

The Impact of Special Economic Zones on the Social and Economic Development of Regions of Kazakhstan

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Abstract

There are fourteen special economic zones (SEZ) in Kazakhstan designed to drive industrial modernization, enhance economic competitiveness, and reduce regional disparities. However, the current regional programs lack indicators that enable an objective evaluation of their impact. This study aims to measure the effect of SEZs on regional socio-economic development using multivariate correlation and regression analysis based on official statistics for 2005–2023, to identify the spatial heterogeneity of these effects, and to evaluate the effectiveness of public expenditures.

The results indicate that investments in SEZs show a statistically significant positive association with gross regional product (GRP) growth only in the Atyrau Region and the city of Astana, furthermore, no such relationship is observed in other regions. These findings suggest the need to revise

SEZ governance and evaluation approaches, given the substantial public expenditures required over their 25-year operating period. The contribution of the study is to refine the quantitative assessments of the effectiveness of SEZs compared to previous descriptive studies. Practical recommendations include introducing a standardized indicator framework for SEZ assessment within regional programs, prioritizing innovative and export-oriented projects, and adjusting spatial development policies.

Keywords: economic zone, region, social and economic development, correlation-regression method, investments, gross regional product.

JEL: R11, R12, R58

Introduction

Economic zones play a key role in stimulating growth, attracting foreign investment, developing exports, and creating jobs (Łukaniszyn-Domaszewska et al. 2023). They are significant for developing countries, where economic zones serve as a crucial tool of economic policy and a catalyst for

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industrial development and technological innovation (Zaldívar & Molina 2018). This study aims to measure the effect of Special Economic Zones (SEZs) on regional socioeconomic development in Kazakhstan, identify the spatial heterogeneity of these effects. The concept of zonal formations was first introduced in Kazakhstan during the 1990s, with the establishment of nine SEZs to foster socio-economic growth and accelerate the transition of the national economy from a directive system to a market-oriented one.

Nevertheless, all of the initiatives mentioned above proved to be ineffective, except for the SEZ Lisakovsk, which yielded a return of 2.93 tenge per 1 tenge invested. Following this, the SEZ Lisakovsk was abolished after a relatively short period (Nevmatulina, 2014). The history of the formation of special economic zones (SEZs) in Kazakhstan dates back to the adoption of the law "On Free Economic Zones in the Kazakh SSR", which provided the first legal basis for the formation of special economic regimes. Based on this law, nine SEZs were created in the 1990s, including zones in Zhaimem-Atasu in the Zhezkazgan Region, Alakol and Zharkent in the Taldykorgan Region, as well as a sub-zone based on the Taldykorganvneshttrans enterprise in the city of Taldykorgan. In addition, the Atakent free trade zone operated in Almaty. However, the experience of their operation was limited: most zones existed for about two years and did not achieve their goals. The exception was the Lisakovsk SEZ, which ensured a return of 2.93 tenge per 1 tenge invested, but it was also abolished after a relatively short period of time (Nevmatulina, 2014). The ineffectiveness of the first initiatives was due to insufficient development of organizational and institutional mechanisms, the lack of clear industry specialization, as well as a

weak investment climate during the transition period.

Given these shortcomings, the state revised its approach to the creation and development of SEZs. Since 2001, a new stage of policy has begun, providing for the formation of more sustainable and targeted zones. The main focus was on identifying priority industries, creating favorable conditions for investors and ensuring developed infrastructure. Modern SEZs in Kazakhstan provide a wider range of benefits compared to the first projects. Key benefits include zero rates on corporate income tax, land and property taxes, exemption from customs duties, as well as access to ready-made engineering and transport infrastructure (heat and electricity networks, water supply, sewerage, road and railway sections). Such measures have increased the attractiveness of the zones and made them a tool for stimulating investment inflows and the development of individual sectors of the economy. At the same time, the mere existence of a certain number of SEZs does not guarantee success, as their effectiveness in some cases is reduced due to poor location, weak policy frameworks, bureaucratic barriers, and inefficient management (Cheng, 2019).

A comparison of special economic zones (SEZs) with other instruments of regional policy and the overall business climate of Kazakhstan allows us to identify their unique institutional and economic advantages. Unlike national incentive measures, such as tax breaks for individual industries, subsidized loans, or the implementation of large-scale infrastructure programs, SEZs are a comprehensive mechanism combining tax and customs preferences, simplified administrative procedures, and the availability

of ready-made infrastructure (Aggarwal, 2007; Akinci & Farole, 2011).

The international literature on SEZs covers the institutional, investment, legal, and export-related aspects of their operation (Narula & Zhan, 2019; Farole, 2025; Wu, Liu & Huang, 2021). However, most studies are predominantly descriptive or comparative in nature (Ambroziak & Hartwell, 2017; Durongkaveroj, 2023), and rigorous quantitative assessments remain scarce. A significant gap exists in the study of the regional socioeconomic effects of SEZs, including their impact on gross regional product (GRP), employment patterns, and fiscal efficiency (Goldman & Zhelyazkova, 2023). Cross-country analyses often average out results, masking spatial heterogeneity, while the assessment of institutional and fiscal drivers of zone effectiveness remains limited.

Modern research underscores the necessity of shifting from descriptive approaches to integrated quantitative models capable of measuring the socioeconomic effectiveness of SEZs at the regional level. For Kazakhstan, where SEZs are a key instrument for economic diversification and spatial development, an analysis of their actual contribution to GRP growth, employment, investment activity, and fiscal efficiency is particularly relevant.

In addition, the budgetary costs of SEZ operations and the absence of robust indicator systems in regional programs are rarely addressed. Consequently, the purpose of this study is to quantify the impact of SEZs in Kazakhstan on the socio-economic development of regions, identify the spatial heterogeneity of their effect, and assess the effectiveness of budget expenditures.

The scientific novelty of this study is the application of multivariate correlation and

regression analysis to official statistics for 2005–2023, which moves the discussion beyond descriptive accounts to rigorous empirical testing. The findings indicate that the impact of SEZs in Kazakhstan is localized rather than systemic, concentrating primarily in major urban centers and not exerting a significant influence on the development of the regions in which they are located. Moreover, the multi-sectoral orientation of SEZs is observed, which, according to Zeng's research, is characteristic mainly of developing countries (Zeng, 2021). In contrast, in developed countries, economic zones are highly specialized and make use of innovative technologies (Zeng, 2021). Furthermore, the study reveals significant fiscal costs and the absence of a comprehensive framework of performance indicators in government programs, underscoring the need to revise spatial development policy and implement a system for monitoring performance.

Thus, the contemporary scholarly discourse on SEZs converges on three key themes: legal (the balance between sovereignty and international obligations), institutional (the quality of governance and infrastructure), and empirical (the quantitative assessment of effectiveness). These approaches form the foundation for future research aimed at developing comprehensive models that allow for the evaluation of not only the functions but also the real-world effectiveness of SEZs in the context of sustainable regional development.

1. Literature review

In their research, Arskaya E.V., Kravchenko L.N., and Usatova L.V. (2018) identify the following key stages in the development of free economic zones. In 166 BC, the Greek island of Delos became the first free trade

area, offering exemptions from taxes and duties. In 1547, the Italian city of Livorno was designated as a free-trade port, where merchants were exempt from paying taxes on their trading activities. This was followed by the designation of zones, including the waterfront ports of Genoa, Venice, and Marseille. In these port cities, customs duties were not levied on goods moving from these ports to foreign countries.

