: Attractiveness	Growth potential, profitability, industry innovation, technology, resource usage	20-30 %
Environmental Sustainability	Inflation rates, bureaucratic decisions; tax burden; attractiveness level, civil legislation, risks	80-90 %

Note: compiled by the authors

As shown in Fig. 1, the primary determining factors are the effectiveness of market-regulating laws, the actions and decisions of government authorities, and regulatory measures.

In companies, market opportunities are the conditions that enable a corporation to gain a competitive advantage in the market. Market opportunities are increased by growth in income and consumer demand, the weakening of competitors, and the emergence of new types of equipment and production technologies.

A company's financial situation and stability are largely determined by the proper allocation of investments in financial assets. Consequently, the study and assessment of assets and sources thereof using horizontal and vertical analysis provide us with significant opportunities. Nevertheless, the analysis of financial ratios has several disadvantages; when it comes to digitization, quantitative indicators alone cannot fully provide qualitative data.

Financial stability criteria also align with the principles of capital preservation in accounting theory, but financial stability is not widely regarded as a self-contained theory.

In addition, it is assumed that companies receive capital from investors on a regular basis only if the expected return matches the cost of capital. Using the market risk premium (λ) and the company's earnings risk, a minimum requirement is established in accordance with return on investment (Gleißner & Walkshäus, 2018).

Summing up, the following circumstances should be given special attention when assessing companies' financial stability indicators:

1. It is normal if sales volume and capital levels align; if the growth rate consistently exceeds the expected inflation rate (including during the period of the ongoing company valuation), the company can be considered financially stable.

If the global economy grows steadily over several years and continues to grow in the future due to technological progress, then a company's growth in line with inflation indicates that it is losing its significance in the global economy.

As opposed to dividend growth rates, special consideration should be given to profit growth rates, which are independent of profit distribution policies.

2. In determining the financial stability of any company, it is important to assess its profitability correctly, and to establish an optimal balance between risk and return.

Additionally, propensity for risk can be expressed in relative terms as the company's excess

return per unit of risk (measured by a selected risk indicator). In fact, an alternative approach to assessing propensity for risk allows for higher levels of risk if they are offset by sufficient returns.

Consequently, placing absolute limits on the overall level of earnings risk will be irrelevant, but it will meet the requirements for an attractive risk-return ratio to the company's owners.

3. It is crucial to evaluate monthly regression models within the company at the individual firm level; for instance, a company's monthly stock returns depend on four key factors: actual growth, survival probability, earnings decline risk, and value creation, along with general control variables based on company size, the book-to-market ratio, and dynamics.

4. Highly financially stable companies A and B typically have a lower price-to-book ratio and higher growth rates. Although they have low risk and low return volatility, these companies generate returns that exceed the average stock market return. The risk-adjusted return, based on the capital asset pricing model and the four-factor model, shows a statistically and economically significant risk-adjusted excess return.

These incomes simply increase (measured in points) with greater financial stability and are highest for companies with high financial stability (a score of 4).

These empirical results are in line with more detailed expected findings, in which companies with low returns and low default risk—components of financial stability—receive risk-adjusted excess returns. Therefore, financial stability is an essential aspect for overall stability in the capital market. It is challenging to reconcile the excess returns of such risk-oriented firms with the predictions of a perfect capital market.

Other studies generally use indicator variables for the four main components in their regression models; therefore, it is possible to directly interpret the average coefficient values as an average difference in earnings between companies that meet and those that do not meet a given condition. (Gleißner *et al.*, 2022).

Apart from sustainability management, the concept of measuring financial sustainability is also important for risk management, especially as part of a strategic and comprehensive approach to risk management (Shtein *et al.*, 2019).

Nowadays, risk management is evaluated in terms of its impact on a company's value.

Nevertheless, a company's value only partially reflects the objectives of risk management,

as it does not account for the goal of limiting risks. An analysis and recommendations for assessing financial stability indicators, presented in this article, rectify this shortcoming. It is not only a generally accepted control parameter for risk management and sustainable development, but is also suitable for empirical research, as it enables the advantages of risk management concepts to be demonstrated.

In addition, Kazakhstan companies have to deal with some serious challenges: inadequate external and internal financial controls, the mismatch between certain indicators and the international economic situation, and rapid changes in the country's tax and monetary policies.

Although there have been many studies on this topic, methods for assessing corporate financial stability do not fully capture effectiveness, even though absolute and relative stability indicators are central to most common financial stability assessment methods.

The authors of the financial stability assessment methodologies described in a variety of studies often form ambiguous frameworks that rely on an excessive number of indicators, the calculation of which involves repetitive ratios.

Accordingly, a company's financial stability is one of the most important characteristics of its financial condition. Financial stability is a balance between equity and borrowed funds, and reliable guaranteed solvency.

Conclusion

Effectiveness of financial stability assessments is rarely addressed in both research and practice in the fields of stability management and reporting. The article provides a conceptual qualitative criterion for financial stability and examines its close relationship with financial market returns.

It refers to sustainable development, unregulated risk management, and opportunity assessment. Financial stability is viewed as a key control indicator complementing shareholder value and may be considered by risk-averse investors as a secondary condition for investment decisions.

An update to international standards strengthens the role of financial condition assessment in the national economy. The incorrect formulation of finan-

cial plans, failure to comply with strategic decisions, and ignorance of consumer requirements and satisfaction begin to impact the financial growth or costs of manufacturing enterprises, and companies begin to compare sources of profit to avoid compromising financial stability.

This study focuses on the following aspects to improve the effectiveness of analyzing a company's financial stability amid changes in companies' financial conditions: that is, the proposed models for enhancing financial stability through the effective use of a company's labor, material, property, and monetary resources underscore the need for strict adherence to the debt-to-equity ratio.

An assessment of commercial banks' assets in terms of liquidity, time frames, and quality requires proper preparation of the company's accounting and financial reports consistent with strategic financial plans.

Conflict of Interest

The authors declare no conflict of interest

Author Contributions

SBI:

- Conceptualization: Developed the research concept. – Theory/Framework: Established the theoretical foundation.

- Supervision: Provided overall project management and direction.

- Writing – Review & Editing: Contributed to the revision and final improvement of the manuscript.

PGA & SNK:

- Methodology: Designed the research framework and scenario models.

- Data Curation: Involved in the collection and systematization of industry data.

SBI, PGA, SNK, & UM:

- Formal Analysis: Analyzed the collected simulation data.

- Interpretation: Explained the results of analytical divergence.

- Writing – Original Draft: Prepared the initial draft of the manuscript.

All Authors:- Validation: Jointly reviewed the final version of the manuscript, made corrections, and approved it for publication.

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RESEARCH AND ANALYSIS OF NON-MANIPULATABLE MECHANISMS IN LOGISTICS AND SUPPLY CHAIN MANAGEMENT

Contemporary supply chains operate under growing pressures of globalization, digital transformation and increasingly complex coordination. Under these conditions, information asymmetry, limited transparency and opportunistic behaviour weaken operational performance and raise legal and organizational risks. The article examines non-manipulable mechanisms in logistics and supply chain management as institutional and technological arrangements that limit such distortions through transparency, verifiability, traceability and protection from unilateral influence. The study aims to determine how these mechanisms affect operational efficiency, customer satisfaction and risk reduction, proceeding from the idea that incentive alignment, transparency and verifiability jointly shape logistics outcomes and should be viewed as a unified governance approach. A mixed-method quasi-experimental comparative design was used. Data were collected from 80 enterprises, with an implementation group (50 companies) and a control group (30 companies). The empirical base includes standardized questionnaires, internal records, semi-structured interviews and comparable before–after indicators. Statistical analysis relied on Student's t-tests, and qualitative materials were examined using thematic analysis. Enterprises applying non-manipulable mechanisms, compared with those using standard practices, demonstrated shorter order processing times, lower inventory costs, higher customer satisfaction and lower fraud-related and legal risks, as well as better coordination and greater trust among partners. The study integrates mechanism design, transparency-oriented governance and logistics performance into a single analytical framework and provides empirical confirmation of the practical relevance of non-manipulable mechanisms for designing more transparent, resilient and efficient supply chain management systems.

Keywords: supply chain management, non-manipulable mechanisms, transparency, efficiency, risks, quantitative analysis, qualitative analysis.

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Логистика және жеткізу тізбектерін басқару саласындағы манипуляциялық емес механизмдерді зерттеу және талдау

Қазіргі заманғы жеткізу тізбектері жаһанданудың, цифрлық трансформацияның және үйлестірудің күрделене түсуінің қысымымен жұмыс істейді. Мұндай жағдайларда ақпараттық асимметрия, шектеулі ашықтық және оппортунистік мінез-құлық операциялық тиімділікті әлсіретеді және құқықтық және ұйымдастырушылық тәуекелдерді арттырады. Бұл мақалада логистика мен жеткізу тізбегін басқарудағы манипуляциялық емес механизмдер ашықтық, аудиторлық, бақылау және біржақты ықпалдан қорғау арқылы мұндай бұрмалануларды шектейтін институционалдық және технологиялық механизмдер ретінде қарастырылады. Зерттеудің мақсаты – бұл механизмдердің операциялық тиімділікке, тұтынушылардың қанағаттанушылығына және тәуекелдерді азайтуға қалай әсер ететінін анықтау, ынталандыруды үйлестіру, ашықтық және аудиторлық логистикалық нәтижелерді бірлесіп қалыптастырады және оларды тұтас басқару тәсілі ретінде қарастыру керек деген идеяға негізделген. Аралас квазиэксперименттік салыстырмалы дизайн қолданылды. Деректер 80 кәсіпорыннан жиналды, енгізу тобы (50 компания) және бақылау тобы (30 компания). Эмпирикалық базаға стандартталған сауалнамалар, ішкі жазбалар, жартылай құрылымдалған сұхбаттар және салыстырмалы «бұрын» және «кейін» көрсеткіштері кіреді. Статистикалық талдау Студенттің t-тестін қолдану арқылы жүргізілді, ал сапалық деректер тақырыптық талдауды қолдану арқылы зерттелді. Стандартты әдістерді қолданатын компаниялармен салыстырғанда, манипуляциялық емес механизмдерді қолданатын компаниялар тапсырыстарды өңдеу уақытының қысқарғанын, тауарлық-материалдық құндылықтардың төмендеуін, тұтынушылардың қанағаттанушылығының

дерінің төмендегенін, сондай-ақ серіктестер арасындағы үйлестірудің жақсарғанын және сенімдің артқанын көрсетті. Зерттеу механизмді жобалауды, ашықтыққа бағытталған басқаруды және логистика тиімділігін бірыңғай аналитикалық негізге біріктіреді және жеткізу тізбегін басқарудың ашық, тұрақты және тиімді жүйелерін әзірлеу үшін манипуляциялық емес механизмдердің практикалық құндылығының эмпирикалық дәлелдерін ұсынады.

Түйін сөздер: жеткізу тізбегін басқару, басқарылмайтын механизмдер, ашықтық, тиімділік, тәуекелдер, сандық талдау, сапалық талдау.

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Исследование и анализ неманипулируемых механизмов в логистике и управлении цепями поставок

Современные цепочки поставок функционируют под растущим давлением глобализации, цифровой трансформации и все более сложной координации. В этих условиях информационная асимметрия, ограниченная прозрачность и оппортунистическое поведение ослабляют операционную эффективность и повышают юридические и организационные риски. В статье рассматриваются неманипулируемые механизмы в логистике и управлении цепочками поставок как институциональные и технологические механизмы, ограничивающие такие искажения посредством прозрачности, проверяемости, отслеживаемости и защиты от одностороннего влияния. Цель исследования – определить, как эти механизмы влияют на операционную эффективность, удовлетворенность клиентов и снижение рисков, исходя из идеи, что согласование стимулов, прозрачность и проверяемость совместно формируют результаты логистики и должны рассматриваться как единый подход к управлению. Использовался смешанный квазиэкспериментальный сравнительный дизайн. Данные были собраны у 80 предприятий, с группой внедрения (50 компаний) и контрольной группой (30 компаний). Эмпирическая база включает стандартизированные анкеты, внутренние записи, полуструктурированные интервью и сопоставимые показатели «до» и «после». Статистический анализ проводился с использованием t-критерия Стьюдента, а качественные материалы изучались с помощью тематического анализа. Предприятия, применяющие неманипулируемые механизмы, по сравнению с теми, кто использует стандартные методы, продемонстрировали сокращение времени обработки заказов, снижение затрат на складские запасы, повышение удовлетворенности клиентов и снижение рисков, связанных с мошенничеством и юридическими нарушениями, а также улучшение координации и повышение доверия между партнерами. Исследование объединяет разработку механизмов, ориентированное на прозрачность управление и эффективность логистики в единую аналитическую структуру и предоставляет эмпирическое подтверждение практической значимости неманипулируемых механизмов для разработки более прозрачных, устойчивых и эффективных систем управления цепочками поставок.

Ключевые слова: управление цепями поставок, неманипулируемые механизмы, прозрачность, эффективность, риски, количественный анализ, качественный анализ.

Introduction

Globalization and rapid technological advancements are fundamentally reshaping logistics and supply chain management, positioning them as critical factors in the competitiveness of modern enterprises. The effectiveness and transparency of these systems are contingent upon minimizing the risks arising from manipulative practices by stakeholders, thereby highlighting the necessity for thorough investigation and analysis of mechanisms that prevent such manipulation Hu & Haddud, (2020).

In supply chain management, manipulative practices by large corporations are particularly evident in the biased selection of suppliers, where criteria such as quality and cost-efficiency are over-

looked in favor of personal preferences or external influence. These actions increase the likelihood of compromised product quality and rising operational costs. At the level of individual participants, data concerning inventories, delivery schedules, and quality metrics may be manipulated to serve personal interests, ultimately harming partners. The concealment of information regarding failures or delays can lead to significant disruptions in logistics planning. To mitigate such abuses, it is essential to implement transparent and independent supplier selection procedures based on objective, verifiable metrics, alongside the deployment of real-time monitoring and control systems that ensure data transparency for all supply chain stakeholders (Rogulin, 2023).

The existing body of research on supply chain management primarily emphasizes the optimization of individual operational processes, while the strategic behavior of actors pursuing their own interests has been largely overlooked. This disparity results in information asymmetry and contributes to inefficient resource allocation. The current study examines mechanisms that promote transparency and prevent manipulative practices within logistics and supply chain management Antyushin, (2020).

In this study, non-manipulatable mechanisms are understood as institutional and technological configurations in supply chain management that limit the scope for individual actors to distort information or influence decisions in their own interest. Conceptually, this notion is not tied to any specific technology. It refers to management solutions that satisfy four key requirements: procedural transparency, the possibility to verify data and decisions, protection from one-sided interference, and the ability to trace operational actions. On this basis, blockchain platforms, IoT-based monitoring systems, audit practices, and formalized decision rules are considered not as synonymous terms, but as distinct implementation tools that can be used to achieve these requirements.

The relevance of this study stems from the increasing challenges faced by companies in the context of global instability. Of particular significance is the development of resilient and adaptive supply chains founded on trust and transparency. The purpose of this study is to examine which institutional and technological configurations make supply chain management less vulnerable to opportunistic manipulation, and to evaluate how the joint action of incentive alignment, transparency, and verifiability influences operational efficiency and the reduction of risks. The study will explore the characteristics of non-manipulatable mechanisms, assess their impact on logistics performance, and provide practical recommendations for their implementation.

At the same time, analysing supply chains in transition economies requires going beyond a narrow, operational view of efficiency. It is necessary to take into account the institutional architecture of logistics systems and the behavioural limits of their participants, since opportunism, weak coordination and misaligned incentives can distort outcomes even where formal procedures look efficient. In

this perspective, non-manipulatable mechanisms are significant not only as technological instruments, but also as institutional arrangements that align incentives, reduce information asymmetry and restrict strategic distortions in supply chain interactions.

Building on the previously presented conceptual framework, the empirical part of the study was structured around three working hypotheses.

H1: enterprises that introduce non-manipulatable mechanisms achieve larger gains in operational efficiency than enterprises that rely on standard supply chain management practices.

H2: the use of non-manipulatable mechanisms corresponds to a detectable decrease in fraud-related exposure and legal risk levels.

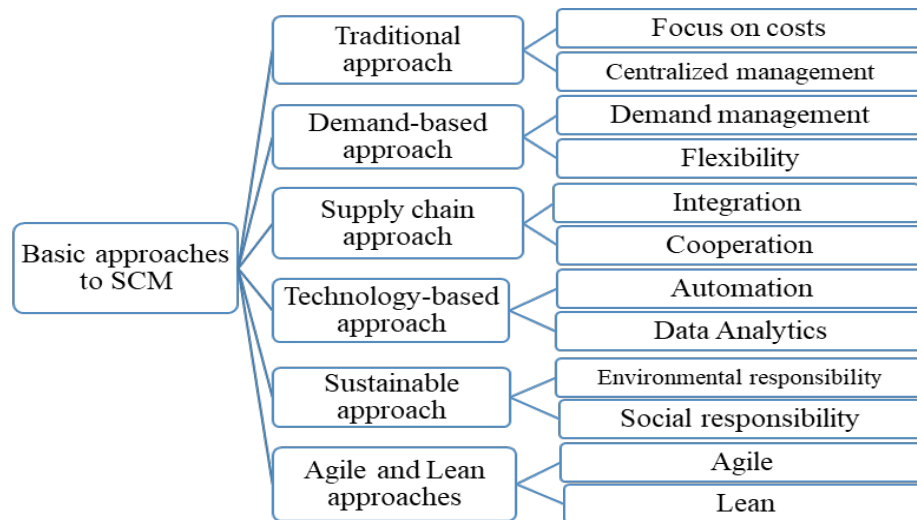
H3: non-manipulatable mechanisms enhance coordination among supply chain participants, which is manifested in higher customer satisfaction and a stronger sense of trust in partner relationships.