Additionally, the concept of “free ports” emerged, encompassing Hamburg, Lübeck, Danzig, Genoa, Marseille, and the Russian ports of Odessa, Vladivostok, and Batumi. This system permitted duty-free trade in foreign goods. In the late 19th and early 20th centuries, the “free port” concept was characterized by a combination of tax concessions and state regulation of its operations. Marjanac D. and Alfirević A. (2021) argue that economic zones were initially created as free trade zones to encourage trade (Gibraltar, 1704; Singapore, 1819; Hong Kong, 1848; Hamburg, 1888; Copenhagen, 1981), with the primary purpose of the import and export of goods.

The concept of establishing economic zones can also be traced back to medieval trading city-states such as Genoa and Venice, which offered traders a favorable business environment. The idea of modern economic zones (EZs) originated in the 1950s with the establishment of one of the first free-trade areas by the Irish government in Shannon (Jarosiński & Maśloch 2016). This was followed by the establishment of export-processing zones, which were granted a preferential legal and financial regime in 1959 (the airport in Shannon, Ireland).

Nevertheless, the idea of economic zones gained momentum in the 1970s, especially after China’s special economic zones (SEZs), such as Shenzhen, proved to be successful

(Huang 2023; Wang 2013; Zhu 1994). These zones showed how favorable terms can draw significant investment and foster growth in the export and industrial sectors.

By the end of the 20th century, free economic zones had become a prominent feature of the global economic landscape, with their presence spreading to Europe, the CIS, Hungary, Yugoslavia, Romania, Bulgaria, Poland, Vietnam, and China. The active participation of countries in international economic relations gave rise to the emergence and widespread proliferation of economic zones, which facilitated the integration of national economies into the global system (Arskaya et al. 2018). In the subsequent period, EZs have become a widespread phenomenon across geographically diverse regions of the globe, including Latin America and Africa. As of today, more than 5,000 EZs operate worldwide (Zeng 2021; Jarosiński & Maśloch 2016; Wong & Chu 1984).

Zeng (2021) argues that there has been a significant evolution of economic zones: while at the initial stage they functioned primarily as “enclaves,” today their development reflects the concept of “Economic Zone 5.0.” The first modern-format economic zone of this kind was the Shannon Free Zone in Ireland. Chaisse (2023) examines the five stages of SEZ development, ranging from the first zone in Shannon to modern Digital Free Trade Zones (DFTZ) (Chaisse, 2023).

Narula, R. & Zhan, J. (2019) also examined the emergence of SEZs, their evolution, and the associated policy trajectories underpinning their formation. The authors argue that successful zones must adapt to changing comparative advantages and stages of economic development, gradually moving from using “general” competitiveness factors to creating “specialized” advantages. The

work also focuses on the sustainability of zones, their role in the digital economy and Industry 4.0, and the attraction of new sources of funding. Research on regional development in the Russian Federation has a similar focus (Sabitova, Shavaleeva, Lizunova, Khairullova, & Zahariev, 2020).

Meanwhile, SEZs are also transforming into higher value-added service sectors (such as financial and trade services) and becoming more business-friendly in terms of laws and regulations. In the SEZs, the coevolution between education and business creates new value and accelerates growth (Bezgin et al., 2022). They are a platform for the sustainable development (Zhelyazkova, 2018) of new economic sectors with high export potential (pharmaceuticals (Zaharieva, Tarakchiyan, & Zahariev, 2022), new technologies, the aerospace industry, etc.) and high potential for market capitalization. Among the motives for companies to operate in special economic zones, the reporting of better analytical indicators (Nenkov & Hristozov, 2022) in annual financial statements is logically included, and emerging export potential for various traditional economic sector (manufacturing, agriculture (Lyubenov, 2020), etc.) as well. Our assessment is that SEZs companies have a stronger immune system for anti-crisis protection (Nozharov & Hristozov, 2023), public support for a better access to the labor market (Atanassov & Trifonova, 2020) and more effective partnership with the public sector of the economy (Borissov & Hristozov, 2024) and public administration.

Zaldívar F. G. and Molina E. (2018) examined the positive spillovers of investment in economic zones in China. They found that the concentration of investment in coastal areas of China hosting SEZs significantly accelerates the growth of inland regions. They

note that without these interregional effects, inland regions would grow more slowly. Frick S. and Rodríguez-Pose A. (2019) found that the growth of an SEZ has a positive impact on the economic performance of surrounding areas. However, the magnitude of the effect decreases steadily and is felt at distances of up to 50 km.

Chaisse J. and Hu J. (2019) describe SEZs as special territories with economic and fiscal incentives used by governments to stimulate growth and attract investment. They identify the main types of zones (FTZs, EPZs, FEZs, and free ports) and note that their successful development depends on the availability of infrastructure, a skilled workforce, and a favorable business climate (Chaisse & Hu, 2019). This combination of factors makes SEZs not only a tool for supporting business but also a means of accelerated spatial development, creating a predictable and favorable institutional environment for the localization of production capacities. Although Kazakhstan has made some progress in improving its business climate in recent years through reforms in the digitalization of public services and a reduction in the regulatory burden, systemic constraints such as administrative barriers, uneven infrastructure provision, and regional differences in investment attractiveness remain. Under these conditions, SEZs act as a tool for compensating for institutional and infrastructure deficiencies, providing companies with a higher level of legal protection, a modern production base, and support services (Zeng, 2021). For economic zones to function successfully, the existence of a solid legislative framework is essential. In developing countries, insufficient regulatory foundations lead to uncertainty in the protection of investors' rights, which in turn

reduces their interest in investing in economic zones (Zeng, 2021; Chaisse & Dimitropoulos, 2021; Chaisse, 2021).

Special Economic Zones (SEZs) are economic and fiscal enclaves established by governments to stimulate socioeconomic development, attract investment, and pilot reforms within a limited area through a system of tax and administrative incentives (Chaisse & Hu, 2019). The concept of SEZs has undergone a lengthy evolution, encompassing five generations of development, from the first industrial zone in Shannon, Ireland, to modern digital free trade zones (DFTZs) focused on fostering e-commerce and digital infrastructure (Chaisse, 2023). In the contemporary legal doctrine of international economic law, SEZs are viewed as a form of "unilateral economic law," whereby states create isolated jurisdictions with a liberalized regime to achieve trade and investment liberalization goals without applying these reforms to the entire economy, thus preserving state sovereignty (Chaisse & Dimitropoulos, 2021).

Despite their domestic nature, SEZs interact closely with international investment law and the investor-state dispute settlement (ISDS) system. These interactions often create "dangerous liaisons," as international investment agreements (IIAs) provide legal protection to foreign investors, including the right to fair and equitable treatment (FET) and protection against indirect expropriation (Chaisse, 2021).

The proliferation of SEZs has intensified in recent decades amidst globalization and heightened competition for foreign direct investment. Successful examples, most notably China's SEZs, have become a model for developing economies aspiring to achieve rapid industrialization and integration into

global value chains (Lu et al., 2019; Wang, 2013; Zheng, 2021). Empirical research indicates that Chinese zones have contributed to export growth, job creation, and structural transformation, setting a benchmark for other nations (Zeng, 2021). Influenced by the Chinese experience, governments in Asia, Africa, and Latin America are implementing similar mechanisms; however, their outcomes vary significantly depending on the institutional environment, infrastructure levels, and public governance (Davies & Mazhikeyev, 2019; Phommachanh, 2024; Crane et al., 2018). At the same time, Zeng (2021) associates the prospective development of economic zones with ensuring balanced economic growth that accounts for social factors (such as job creation and income growth) and environmental aspects of development. As economic zones gain greater autonomy, the transfer of legislative authority to them becomes increasingly important, enabling local governments to formulate their own regulations that consider regional characteristics and the specific conditions of each zone (Zeng, 2021; Chaisse & Dimitropoulos, 2021; Dimitropoulos, 2023; Sharmin, 2025). At the same time, according to Dimitropoulos (2023), it should be noted that domestic regulations should not be viewed as entirely independent, as they reflect the state's decision to create legal conditions for investors to conduct business and resolve disputes, while aligning international legal norms with the national legal system to ensure a balance between the interests of investors and the state, thereby promoting economic growth and improving public welfare. (Dimitropoulos, 2023). However, it is necessary to continuously conduct research on the investor-state dispute settlement system by thoroughly analyzing the boundaries of state regulation, the protection of investor

rights, and the need to update international investment law (Sharmin, 2025).

International practice confirms the effectiveness of this mechanism. For example, in China, SEZs have become key drivers of industrialization and exports, ensuring employment growth and the formation of high-tech industry clusters (Zeng, 2012). In the United Arab Emirates, SEZs are integrated into the economic diversification strategy: here they offer not only tax incentives, but also a developed system of “one-stop shop” services, which significantly reduces transaction costs for investors (Farole, 2011). In Poland and other Eastern European countries, SEZs have proven their role in levelling regional development and attracting foreign producers, especially in the manufacturing industry (Harding & Javorcik, 2011). Compared to these examples, Kazakhstan’s SEZs have so far been less involved as platforms for the formation of high-tech industries and integration into global value chains. However, their potential can be realized through institutional improvement, expansion of the range of services provided, and strategic positioning within the framework of national and international industrial policies (UNCTAD, 2019). Thus, compared to standard regional policy measures, SEZs have a systemic impact: they provide companies with a holistic set of advantages, and regions with opportunities for accelerated socio-economic development and inclusion in global economic processes.

2. Methodology

Models of economic growth play a key role in explaining the long-term dynamics of economies and identifying the factors that determine the sustainability of growth. The classical Solow-Swan model formed

the basis of modern theory, suggesting that economic growth is determined by capital accumulation, population growth, and technological progress, which is considered an exogenous factor (Solow, 1956). Later, endogenous growth models, such as those of Romer (1986) and Lucas (1988), shifted the focus to internal sources of development – innovation, human capital, and scientific and technological progress, which depend on government policies and investment decisions. These models showed that sustainable growth can be maintained through investment in education, research, and technology development. Empirical research (Barro, 1991; Aghion & Howitt, 1992) confirms that the key factors of growth are the quality of institutions, the level of openness of the economy, and innovative activity. To test theoretical assumptions in applied research, the correlation-regression model is widely used, allowing a quantitative assessment of the influence of various factors on economic growth. First, correlation analysis identifies the strength and direction of relationships between variables, such as investment, employment, export, or education level, are identified. This allows us to determine which factors can be included in the regression model. Then, regression analysis makes it possible not only to record the presence of a relationship, but also to measure its strength and statistical significance, that is, to establish to what extent, for example, a 1% increase in investment leads to an increase in GDP. This approach helps to exclude random dependencies and identify key growth drivers. In the empirical literature, similar methods have been used, for example, to analyze sources of growth in developing countries (Mankiw, Romer & Weil, 1992), where it was shown that including human

capital in the model significantly increases the explanatory power of growth equations. Thus, a review of theoretical models and the use of correlation-regression analysis create a comprehensive basis for studying economic growth. Theoretical models form hypotheses about significant factors, and econometric methods allow testing these hypotheses on statistical data, refining quantitative impact assessments, and identifying the specifics of the development of a particular economy. This makes the correlation-regression model an important tool that ensures the practical applicability of theoretical concepts and allows economic policy to be substantiated based on data.

During the study, retrospective data analysis and correlation-regression methods were applied.

The retrospective analysis allowed us to study the identified trends in the development of SEZs over the period of their operation from the moment of their creation until 2023. The correlation-regression analysis enabled the determination of the degree of relationship between the introduced variables (Y - gross regional product, X_1 - investments in fixed capital, X_2 - investments in special economic zones, X_3 - number of permanent jobs created). The correlation-regression approach, widely used in empirical research, is used to test the influence of individual factors on economic growth and to assess the strength of these relationships. For example, studies show that fixed capital investment has a positive and statistically significant effect on GDP growth (Barro, 1991), and export performance is a driver of growth in open economies (Edwards, 1998).

The initial data were obtained from official sources: the Ministry of Industry and Construction of the Republic of Kazakhstan,

the Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, JSC KazakhInvest, JSC Qazindustry, RSE Gosgradkadastr (Appendix 1), as well as analytical reports from the World Bank, OECD, National Reports of Kazakhstan and articles indexed in Scopus database, Web of Science, Google Scholar, etc. The inclusion of a substantial quantity of data enabled comprehensive analysis, which in turn permitted the formulation of conclusions regarding the present trends and prospective developments of special economic zones.

This study assesses the impact of SEZs on the socio-economic development of regions, focusing on the effect of fixed capital investment and SEZs on the gross regional product (GRP) of the respective regions (Phommachanh 2024; Ciżkowicz et al. 2017).

A multifactor correlation-regression model is employed to calculate the correlation coefficient, which characterizes the correlation between investment, employment and GRP (O'Brien & Scott 2012; Pandey 2020; Marjanac & Alfrević 2021; Mohr et al. 2022; Xu et al. 2022; Dorożyński et al. 2021).

$$Y = \beta_0 + \beta_1 \cdot X_1 + \beta_2 \cdot X_2 + \beta_3 \cdot X_3, \quad (1)$$

where β_0 - constant term equal to the GRP when investments are zero, $\beta_0 = \bar{Y} - \beta_1 \cdot \bar{X}_1 - \beta_2 \cdot \bar{X}_2 - \beta_3 \cdot \bar{X}_3$; β_1 , β_2 and β_3 - regression coefficients or coefficients indicating the impact of changes in investment volume on changes in GRP (Appendix 15, formula 1).

The initial data of the SEZ for applying the correlation-regression model are provided in Appendices 2-14.

The largest volume of total investments in 2023 was attracted by the territory of the SEZ "NINT" in Atyrau region. Authors will use the data for Atyrau region presented in Appendix

2 along with the SEZ “NINT” data for the years 2007-2023.

To determine the impact of investments on the GRP of Atyrau region, it is necessary to calculate the average values for each indicator. For $n = 17$ the average values of the indicators will be equal to $\bar{Y} = 3,279.2$ billion tenge, $\bar{X}_1 = 1.055.7$ billion tenge, $\bar{X}_2 = 97.2$ billion tenge, $\bar{X}_3 = 66.8$ units.