Literature review

Supply chain management (SCM) is a set of conceptual models aimed at improving corporate processes, reducing costs, and increasing operational efficiency. Figure 1 shows the key approaches to implementing SCM.

Traditional approaches prioritize cost reduction through centralized decision-making, often at the expense of quality and responsiveness. Demand-driven methods use accurate forecasting and built-in flexibility to align production and inventory with customer needs. Supply-chain models integrate suppliers, manufacturers and distributors to synchronize activities and share data seamlessly. Technological strategies deploy ERP, IoT, blockchain and analytics to automate processes and boost transparency. Sustainable practices embed environmental stewardship and social responsibility – including labor and human-rights considerations – across the chain. Finally, Agile promotes rapid, iterative adaptation, while Lean focuses on eliminating waste and streamlining operations. In this study, Figure 1 is used to show non-manipulatable mechanisms not as an independent SCM model, but as an overarching governance approach that can be built into demand-driven, technology-focused, and resilience-oriented supply chain designs.

Figure 1
Basic approaches to supply chain management



Note: compiled by the author based on the source Christopher, (2016); Gunasekaran & Ngai, (2004)

Each of the models considered is characterized by a unique set of advantages and limitations, and the choice of the most appropriate one is determined by the industry specifics, the company's strategic goals and current market conditions. In practice, enterprises often combine elements of different approaches to achieve the best optimization of supply chain management. A comparative analysis of existing management systems reveals significant differences between classical methods and mechanisms protected from manipulation. Traditional solutions often rely on techniques that allow for distortion of information, which reduces the transparency of processes and increases the risk of unfair actions.

Conventional supply chains often use distortive practices – distorting data or hiding inventory delays – that erode trust. Opacity enables unethical behavior (e.g., forged documents, price manipulation), undermines traceability and reputation, and exposes firms to financial and legal risks. As networks globalize and grow more complex, these vulnerabilities intensify, underscoring the need for stronger, transparent governance.

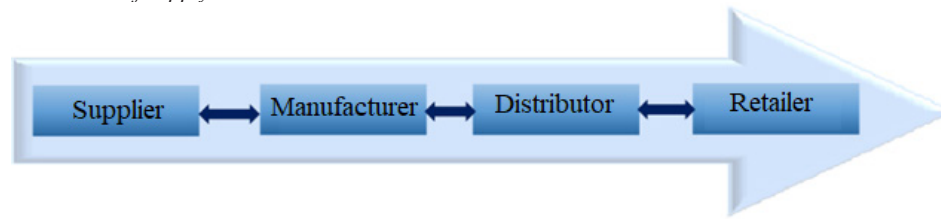
Technological tools, including blockchain platforms and Internet of Things (IoT) systems, can

function as practical means for implementing non-manipulable mechanisms, as they enhance transparency, improve traceability, and limit the scope for information distortion within supply chains. Blockchain provides decentralized data storage, offering all participants equal and prompt access to up-to-date information, significantly reducing the risk of falsification. This technology allows for continuous monitoring of transactions and product status, creating a trusted environment and minimizing the likelihood of unethical practices.

IoT devices continuously collect and transmit real-time data on the status and location of cargo, significantly increasing the control and management of logistics operations. This functionality enables automation of processes, reduces the risk of errors and manipulations, and allows for rapid response to changes, which ultimately leads to optimization of operations and increased overall efficiency.

From a theoretical perspective, non-manipulable mechanisms can improve the interaction of supply chain participants by making information flows more transparent, verifiable, and mutually observable. Figure 2 shows a diagram of information flows and levels of trust between key stakeholders: suppliers, manufacturers, distributors, and retailers.

Figure 2
Interaction of supply chain entities



Note: compiled by the author based on sources Christopher, (2016); Wang et al, (2016); Waller & Fawcett, (2013); Ivanov& Dolgui (2020)

In this study, Figure 2 is used to depict the governance logic on which non-manipulable mechanisms rest. It highlights that the key issue is not simply the presence of information exchange between suppliers, producers, distributors, and retailers, but the way this exchange is organized: when information flows are open, checkable, and visible to several parties at once, the scope for unilateral manipulation is reduced. In this respect, the figure underlines the argument that transparency and traceability are not secondary technical options, but structural prerequisites for limiting opportunistic behaviour in supply chain coordination.

The body of literature relevant to this research can be grouped into three closely related lines of analysis. The first deals with mechanism design and the task of coordinating actors when information is unevenly distributed and incentives do not coincide. The second focuses on transparency, verifiability, and visibility as governance conditions that narrow the room for opportunistic intervention in supply chain operations. The third explores how such arrangements affect logistics performance, particularly with regard to efficiency, resilience, and risk mitigation. In this article, these three directions are considered as elements of a unified analytical framework. The term non-manipulable mechanisms is therefore used in a strictly analytical sense to describe coordination and control configurations that restrict opportunistic interference in information flows, operational choices, and transaction records. In this framework, such mechanisms are characterized by five basic properties: transparent procedures, traceable actions, adaptability to changing conditions, protection from unilateral influence, and verifiable data and decisions. Within this context, Klaus Schwab, in “The Fourth Industrial Revolution” (2016), underscores that trust and transparency – supported above all by blockchain technologies – are key to constructing more reliable and open organizational architectures. This research trajectory

has gained particular importance under conditions of globalization, digitalization, and increasing complexity of supply chains.

Significant achievements in the study of this issue include the work of Michael Christopher “Logistics and Supply Chain Management” (2016), which examines the issues of sustainability of logistics systems. The author emphasizes the critical role of non-manipulable mechanisms in increasing the stability and adaptability of supply chains in changing conditions. According to Christopher, ensuring sustainability is impossible without the integration of effective management strategies and the implementation of technologies aimed at minimizing the risks associated with potential manipulation.

In the article “Blockchain Technology in Supply Chain Management: A Review” (2020), Kumar, S., et al., and co-authors consider blockchain as a technology that provides protection against manipulation. The researchers note its high efficiency in maintaining transparency and traceability of logistics operations, which helps reduce the likelihood of information distortion. The authors also emphasize that the implementation of blockchain solutions requires not only technical adaptation, but also deep transformations of management practices and corporate culture of organizations.

More recent studies develop this discussion by arguing that blockchain should be viewed not only as a traceability instrument, but also as a factor shaping overall supply chain performance. Shahzad *et al.*, (2025); Grigoryev *et al.*, (2021), in particular, show that the impact of blockchain on sustainable supply chain outcomes is mediated by supply chain ambidexterity and survivability, drawing attention to the fact that the effectiveness of digital anti-manipulation tools depends on organizational fit and the ability of firms to embed transparency-oriented technologies in everyday operations. From a broader methodological standpoint, Hübschke *et al.*, (2025) generalize approaches to evaluating blockchain use

in supply chains and single out transparency, traceability, and operational efficiency as central assessment dimensions.

Among Russian scientific works, the collective monograph edited by N. Grigorieva “Logistics and Supply Chain Management: Fundamental Principles. Volume 1. Theoretical Foundations” (2021) deserves attention. It analyzes modern approaches to supply chain management with an emphasis on non-manipulable mechanisms. The authors emphasize that when studying the features of the Russian market, it is necessary to take into account its specific economic and institutional characteristics.

An important contribution to the study of non-manipulable mechanisms in logistics and supply chain management was the work of N. A. Korgin (2003). It proposed a universal mathematical model of exchange problems in active systems with asymmetric information and developed both discrete and continuous methods for constructing effective non-manipulable exchange mechanisms. Korgin proved the equivalence of exchange and motivation problems under a number of special conditions and emphasized the practical applicability of the proposed solutions in real socio-economic systems. Particular attention is paid to the analysis of non-hierarchical bilateral exchanges involving “quasi-intelligent” and “intelligent” agents.

Korgin’s theory is relevant to this study because supply chains function as multi-participant systems in which actors have uneven access to information and may pursue their own interests strategically. In this context, the task goes beyond solving purely operational coordination issues and extends to shaping rules that make opportunistic behavior economically disadvantageous. Korgin’s approach thus provides a conceptual lens for viewing supply-chain relations as exchange mechanisms subject to incentive constraints: requirements of transparency, verifiability, independence, and traceable decision procedures can be treated as institutional tools that limit opportunism. This reading corresponds to the conclusions of Mukhamedova *et al.*, (2023) and Mukhamedova *et al.*, (2023) (2023), who maintain that logistics systems in transition economies should be evaluated in terms of how well economic mechanisms reflect participant incentives, rather than solely on the basis of technical performance metrics.

This institutional reading is likewise in line with recent empirical studies on transparency and visibility in supply chains. Li *et al.*, (2025) argue that strong firm performance is driven not by transparency in isolation, but by its interplay with supply

chain visibility, particularly visibility of demand. Their results indicate that anti-manipulation mechanisms are most effective when clear, transparent rules are coupled with timely access to operational data, which directly reinforces this study’s focus on verifiability, traceability, and coordinated decision-making. Taken as a whole, this body of work allows mechanism design theory to be directly related to current approaches to supply chain governance. In this view, the key analytical sequence can be described as follows: when participants in a supply chain interact under conditions of asymmetric information, institutional arrangements must first limit the scope for opportunistic behaviour; this, in turn, generates the requirement for procedures that are transparent, verifiable, and traceable; once such conditions are in place, they affect logistics performance by lowering coordination losses, decreasing the risk of manipulation, and supporting more reliable operational decisions. Accordingly, transparency in this study is understood not as an abstract normative principle, but as a functional link between incentive-compatible mechanism design and observable efficiency results.

An active contribution of Kazakhstani scientists to the study of this issue is presented by the work of Gabdullina, L. *et. al.*, (2020) and co-authors “Transport and logistics innovations in supply chain management: the experience of Kazakhstan”, which analyzes the potential for introducing non-manipulable mechanisms in the context of the national economy. The authors note that the effective implementation of such mechanisms is impossible without the development of appropriate infrastructure and achieving a higher level of digitalization at the state level.

At the same time, recent studies more often associate non-manipulable mechanisms with digital twins, real-time analytics, and resilient decision-making architectures. Roman *et al.*, (2025) contend that digital twins strengthen supply chain resilience by improving visibility, responsiveness, and decision quality under disruption, while Pan *et al.*, (2025) show that logistics research is shifting toward sustainable, resilient, and digitally synchronized supply-chain configurations in which real-time data integration becomes a core managerial prerequisite. Taken together, these trends suggest that non-manipulable mechanisms should be viewed within the wider transformation of supply chains toward adaptive, data-driven forms of governance.

Modern theoretical approaches to the design of mechanisms and management of organizational

systems indicate that optimization of processes in conditions of high complexity and information inequality, typical of supply chains, is associated with a number of significant difficulties. Centralized management models, where key decisions are made by one participant, contradict the principles of trust and partnership interaction. At the same time, under certain conditions, models resistant to manipulation can be developed. The concept of “limited influ-

ence” assumes that the contribution of each participant to the final result is minimal, which helps to achieve optimal indicators. The use of the principles of openness and transparency reduces incentives for dishonest behavior, making it economically inexpedient. This approach is based on the construction of an effective information exchange system aimed at eliminating data asymmetry and ensuring coordination between all parties.

Table 1

Analytical criteria used to operationalize non-manipulatable mechanisms

Name	Description
Transparency	Full transparency of the planning process implies providing all interested parties with access to the initial data, methods and criteria for decision-making. The presence of hidden parameters or hidden evaluation indicators is excluded. Each stage of the procedure is documented in detail and is subject to verification. In addition, information on the weighting factors involved in the decision-making algorithms must be publicly available, which ensures control over the process and allows for the prompt identification of possible attempts at manipulation.
Traceability	The mechanism provides for tracking and reconstruction of all actions, transactions, and decision steps along the supply chain. This is supported by continuous logging of operational events, open documentation, time-stamped records, and protected digital registers that allow identification of who carried out a particular action, at what time, and on what grounds. As a result, traceability limits the scope for hidden interference and reinforces the responsibility of all parties involved.
Adaptability	The mechanism must be adaptable, allowing for the prompt revision of plans when external conditions or participant preferences change: for this purpose, regulated procedures for adjustment are introduced based on new data, feedback and emerging circumstances, and the chosen planning method allows for such changes without compromising the integrity and openness of the process, ensuring an effective response to unforeseen situations while maintaining transparency and independent verification.
Independence	The mechanism should exclude the possibility of unfair influence of individual participants by implementing a distributed management model, involving impartial mediators to resolve conflicts, introducing regulated procedures based on clear objective rules and creating conditions that prevent collusion of participants for personal gain to the detriment of the system.
Verifiability	Each stage of the process, including final decisions, is monitored by independent experts or auditors by checking the reliability of the initial data, the correctness of the methodological approach and the integrity of the decision taken, and the use of electronic signatures and hash functions increases verifiability, eliminates the possibility of data falsification and ensures the reliability of the results obtained.

Note: compiled by the author based on sources (Ivanov, 2020; Waller & Fawcett, 2013; Tseng et al., 2018; Melnyk, 2014)

Table 1 summarizes the analytical criteria used in this study to operationalize non-manipulatable mechanisms. On their basis, the focal phenomenon can be separated from related, but not identical, notions such as purely technical protection against unauthorized access, simple immutability of records, or broad organizational transparency. In this framework, non-manipulability is not treated as a solely technical attribute; it is seen as an institutional and operational quality that arises when transparency, verifiability, independence, and adaptability are built into a single, coherent management configuration. This perspective sharpens

the boundaries of the research object and offers a more robust foundation for interpreting the empirical findings.

Although the number of recent studies is growing, a significant conceptual gap still persists. In much of the literature, mechanism design, technologies that increase transparency, and logistics performance are discussed as related topics, but they are not brought together into a single coherent framework. Consequently, there is still no fully developed analytical model showing how incentive-compatible arrangements lead to operational improvements via transparency, verifiability, and traceability.

In this article, non-manipulable mechanisms are treated as the linking category between these strands. Understood as institutional and technological configurations, they limit the scope for opportunistic distortion, enhance the quality and observability of information flows, and thus influence concrete indicators such as processing times, costs, customer satisfaction, and risk levels. This integrated view forms the conceptual foundation for the empirical analysis presented in the subsequent sections.

Methodology

The study was based on a mixed-method quasi-experimental comparative design aimed at evaluating how non-manipulable mechanisms affect supply chain performance and risk management. The empirical sample comprised 80 enterprises: 50 firms formed the implementation, or experimental, group, while 30 firms were included in the control group. The groups were not created through random assignment; instead, they were formed according to observed characteristics. Enterprises were assigned to the experimental group if they had used non-manipulable mechanisms for at least six months and were able to provide comparable operational data for the periods before and after implementation. The control group consisted of firms that continued to use standard supply chain management practices during the same observation period.

The analysis was built around five key indicators: order processing time, inventory management costs, customer satisfaction, fraud incidence, and level of legal risk. Order processing time was defined as the number of hours between receiving an order and confirming its execution. Inventory management costs were taken from firms' internal accounting records and covered storage, handling, and inventory maintenance expenses. Customer satisfaction was calculated as the proportion of positive responses in internal feedback forms and post-service surveys. Fraud incidence reflected changes in the number of recorded cases related to document falsification, reporting discrepancies, and other internal violations. Legal risk was measured using a relative expert-based index that considered compliance-related events, contractual disputes, and alerts from internal legal reviews.

Quantitative data were gathered using standardized questionnaires, internal company records, and comparable indicators measured before and after the observed period. In the experimental group, the

baseline covered the six months preceding the introduction of non-manipulable mechanisms, and the follow-up covered the first six months of their use. In the control group, the comparison was based on two consecutive six-month periods of equal duration. Operational indicators were analyzed in their original measurement units, whereas fraud incidence and legal risk were expressed as index values, with the baseline level set at 100.

Qualitative information was obtained through semi-structured interviews with logistics directors and supply chain managers representing both groups. The interview questions addressed issues of process transparency, trust among supply chain partners, difficulties encountered during implementation, and the organizational effects associated with the use of these mechanisms.

Quantitative data were processed using Student's t-test at a significance level of $p < 0.05$. Independent-samples t-tests were applied to compare the changes observed in the experimental and control groups, whereas paired-samples t-tests were used for before-and-after comparisons, including the customs-post data presented in Tables 3 and 4. Before conducting the tests, the dataset was examined for distribution symmetry, outliers, comparability of measurement scales, and homogeneity of variance. In cases where the assumption of equal variance was not satisfied, unequal-variance estimates were taken into account. The qualitative interview data were analysed through thematic analysis, which made it possible to identify recurring themes, common patterns, and repeated managerial interpretations.

The interpretation of the findings should take into account several limitations: the groups were not formed randomly, company data may be incomplete, and the fraud and legal-risk indicators partly rely on expert assessment. For this reason, these indicators are better understood as structured comparative estimates rather than fully standardized external measurements.

Results and discussion

The empirical analysis first considers the changes recorded in enterprises that introduced non-manipulable mechanisms. Table 2 includes ten participating enterprises from different sectors of Kazakhstan's economy and compares the dynamics of three indicators after implementation: order processing time, inventory management costs, and customer satisfaction.

Table 2*Examples of study participant enterprises and changes in key indicators*

№	Company	Sector	Reduction in order processing time	Reduction in inventory management costs	Increased customer satisfaction levels
1	«OASIS BREEZE» LLP	Production of consumer goods	–30%	–22%	+17%
2	ENERGYGROUP-PVL LLP	Energy	–25%	–18%	+14%
3	IKON TIRES KAZAKHSTAN LLP	Automotive industry	–28%	–20%	+16%
4	LLP «STUWA/SHTYUVA»	Metal products	–32%	–24%	+19%
5	SATORY KZ LLP	Mechanical engineering	–27%	–17%	+15%
6	SHYMKENT GROUP STROY LLP	Construction	–29%	–21%	+18%
7	ABSOLUTE SALE LLP	Trade	–26%	–19%	+13%
8	PE «CHARGE LTD.»	Logistics and service	–24%	–16%	+12%
9	Alex Group LLC LLP	Import-export	–31%	–23%	+18%
10	«FACTORY OF METAL STRUCTURES UKO-S STAR» LLP	Metal structures	–33%	–25%	+20%

Note: compiled by the author

As Table 2 shows, in every example examined the implementation of non-manipulatable mechanisms led to a substantial reduction in order-processing time (–24% to –33%), lower inventory-management costs (–16% to –25%), and an increase in customer satisfaction (+12% to +20%).