Next, we will calculate the indicators of the multifactor correlation-regression model, using formulas (2)-(6) in Appendix 15.

For multiple regression, the coefficients are calculated using the formulas (5) and (6) from Appendix 15. Using the data from Appendix 2, we obtain: $\beta_1 = 1.3$, $\beta_2 = 19.9$, $\beta_3 = -0.8$. By substituting the obtained data into formula (5), we find the value of the constant term $\beta_0 = 1\,622.8$. Based on the coefficients, we will construct the regression equation using the formula (1)

$$Y = \beta_0 + \beta_1 \cdot X_1 + \beta_2 \cdot X_2 + \beta_3 \cdot X_3 = 1.622.8 + 1.3X_1 + 19.9X_2 - 0.8X_3 \quad (2)$$

Based on the calculated data, we can conclude that when fixed capital investments, investments in SEZ “NINT” and number of created permanent jobs are equal to 0, the expected value of GRP of Atyrau region will be 1,622.8 billion tenge.

At the same time, it is noted by authors that an increase in the volume of investment in projects in the SEZ “NINT” by 1 billion tenge will lead to an increase in GRP by 19.9 billion tenge.

Figure 1 presents a graphical representation of the relationship between the regression equation of Atyrau region and the volume of fixed capital investment of the region, investment in the SEZ “NINT” and number of created permanent jobs.

The dotted blue line represents a linear trend for fixed capital investment with a negative trend since 2019. Investment in

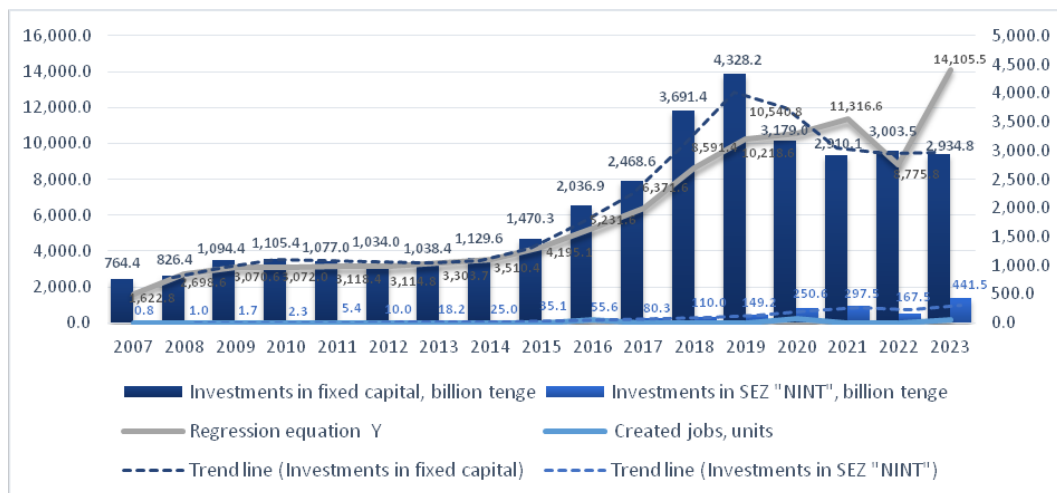


Figure 1. The relationship of the regression equation between regional GRP and the volumes of investments in fixed capital of the region and investment in the SEZ “NINT”, and number of created permanent jobs

Source: Bureau of National statistics, Agency for Strategic planning and reforms of the Republic of Kazakhstan 2024; authors own calculations

SEZ, meanwhile, increases slowly, which is reflected by the light blue dotted line with a less steep slope.

The gray Y line is the regression equation, which shows a stable growth starting from 1,622.8 billion tenge and reaching 14,105.5 billion tenge, indicating a positive outlook despite the negative trend of fixed capital investment and unstable dynamics of creation of permanent jobs, i.e. it will have a positive impact on the socio-economic development of the region in the future.

Thus, for Atyrau region there is a dependence of attracting investors in SEZ "NINT" and the volume of GRP.

Similarly, as a result of the analysis carried out using multifactor correlation-regression model, the results for other SEZs were obtained.

Thus, for SEZ "Astana - Technopolis" for $n = 7$ the average values of the indicators will be equal to $\bar{Y} = 8,686.9$ billion tenge,

$\bar{X}_1 = 1.201.6$ billion tenge, $\bar{X}_2 = 13.0$ billion tenge, $\bar{X}_3 = 45.0$ units.

Using the data from Appendix 3, we obtain: $\beta_1 = 5.2$, $\beta_2 = 12.1$, $\beta_3 = 7.8$. By substituting the obtained data into formula (5), we find the value of the constant term $\beta_0 = 1,200.0$. Based on the coefficients, we will construct the regression equation using the formula (1)

$$Y = 1.200.0 + 5.2X_1 + 12.1X_2 + 7.8X_3 \quad (3)$$

Based on the calculated data, we can conclude that when fixed capital investments, investments in SEZ "Astana - Technopolis" and number of created permanent jobs are equal to 0, the expected value of GRP of Astana city will be 1,200.0 billion tenge. The growth of the GRP of the city is directly proportional to the growth of investments in SEZ.

At the same time, it is noted by authors that an increase in the volume of investment in projects in the SEZ "Astana - Technopolis"

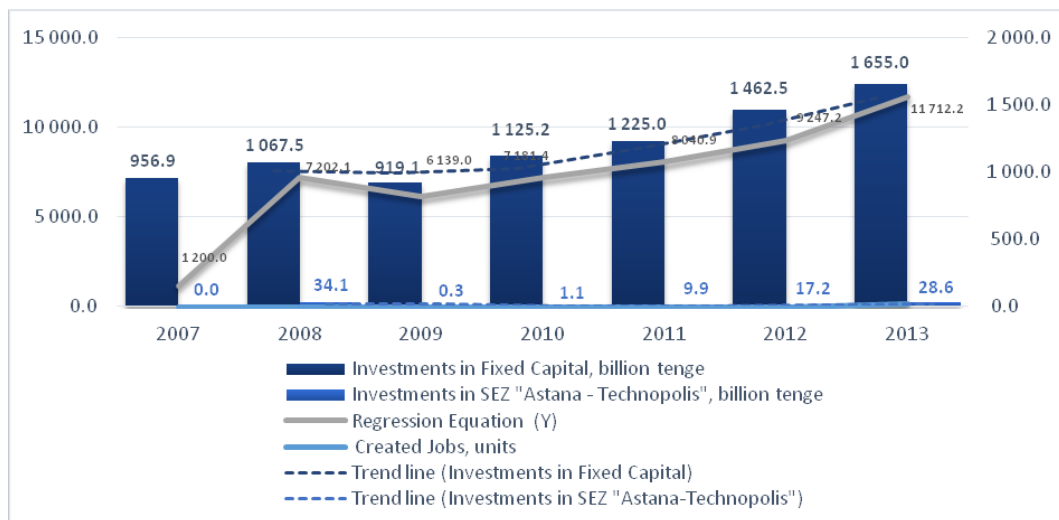


Figure 2. The relationship of the regression equation between regional GRP and the volumes of investments in fixed capital of the region and investment in the SEZ "Astana – Technopolis", and number of created permanent jobs

Source: Bureau of National statistics, Agency for Strategic planning and reforms of the Republic of Kazakhstan 2024; authors own calculations

by 1 billion tenge will lead to an increase in GRP by 12.1 billion tenge.

Figure 2 presents a graphical representation of the relationship between the regression equation of Astana city and the volume of fixed capital investment of the region, investment in the SEZ “Astana - Technopolis” and number of created permanent jobs.

In the diagram, the dotted blue line represents the linear trend for investment in SEZ, which shows growth.

Gray line Y - regression equation, which shows a stable dynamic starting from 1,200.0 billion tenge and reaching 11,712.2 billion tenge indicating sustainable dynamic growth, that is, will have a positive impact on the socio-economic development of the city in the future.

For $n = 23$ the average values of the indicators for the SEZ “Astana - New City” (Appendix 4) will be equal to $\bar{Y} = 3,966.4$ billion tenge, $\bar{X}_1 = 663.5$ billion tenge, $\bar{X}_2 = 81.3$ billion tenge, $\bar{X}_3 = 227.4$ units.

Regression coefficients: $\beta_1 = 1.6$, $\beta_2 = 19.9$, $\beta_3 = 0.9$, $\beta_0 = -179.6$. Then, the regression equation for the SEZ “Astana - New City” is as follows:

$$Y = -179.6 + 1.6X_1 + 19.9X_2 + 0.9X_3 \quad (4)$$

It can be inferred from the calculated regression equation that in the absence of fixed capital investment, investments in the SEZ “Astana - New City” and newly created permanent jobs (i.e. when all explanatory variables equal zero), the expected GRP of Astana would amount to -179.6 billion tenge. This value has no practical economic interpretation and only represents a statistical interception.

Moreover, an increase in the volume of fixed capital investment by 1 billion tenge will result in a growth of the city's GRP by approximately 1.6 billion tenge, while an additional 1 billion tenge invested in projects within the SEZ “Astana - New City” will lead to an increase of about 19.9 billion tenge. In addition, the creation of one permanent job contributes, on average, to an increase of the GRP by 0.9 billion tenge.

The regression results confirm that both investment flows and employment creation play a significant role in shaping the gross regional product of Astana, with the largest marginal effect being attributed to investments in the SEZ “Astana - New City”.

Figure 3 presents a graphical representation of the correlation between the regression equation for the city of Astana and the volumes of investments in fixed capital and the SEZ.

The dotted blue line represents the linear trend for fixed capital investment, showing a positive dynamic. Investments in the SEZ are also increasing, as indicated by the light blue dotted line, which has a less steep slope with a sharp decline in 2019-2022.

The gray line Y shows the regression equation, which shows a steady growth until 2019, starting from -179.6 billion tenge and reaching 6,538.9 billion tenge in 2018 with a sharp decline due to a decrease in the volume of investments in the SEZ in 2019-2022. This suggests that an increase in the volume of investments in the SEZ will give a positive forecast, which can have a favorable impact on the socio-economic development of the city in the future.

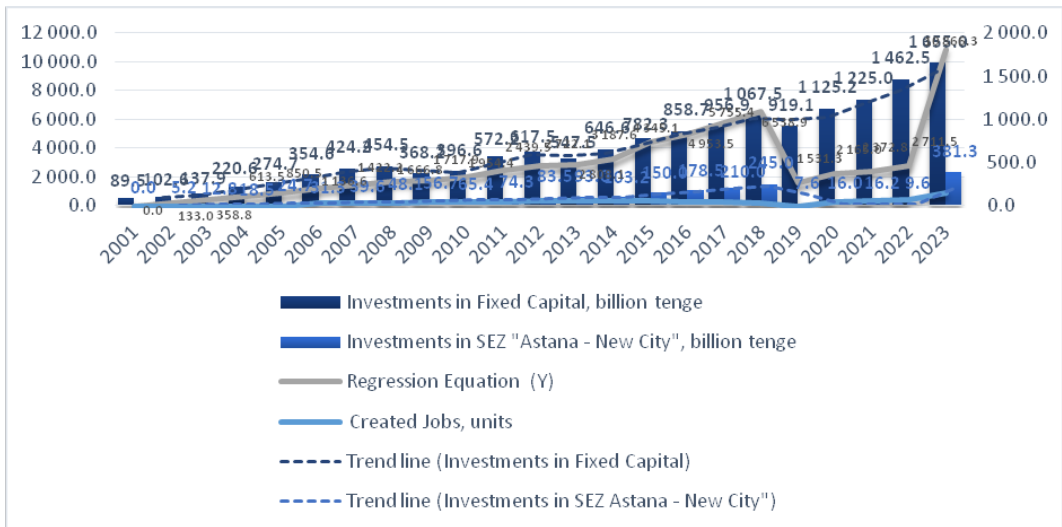


Figure 3. The relationship of the regression equation between regional GRP and the volumes of investments in fixed capital of the region and investment in the SEZ “Astana - New City”, and number of created permanent jobs

Source: Bureau of National statistics, Agency for Strategic planning and reforms of the Republic of Kazakhstan 2024; authors own calculations

Calculated average values for $n = 6$ of the indicators for the SEZ “TURAN” (Appendix 5) in Turkestan region will be equal to $\bar{Y} = 2,739.9$ billion tenge, $\bar{X}_1 = 635.6$ billion tenge, $\bar{X}_2 = 168.7$ billion tenge, $\bar{X}_3 = 989.2$ units, regression coefficients: $\beta_1 = 2.0$, $\beta_2 = 0.4$, $\beta_3 = 0.3$, $\beta_0 = 1,375.1$.

In this case, the regression equation for the SEZ “TURAN” is as follows:

$$Y = 1,375.1 + 2.0X_1 + 0.4X_2 + 0.3X_3 \quad (5)$$

Based on the calculated data, it can be concluded that in the absence of fixed capital investments and investments in the SEZ “TURAN” the expected gross regional product (GRP) of the Turkestan region will amount to 1,375.1 billion tenge.

Moreover, an increase in the volume in the region’s fixed capital investment by 1 billion tenge will result in a growth of the GRP by 2.0 billion tenge. Value $\beta_2 = 0.4$ indicates a positive correlation between investments in

the SEZ and the region’s GRP, because of the efficient use of funds in the SEZ, as well as sufficient concentration of investments in the economy, which leads to a positive forecast.

Figure 4 illustrates the graphical representation of the relationship between the regression equation for the region and the volumes of fixed capital investments of the Turkestan region, as well as the investments in the SEZ “TURAN”.

The dotted blue line represents the trend line moving average for fixed capital investment, showing positive dynamics. Despite an increase in investment in the SEZ, this growth is occurring at a slower rate, as illustrated by the light blue dotted line.

The gray Y line represents the regression equation, demonstrating steady growth from 1,375.1 billion tenge to 3,690.1 billion tenge. This indicates a positive forecast and suggests a favorable impact on the region’s socio-economic development in the future.