Table 3 reports four key performance indicators for eight selected customs posts before and after the introduction of non-manipulatable mechanisms: declaration processing time, delay rate, number of admin-

istrative adjustments, and the level of foreign-trade participants' satisfaction. To evaluate the statistical significance of the observed changes, a paired t-test was employed; its results are shown in Table 4.

The data in Table 3 indicate that the average declaration-processing time across all posts fell by roughly 30–35 %, the delay rate dropped by 40–50 %, the number of administrative adjustments more than halved, and the satisfaction level of foreign-trade participants rose by 20–25 %.

Table 3*Customs posts: before and after indicators*

Customs post	Processing time before (h)	Processing time after (h)	Delays before (%)	Delays after (%)	Administrative adjustments before (pcs)	Administrative adjustments after (pcs)	Satisfaction before (%)	Satisfaction after (%)
Zhetysu	55	38	25	12	75	30	65	85
Almaty-Center	60	42	28	15	80	35	60	88
Almaly – CTO	58	40	30	14	70	28	68	90
Ile	54	36	22	10	65	25	66	87
Altynkol	62	44	27	13	85	40	62	84
Nur Zholy	50	35	24	11	60	22	70	89
Park InfoTech	57	39	26	12	78	32	64	86
Temirzhol	59	41	29	14	82	38	63	88

Note: compiled by the author based on the customs post performance indicators; calculations by the author

Table 4
Paired t-test results for PTO indicators

Metric	t-statistics	p-value
Time (h)	46.30	$p < 0.001$
Delays (%)	30.34	$p < 0.001$
Adjustments (pcs)	42.79	$p < 0.001$
Satisfaction (%)	-22.01	$p < 0.001$

Note: compiled by the author based on paired t-test calculations for customs post performance indicators

As shown in Table 4, all recorded changes were statistically significant ($p < 0.001$), which provides empirical support for the effectiveness of the implemented non-manipulable mechanisms. In addition to meeting conventional significance thresholds, the changes observed are large enough to matter in practice: shorter processing times, fewer delays, and reduced administrative rework point to tangible improvements rather than minor statistical variation. This distinction is crucial for interpreting the findings in real-world logistics operations.

The quantitative results that follow are examined with reference to the three working hypotheses set out in the introduction. They rely on the unified indicator definitions specified in the methodology and cover both directly recorded operational measures (order processing time in hours, cost indicators, proportions of satisfied customers) and relative shifts computed from documented baseline values (for fraud incidence and legal risk). This arrangement makes it possible to evaluate not only the fact of change, but also whether the identified trends correspond to the anticipated effects of non-manipulable mechanisms.

H1: non-manipulable mechanisms are associated with higher operational efficiency. The comparative results are in line with this hypothesis. In the experimental group, all core operational indicators improved: order processing times shortened, inventory management costs declined, and customer satisfaction increased. In the control group, by contrast, changes were either marginal or did not reach statistical significance. Table 5 presents the detailed

indicators for the experimental group. In combination with the previously discussed control-group results, the consistent improvements in the main operational measures are unlikely to be attributable to normal random fluctuations in activity.

H2: non-manipulable mechanisms are associated with lower fraud-related and legal risks. The empirical material does not contradict this assumption. Based on combined survey responses and supporting documentation, the experimental group reported a 22% decline in fraud incidence, while no change was observed in the control group. Expert comparative scoring also indicated a 17% drop in legal risk for the experimental group, whereas the control group showed a 4% increase. Although both indicators represent structured comparative assessments rather than externally standardized measures, the direction of change in each case points to a reduction in exposure to opportunistic behaviour and compliance-related risks under non-manipulable mechanisms.

H3: non-manipulable mechanisms improve coordination and perceived trust among supply chain participants. The qualitative materials are in line with this hypothesis. Interview and survey data suggest that the introduction of non-manipulable mechanisms made operations more transparent, facilitated interaction between supply chain participants, and reinforced confidence in counterparties. Representatives of the experimental group also noted that supply relationships became more predictable, while at the same time pointing out that these improvements were accompanied by additional investment and the need to revise internal procedures.

To increase the precision of the quantitative analysis, the principal effects of introducing non-manipulable mechanisms are shown in a structured table. Table 5 presents the main performance indicators for the experimental group (companies that implemented non-manipulable mechanisms), including initial and post-implementation values, relative changes, and, where relevant, measures of statistical significance. This tabular representation ties the analysis more directly to the empirical data and enables a clearer, methodologically consistent interpretation of the main effects of the implemented mechanisms.

Table 5*Quantitative measures for the experimental group following the introduction of non-manipulable mechanisms*

Indicator	Unit of measurement	Experimental group (n = 50), before	Experimental group (n = 50), after	Change (%)	Statistical significance
Order processing time	hours	52	37	-28	p < 0.01
Inventory management costs	USD	1,600,000	1,312,000	-18	p < 0.05
Customer satisfaction	%	75	86	+14.7	p < 0.01
Fraud incidence	% change from baseline	100	78	-22	based on survey results
Legal risk level	% change from baseline	100	83	-17	based on expert assessment

Note: Order processing time is reported in hours; inventory management costs are given in USD; customer satisfaction is indicated as the percentage of positive responses. Fraud incidence and legal risk level are shown as index-based relative changes, where the baseline pre-implementation value is set equal to 100

As shown in Table 5, the introduction of non-manipulable mechanisms in the experimental group coincided with consistent improvements across all key indicators. The directions of change align with each other: operational measures became more favourable, customer satisfaction increased, and both fraud incidence and legal risk moved down from their baseline levels. For the main operational indicators, these changes were statistically significant, and their scale suggests a noticeable practical effect rather than a purely formal one. While the research design does not allow for a strict experimental causal claim, the contrast with the control group and the coherence of the results indicate that non-manipulable mechanisms were an important factor contributing to the observed improvements.

Overall, the empirical results support all three working hypotheses and show that the influence of non-manipulable mechanisms extends beyond single operational improvements. The effects manifest along several connected dimensions: higher efficiency, more reliable procedures, and lower susceptibility to opportunistic behaviour. This configuration corresponds to the conceptual model outlined in the literature review, where incentive alignment, transparency, and verifiability together determine observable logistics performance.

Conclusion

The study found that the implementation of non-manipulable mechanisms, including blockchain-based transaction registration, IoT-based monitoring and distributed ledger solutions, was associated with significant improvements in supply chain efficiency and reliability. After transparent, auditable and more autonomous procedures were introduced

in the surveyed companies, key operational indicators showed marked improvement. A comparable trend was recorded in the separate customs-post dataset, where declaration processing times, delays and administrative adjustments decreased following the adoption of non-manipulable mechanisms. At the same time, the satisfaction level of participants in foreign trade operations increased by 15-20%. All changes were statistically significant ($p < 0.001$). The qualitative analysis of interviews also indicated that the introduced mechanisms strengthened trust and improved the quality of communication between participants, although their implementation required initial investment in technical infrastructure and staff training. In future work, it is important to investigate how non-manipulable mechanisms operate in small and medium-sized enterprises, where financial and organizational limitations may strongly influence implementation results. It would also be valuable to analyse their long-term impact in various sectors and under different levels of digital maturity within supply chain systems.

Conflicts of Interests

The authors declare no conflict of interest

Author Contributions

KZh.Zh: Conceptualization, Formal Analysis, Investigation, Resources, Data Curation, Writing – Original Draft Preparation, Writing – Review & Editing, Visualization.

ASK: Methodology, Validation, Writing – Review & Editing, Supervision, Project Administration, Funding Acquisition.

All authors discussed the research results, reviewed the final version of the manuscript, and approved its submission to the journal.

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THE EFFECTIVENESS OF INVESTMENT PROJECTS IN KAZAKHSTAN'S LOGISTICS SECTOR

The logistics sector of Kazakhstan plays a strategic role in ensuring national transit competitiveness and integration into global supply chains. This study considers Air Astana as a representative case of a capital-intensive logistics operator to bridge the gap between sector-wide investment trends and micro-level financial performance. The increasing scale of capital-intensive projects in transport and aviation infrastructure necessitates the development of methodological tools for evaluating investment efficiency under conditions of limited informational transparency. From a project management perspective, it is necessary to adopt value-based management tools, specifically EVA and ROIC, as primary mechanisms for monitoring and controlling value creation throughout the project lifecycle.

To understand how these significant capital flows translate into actual financial performance, a transition from a macro-level sector overview to a micro-level analysis of a specific market leader is necessary. The purpose of this study is to conduct a methodological synthesis and empirically test the indicators to assess the effectiveness of investment projects in Kazakhstan's logistics system based on portfolio management principles and value-based management (VBM) indicators. The research integrates a macro-level analytical synthesis of major greenfield logistics projects (2015–2024) with micro-level financial modeling of a representative capital-intensive operator.

The methodological framework combines project portfolio analysis, structural investment diagnostics, ROIC and EVA modeling, cash flow evaluation, and payback simulation, all adjusted for weighted average cost of capital (WACC). The study introduces an evaluation approach linking project governance quality with economic value creation by treating financial metrics as project KPIs.

The findings demonstrate that large-scale logistics investments in Kazakhstan generate positive economic value when ROIC exceeds the cost of capital. The application of cost management indicators enables project managers in transition economies to better navigate an environment of high-cost capital and ensure that infrastructure development aligns with the principles of long-term financial sustainability. At the same time, portfolio dominance of greenfield projects increases capital intensity and risk exposure. This requires advanced risk management as well as systematic training of project teams. The study contributes to the development of a project-oriented evaluation framework applicable to emerging transit economies and provides practical recommendations for improving investment project selection and governance in national logistics systems.

Keywords: investment project management, logistics systems, Project Portfolio Management, EVA, ROIC, economic effectiveness, Kazakhstan.

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Қазақстан логистика саласындағы инвестициялық жобалардың тиімділігі

Қазақстанның логистика саласы ұлттық транзиттік бәсекеге қабілеттілікті қамтамасыз етуде және жаһандық жеткізу тізбектеріне интеграциялануда стратегиялық рөл атқарады. Бұл зерттеуде Air Astana компаниясы капиталды көп қажет ететін логистикалық оператордың типтік мысалы ретінде пайдаланылады, бұл жалпы салалық үрдістерді микроэкономикалық көрсеткіштермен байланыстыруға мүмкіндік береді. Көлік және авиациялық инфрақұрылым салаларындағы капитал сыйымды жобалардың ауқымының ұлғаюы шектеулі ақпараттық ашықтық жағдайында инвестициялық тиімділікті бағалаудың әдіснамалық құралдарын әзірлеу қажеттілігін тудырады. Жобаны басқару тұрғысынан алғанда, жобаның өмірлік циклі бойында құндылық жасауды бақылау және бақылаудың негізгі тетіктері ретінде құндылыққа негізделген басқару құралдарын, атап айтқанда EVA және ROIC-ті қабылдау қажет.

Зерттеудің мақсаты – портфельдік басқару қағидаттары мен құнға негізделген басқару (VBM) көрсеткіштері негізінде Қазақстанның логистикалық жүйесіндегі инвестициялық жобалардың тиімділігін бағалаудың екі деңгейлі әдіснамасын әзірлеу және оны эмпирикалық тұрғыдан

нау. Ірі инвестициялық ағындардың нақты қаржылық нәтижелерге трансформациялануын талдау үшін салалық макродеңгейдегі шолудан нақты нарықтық көшбасшының қызметін макродеңгейде зерттеуге көшу негізделеді. Зерттеу 2015–2024 жылдар аралығындағы ірі greenfield форматындағы логистикалық жобалардың макродеңгейдегі портфельдік талдауын капитал сыйымды оператор қызметін макродеңгейде қаржылық модельдеумен ұштастырады.

Әдіснамалық негіз жобалар портфелін талдауды, инвестициялардың құрылымдық диагностикасын, ROIC және EVA көрсеткіштерін модельдеуді, ақша ағындарын бағалауды және капиталдың орташа өлшенген құнын (WACC) ескере отырып өтелу мерзімін модельдеуді қамтиды. Зерттеу шеңберінде қаржылық көрсеткіштер инвестициялық жобалардың негізгі тиімділік көрсеткіштері (KPI) ретінде қарастырылады. Жұмыста жобалық басқару сапасы мен экономикалық қосылған құнды қалыптастыру арасындағы байланысты айқындайтын интеграцияланған бағалау моделі ұсынылады.

Нәтижелер бойынша, Қазақстанның логистика саласындағы ауқымды инвестициялар ROIC капитал құнынан асқан жағдайда оң экономикалық қосылған құн қалыптастырады, ал greenfield жобаларының басымдығы капитал сыйымдылықты арттырып, портфельдік тәуекелдер деңгейін күшейтеді. Бұл тәуекелдерді басқарудың жетілдірілген тетіктерін дамыту мен жобалық командаларды жүйелі түрде даярлау қажеттілігін айқындайды.

Түйін сөздер: инвестициялық жобаларды басқару, логистикалық жүйелер, жоба портфелін басқару, EVA, инвестициялардың рентабельділігі, экономикалық тиімділік, Қазақстан.

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Эффективность инвестиционных проектов в логистическом секторе Казахстана

Логистический сектор Казахстана играет стратегическую роль в обеспечении национальной транзитной конкурентоспособности и интеграции в глобальные цепочки поставок. В данном исследовании в качестве примера капиталоемкого логистического оператора используется компания Air Astana, что позволяет связать общие отраслевые тенденции с микроэкономическими показателями. Рост масштабов капиталоемких проектов в сфере транспортной и авиационной инфраструктуры обуславливает необходимость разработки методологических инструментов оценки инвестиционной эффективности в условиях ограниченной информационной прозрачности. С точки зрения управления проектами необходимо внедрить инструменты управления на основе ценности, в частности, EVA и ROIC, в качестве основных механизмов мониторинга и контроля процесса создания ценности на протяжении всего жизненного цикла проекта.

Целью исследования является разработка и эмпирическая апробация двухуровневой методологии оценки эффективности инвестиционных проектов в логистической системе Казахстана, на основе принципов управления портфелем проектов и показателей стоимостного управления (VBM). Для анализа трансформации значительных инвестиционных потоков в реальные финансовые результаты обоснован переход от макро уровня отраслевого анализа к микро уровневому исследованию деятельности конкретного рыночного лидера. Исследование сочетает макро уровневый портфельный анализ крупных логистических проектов формата greenfield за период 2015–2024 гг. с микро уровнем финансовым моделированием деятельности представителя капиталоемкого оператора.

Методологическая база включает анализ портфеля проектов, структурную диагностику инвестиций, моделирование показателей ROIC и EVA, оценку денежных потоков и моделирование срока окупаемости с учётом средневзвешенной стоимости капитала (WACC). В рамках исследования финансовые показатели рассматриваются в качестве ключевых показателей эффективности (KPI) инвестиционных проектов. В работе предложена интегрированная модель оценки, связывающая качество проектного управления с созданием экономической добавленной стоимости.

Полученные результаты показывают, что крупномасштабные инвестиции в логистику Казахстана формируют положительную экономическую добавленную стоимость при условии превышения ROIC над стоимостью капитала, при этом доминирование проектов типа greenfield усиливает капиталоемкость и повышает уровень портфельных рисков. Это обуславливает необходимость развития продвинутых механизмов управления рисками, а также системной подготовки проектных команд.

Исследование вносит вклад в развитие проектно-ориентированной методологии оценки инвестиций для транзитных экономик и формирует практические рекомендации по совершенствованию отбора и управления инвестиционными проектами в национальных логистических системах.

Ключевые слова: управление инвестиционными проектами, логистические системы, управление портфелем проекта, EVA, рентабельность инвестиций, экономическая эффективность, Казахстан.

Introduction

Logistics plays a key role in the economic development of the Republic of Kazakhstan. Logistics infrastructure is an important factor in the economic and transport strategy of the Republic of Kazakhstan. At the same time, the performance of the logistics systems depends on several directions, including air transportation. Major governmental and private investors prefer to invest in transport infrastructure and aviation logistics, huge warehouse complexes, and digital decisions. Recent reports support the trend: a methodological synthesis of strategic investment initiatives reveals a significant scale of capital commitment in this sector Bureau of National Statistics of Kazakhstan, (2024). According to recent industry analyses, the strategic modernization of the Trans-Caspian International Transport Route (TITR) and the expansion of the Almaty aviation hub have become the main drivers of investment growth in 2024–2025 (World Bank, 2024; OECD, 2025). This study fills the existing literature gap by transitioning from a macroeconomic description of the industry to a detailed financial analysis using the EVA indicator to account for the high cost of capital, which is typical of the Kazakh market. Nevertheless, as investment volume grows, the system evaluation of the EVA and long-term efficiency remains critically unexplored from a project governance perspective. Existing literature mostly focuses on macroeconomic descriptions or infrastructure volumes. There is a lack of research quantifying how project-level governance directly impacts economic value in the Central Asian context by applying VBM.

There is a limited number of empirical studies that assess the effectiveness of investment projects in Kazakhstan's logistics sector by using financial indicators. Recent academic work highlights that despite the growth of transit potential, there remains a gap in micro-level performance indicators for national logistics operators (Auezov & Karimov, 2024). Most studies focus on investment volume, infrastructure development, and macroeconomic impacts, while project-level efficiency within the organizational context, especially using cost-based indicators, is only partially considered. This creates a research gap that is addressed in this article.