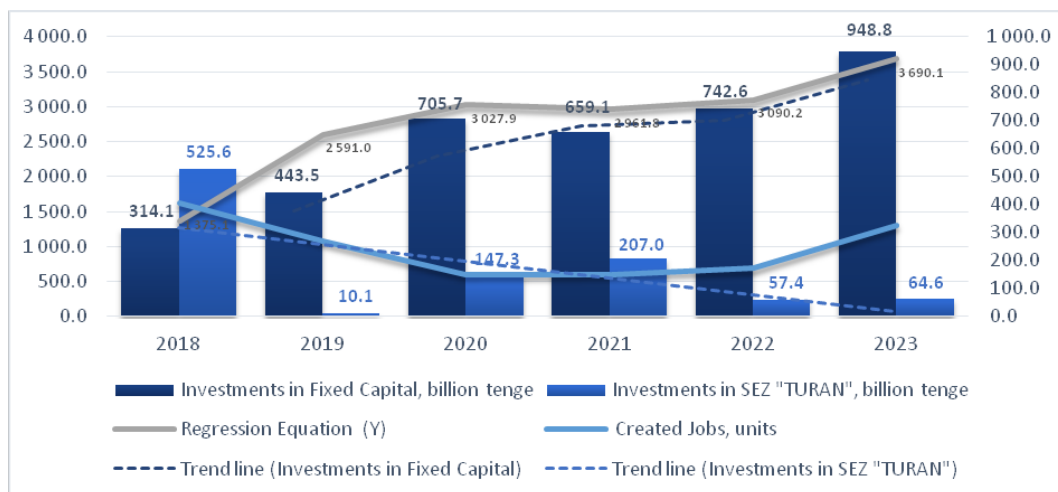


Figure 4. The relationship of the regression equation between regional GRP and the volumes of investments in fixed capital of the region and investment in the SEZ "TURAN", and number of created permanent jobs

Source: Bureau of National statistics, Agency for Strategic planning and reforms of the Republic of Kazakhstan 2024; authors own calculations

All the coefficients are relatively small, but positive.

For $n = 6$ the average values of the indicators for the SEZ "Seaport Aktau" (Appendix 6) in the Mangistau region will be equal to $\bar{Y} = 2,129.0$ billion tenge, $\bar{X}_1 = 431.8$ billion tenge, $\bar{X}_2 = 32.3$ billion tenge, $\bar{X}_3 = 218.0$ units. Regression coefficients for the SEZ "Seaport Aktau": $\beta_1 = 2.4$, $\beta_2 = 4.2$, $\beta_3 = 0.9$, $\beta_0 = 150.4$, regression equation

$$Y = 150.4 + 2.4X_1 + 4.2X_2 + 0.9X_3 \quad (6)$$

The region's baseline GRP is estimated at 150.4 billion tenge in the absence of any investments.

The data confirms that an increase in total investment contributes to GRP growth, as indicated by the regression coefficient of 2.4. This suggests that a 1 billion tenge increase in total investment would result in a 2.4 billion tenge increase in the region's GRP.

The relationship between investment in the SEZ and the region's GRP is positive, as reflected by the regression coefficient of 4.2. This may be due to the efficient use of funds within the SEZ, as well as sufficient concentration of investments in the economy. These factors could contribute to the positive impact observed.

Figure 5 presents a graphical representation of the correlation between the regression equation of the region and the volume of fixed capital investment of the Mangistau region and investment in SEZ "Seaport Aktau, as well as employment creation.

The linear trend for fixed capital investments is represented by the dotted blue line, which shows clear positive dynamics. The light blue dotted trend line shows that while investments in the SEZ are rising as well, they are doing so at a slower pace.

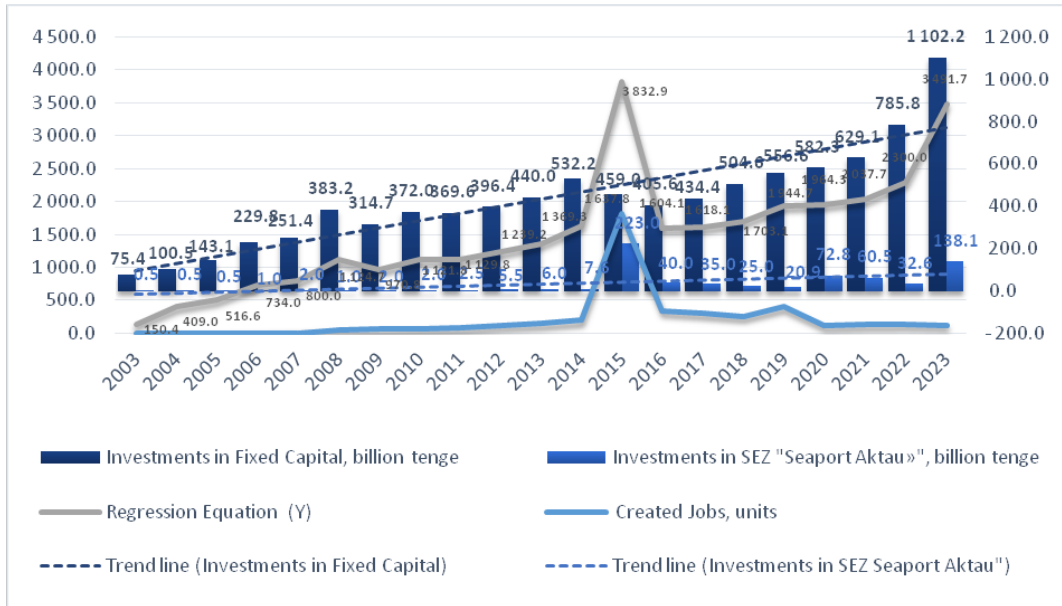


Figure 5. The relationship of the regression equation between regional GRP and the volumes of investments in fixed capital of the region and investment in the SEZ "Seaport Aktau", and number of created permanent jobs

Source: Bureau of National statistics, Agency for Strategic planning and reforms of the Republic of Kazakhstan 2024; authors own calculations

The regression equation is represented by the gray Y line, which shows a consistent increase from 150.4 billion tenge to 3,491.7 billion tenge. This points to a promising future and a positive influence on the socio-economic growth of the area.

The average values of the indicators for the SEZ "Saryarka" (Appendix 7) in the Karaganda region will be equal to $\bar{Y} = 4,282.0$ billion tenge, $\bar{X}_1 = 523.8$ billion tenge, $\bar{X}_2 = 29.9$ billion tenge, $\bar{X}_3 = 396.9$ units, regression coefficients are as follows $\beta_1 = 8.0$, $\beta_2 = 8.2$, $\beta_3 = 1.3$, $\beta_0 = -301.5$, accordingly, the regression equation for the SEZ "Saryarka" is as follows:

$$Y = -301.5 + 8.0X_1 + 8.2X_2 + 1.3X_3 \quad (7)$$

If investment in both the regional economy and the SEZ is zero, the region's GRP will total

-301.5 billion tenge. Nevertheless, investments in the regional economy are associated with a decrease in GRP, as shown in Fig. 6, which may suggest inefficient fund allocation or that implemented projects fail to achieve expected outcomes. Similarly, investments in the SEZ "Saryarka" correlate with a reduction in GRP, possibly pointing to profitability issues or organizational challenges within SEZ operations. Together, these factors may reflect broader economic concerns, such as insufficient return on investment or structural imbalances within the economy.

The blue dotted line represents a linear trend for fixed capital investments with fluctuations, but a generally positive trend. Meanwhile, investments in SEZ increase, at a slower pace, which is illustrated by the light blue dotted line.

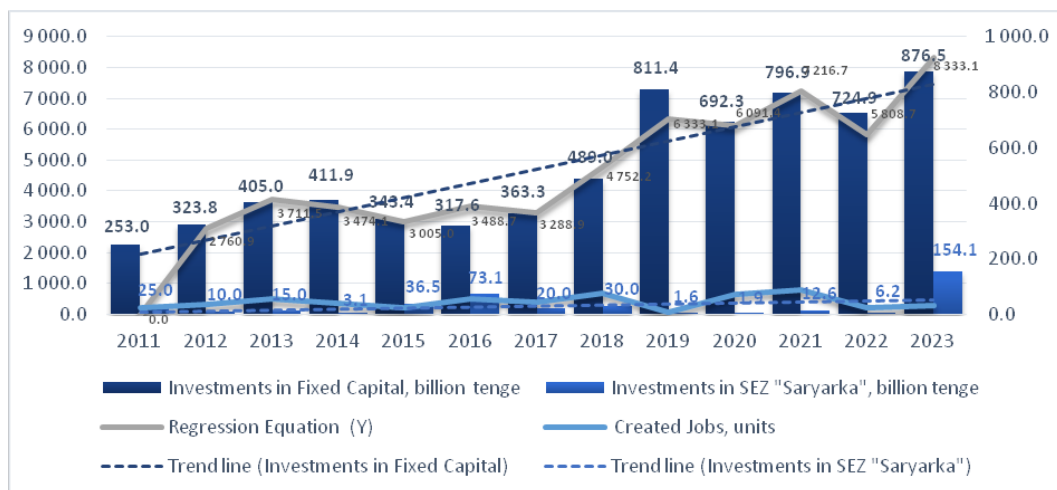


Figure 6. The relationship of the regression equation between regional GRP and the volumes of investments in fixed capital of the region and investment in the SEZ “Saryarka”, and number of created permanent jobs. The relationship between the regression equation, investments in fixed capital, and investments in the SEZ “Saryarka”

Source: (Bureau of National statistics, Agency for Strategic planning and reforms of the Republic of Kazakhstan 2024; authors own calculations)

Gray line Y represents the regression equation. According to the data, investments in the regional economy and the SEZ “Saryarka” are associated with a decline in the GRP. This trend shows a decline from -301.5 billion tenge to 8 333,1 billion tenge, suggesting potential challenges for the socio-economic development of the region.

For $n = 23$ the average values of the indicators for the SEZ “Pavlodar” (Appendix 8) in Pavlodar region will be equal to $\bar{Y} = 2,621.4$ billion tenge, $\bar{X}_1 = 460.1$ billion tenge, $\bar{X}_2 = 19.8$ billion tenge, $\bar{X}_3 = 148.1$ units. The coefficients of regression for the SEZ “Pavlodar” are $\beta_1 = 5.9$, $\beta_2 = 1.7$, $\beta_0 = -1.4$. The regression equation for the SEZ “Pavlodar” is as follows:

$$Y = 2,621.4 + 5.9X_1 + 1.7X_2 - 1.4X_3 \quad (8)$$

The regression equation indicates that in the absence of any investment, the baseline level of GRP in the region would be 2,621.4 billion tenge. The regression coefficient of

5.9 shows that for every increase of 1 billion tenge in total investment, the GRP of the region increases by 5.9 billion tenge. This confirms that an increase in total fixed capital investments in the Pavlodar region contributes to GRP growth. However, the regression coefficient of -1.4 indicates a negative correlation between created jobs and the GRP of the region. This fact can be explained by the fact that jobs in the Pavlodar SEZ are not a determining factor in the growth of the region's GRP. At the same time, economic growth is ensured by investments and capital growth, and not by labor resources. Compared with 5.9 and 1.7, the regression coefficient of -1.4 is smaller in magnitude, indicating a smaller negative impact of job creation in the SEZ. Therefore, corrective actions can lead to a positive value of β_3 , which will give the regression equation a positive value and have a positive impact on the socio-economic development of the Pavlodar region.

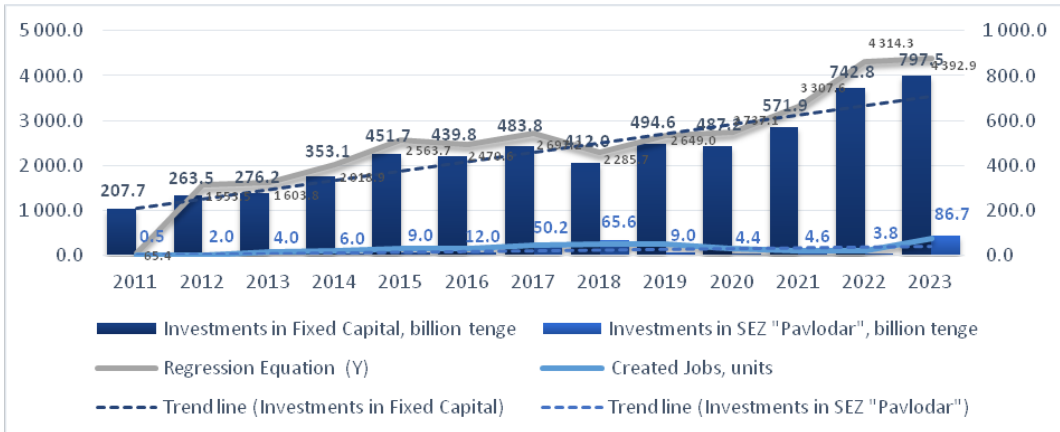


Figure 7. The relationship of the regression equation between regional GRP and the volumes of investments in fixed capital of the region and investment in the SEZ "Pavlodar", and number of created permanent jobs

Source: (Bureau of National statistics, Agency for Strategic planning and reforms of the Republic of Kazakhstan 2024; authors own calculations)

Figure 7 shows the graphical correlation between the GRP of the region and the volume of investment in fixed assets, the volume of investment in the SEZ and the jobs created.

In the diagram, the blue dotted line represents a linear trend for fixed capital investment with significant positive dynamics. Investments in SEZs illustrate variable dynamics, although at a slower pace, which is depicted with a light blue dotted line trend.

Gray line Y represents the regression equation, which illustrates a constant increase from 65.4 billion tenge to 4,392.9 billion tenge. It also shows a positive forecast, meaning a positive impact on the region's social-economic development in the future. In order for the growth of GRP to correspond to the growth of employment, it is necessary to reorient the policy in the Pavlodar SEZ towards increasing not only productivity and exports, but also towards ensuring mass employment.

For SEZ "PIT" (Appendix 9) in Almaty for $n = 21$ the average values of the indicators

will be equal to $\bar{Y} = 8,287.5$ billion tenge, $\bar{X}_1 = 643.4$ billion tenge, $\bar{X}_2 = 11.3$ billion tenge, $\bar{X}_3 = 173.3$ units. Regression coefficients of SEZ: $\beta_1 = 10.5$, $\beta_2 = 250.0$, $\beta_3 = 5.2$, $\beta_0 = 200.0$.