The relevance of the topic can be defined by its theoretical and practical importance. From the theoretical perspective, this research contributes to the understanding of economical effectiveness of the investments in developing countries. The research

focuses on the adaptation of value-based management (VBM) models to the specific conditions of developing markets, which can be described by partial informational transparency. In practice, it provides a framework to screen the project and monitor the efficiency within the national logistics system by aligning the project's profit with strategic value creation.

The object of the research is the investment landscape in the logistics sector of Kazakhstan, viewed as a complex of capital-intensive projects and infrastructure programs focused on aviation hubs.

As per the classical approach by Igoshin (1999), an investment project is considered not only as a set of documents but as a goal-oriented business activity aimed at achieving specific economic results. In the context of this research, this definition was extended to emphasize the role of the project as a significant element of the logistics system, where the project governance must align with the strategy of value creation.

In this study, an investment project is considered as a strategic management tool in the logistics system, which requires synchronized management of the capital structure and operational returns in order to ensure sustainability.

Implementation of the investment projects in an organization is always connected with its modernization, improvement of technological processes, establishment of new equipment, which leads to productivity growth, expansion of the business scale, and attraction of new resources.

Investment project considers the creation of new objects of the social infrastructure, or if it is made within the existing business, it can increase the production capacity, increases the number of employees. From the PM perspective, these activities represent critical phases of the project lifecycle, where the final EVA directly depends on resource allocation and risk mitigation.

The subject of the research is the economic effectiveness of the investment projects. The research aimed to empirically test the link between capital investment and economic value creation by integrating financial KPIs into the project performance evaluation framework.

This article also examines whether publicly available data from Air Astana and national aviation statistics are sufficient to evaluate direct investment projects in aviation logistics, and what methodological adjustments are needed in the context of partial transparency.

Literature review

The issue of the effectiveness of investment projects in the logistics sector is considered in the works of several researchers. The first direction of the research is focused on the microeconomic effect of logistics infrastructure. Researchers underline that investments in transport networks directly affect the efficiency of the supply chain and national logistics costs Bowersox *et al.*, (2003). Logistics is considered an important component of the larger economic system, where investments act as a catalyst for regional development and economic integration (Khan, 2004; Gwilliam, 2008) to the global supply chains (Iastremska *et al.*, 2023).

Some scholars analyze the investment process through the prism of their structural characteristics. The difference between investment in tangible and intangible assets and the difference in their effect was emphasized in those works. The authors state that the investment in intangible assets can have a more long-term effect; however, it needs a favorable institutional and financial environment for the realization Adarov & Stehrer (2019). In the context of national performance metrics, results often overlook the “opportunity cost” of invested capital. Given high interest rates and risks, EVA serves as a more accurate indicator, as project efficiency is adjusted to reflect the weighted average cost of

capital (WACC). By incorporating a risk-adjusted cost of equity, EVA bridges the gap between financial reporting and strategic risk management. This transformation of the performance measurement framework is particularly important for emerging markets, where ignoring the cost of equity can lead to a misleading perception of a project's viability and long-term sustainability. However, the existing research suffers from the aggregation bias, as they evaluate the logistics investments at the industry level without any details of the financial performance of individual projects.

Other researchers consider the logistics sector as an innovative opportunity for organizational changes. Authors emphasize that the development of logistics services is closely connected with the establishment of new managerial and technological solutions, which increase the sustainability of supply chains and decrease the operational risks Grawe, (2009). In this context, the investments are usually analyzed through the perspective of innovative outputs rather than the rigorous financial performance of the fundamental investment projects Wang *et al.*, (2020). This, in its turn, leads to the necessity of applying VBM tools to bridge the gaps between innovations and earnings. To address the reviewer's recommendation for a more structured literature review, Table 1 summarizes key contemporary studies on Kazakhstan's logistics sector.

Table 1
Comparative Analysis of Logistics Sector Studies in Kazakhstan (2022–2025)

Author(s)	Year	Focus of Research	Key Findings/Research Gap
Iastremska et al.	2023	Global supply chain integration	Emphasizes TRACECA corridors but lacks project-specific financial KPIs.
Kargi	2022	Logistics and GDP correlation	Confirms macroeconomic impact but ignores micro-level VBM indicators.
Auezov & Karimov	2024	Digitalization of transport	Focuses on IoT and blockchain; ROI of digital investment remains unquantified.
Bureau of National Statistics	2024	Capital investment dynamics	Provides volume-based data without evaluating project governance efficiency.
OECD	2025	Central Asian Infrastructure	Highlights high capital intensity and the need for standardized efficiency metrics.

Note: compiled by the author

This synthesis demonstrates that while macro trends are well covered, there is a lack of empirical research using EVA and ROIC to analyze project-level performance in the context of Kazakhstan.

Some researches focus on the formation of logistics opportunities and their effect on the economic results. These works pay close attention to the fact that logistics can have not only a supportive function but also become an independent factor of competitiveness in conditions of world trade and transit economics Morash, (2001).

Strategic investment in logistics is considered an independent factor of competitiveness in transit economies. However, the effectiveness of these projects depends on the coherence of national trade strategies and corporate investment policies Kargi, (2022). There remains a significant gap in the literature regarding the use of leading indicators, such as economic value added (EVA), to monitor these large investments.

Comparative analysis of works allows us to reveal some common limitations. First of all, most researches based on the analysis of the inter-relationship between investment, innovations, and logistics performance, but does not consider the effectiveness of the investment projects as a separate object of analysis. Some researchers believe that the effectiveness of investment projects in logistics should be assessed based on multi-criteria models that take into account not only financial indicators but also socio-economic impact Solonina *et al.*, (2019). Secondly, the indicators used are common, and sometimes it is not possible to assess the results of some investment decisions. Thirdly, while the significance of logistics for transit economies is studied widely, the national uniqueness of Kazakhstan remains unstudied. There is a lack of empirical studies that could include macro-level portfolio information with micro-level financial analysis of the national logistics representatives, which shows the novelty of this research.

Methodology

The methodological base of the research is focused on a comprehensive evaluation of investment processes in logistics of Kazakhstan and the determination of the effectiveness of major investments in transport infrastructure and related activities. The study includes an integrated research framework: a methodological synthesis of strategically important

logistics investment projects (based on fDi markets) and a micro-level case study of Air Astana for testing the value-based efficiency indicators. The selection of Air Astana as a benchmark entity is justified by the fact that its large-scale fleet and infrastructure renewal projects mirror the capital intensity and risk profile of the entire national logistics system. The following structural criteria were applied for project selection from fDi Intelligence (2024) in order to ensure the robustness and replicability of the macro-level analysis:

- temporal boundary restricted to 2015–2024
- geographic focus on joint logistics infrastructure within Kazakhstan
- functional alignment with strategic transportation clusters

As a result of the filtering, a localized portfolio of key infrastructure initiatives was identified. The rationale for choosing Air Astana as the primary empirical reference is powered by its systemic position as the national flag carrier and regional transit hub operator. In addition, it successfully executed an International Public Offering (IPO) in 2024 and provided audited financial disclosures via KPMG to provide data transparency and granular reliability, which is usually restricted or unavailable among state-owned or closely-held transport monopolies in Kazakhstan. This is a scientifically rigorous benchmark for stress-testing value-based efficiency metrics.

The hypothesis is that while logistics investments provide a strategic foundation for growth, their Economic Value Added (EVA) is limited by the high capital intensity and cost of capital in the Kazakhstani economy. This requires a shift from simple operational monitoring to advanced project governance.

The choice of ROIC and EVA as primary metrics is theoretically justified by the concept of value-based management (VBM). According to Damodaran (2013), these metrics are important for assessing whether a project creates real economic value in emerging markets with a high cost of capital. Furthermore, the use of project portfolio management (PPM) methods allows for a structured comparison between large-scale greenfield projects and operational modernization Cooper *et al.*, (2021).

The mathematical apparatus from the empirical findings consists of the following foundational formulas Damodaran, (2013); Cooper *et al.*, (2021):

Compound Annual Growth Rate

$$CAGR = \frac{RI}{RF} - 1 \quad (1)$$

where:

RI- Initial Revenue;

RF- Final Revenue;

CAGR-Compound Annual Growth Rate.

2. Net Operating Profit After Taxes

$$NOPAT = EBIT \times (1 - TAXRATE) \quad (2)$$

where:

EBIT- Earnings Before Interest and Taxes;

TAXRATE- Corporate tax rate.

3. Return on Invested Capital:

$$IC = E + D \quad (3)$$

$$ROIC = \frac{NOPAT}{IC} \times 100\% \quad (4)$$

where:

ROIC – Return On Invested Capital, %;

IC- Invested Capital,

E-Total equity;

D- Interest-bearing debt liabilities inclusive of lease obligations;

4. Economic Value Added:

$$EVA = NOPAT - IC \times WACC \quad (5)$$

where:

WACC – Weighted Average Cost of Capital

RE – Cost of Equity;

RD Cost of Debt;

T – Tax rate

5. Nominal Investment Payback Period:

$$PP = \frac{IC}{ACFO} \quad (6)$$

where:

PP – payback period;

ACFO – Annual Cash Flow from Operations.

Methodology includes several stages that require step-by-step realization. The research process is organized as follows:

1. Macro-level data collection. The collection and systematization of quantitative data on strategic

logistics investment projects within the national investment landscape. This operational phase entails the execution of the defined four-tier filtration matrix against raw fDi Intelligence records

2. Cost of Capital Benchmarking. To ensure objectivity under conditions of limited transparency regarding internal company data, the model utilizes industry WACC benchmarks as a baseline for assessing the cost of capital. The analytical bridge between sectoral macro-dynamics and firm-level micro-performance were institutionalized by contrasting capital deployment vectors

3. Dynamic Analysis. The next stage involved the analysis of the dynamics of logistics assets by calculation of the compound annual growth rate (CAGR) and provided an opportunity to assess the intensity of the investment development across the project lifecycle.

4. Structural analysis. The fourth stage completed the structure analysis of the capital investments by main directions, such as renewal, technical development, digitalization, and capacity building for project teams.

5. Efficiency Modeling. The last stage includes the calculation of Net Operating Profit After Tax (NOPAT), Return on Invested Capital (ROIC), and Economic Value Added (EVA) to evaluate the effectiveness of investments and to predict the approximate investment payback period (PP).

This research primarily employed quantitative methods, including financial analysis, index methods, structural analysis, and elements of financial modeling. It also included the calculation of the financial flows and cost of capital. Selected indicators were illustrated using data from one of Kazakhstan's major logistics companies, providing an opportunity to demonstrate the typical investment processes and project governance standards of this sector. This approach ensures the validity of conclusions and allows comparison of the theoretical models with real parameters of investment activities.

In this research, financial indicators (EVA, CAGR, and ROIC) are used in the framework of Project Management focused on value creation. The approach considers each investment as a strategic project where the initial goal is not limited by operational completion only, but also the maximization of stockholder value. The methodology switches from the descriptive analysis of data to the performance assessment of Project Governance, where the numbers serve as the final KPI to select projects effectively and execute.

Results and discussion

This study first analyzes a portfolio of major investment projects in the logistics sector of Kazakhstan to provide a systematic approach for evaluating the logistics efficiency of investments. The data, extracted from the Financial Times database, covers the period of 2015-2024 and shows the priorities of international investors (fDi Intelligence, 2024).

The considered project portfolio represents a total capital commitment of \$8.27 billion and is divided into three main clusters:

1. Strategic Infrastructure and aviation hubs, including the expansion of Almaty International Airport, which cost equate to approximately \$780 million or local currency equivalent, rather than billions; cf. TAV Airports, 2021 (TAV Airports, 2021).

2. Maritime and transit connectivity. The main focus of the projects directed by AD Ports Group was the Port of Kuryk (AD Ports Group, 2024).

3. Global 3PL and distribution networks powered by investments of the global leaders such as UPS, DB Schenker, CEVA logistics and DHL.

The high concentration of “Greenfield” projects within this portfolio heightens exposure to systemic risks, such as tenge exchange rate volatility, prolonged construction timelines, and geopolitical uncertainty. These factors necessitate the incorporation of an elevated risk premium, rendering EVA a critically important tool for “stress-testing” project viability.

From the Project Portfolio Management (PPM) prism, the dominance of the “Greenfield” projects shows a specific risk profile. In comparison with “Brownfield” projects, “Greenfield” projects in Kazakhstan’s logistics require professional Scope Management and Stakeholder Engagement to navigate direct environmental and regulatory complications. The effective initiation of high-value projects illustrates a maturing project maturity level in the

national investment policy, changing the focus to the creation of long-term strategic assets. These projects show the systemic shift toward “greenfield” investments, meaning that new logistics capacities are created to meet international transit demand through structured project execution. The presence of such world leaders confirms the high investment attractiveness of Kazakhstan’s logistics sector. However, it is necessary to provide a transition from a macro-level sector overview to a micro-level analysis of a specific market leader in the region.

The results of the research allow to evaluate dynamics of the investment development based on project KPIs such as compound annual growth rate (CAGR), net operating profit after taxes (NOPAT), return on invested capital (ROIC), economic value added (EVA), cash flow (CF), payback period (PP), discounted payback period (DPP). The study was focused on the data retrieved from the reports of the independent auditor, KPMG, about Air Astana. As a key investment player in the industry, its projects reflect the strategic development trends in logistics in Kazakhstan.

The shift from global databases to targeted disclosure at the individual company level allows for detailed testing of macro hypotheses in a controlled environment. The selected indicators serve as a comprehensive diagnostic system that reflects aspects of corporate metrics project management, transforming static accounting reports into dynamic indicators of operational performance. The performance assessment of the national airline serves as a benchmark to verify whether capital accumulation is translating into real wealth creation in the context of regional risk premiums.

1. Dynamics of logistics assets

In 2024, the cost of logistics assets of the national air company Air Astana increased from 387885 to 558341 mln KZT, so the annual growth rate (Table 2):

Table 2

Consolidated statement of financial position of Air Astana for the year ended 31 December, 2024

thousand tenge	31 December 2024	31 December 2023
Property, plant, and equipment	558 341 061	387 885 139
Intangible assets	160 112	1 289 132
Prepayments	10 287 430	8 387 087
Guarantee deposits	20 319 131	15 137 757
Deferred tax assets	25 521 921	16 836 902

Continuation of the table

thousand tenge	31 December 2024	31 December 2023
Trade and other receivables	330 819 610	474 617 960
Inventories	34 724 999	30 704 619
Prepayments	15 905 582	11 284 452
Income tax prepaid	6 825 905	6 027 011
Trade and other payables	10 922 813	10 693 524
Other taxes prepaid	7 242 317	4 657 876
Guarantee deposits	1 700 831	899 574
Cash and cash equivalents	256 622 307	124 552 167
Other financial assets	158 583	346 829
Total current assets	334 103 337	189 166 052
Total assets	952 063 811	619 312 543
Share capital	56 758 223	2 501 550
Functional currency transition reserve	(3 952 306)	-
Other reserves	1 455 281	-
Treasury shares	40 842 148	12 323 792
Reserve on hedging instruments, net of tax	(1 965 955)	(5 489 830)
Retained earnings	113 985 260	87 599 957
Total equity	207 171 647	96 984 465
Loans	273 582	-
Lease liabilities	376 385 720	247 233 366
Provision for aircraft maintenance	152 211 535	67 555 798
Employee benefits	429 540	283 191
Total non-current liabilities	529 300 377	315 072 355
Loans	29 406	187 279
Lease liabilities	90 259 057	79 546 636
Deferred revenue	47 155 403	38 350 318
Provision for aircraft maintenance	13 269 005	47 806 075
Trade and other payables	64 878 916	41 365 415
Total current liabilities	215 591 787	207 255 723
Total liabilities	744 892 164	522 328 078
Total equity and liabilities	952 063 811	619 312 543

Note: compiled by the author based on AIR ASTANA GROUP Integrated Annual Report, 2024)

The structural data presented in Table 2 empirically confirm the intensive allocation of capital. The increase in the net book value of fixed assets by 44% clearly indicates the accelerated implementation of the macro-corridor infrastructure expansion projects discussed at the industry level. Most importantly, the parallel increase in total assets to 952,063,811 thousand tenge was largely due to long-term lease obligations (376,385,720 thousand tenge), which

indicates that the expansion of production capacity is closely related to long-term capital commitments. This active accumulation of assets directly confirms the central hypothesis: expanding the invested capital base automatically raises the absolute marginal level of capital expenditures – an obstacle that the firm must overcome to achieve positive EVA.

$$CAGR = \frac{387885}{558341} - 1 = 44\%$$

The increase in assets shows the modernization of logistics infrastructure, including vehicle renewal, technological development, and digitalization. This growth rate of 44% provides a micro-level validation of the intensive capital inflow, which was defined in portfolio analysis. As per global market research, the global logistics industry revenue is expected to increase, representing a CAGR of around 7.2% from 2025 to 2030 (Grandview, 2025). This means that Kazakhstan's logistics sector demon-

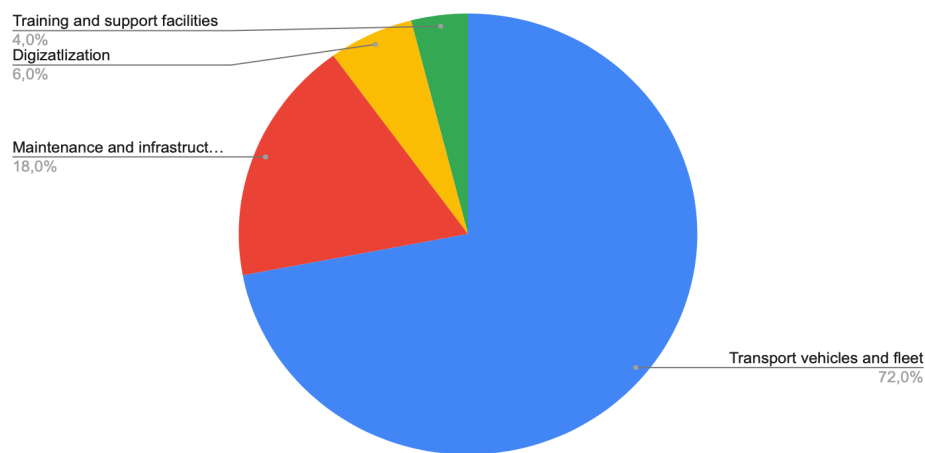
strates considerably faster growth of assets, which necessitates advanced Project Resource Planning and strategic scalability to manage such intensive expansion. This can be attractive for foreign investors and motivate them to invest in Kazakhstan's logistics in the long term.

2. The structure of capital investments.

As per the annual report of Air Astana, the distribution of investments of Air Astana corresponds to the typical model of capital-intensive industries:

Figure 1

The distribution of investments of Air Astana in 2024



Note: compiled by the author based on Air Astana annual report, 2024

The major part of the investment in 2024 was spent on the transport vehicles and fleet, which is typical for capital-intensive spheres and leads to a high depreciation burden. From the Project Management standpoint, the focus on tangible assets is another piece of evidence of the “Greenfield” investment model. Other investments were split between

maintenance, digitalization, and capacity building for project teams, which support operational effectiveness throughout the project lifecycle. This, in turn, opens new investment horizons: investments in technologies, automation, and AI within the industry to optimize processes and costs.

3. Evaluation of the investment effectiveness

Table 3

Consolidated statement of profit or loss of Air Astana for the year ended 31 December 2024

thousand tenge	2024	2023
Passenger revenue	585,810,042	521,074,736
Cargo and mail revenue	12,413,214	10,284,481
Other income	5,427,382	3,810,285
Total revenue and other income	616,152,033	535,169,502
Fuel and oil costs	(143,373,122)	(127,357,770)

Continuation of the table

thousand tenge	2024	2023
Employee and crew costs	(106,675,293)	(88,102,136)
Depreciation and amortization	(88,717,693)	(73,944,311)
Handling, landing fees, and route charges	(56,732,135)	(48,241,120)
Passenger service	(55,787,727)	(46,124,472)
Engineering and maintenance	(55,443,453)	(49,388,554)
Selling costs	(20,777,116)	(18,444,763)
Insurance	(6,013,245)	(5,011,359)
Consultancy, legal, and professional services	(3,874,604)	(2,631,258)
IT and communication costs	(3,224,735)	(2,980,328)
Aircraft lease costs	(2,384,213)	(1,000,743)
Property and office costs	(2,200,684)	(1,766,071)
Taxes	(2,043,010)	(1,787,829)
Impairment loss on trade receivables	-36,532	-57,402
Other operating costs	(6,545,924)	(7,045,247)
Total operating expenses	(553,829,486)	(473,883,363)
Operating profit	62,322,547	61,286,139
Finance income	10,376,957	6,757,281
Finance costs	(30,618,503)	(22,765,053)
Foreign exchange loss, net	(9,939,963)	(6,280,403)
Profit before tax	32,141,038	38,997,964
Income tax expense	(6,618,444)	(8,258,890)
Profit for the year	25,522,594	30,739,074
Basic and diluted earnings per share (tenge)*	73.156	100.454

Note: compiled by the author based on the source (AIR ASTANA GROUP Integrated Annual Report, 2024)

As per tax law, a flat tax rate of 20% was applied to EBIT, yielding the following NOPAT calculation:

$$\begin{aligned} \text{NOPAT} &= 62322547 \times (1 - 0.2) = \\ &= 49858038 \text{ thousand of KZT} \end{aligned}$$

The company saves about 50 billion KZT of operational revenue, which shows the high effectiveness of operations. While NOPAT confirms operational sustainability, a positive EVA figure of 22.79 billion tenge demonstrates that the company is not merely profitable in an accounting sense but also generates real economic wealth in excess of its cost of capital. A high NOPAT value can inform investors that the company can generate stable cash flow and recoup the invested capital.

As per the financial report of Air Astana, equity in 2024 was 207 171 647 thousand KZT, and inter-

est-bearing debt, inclusive of lease obligations, was compiled to calculate total invested capital:

$$\begin{aligned} \text{IC} &= 207171647 + 115038430 = \\ &= 322210077 \text{ thousand KZT} \end{aligned}$$

$$\text{ROIC} = \frac{49858038}{322210077} \times 100 \approx 15.47\%$$

As per the latest research, the estimated WACC for air companies is around 8.4% (Gurufocus, 2025). This indicator serves as a conservative estimate, taking into account Kazakhstan's country risk and the high cost of debt servicing for transport operators during the current period. This benchmark is in line with industry reports for 2025 for Central Asian transport operators, reflecting current risk premiums and the cost of debt capital in the region (KPMG, 2025). The WACC value is used as a benchmark es-

timate, as there is a lack of disclosed company-specific capital investment data for the current reporting period. The ROIC of Air Astana in 2024 was around 15.5%, which exceeds the WACC of 8.4% showing that the company is creating value for its shareholders. It shows that the company is managing its assets well and generating stable revenue.

$$EVA = 49858038 - (322210077 \times 0.084) \approx 22792392 \text{ thousand KZT}$$

The economic value added of the company in 2024 was approximately 22.79 billion KZT, which indicates that the company's revenue exceeds the cost of capital. The Positive EVA confirms that Air Astana's operations provide value for its shareholders. It also demonstrates that the large-scale infrastructure investments have a strong potential to generate economic value.

By combining the empirical data from Tables 2 and 3, the total invested capital amounts to 674119412 thousand tenge (including equity and consolidated financial leases). Operating profit (EBIT) of 62322547 thousand tenge yields a Net Operating Profit After Tax (NOPAT) of 49858038 thousand tenge. This indicates an empirical Return on Invested Capital of 15.5%, adjusted for lease amortization. This positive spread in returns exceeding the conservative Weighted Average Cost of Capital (WACC) benchmark of 8.4% results in an absolute EVA of 22.79 billion tenge, thereby validating the key hypothesis that structured corporate project management effectively mitigates the capi-

tal intensity inherent in logistics investments within Central Asia.

The positive EVA in this case is a key indicator of Project Lifecycle Management efficiency, confirming that the structure of project governance allows for managing the cost of capital effectively. From the PV viewpoint, it demonstrates that the strategic decision to invest more in fleet modernization was reinforced by diligent Risk Mitigation and Resource Allocation strategies.

Stable added value dynamics indicate that the chosen project management model is successfully adapting to the region's macroeconomic risks. To more fully assess investment attractiveness, it is necessary to compare current profitability with the rate of return on investment, which allows one to determine the liquidity of the project portfolio.

4. Investment payback period.

Payback period can be calculated as the simple payback period (PP) and the discounted payback period (DPP). Simple PP shows the number of years necessary for the return of investments through the operational cash flow without considering the time value of money. Discounted payback period considers the fact that future cash flows cost less than cash today by discounting with the use of WACC. It is necessary to calculate a simple payback period, as PP indicates the nominal rate of return on an investment, taking into account that the calculation is only illustrative, as the risks were not considered.

Annual cash flow from the operation of Air Astana in 2024 was equal to 172 537 380 thousand KZT (Table 4).

Table 4

Consolidated statement of cash flows of Air Astana for the year ended 31 December 2024

thousand tenge	2024	2023
OPERATING ACTIVITIES		
Profit before tax	32 141 038	38 997 964
Adjustments for:		
Depreciation and amortization of property, plant and equipment, and intangible assets	73 944 311	88 717 693
Gain on disposal of property, plant, and equipment	717 693	(1 571 644)
Change in impairment allowance for trade receivables, advances issued, guarantee deposits, and cash and cash equivalents	(539 856)	(34 680)
Provision for obsolete inventories	165 712	(283 369)
Change in vacation reserve	552 061	(144 194)
Accrual of provision for aircraft maintenance	44 656 280	39 127 998
Change in customer loyalty program provision	1 909 682	1 265 804
Foreign exchange loss, net	939 963	6 280 403

Continuation of the table

thousand tenge	2024	2023
Finance income, excluding impairment	(10 241 249)	(6 538 656)
Finance costs, excluding impairment	30 594 906	22 567 976
Income from the early return of the engine	(1 270 825)	-
Equity-settled share-based payment	2 841 547	-
Cash generated from operating activities before changes in working capital	186 624 398	173 611 913
Change in trade and other receivables	(842 175)	(379 194)
Change in prepaid expenses and advances issued	(4 788 757)	(2 566 744)
Change in inventories	768 943	(7 660 076)
Change in trade and other payables and aircraft maintenance provision	(8 373 871)	(8 210 386)
Change in deferred revenue	1 503 495	657 999
Change in other financial instruments	419 210	(58 864)
Cash generated from operating activities	175 311 243	155 394 648
Income tax paid	(12 997 706)	(19 602 319)
Interest received	10 223 843	6 430 778
Net cash generated from operating activities	172 537 380	142 223 107
INVESTING ACTIVITIES		
Purchase of property, plant, and equipment	(45 980 710)	(19 063 263)
Proceeds from the sale and leaseback	42 484 321	-
Proceeds from disposal of property, plant, and equipment	1 283 449	2 272 424
Purchase of intangible assets	(1 775 326)	(961 955)
Placement of bank and guarantee deposits	(5 972 685)	(4 553 517)
Withdrawal of bank and guarantee deposits	1 428 975	1 312 348
Net cash used in investing activities	(8 531 976)	(20 993 963)

Note: compiled by the author based on the source (Air Astana Group Integrated Annual Report, 2024)

$$PP = \frac{322210077}{172537380} = 1.87 \text{ years}$$

This means that the payback period, as per data from 2024, was about 1.87 years. The short payback period shows the high operational effectiveness and rapid capital recovery, which is a critical factor in Project Risk Management. It is important to note that this payback period calculation is illustrative and based on operational cash flows in relation to total invested capital. Since capital expenditures are not presented as a separate investment project in the financial statements, this result indicates that the company's overall asset turnover is high. However, such rapid recovery rates are in line with the high demand associated with the expansion of the regional transit hub.

Based on the analysis of the project efficiency, the following recommendations were proposed to

improve the management of logistics investment projects.

1. Establishment of flexible management: Considering the high volatility of the international transit routings, logistics projects should shift from rigid waterfall planning to agile governance to allow for ceaseless scope adjustments.

2. Entering the standards into KPI dashboards: In order to keep the high level of EVA, the managers must establish financial monitoring in real time at all stages of the project lifecycle.

3. Enhanced risk integration: The dependence on "Greenfield" projects requires the integration of the Quantitative Risk Analysis, i.e., Monte Carlo simulations on the stage of feasibility for protection of investments from inflation and geopolitical fluctuations.

4. Capacity creation and PM training: Instead of the traditional approach, emphasis should be placed on systematic training and certification of project

teams. Specialized professional development programs for new projects must be created to ensure operational processes meet the quality standards.

Limitations and future research directions

Several limitations need to be clearly stated to ensure the scientific rigor of this study. First, while the Air Astana case clearly illustrates macroeconomic trends and business growth dynamics, the empirical analysis at the micro level is limited to the example of a single market leader. Consequently, corporate investment dynamics may differ significantly for state-owned railway monopolies or low-profit surface infrastructure operators in Kazakhstan. Second, due to the limited public availability of information on the level of barriers for specific projects, this model uses a normalized industry WACC (8.4%) when calculating the economic value added (EVA). Finally, this study covers the financial reality up to the reporting period of 2024, leaving the analysis of long-term changes in the project life cycle for future observations.

In this regard, promising areas of further research should include:

- Expanding the analytical scope by building comparable financial models for several companies, including other large operators in the air transport, surface transit and dry port sectors of the Republic of Kazakhstan;
- Conducting longitudinal investment performance studies to track the full implementation and work cycle of logistics projects over a 5-10 year period; and
- Integrating non-financial operational KPIs, such as regional transit speeds, infrastructure capacity utilization indicators, and project risk management indicators, into project management systems aimed at creating economic value.

Conclusion

The conducted study confirms the relevance of the evaluation of the economic effectiveness of investment projects in the logistics sector of Kazakhstan using a methodological synthesis of strategic trends and empirical modeling. It also proves that the economic effectiveness of Kazakhstani logistics is fundamentally driven by the quality of strategic Project Management. Thus, the investment success is a result of effective project governance, which allows for the transformation of capital into sustainable economic value. The results evidence that logistics, particularly air transport, has a key role in the economic well-being of the Republic of Kazakh-

stan. Investments in logistics currently have a stable, positive dynamic, shifting towards high-value infrastructure development.

The link between macroeconomic trends and microeconomic value creation is substantiated by the fact that aggressive asset accumulation significantly outpaces the global benchmark average annual growth rate of 7.2%, thereby expanding the capital base and necessitating stricter project oversight. Portfolio analysis reveals a systematic shift toward high-cost “greenfield” configurations, underscoring the need to transition from purely operational control to advanced, value-based project portfolio management. Company-level financial modeling demonstrates that achieving a positive EVA margin (22.79 billion tenge) and reducing payback periods (1.87 years) while remaining within the bounds of regional risk premiums requires mature project lifecycle frameworks. Identified limitations regarding data transparency and reliance on normalized WACC proxies highlight the need to adapt value-based project portfolio management methodologies to the unique institutional landscape of Central Asian markets. Ultimately, the adoption of value-based criteria for project portfolio management provides a robust decision-making framework for government institutions, international financiers, and corporate executives alike.

In general, the results of the article show that investment projects in the logistics sector of Kazakhstan are economically effective and show high potential for value creation. The results of the research contribute to the existing approaches of assessment by integrating value-based KPIs into project governance frameworks and can be used by the investors, government, and managers during the decision-making processes.

The research revealed that the growth of the fixed assets illustrates the processes of the modernization of logistics infrastructure, including the renewal of the vehicles, technological development, and digitalization. From a Project Management standpoint, such a high growth rate necessitates advanced Resource Planning and Scalability. In comparison to the global average CAGR of 7.2%, Kazakhstan has higher indicators that improve its investment climate and can motivate local and foreign investors to invest in the logistics sector of Kazakhstan.

The project portfolio analysis of logistics projects, valued at \$8.27 billion, further supports this trend. The study revealed that the major part of these initiatives is “greenfield” investments, which require specialized Scope Management and Risk

Mitigation to navigate environmental and regulatory complexities.

The financial analysis of the projects provided an opportunity to calculate the illustrative payback period. In this research, the payback period of the object was 1.87 years, which proves the sector's operational effectiveness. In the context of Project Risk Management, a short payback period corresponds to the world practice in the sector of logistics, where the investments can be characterized by the speed of pay-off. This confirms the ability of Kazakhstan's investment projects to create economic value in the short-term period as well as to save the potential of long-term development within the project lifecycle.

At the same time, the research revealed some limitations connected with the availability of information and the transparency of public data. The reliance on benchmark estimates for some indicators, like WACC, emphasizes the importance of more detailed corporate disclosure. This gap highlights the need to adapt project-oriented methodological approaches to better account for the specific risks and long-term factors influencing investment decisions in emerging markets.

Conflict of Interest

The authors declare that there are no conflicts of interest that could have influenced the results of the study or their interpretation.

Author Contributions

AND: contributed substantially to the conceptualization of the study, identification of the research problem, formulation of the research objectives, tasks, and hypotheses, development of the methodological approach for assessing the effectiveness of investment projects in Kazakhstan's logistics sector, interpretation of the obtained results, preparation of scientific conclusions and practical recommendations, scientific editing of the manuscript, and overall coordination of the research process.

NAB: was responsible for the collection, systematization, and processing of statistical, analytical, and financial data; performed calculations of investment project performance indicators (ROIC, EVA, CAGR, and PP); prepared tables, figures, and analytical materials; conducted the literature review; and prepared the initial draft of the manuscript.

KM: provided scientific consultation throughout the study, contributed to the improvement of the methodology and verification of the results, conducted an expert assessment of the analytical findings, proposed recommendations to enhance the scientific validity of the research, and carried out the final review of the manuscript prior to publication.

All authors participated in discussing the research results, reviewed and approved the final version of the manuscript, and agreed with its content and conclusions.

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ИНТЕГРАЦИЯ КРИТЕРИЕВ ПРИНЯТИЯ РЕШЕНИЙ В МАРКЕТИНГОВЫЙ АУДИТ МАЛОГО БИЗНЕСА КАЗАХСТАНА

Малый бизнес развивается в условиях обостряющейся конкуренции, ограниченности ресурсов и значительной рыночной неопределенности. В таких условиях возрастает потребность в аналитически обоснованных инструментах маркетингового управления. Цель исследования заключается в определении наиболее эффективных подходов к маркетинговому аудиту для малых предприятий Казахстана, работающих в нестабильной рыночной среде. Центральная идея исследования заключается в том, что интеграция формальных критериев принятия решений в условиях неопределенности в структуру маркетингового аудита повышает его стратегический и прогностический потенциал.

Научная значимость данной работы заключается в восполнении методологических пробелов в литературе, где маркетинговый аудит часто рассматривается в первую очередь как диагностический или контрольный инструмент. Методология исследования основана на концептуальном анализе и аналитическом моделировании с использованием критериев Лапласа, Максимакса, Вальда и Сэвиджа интегрированных в систему маркетингового аудита. В работе предложена расширенная интерпретация маркетингового аудита как инструмента поддержки управленческих решений в условиях неопределенности.

Результаты подтверждают, что интеграция количественных критериев принятия решений с показателями маркетинговой эффективности формирует более адаптивную и чувствительную к риску структуру по сравнению с традиционными подходами. Предложенная модель способствует повышению точности прогнозирования, рациональному распределению ресурсов и улучшает стратегические позиции малых предприятий.

Практическая значимость исследования заключается в разработке адаптивной модели маркетингового аудита, адаптированной для малых предприятий в странах, переживающих институциональные и рыночные трансформации. Полученные результаты предоставляют предпринимателям структурированный алгоритм проведения независимого аудита, что повышает качество управленческих решений и долгосрочную устойчивость.

Ключевые слова: малое предприятие, маркетинговый аудит, малый и средний бизнес, прогноз роста, принятие решений в условиях неопределенности.

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Integrating decision-making criteria into small business marketing

Small businesses operate in an environment of increased competition, limited resources, and high market uncertainty. In such circumstances, the need for structured and analytically sound marketing management tools becomes critically important. The purpose of this study is to determine which modern approaches to marketing audit are most effective for small businesses operating in unstable market conditions, taking into account the economic and institutional context of Kazakhstan. The central idea of the study is that the integration of formal decision-making criteria in the context of uncertainty into the structure of marketing audit increases its strategic and predictive potential.

The scientific significance of this work lies in eliminating methodological gaps in the literature, where marketing audit is often considered primarily as a diagnostic or control tool. The study suggests an expanded interpretation of marketing audit as an integrated decision support system combining performance diagnostics with quantitative assessment models. Methodologically, the study uses conceptual synthesis and analytical modeling, which include Laplace, Maximax, Wald and Savage criteria (minimax regret) in the marketing audit process and illustrate their application using the example of structured decision-making scenarios.

The results confirm that the combination of quantitative decision-making criteria with marketing performance indicators creates a more adaptive and risk-sensitive structure than traditional audit approaches applied independently of each other. The proposed model increases the accuracy of forecasting, promotes the rational allocation of resources and improves the strategic positioning of small enterprises.

The contribution of this research is to develop an adaptive marketing audit model adapted for small businesses operating in economies undergoing institutional and market transformation. From a practical point of view, the results obtained provide entrepreneurs with a structured algorithm for conducting an independent audit, which improves the quality of management decisions and long-term sustainability.

Keywords: small enterprise, marketing audit, small and medium-sized businesses, growth forecast, decision-making in conditions of uncertainty.

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Шешім қабылдау критерийлерін шағын бизнестегі маркетингтік аудитке біріктіру

Шағын бизнес жоғары бәсекелестік, шектеулі ресурстар және нарықтық белгісіздіктің жоғары деңгейі жағдайында қызмет етеді. Мұндай жағдайда маркетингтік басқарудың құрылымдалған және аналитикалық құралдарына деген қажеттілік ерекше маңызға ие. Осы зерттеудің мақсаты – Қазақстанның экономикалық және институционалдық ерекшеліктерін ескере отырып, тұрақсыз нарықтық ортада жұмыс істейтін шағын бизнес үшін маркетингтік аудиттің қандай заманауи тәсілдері неғұрлым тиімді екенін анықтау. Зерттеудің негізгі идеясы маркетингтік аудит құрылымына белгісіздік жағдайында шешім қабылдаудың формалданған критерийлерін енгізу оның стратегиялық және болжамдық әлеуетін арттыратынына негізделген.

Жұмыстың ғылыми маңыздылығы маркетингтік аудит саласындағы әдіснамалық олқылықтарды толықтырумен байланысты, өйткені қолданыстағы әдебиеттерде маркетингтік аудит көбінесе диагностикалық немесе бақылау құралы ретінде ғана қарастырылады. Зерттеу маркетингтік аудитті тиімділікті диагностикалаудың сандық бағалау модельдерімен біріктірілген шешім қабылдауды қолдау жүйесі ретінде кеңейтілген тұрғыда түсіндіруді ұсынады. Әдіснамалық тұрғыдан зерттеуде маркетингтік аудит үдерісіне Лаплас, Максимакс, Вальд және Сэвидж (минимакс өкініш) критерийлерін енгізуге негізделген тұжырымдамалық синтез бен аналитикалық модельдеу қолданылған. Олардың практикалық қолданылуы құрылымдалған шешім қабылдау сценарийлері арқылы көрсетілген.

Зерттеу нәтижелері сандық шешім қабылдау критерийлерін маркетинг тиімділігінің көрсеткіштерімен үйлестіру дәстүрлі аудит тәсілдерін жеке-жеке қолдануға қарағанда икемдірек әрі тәуекелдерге сезімтал басқару құрылымын қалыптастыратынын дәлелдейді. Ұсынылған модель болжамдардың дәлдігін арттырып, ресурстарды тиімді бөлуге ықпал етеді және шағын бизнестің нарықтағы стратегиялық позициясын нығайтады.

Зерттеудің негізгі үлесі – институционалдық және нарықтық трансформация жағдайындағы елдердегі шағын бизнес субъектілеріне бейімделген маркетингтік аудиттің интеграцияланған моделін әзірлеу болып табылады. Практикалық тұрғыдан алғанда, алынған нәтижелер кәсіпкерлерге маркетингтік аудитті өз бетінше жүргізудің құрылымдалған алгоритмін ұсынады, бұл басқарушылық шешімдердің сапасын арттыруға және бизнестің ұзақ мерзімді тұрақтылығын қамтамасыз етуге мүмкіндік береді.

Түйін сөздер: шағын бизнес, маркетингтік аудит, шағын және орта бизнес, өсу болжамы, белгісіздік жағдайында шешім қабылдау

Введение

В контексте текущей экономической политики Казахстана малые и средние предприятия (МСП) играют ключевую роль в обеспечении устойчивого экономического роста. Исследования показывают, что для перехода страны к развитой экономике доля МСП в валовом внутреннем продукте (ВВП) должна как правило превышать 50% (Ardic et al., 2011). В настоящее время этот показатель составляет примерно 39%, что свидетельствует о наличии серьезной проблемы (Бюро национальной статистики, 2025). Многие малые предприятия сталкиваются с ограниченностью ресурсов и нестабильностью рынка, что делает их особенно уязвимыми и требует научного анализа для выявления эффективных инструментов и методов.

Растущий интерес к развитию МСП в Казахстане подкрепляется инициативами правительства и острой необходимостью в инновационных методах повышения их эффективности в условиях глобальных экономических вызовов. Несмотря на внимание, уделяемое этой теме, многие вопросы, касающиеся взаимосвязи между маркетинговыми аудитами и результатами деятельности малых предприятий, остаются недостаточно изученными. Этот пробел создает как теоретическую, так и практическую значимость для дальнейшего изучения.

Основная цель данного исследования заключается в анализе влияния маркетингового аудита на эффективность малых предприятий в Казахстане. Существует необходимость в выявлении универсальных инструментов и методов, которые могут помочь малым и средним предприятиям адаптироваться и процветать в условиях экономической нестабильности.

Объектом исследования являются малые предприятия Казахстана, функционирующие в условиях рыночной неопределенности. Предметом исследования выступает интеграция критериев принятия решений в условиях неопределенности в систему маркетингового аудита малого бизнеса.

Для достижения поставленной цели необходимо решить следующие задачи: изучить методы маркетингового аудита, используемые в настоящее время в малых предприятиях Казахстана; оценить влияние маркетингового аудита на финансовые и операционные показатели малых предприятий, а также предложить рекомендации по внедрению маркетинговых аудитов

для повышения устойчивости бизнеса. Методы исследования включают анализ научной работы, концептуальное моделирование и применение критериев принятия решений в условиях неопределенности к задачам маркетингового аудита малого бизнеса на основе результатов анкетного опроса предпринимателей. Систематическое проведение маркетинговых аудитов положительно повлияет на эффективность малых предприятий в условиях экономической нестабильности.

Обзор литературы

Определение маркетингового аудита начинается с 1950-х годов в отчетах Американской ассоциацией менеджмента. В формирование концепции маркетингового аудита значительный вклад внесли работы Шухмана (Shuchman, 1959), Сешнса (Sessions, 1959), Оксенфельдта (Oxenfeldt, 1959) и Криспа (Crisp, 1959). Оценка маркетинговой деятельности как маркетинговый аудит был определен как систематический беспристрастный обзор деятельности (Шухман, 1959). Ученые Нэйлор и Воод впервые определили связь между маркетинговым аудитом и финансовыми показателями бизнеса. Отсутствие необходимой информации и непонимание собственника бизнеса и аудитора были отмечены в работах Capella Sekely как основные проблемы при проведении маркетингового аудита.

Согласно Моква (Mokwa, 1986), маркетинговый аудит следует рассматривать как процедуру, выходящую за рамки традиционного маркетингового контроля: он предполагает не только оценку выполненных действий, но и возможность пересмотра маркетинговой политики организации, а также инициирования внутренних организационных изменений, включая внедрение новых управленческих механизмов. Ряд авторов подчеркивает, что методологически полноценный аудит должен включать внешнюю перспективу – анализ клиентов и потенциальных клиентов, конкурентной среды и системы распределения и иных элементов рынка. При этом получение беспристрастных выводов в значительной степени связано с независимостью аудитора; в литературе отмечается, что привлечение внешних специалистов повышает объективность результатов (Boyd & Walker, 1990). В условиях интернационализации рынков особую актуальность приобретает глобальное измерение маркетингового аудита; в работах James T. Rothe

и Michael G. Harvey отдельно акцентируется необходимость тщательной оценки внутренней среды как составляющей адекватной аудиторской диагностики (Rothe & Jackson, 1997).

В научной и прикладной плоскости маркетинговый аудит выступает инструментом, поддерживающим обоснованный выбор стратегии маркетинговых действий и обеспечивающим системную диагностику маркетинговой результативности организации. В отличие от маркетингового контроля, который преимущественно сопоставляет результаты с плановыми показателями и оценивает исполнение стратегических решений, маркетинговый аудит имеет более широкий аналитический охват. Он предполагает обследование не только стратегий, но и целей, процессов и используемых практик, а также анализ внешней среды и внутренних возможностей компании, что позволяет выявлять причины отклонений, скрытые ограничения и перспективные направления развития.

Систематизация исследований, посвященных маркетинговому аудиту с конца 1950-х годов до настоящего времени, демонстрирует расширение функционального содержания данного инструмента и постепенный переход от узких контрольных процедур к комплексным диагностическим моделям. При этом применимость конкретных концепций определяется контекстом организации: уровнем ресурсов, стратегическими приоритетами, рыночной позицией и особенностями управленческой системы. Для малых предприятий целесообразно рассматривать маркетинговый аудит прежде всего через призму процессов и тактических маркетинговых функций, поскольку именно они формируют повседневную эффективность, скорость реакции на рынок и устойчивость к неопределенности, тогда как размер организации сам по себе не является достаточным объяснительным параметром.

Дополнительно методология маркетингового аудита должна учитывать макро контекст: тип страны, культурные особенности и уровень экономического развития, поскольку эти факторы влияют как на выбор методов, так и на интерпретацию результатов. Существенное значение имеет анализ нематериальных активов – деловой репутации, клиентской лояльности и качества сервиса (Lusch & Harvey, 1994; Nekimian & Jones, 1967), а также устойчивости взаимоотношений с ключевыми контрагентами, включая поставщиков и покупателей (Brummet

et al., 1968). В литературе также подчеркивается, что регулярность аудита повышает качество управленческих решений и способствует успешной реализации стратегии, поскольку позволяет своевременно фиксировать изменения среды и корректировать маркетинговые действия (Hall, 1993; Taghian & Shaw, 2008).

Для малого бизнеса, ориентированного на укрепление позиций на рынке, первостепенное значение имеет диагностика собственной маркетинговой функции, при этом ключевая роль, как правило, принадлежит собственнику или руководителю. В условиях динамичной трансформации маркетинга и постоянного появления новых практик и каналов продвижения способность адаптироваться к изменениям становится не дополнительным преимуществом, а необходимым условием конкурентоспособности.

Методология

Центральный исследовательский вопрос в основе данного исследования звучит таким образом: какие современные подходы и методы маркетингового аудита наиболее эффективны для малых предприятий, функционирующих в условиях рыночной неопределенности, с учетом специфики Казахстана?

Гипотеза заключается в том, что интеграция количественных критериев принятия решений (критерий Лапласа, критерий максимакса или оптимизма, критерий Сэвиджа или минимакса (критерий потерь), критерий Вальда (Брюс & Брюс, 2018) (Андрианова & Хабибуллин, 2015) (Вентцель, 1972) с диагностическими инструментами для показателей маркетинговой эффективности обеспечивает более надежную и адаптируемую основу для малых предприятий, чем традиционные методы аудита в отдельности. Ожидается, что эта комбинированная методология повысит точность прогнозирования, снизит риски и улучшит стратегическое позиционирование предприятий на конкурентных рынках.

В рамках проведенного анализа ключевой акцент делается на том, что маркетинговый аудит выступает одним из наиболее результативных инструментов повышения эффективности малого бизнеса: он позволяет выявлять точки улучшения и корректировать маркетинговую деятельность при относительно низких издержках, обеспечивая заметный управленческий эффект. В этом контексте владельцы и руководители малых предприятий могут проводить аудит соб-

ственными силами, интерпретировать полученные данные и на их основе формировать решения, направленные на рост, усиление рыночных позиций и повышение итоговых показателей за счёт более рационального планирования и реализации маркетинговых мероприятий.

Поскольку малые предприятия функционируют в условиях ресурсных ограничений, особое значение приобретает уровень компетентности собственника или управляющего. Наличие базовых и прикладных знаний в маркетинге, а также навыков диагностики и оценки результативности маркетинговых действий становится необходимым условием для самостоятельного и методически корректного проведения маркетингового аудита.

Применение количественных критериев принятия решений на примере малого бизнеса в Казахстане. Рассмотрим условный пример малого торгового предприятия Казахстана, осуществляющего розничную реализацию потребительских товаров. Из-за неопределенности спрос может быть слабым, и товар может остаться на складе, что ухудшит финансовые результаты. В то же время задержка увеличивает риск того, что конкуренты заберут деньги быстрее, что приведет к потере продаж и прибыли. Если несколько релевантных вариантов сходятся в одной позиции, это можно считать наиболее разумным; в случае расхождений следует полагаться на ожидаемое значение и/или дополнительную проверку. Прогнозирование прибыльности требует междисциплинарного набора компетенций: маркетинга, статистики, теории вероятностей, эконометрики и правовых основ.

Критерий Лапласа часто применяется при прогнозировании в условиях неопределенности, предполагая равновероятность состояний рынка. Собственники малых предприятий могут использовать его для оценки стратегических альтернатив, применяя предварительные знания рынка. Стоит отметить, что результаты остаются гипотетическими, поскольку стабильность рынка не может быть гарантирована в будущих условиях.

Критерий основан на принципе равновероятности состояний среды и предполагает выбор альтернативы по среднему ожидаемому результату при отсутствии достоверной информации о вероятностях. Соответствующее выражение представлено в формуле (1) – критерий Лапласа (Богоявленский, 2014)

$$L_i = \frac{\sum_{j=1}^M a_{ij}}{M} \quad (1)$$

где:

L_i – среднее ожидаемое значение результата по стратегии i ;

M – вероятность j -ого наступления

i – число стратегий;

a_{ij} – результат при i -ой стратегии при j состоянии рынка.

Критерий Максимакса, часто называемый критерием оптимизма, используется при прогнозировании сценариев, предполагающих исключительно благоприятные рыночные условия. Он направлен на поиск стратегии, приносящей максимально возможную прибыль, что отражает предпринимательский принцип, согласно которому больший риск может привести к большему вознаграждению. В рамках этой концепции предприниматели определяют приоритеты наиболее выгодного использования имеющихся ресурсов и управленческих факторов, исходя из того, что рыночная среда является оптимально благоприятной:

$$M_i = \max(x_{ij}), j = 1 \dots M \quad (2)$$

где:

M_i – максимальное значение результата по стратегии i ;

x_{ij} – результат стратегии i при состоянии рынка j .

В соответствии с критерием Максимакса предпочтение отдается тому варианту, который обеспечивает наибольший возможный финансовый результат. Однако данный подход характеризуется повышенным уровнем риска, поскольку при выборе не принимаются во внимание альтернативные сценарии развития событий. В связи с этим его применение требует взвешенного и осторожного подхода.

Критерий Вальда, часто называемый пессимистическим подходом, является методологической противоположностью принципа Максимакса. Он выбирает наиболее благоприятный исход из наименее благоприятных альтернатив, обеспечивая тем самым максимальную безопасность в неблагоприятных условиях. Например, при определении нескольких вариантов выхода на рынок – немедленного, краткосрочного или долгосрочного. Каждый из этих сценариев рассматривается с учетом изменений рынка (положительных, нейтральных, отрицательных). Для

каждой альтернативы определяются минимальные значения прибыли, и выбирается стратегия с наибольшим из этих минимумов. Такой подход обеспечивает надежную связь для малого бизнеса, особенно когда предприниматели предпочитают минимизировать риск и придерживаются консервативного подхода к принятию решений в условиях неопределенности.

$$W_i = \min(x_{ij}), j = 1 \dots M, \quad (3)$$

где:

W_i – максимальный гарантированный результат по стратегии i .

Пример применения критерий Вальда для малого бизнеса у которого есть два проекта X1, X2 и необходимо оставить самый лучший для реализации в бизнесе. С учетом условия рынка, где есть также развития три разных сценария и соответственно будет три разных итога по прибыли бизнеса. Имея данные малого бизнеса, предпринимателю необходимо выбрать тот проект, который максимально будет выгодным бизнесу по критерию Вальда (таблица 1).

Таблица 1

Выбор проекта по критерию Вальда

Проекты	Состояние рынка на определенный период: альтернативные варианты финансового результата		
	1	2	3
X1	35	15	40
X2	10	50	15

Примечание: составлена авторами на основе источника (Богоявленский, 2014)

Данные таблицы 1 показывают, что два проекта для предпринимателя выглядят одинаково привлекательно, поэтому выбор чтобы был аналитически правильно рассчитан, необходимо применить критерий Вальда, критерий с минимальным риском при получении максимальной прибыли от проекта. Первым шагом вычисляем минимальные для каждого проекта

$W1 = \min(x_{1j}), j = 1, 2, 3; W1 = \min(35, 15, 40) = 15;$

$W2 = \min(x_{2j}), j = 1, 2, 3; W2 = \min(10, 50, 15) = 10$

$W1 = 15$ и $W2 = 10$. Сравниваем их и получаем, $W1 > W2$, необходимо выбрать проект 1,

поскольку прибыль при самом плохом сценарии будет выше, данный критерий еще называют критерием гарантированного результата.

Следующий критерий для предпринимателей называется еще «матрица рисков» -критерий Сэвиджа, делается расчет упущенной прибыли и выбирается проект где риск недополучения прибыли минимален.

$$\Delta k_{ij} = \max_i k_{ij} - k_{ij} \quad (4)$$

$$K(a_i) = \max_j \Delta k_{ij} \quad (5)$$

$$K_{opt} = \min_i (\max_j \Delta k_{ij}) \quad (6)$$

где:

Δk_{ij} – величина упущенной прибыли;

$K(a_i)$ – максимальная упущенная выгода по стратегии i ;

K_{opt} – минимально из максимально упущенной выгоды.

Используя критерий Сэвиджа проанализируем с выбором проекта используя данные таблицы 1. С учетом знаний трех разных состояний рынка находим максимальное значение.

$y_1 = \max(x_{11}, x_{21}) = \max(35, 10) = 35;$

$y_2 = \max(x_{12}, x_{22}) = \max(15, 50) = 50;$

$y_3 = \max(x_{13}, x_{23}) = \max(40, 15) = 40.$

Находя отклонения от лучших результатов, вычисляем недополученную прибыль при всех сценариях.

Для проекта X1:

$35-35=0$

$50-15=35$

$40-40=0$

Для проекта X2:

$35-10=25$

$50-50=0$

$40-15=25$

Полученные данные представлены в таблице 2.

Таблица 2

Матрица упущенной прибыли

Проекты	Состояние рынка на определенный период			Максимальная упущенная прибыль
	1	2	3	
X1	0	35	0	35
X2	25	0	25	25

Примечание: составлена авторами на основе источника (Богоявленский, 2014)

Сравнивая результаты по данным таблицы 2, предприниматель выбирает тот проект, где потеря упущенной прибыли будет минимальной.

Максимально упущенная прибыль по проектам $X_1=35$, $X_2=25$, так как $X_1 > X_2$, значит бизнесу лучше проект 2, так как там меньше упущенной прибыли.

Применяя вышеописанный концептуальный подход малый бизнес минимизирует риски, улучшает финансовые показатели за счет сохранения ресурсов рассчитав с математической точностью возможные потери ресурсов при различных сценариях рынка. Данный подход маркетингового аудита является синтезом математических и маркетинговых инструментов по прогнозированию и анализу, является современным и адаптированным под реалии малого бизнеса.

Результаты и обсуждение

Малые предприятия функционируют в среде, характеризующейся усилением конкурентного давления, дефицитом ресурсов и значительной рыночной неопределенностью. Снижение негативного влияния указанных факторов во многом возможно при корректном применении инструментов маркетингового управления, в том числе маркетингового аудита как диагностической и профилактической процедуры. Поскольку малый бизнес, как правило, ограничен в возможностях проведения систематических маркетинговых исследований и не располагает специализированным маркетинговым подразделением, критически важным становится уровень маркетинговой компетентности собственника и/или руководителя. В этой связи возрастает потребность в универсальном и практико-ориентированном алгоритме самостоятельного проведения маркетингового аудита – наборе диагностических вопросов и шагов, позволяющих выявлять проблемные зоны и определять направления корректировок на перспективу. Маркетинговый аудит целесообразно рассматривать как регулярный элемент процесса маркетингового планирования, учитывающий специфические особенности малых фирм, определяющие их рыночное поведение и характер маркетинговой активности.

Для повышения практической применимости предложенного подхода была проведена аналитическая апробация модели на примере типовой ситуации малого торгового предпри-

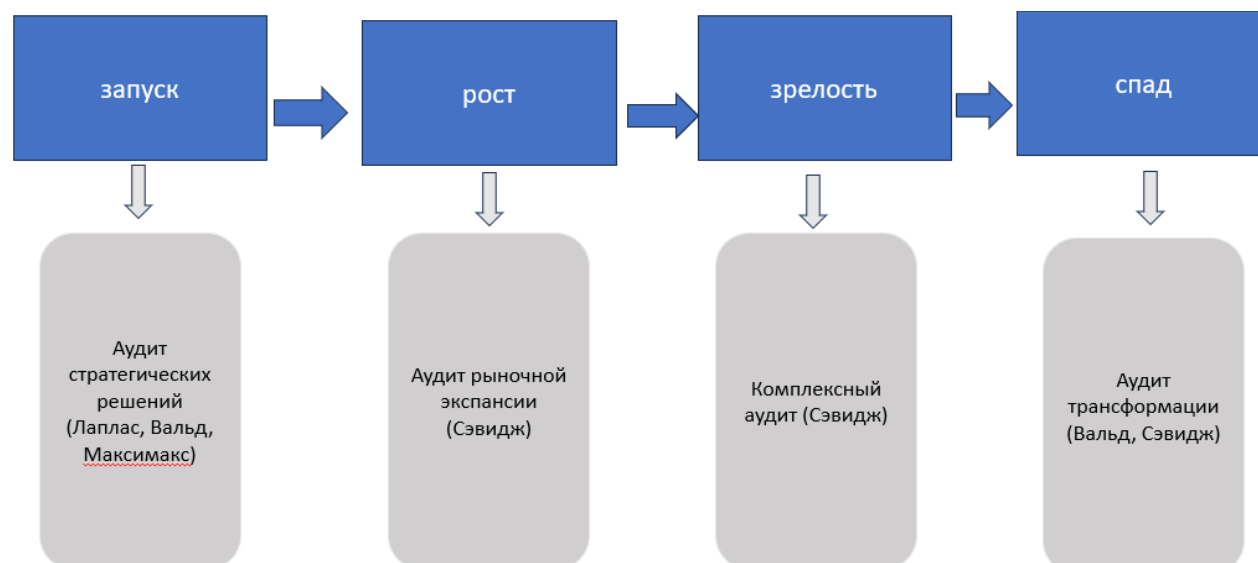
ятия Казахстана. Моделирование показало, что использование критериев принятия решений позволяет предпринимателям структурировать выбор стратегических альтернатив в условиях неопределенности спроса и ограниченности ресурсов. Полученные результаты демонстрируют возможность применения интегрированной модели маркетингового аудита в практической деятельности малых предприятий, особенно при планировании вывода новых продуктов, распределении маркетингового бюджета и оценке рисков рыночных изменений.

При этом проведение маркетингового аудита в малых организациях характеризуется рядом специфических факторов, которые систематизированы и представлены далее (рисунок 1). Представленная адаптивная модель маркетингового аудита основывается на предположении о том, что на различных стадиях жизненного цикла предприятия изменяются уровень рыночной неопределенности, степень ресурсных ограничений, интенсивность конкурентного давления и приоритеты управленческих решений.

На этапе запуска предприятия доминирующее значение приобретают критерии, ориентированные на поиск потенциальных возможностей роста и допустимого уровня риска, в частности критерии Лапласа и Максимакса. На стадии роста возрастает значение оценки рыночной устойчивости и эффективности маркетинговых решений. Для стадии зрелости характерна ориентация на поддержание стабильности рыночных позиций и минимизацию стратегических потерь. В условиях спада или снижения эффективности деятельности предприятия возрастает необходимость применения более консервативных подходов к принятию решений, включая критерии Вальда и Сэвиджа, позволяющие минимизировать возможные потери и корректировать стратегию развития.

Предложенная модель также учитывает такие факторы, как ограниченность маркетингового бюджета, уровень аналитической компетентности собственника бизнеса, нестабильность спроса, изменение конкурентной среды и необходимость оперативной адаптации маркетинговых решений.

Таким образом, маркетинговый аудит в рамках предложенной модели рассматривается не только как инструмент контроля, но и как механизм поддержки адаптивного управленческого решения в условиях нестабильной рыночной среды.

Рисунок 1*Адаптивная модель маркетингового аудита**Примечание: составлен авторами*

Несмотря на значительный объем публикаций по маркетинговому аудиту, в научной литературе сохраняются заметные методологические разрывы: многие работы описывают отдельные элементы аудита, однако не всегда предлагают целостный и корректно выстроенный подход к его проведению, особенно применительно к малым предприятиям.

Поскольку конечной целью предпринимательской деятельности выступает получение прибыли, первичный этап анализа опирается на базовые показатели, позволяющие определить текущую финансово-экономическую состоятельность компании. Далее исследовательский фокус смещается к установлению факторов и переменных, которые формируют наблюдаемый результат и объясняют его устойчивость или уязвимость. Проведенный маркетинговый аудит позволяет объективно зафиксировать реальную рыночную позицию предприятия, оценить достаточность и структуру ресурсов, а также определить направления их укрепления и более эффективного использования в последующем периоде.

Целью данного исследования было определение того, какие современные подходы и методы маркетингового аудита наиболее эффективны для малых предприятий, работающих в условиях нестабильной рыночной конъюнктуры, с учетом экономического и институциональ-

ного контекста Казахстана. Основная задача заключалась не только в обзоре существующих методов аудита, но и в оценке того, повышает ли интеграция количественных критериев принятия решений в систему маркетингового аудита ее стратегический и прогностический потенциал в контексте малого бизнеса.

Полученные результаты подтверждают гипотезу о том, что сочетание формальных критериев принятия решений, таких как подходы Лапласа, Максимакса, Вальда и Сэвиджа (минимальное сожаление), с диагностическими показателями эффективности маркетинга создает более надежную и адаптируемую методологическую основу, чем традиционные аудиторские процедуры, применяемые по отдельности. Когда маркетинговый аудит включает структурированные модели принятия решений в условиях неопределенности, он трансформируется из преимущественно оценочного инструмента в перспективный стратегический инструмент, способный направлять распределение ресурсов и управление рисками.

Срок запуска новых продуктов, демонстрирует практическую значимость этой методологической интеграции. В условиях, когда неопределенность спроса и динамика конкуренции приводят к множеству возможных результатов, различные критерии принятия решений дают четкие стратегические рекомендации в зависимости от склонности предпринимателя к риску.

Критерий Лапласа обеспечивает нейтральную оценку при неизвестных вероятностях на основе средних ожидаемых результатов. Критерий Максимума отражает агрессивную, ориентированную на рост позицию при выборе альтернативы с наибольшей потенциальной доходностью, хотя это подвергает компанию большему риску сокращения. Напротив, критерий Вальда ставит во главу угла безопасность, максимизируя минимально возможную доходность и предлагая консервативную стратегию, подходящую для собственников бизнеса, принимающих решения с осторожностью. Критерий Сэвиджа, основанный на минимизации потенциальных последствий, особенно эффективен при оценке корректировок портфеля или конкурентного позиционирования на рынках с динамичной реакцией конкурентов. Эти результаты показывают, что маркетинговые аудиты, помимо своей традиционной диагностической функции, могут служить интегрированной системой поддержки принятия решений. Вместо простого выявления слабых сторон маркетинговой деятельности, маркетинговый аудит становится механизмом оценки стратегических альтернатив с использованием различных сценариев рынка и возможностей бизнеса.

В исследовании также подчеркивается, что на разных этапах развития компании могут потребоваться различные доминирующие критерии. Предприятия на ранних стадиях развития, сталкивающиеся с высокой степенью неопределенности, могут воспользоваться подходами Лапласа или Максимума при изучении возможностей роста, в то время как зрелые компании, стремящиеся к стабильности, могут больше полагаться на логику Сэвиджа для защиты накопленной стоимости. Поэтому интеграцию критериев принятия решений в маркетинговый аудит следует рассматривать не как статичную, а как динамичную структуру, которая адаптируется к этапу жизненного цикла и изменчивости окружающей среды.

В целом, исследование показывает, что предложенная комбинированная методология повышает точность прогнозирования и стратегическую согласованность маркетинговых аудитов в малом бизнесе. Внедрение формальных инструментов оценки рисков в маркетинговую диагностику позволяет малым предприятиям лучше прогнозировать потенциальные убытки, оптимизировать сроки инвестирования и улучшить свои конкурентные позиции. Такой подход способствует устойчивому развитию, позволяя более эффективно распределять ограниченные

ресурсы и снижая риск предотвратимых стратегических ошибок.

Заключение

На основе проведенного исследования теоретический обзор был сведен в единое методологическое предложение: маркетинговый аудит для малого и среднего бизнеса может быть усовершенствован путем дополнения диагностической оценки четкими критериями принятия решения. Соответственно, исследование объединило концептуальный анализ литературы по маркетинговому аудиту с формальной интеграцией правил Лапласа, Максимума, Вальда и Сэвиджа в логику аудита. Анализ был сосредоточен на совместном использовании этих критериев и показателей эффективности маркетинга для принятия управленческих решений в условиях ограниченных ресурсов и нестабильности рынка. Предложенная структура была проиллюстрирована с помощью аналитического моделирования стратегических альтернатив, в частности, в отношении сроков запуска продукта и оценки сценариев в условиях неопределенного спроса.

Результаты подтверждают обоснованность первоначальной гипотезы. Интеграция формальных критериев принятия решений с инструментами маркетинговой диагностики создает более стабильную и адаптируемую методологическую основу, чем использование только традиционных процедур маркетингового аудита. Когда маркетинговый аудит выходит за рамки своей традиционной оценочной функции и интегрируется в структурированные модели принятия решений, он превращается в комплексный стратегический инструмент. Вместо того чтобы служить исключительно механизмом выявления слабых мест в маркетинговой деятельности, он становится интегрированной системой, способной оценивать альтернативные варианты в различных рыночных сценариях.

Результаты показывают, что малые предприятия работают в среде, характеризующейся повышенным конкурентным давлением, ограниченными финансовыми и аналитическими ресурсами и повышенной подверженностью колебаниям спроса. В таких условиях опора на интуитивные или чисто описательные методы аудита повышает стратегическую уязвимость. Включение количественных критериев позволяет предпринимателям формализовать альтернативные стратегии и оценивать их, используя

последовательные аналитические принципы, отражающие различные степени толерантности к риску. Критерий Лапласа предлагает нейтральный подход, когда вероятности неизвестны; критерий Максимакса поддерживает агрессивные стратегии роста; критерий Вальда обеспечивает безопасность при пессимистических предположениях; а критерий Сэвиджа минимизирует потенциальные сожаления в конкурентной среде. Каждый критерий представляет собой отдельную стратегическую точку зрения, а их совместное применение повышает надежность принятия решений.

Важно отметить, что исследование показывает, что актуальность конкретных критериев принятия решений зависит от стадии развития предприятия. Компании на ранней стадии развития, испытывающие высокую степень неопределенности, могут извлечь выгоду из более ориентированных на исследования или возможности подходов, в то время как зрелые предприятия, отдающие приоритет стабильности, могут придерживаться более консервативной логики, направленной на снижение рисков. Таким образом, интеграция критериев принятия решений в маркетинговый аудит должна пониматься как динамичная и адаптивная структура, соответствующая жизненному циклу компании и изменчивости внешней среды.

Еще один важный вывод касается управленческой компетентности. Учитывая, что малые предприятия часто не имеют специализированных маркетинговых отделов, эффективность маркетингового аудита во многом зависит от аналитических способностей владельца или менеджера. Исследование подчеркивает необходимость структурированных, ориентированных на практику алгоритмов аудита, которые могут быть реализованы самостоятельно. Такие инструменты повышают способность предпринимателя диагностировать рыночные условия, оценивать распределение ресурсов и определять корректирующие действия без чрезмерных затрат на внешние консультации. В этом отношении маркетинговый аудит становится не только диагностической процедурой, но и образовательным механизмом, укрепляющим стратегическое мышление менеджеров.

Данное исследование также вносит вклад в существующий объем знаний, устраняя выявленные пробелы в литературе. Хотя предыдущие исследования часто описывают компоненты маркетингового аудита, они не всегда предоставляют интегрированную структуру,

адаптированную к специфическим условиям малых предприятий в странах, переживающих институциональные и рыночные трансформации. Синтезируя маркетинговую диагностику с формальным моделированием неопределенности, настоящее исследование предлагает более всестороннюю интерпретацию маркетингового аудита как архитектуры поддержки принятия решений, а не просто инструмента контроля.

С практической точки зрения, предложенная модель открывает четкие возможности для внедрения. Малые предприятия могут включать количественные матрицы в периодические маркетинговые аудиты для оценки стратегических инициатив, запуска новых продуктов и сроков выхода на рынок. Такой структурированный подход повышает точность прогнозирования, способствует рациональному распределению ресурсов и снижает риск предотвратимых стратегических потерь. Кроме того, результаты исследования подчеркивают важность институциональных механизмов поддержки, направленных на повышение маркетинговой грамотности владельцев малых предприятий, особенно в странах с развивающейся экономикой.

С точки зрения будущих исследований, рекомендуется провести эмпирическую проверку предложенной интегрированной модели на более широкой выборке предприятий. Количественная оценка результатов деятельности предприятия, таких как повышение прибыльности, снижение рисков и стабильная доля рынка, позволит глубже оценить его долгосрочную эффективность. Сравнительные исследования в различных национальных контекстах также могут прояснить, как институциональная среда влияет на применимость интегрированных систем маркетингового аудита.

В заключение, данное исследование демонстрирует, что включение формальных критериев принятия решений в маркетинговый аудит значительно повышает его аналитическую глубину, стратегическую согласованность и практическую ценность для малых предприятий, работающих в условиях неопределенности. Интеграция математической логики принятия решений с маркетинговой диагностикой является значительным расширением существующей теории и обеспечивает структурированный способ повышения устойчивости и конкурентоспособности малых предприятий на нестабильном рынке.

Ограничением данного исследования является преимущественно концептуальный характер

предложенной модели и отсутствие масштабной эмпирической апробации на выборке предприятий различных отраслей экономики. В исследовании использовалось аналитическое моделирование и теоретическая интеграция критериев принятия решений в систему маркетингового аудита, что требует дальнейшей количественной проверки в реальных условиях функционирования предприятий.

В дальнейшем представляется целесообразным проведение прикладных исследований с использованием эмпирических данных малых предприятий Казахстана для оценки влияния интегрированного подхода на показатели прибыльности, устойчивости бизнеса, эффективности маркетинговых решений и уровня стратегических рисков.

Перспективным направлением дальнейших исследований также является адаптация предложенной модели для различных отраслей эко-

номики с учетом специфики цифрового маркетинга, электронной коммерции и изменения потребительского поведения в условиях высокой рыночной неопределенности.

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Авторы заявляют, что с данным исследованием отсутствуют конфликты интересов.

Вклад авторов

ТАО: разработка концепции исследования, методологии, разработка плана исследования, анализ данных и написание основного текста рукописи.

ДЖМ: рецензирование рукописи и окончательное утверждение версии для публикации.

СМР: обзор литературы и интерпретация результатов.

ТСК: вклад в теоретическую основу и обоснование логики исследования.

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ҚазҰУ Хабаршысы. Экономика сериясында материалдарды жариялау Open Journal System, онлайн жіберу және рецензиялау жүйесі арқылы жүзеге асырылады.

Корреспонденция авторы журналға жариялау үшін ілеспе хат ұсынуға міндетті.

Авторларға қойылатын талаптар: Редакциялық коллегия журналдың ғылыми бағыттары бойынша бұрын жарияланбаған мақалаларды қабылдайды. Мақала журналдың функционал сайтына жүктеу арқылы ғана (Open Journal System) электронды форматта (doc, .docx, .rtf форматында) қабылданады. Шрифт кеглі – 12 (андатпа, түйін сөздер, әдебиеттер тізімі – 10, кесте мәтіні – 9-11), шрифт – Times New Roman, мәтін беттің ені бойынша тегістеу арқылы теріледі, аралығы – бір, абзац бойынша шегініс – 0,8 см, шеттері: үстіңгі және астыңғы – 2 см, сол және оң жақ – 2 см. Сурет, кесте, графика, диаграмма және т.б. мәтін ішінде нөмір және атаумен белгіленеді (мысалы, 1-сурет – Сурет атауы) және және ескерту түрінде дереккөз көрсетіледі (мысалы, Ескерту – ... дереккөзі негізінде автормен құрастырылған). Суреттердің, таблица, графика мен диаграммалардың саны мақала көлемінің 20% -нан (кейбір жағдайда 30%) артық болмауы керек. Мақала көлемі (атауы, авторлар бойынша ақпарат, андатпа, түйін сөздер, әдебиеттер тізімін қоспағанда) әлеуметтік және гуманитарлық бағытта 3 000 сөзден кем емес, 7 000 сөзден артық емес болуы шарт.

Мақаланы жариялау үшін ақы төлеу тәртібі мен құнын «Қазақ университеті» баспасы белгілейді және оны рецензенттер мен ғылыми редактор мақұлдағаннан кейін автор жасайды.

Мақала құрылымы: Бірінші бет: Бірінші жол – FTAXP нөмірі, мәтін беттің сол жақ шетімен тегістеледі, қаралау шрифт. Мақала автор(лар)ы – аты-жөнінің бірінші әріптері және тегі, жұмыс істейтін орны (аффилиация), қала, мемлекет, e-mail, ORCID ID – орыс, қазақ және ағылшын тілдерінде жазылады. Авторлар туралы ақпарат қалыпты шрифтті кіші әріптермен жазылып, беттің ортасында тегістеледі.

Мақала атауы (Тақырып) мақаланың мәні мен мазмұнын көрсетіп, оқырманның назарын аудару керек. Тақырып қысқа әрі ақпараттық, жаргондар мен аббревиатурасыз жазылуы тиіс. Тақырыптың орташа ұзындығы 5-7 сөз (кей жағдайда 10-12 сөз). Мақаланың тақырыбы орыс, қазақ және ағылшын тілдерінде берілуі керек. Тақырып қаралау шрифтті кіші әріптермен, беттің ортасымен тегістеледі. Андатпа көлемі – 150 сөзден кем емес, 300 сөзден артық емес орыс, қазақ, ағылшын тілдерінде жазылады.

Андатпа құрылымында келесі ақпарат міндетті түрде болуы керек: Зерттеу тақырыбы бойынша кіріспе сөз; Ғылыми зерттеудің мақсаты, негізгі бағыттары мен идеялары; Жұмыстың ғылыми және практикалық маңыздылығы бойынша қысқа ақпарат; Зерттеу әдістемесі бойынша қысқа ақпарат; Ғылыми зерттеудің негізгі нәтижелері, талдау және тұжырымдама; Жүргізілген зерттеу жұмысының маңыздылығы (аталған жұмыстың ғылымның сәйкес саласына енгізген үлесі); Жұмыс қорытындысының практикалық маңыздылығы.

Түйін сөздер/сөз тіркестері – орыс, қазақ, ағылшын тілдерінде 3-5 сөз аралығында.

Кіріспе келесіде берілген негізгі элементтерден тұрады: Таңдалған тақырыптың негіздемесі; тақырып өзектілігі мен зерттеу проблемалары. Таңдалған тақырыптың негіздемесінде алдыңғы зерттеушілердің тәжірибелері негізінде проблемалық жағдайдың (зерттеу жұмыстарының жоқтығы, жаңа зерттеу нысанының пайда болғаны және т.б.) бар екендігі айтылады. Тақырыптың өзектілігі аталған зерттеу нысанының қойылған сұрақтарға толық жауаптардың болмаған жағдайда, тақырыптың теориялық және практикалық маңыздылығы арқылы дәлелденіп жалпыға ортақ мүдде арқылы анықталады. Жұмыстың нысанын, пәнін, мақсаттарын, міндеттерін, тәсілдерін, әдістер, гипотезасын анықтау. Зерттеудің мақсаты тезисті дәлелдеумен, яғни зерттеу тақырыбын автор таңдаған аспектімен көрсетумен байланысты.

Әдебиеттерге шолу бөлімінде – зерттеу тақырыбы бойынша ағылшын тілінде шетелдік авторлардың іргелі және жаңа еңбектер (кемінде 15 жұмыс), оларды ғылыми үлесі тұрғысынан талдау, сондай-ақ сіздің мақалаңызда толықтырылған зерттеу кемшіліктері беріледі.

Әдістеме – материалдар мен жұмыс барысының сипаттамасынан, сондай-ақ қолданылатын әдістердің толық сипаттамасынан тұруы керек.

Нәтижелер мен Талқылау бөлімінде сіздің зерттеу нәтижелеріңізді талдауы және талқылауы беріледі. Зерттеу барысында алынған нәтижелер туралы қорытынды беру арқылы негізгі мәні айқындалады. Бұл мақаланың маңызды бөлімдерінің бірі болып саналады. Онда жұмысыңыздың нәтижелерінің талдауы және алдыңғы жұмыстармен, талдаулармен және тұжырымдамаларымен салыстыру арқылы сәйкес нәтижелерді талқылау беріледі.

Қорытынды – жұмыстың осы кезеңдегі нәтижелерін жалпылау және қорытындылау; автор алға қойған тұжырымның растығын және алынған нәтижелерді ескере отырып, ғылыми білімнің өзгеруі туралы автордың қорытындысын растау. Қорытынды абстрактілі болмауы керек, оларды ұсыныстарды немесе одан әрі жасалатын жұмысты сипаттай отырып белгілі бір ғылыми саладағы зерттеу нәтижелерін жалпылау үшін қолдану керек.

Пайдаланылған әдебиеттер тізімі немесе библиографиялық тізім жаратылыстану және техникалық бағыттарға кем дегенде 15 атаулардан тұрады, ал ағылшын тіліндегі жалпы атаулар саны 50%-дан кем болмауы керек. Егер сілтемелер тізімінде кириллицада берілген еңбектер болса, сілтемелер тізімін екі нұсқада ұсыну қажет: біріншісі – түпнұсқада, екіншісі – романизацияланған алфавитте (транслитерация – translit-online.ru).

Әлеуметтік және гуманитарлы бағыттағы мәтіндерде дәйексөз келтірілген сілтемелер жұмыстың бірінші авторы, шыққан жылы: бет нөмір(лер)і жақша ішінде көрсетіліп беріледі. Мысалы, (Залеский, 1991). Әдебиеттер тізімінде бір автордың бір жылда жарық көрген бірнеше жұмысы келтірілген жағдайда, шыққан жылдың тұсына «а», «б» және т.б. әріптерді қосып жазу керек. Мысалы, (Садуова, 2001а: 15), (Садуова, 2001б, 22)

ИНФОРМАЦИЯ ДЛЯ АВТОРОВ

Авторами могут быть:

- докторанты, совместно с руководителем;
- лица, имеющие ученую степень;
- лица, занимающиеся научно-педагогической деятельностью.

Статьи в соавторстве с магистрантами к публикации не допускаются.

Публикация материалов в журнал осуществляется с использованием Open Journal System, системы онлайн-подачи и рецензирования. Регистрация и авторизация доступны в разделе «Отправка материалов».

Автор для корреспонденции обязан предоставить сопроводительное письмо на публикацию в журнале.

Требование для авторов: Редакционная коллегия принимает ранее неопубликованные статьи по научным направлениям журнала. Статья представляется в электронном формате (в форматах .doc, .docx, .rtf) посредством ее загрузки через функционал сайта журнала (Open Journal System); Кегль шрифта – 12 (аннотация, ключевые слова, литература – 10, текст таблиц – 10), шрифт – Times New Roman, выравнивание – по ширине текста, интервал – одинарный, абзацный отступ – 0,8 см, поля: верхнее и нижнее – 2 см, левое и правое – 2 см; Рисунки, таблицы, графики, диаграммы и др. представляются непосредственно в тексте с указанием нумерации, заглавия (Например, Рисунок 1 – Название рисунка) и источника в виде примечания (Например, Примечание – составлено автором на основе источника ...). Количество рисунков, таблиц, графиков и диаграмм не должно превышать 20% от всего объема статьи (в некоторых случаях до 30%); Объем статьи (без учета названия, сведений об авторах, аннотации, ключевых слов, библиографического списка) должен составлять не менее 3 000 слов и не превышать 7 000 слов.

Порядок оплаты и стоимость за публикацию статьи устанавливается издательским домом «Қазақ университеті» и производится автором после одобрения рецензентами и научным редактором.

Структура статьи Первая страница: Первая строка – номер МРНТИ, выравнивание – по левому краю, шрифт – полужирный; Автор(ы) статьи – Инициалы и фамилия, ученая степень, звание, место работы (аффилиация), город, страна, e-mail, ORCID ID – на русском, казахском и английском языках. Сведения об авторах представляются обычным шрифтом строчными буквами, выравнивание – по центру;

Название статьи (Заголовок) должно отражать суть и содержание статьи и привлекать внимание читателя. Название должно быть кратким, информативным и не содержать жаргонизмов или аббревиатур. Оптимальная длина заголовка – 5–7 слов (в некоторых случаях 10–12 слов). Название статьи должно быть представлено на русском, казахском и английском языках. Название статьи представляется полужирным шрифтом строчными буквами, выравнивание – по центру.

Аннотация объемом не менее 150 и не более 300 слов на русском, казахском и английском языках. Структура аннотации включает в себя следующие обязательные пункты: Вступительное слово о теме исследования; Цель, основные направления и идеи научного исследования; Краткое описание научной и практической значимости работы; Краткое описание методологии исследования; Основные результаты и анализ, выводы исследовательской работы.

Ключевые слова/словосочетания – количеством 3–5 на русском, казахском и английском языках;

Введение состоит из следующих основных элементов: Обоснование выбора темы; актуальность темы или проблемы. В обосновании выбора темы на основе описания опыта предшественников сообщается о наличии проблемной ситуации (отсутствие каких-либо исследований, появление нового объекта и т.д.).

Актуальность темы определяется общим интересом к изученности данного объекта, но отсутствием исчерпывающих ответов на имеющиеся вопросы, она доказывается теоретической или практической значимостью темы.

Определение объекта, целей, задач, методов, подходов, гипотезы и значения вашей работы. Цель исследования связана с доказательством тезиса, то есть представлением предмета исследования в избранном автором аспекте.

В секции обзор литературы – должны быть охвачены фундаментальные и новые труды по исследуемой тематике зарубежных авторов на английском языке, анализ данных трудов с точки зрения их научного вклада, а также пробелы в исследовании, которые Вы дополняете в своей статье.

Методология – должны состоять из описания материалов и хода работы, а также полного описания использованных методов.

В разделе Результаты и Обсуждение – приводится анализ и обсуждение полученных вами результатов исследования. Приводятся выводы по полученным в ходе исследования результатам, раскрывается основная суть. И это один из самых важных разделов статьи. В нем необходимо провести анализ результатов своей работы и обсуждение соответствующих результатов в сравнении с предыдущими работами, анализами и выводами.

Заключение – обобщение и подведение итогов работы на данном этапе; подтверждение истинности выдвигаемого утверждения, высказанного автором, и заключение автора об изменении научного знания с учетом полученных результатов. Выводы не должны быть абстрактными, они должны быть использованы для обобщения результатов исследования в той или иной научной области, с описанием предложений или возможностей дальнейшей работы.

Список используемой литературы, или Библиографический список состоит из не менее 15 наименований, и из общего числа наименований на английском языке должно быть не менее 50%. В случае наличия в списке литературы работ, представленных на кириллице, необходимо представить список литературы в двух вариантах: первый – в оригинале, второй – романизированным алфавитом (транслитерация – translit-online.ru).

Ссылки на цитируемые работы в тексте даются в скобках, с указанием первого автора работы, год издания: номер страниц(-ы). Например, (Залесский, 1991).

INFORMATION FOR AUTHORS

The authors can be:

- doctoral students, together with the supervisor;
- persons with an academic degree;
- persons engaged in scientific and pedagogical activities.

Articles co-authored with undergraduates are not allowed for publication.

Submissions to the journal are made using Open Journal System, the online submission and peer review system. Registration and access is available at Submissions. The author for correspondence is obliged to provide a cover letter for publication in the journal.

The requirement for authors: The editorial board accepts previously unpublished articles on the scientific directions of the journal. The article is submitted in electronic format (in the formats .doc, .docx, .rtf) ONLY by downloading it through the functionality of the journal's website (Open Journal System); Font size – 12 (abstract, key words, literature – 10, text of tables – 9-11), font – Times New Roman, alignment – width of text, interval – single, indented margin – 0,8 cm, margins: upper and the bottom – 2 cm, left and right – 2 cm. Figures, tables, graphs, diagrams, etc. are presented directly in the text indicating the numbering, title (For example, Fig. 1 – Name of the figure) and the source as a note (For example, Note – compiled by the author based on the source ...). The number of figures, tables, graphs and diagrams should not exceed 20% of the total volume of the article (in some cases up to 30%); The volume of the article (excluding the title, information about authors, abstract, keywords, references) must be at least 3,000 words and not exceed 7,000 words;

Authors in a mandatory order should indicate in a covering letter in the Open Journal System or the Editorial Manager that the article / manuscript has never been published anywhere, and that the article does not contain borrowed text fragments from other works without reference to them.

Structure of the article: First page: First line – IRSTI number (international rubricator of scientific and technical information), alignment – left, font – bold. Author(s) of the article – Initials and surname, place of work (affiliation), city, country, e-mail, ORCID ID. Information about authors is represented in ordinary type in lowercase letters, alignment in the center. The title of the article should reflect the essence and content of the article and attract the reader's attention. The title should be short, informative and not contain jargons or abbreviations. The optimal length of the title is 5-7 words (in some cases 10-12 words). The title of the article is shown in bold in lowercase letters, alignment – in the center. Abstract – at least 150-300 words.

The structure of the annotation includes the following obligatory items: Opening remarks about the research topic, purpose, main directions and ideas of scientific research, brief description of the scientific and practical significance of the work, brief description of the research methodology, main results and analysis, conclusions of research work, the value of the research carried out (contribution of this work to the relevant field of knowledge).

Keywords – 3-5 words.

Introduction consists of the following main elements: Justification of the choice of topic; relevance of the topic or problem. In substantiation of the choice of topic based on the description of the experience of predecessors, the presence of a problem situation (the absence of any research, the emergence of a new object, etc.) is reported.

The relevance of the topic is determined by the general interest in the knowledge of this object, but the lack of comprehensive answers to the questions, it is proved by the theoretical or practical significance of the topic.

In the literature review section, fundamental and new works on the subject matter of foreign authors in English should be covered (at least 15 works), analysis of the given works in terms of their scientific contribution, as well as research gaps that you supplement in your article.

Methodology should consist of a description of the materials and the progress of the work, as well as a complete description of the methods used.

In the Results and Discussion section an analysis and discussion of the research results you received is provided. The conclusions on the results obtained during the study are given, the main essence is revealed. And this is one of the most important sections of the article. It is necessary to analyze the results of their work and discuss the relevant results in comparison with previous works, analyzes and conclusions.

Conclusion – synthesis and summarizing the work at this stage; confirmation of the truth of the statement put forward by the author, and the author's conclusion on the change of scientific knowledge, taking into account the results obtained. Conclusions should not be abstract, they should be used to summarize the results of research in a particular scientific field, with a description of the proposals or opportunities for further work.

References consists of at least 15 titles, and from the total number of titles in English must be at least 50%. style of the list of references – American Psychological Association (<http://www.apastyle.org/>). The list of references is presented in alphabetical order, and ONLY those works that are cited in the text. References to cited works in the text are given in brackets, indicating the first author of the work, year of publication: the number of pages. For example, (Zalessky, 1991).

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