The regression equation for SEZ "PIT" is as follows.

$$Y = 200.0 + 10.5X_1 + 250.0X_2 + 5.2X_3 \quad (9)$$

From the calculated data it follows that in the absence (equal to 0) of fixed capital investments of both Almaty and SEZ "PIT", the expected value of the city's GRP will be 200.0 billion tenge. In doing so, increasing the amount of fixed capital investment to 1 billion tenge will lead to increasing GRP to 10.5 billion tenge and the amount of investments in projects on the territory of SEZ "PIT".

Figure 8 represents the graphical correlation between the region's regression equation and the volume of the fixed capital investment, investments in SEZ "PIT" and created jobs of both Almaty and SEZ "PIT".

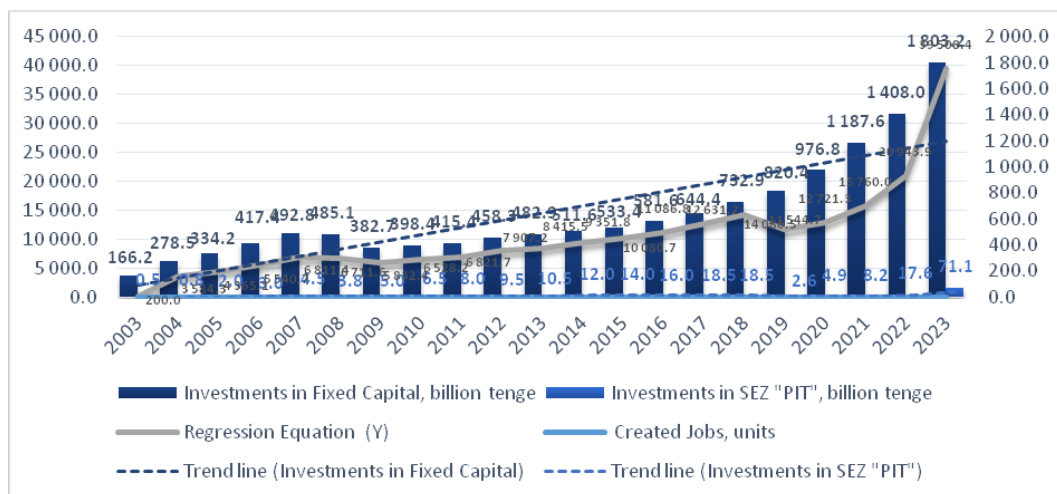


Figure 8. The relationship of the regression equation between regional GRP and the volumes of investments in fixed capital of the region and investment in the SEZ "PIT", and number of created permanent jobs.

Source: Bureau of National statistics, Agency for Strategic planning and reforms of the Republic of Kazakhstan 2024; authors own calculations

The dotted blue line represents the linear trend of Almaty's fixed capital investments with a significant positive trend. At the same time, investments in SEZ "PIT" are increasing, but at a slower pace, which is depicted by the light blue dotted line of the trend.

Thus, gray line Y represents the regression equation, which illustrates increases from 200.0 billion tenge to 39,508.4 billion tenge, and a positive forecast in perspectives, which will lead to the positive socio-economic development of Almaty in the future.

For SEZ "ICBC Khorgos" (Appendix 10) in Zhetisu region for $n = 7$ the average values of the indicators will be equal to $\bar{Y} = 1,244.9$ billion tenge, $\bar{X}_1 = 243.5$ billion tenge, $\bar{X}_2 = 26.4$ billion tenge, $\bar{X}_3 = 285.7$ units. Regression coefficients: $\beta_1 = 2.1$, $\beta_2 = 0.6$, $\beta_3 = 0.5$, $\beta_0 = 539.2$. The regression equation for SEZ "ICBC Khorgos" is as follows:

$$Y = 539.2 + 2.1X_1 + 0.8X_2 + 0.5X_3 \quad (10)$$

Analysis of the calculated data identified that in the absence of fixed capital investments in the Zhetisu region and in SEZ "ICBC Khorgos", and created jobs expected value of GRP will be 539.2 billion tenge. Meanwhile, an increase in fixed capital investments by 1 billion tenge will lead to increasing GRP to 2,1 billion tenge.

Figure 9 represents the graphical correlation between the region's regression equation and the volume of the fixed capital investment, investments in SEZ "ICBC Khorgos" and created jobs of both Zhetisu region and SEZ "ICBC Khorgos".

The dotted blue line represents the linear trend of Zhetisu region's fixed capital investments with a significant positive trend. At the same time, investments in SEZ "ICBC Khorgos" are decreasing, but at a slower pace, which is depicted by the light blue dotted line of the trend.

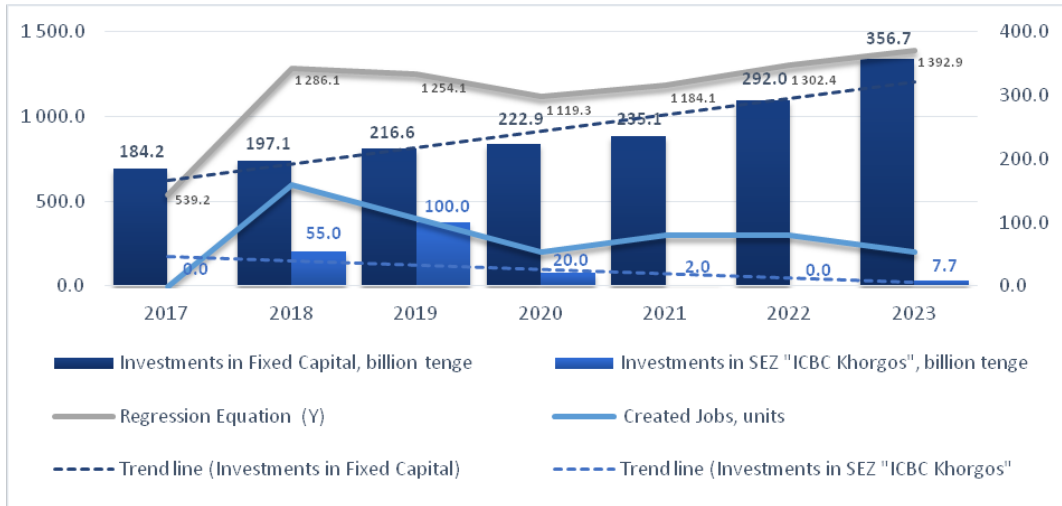


Figure 9. The relationship of the regression equation between regional GRP and the volumes of investments in fixed capital of the region and investment in the SEZ "ICBC Khorgos", and number of created permanent jobs.

Source: Bureau of National statistics, Agency for Strategic planning and reforms of the Republic of Kazakhstan 2024; authors own calculations

Thus, gray line Y represents the regression equation, which illustrates increases from 539,2 billion tenge to 1,392.9 billion tenge, and a positive forecast in perspectives, which will lead to the positive socio-economic development of Zhetisu region in the future.

For SEZ "Khorgos - Eastern Gate" (Appendix 11) in Zhetisu region for $n = 13$ the average values of the indicators will be equal to $\bar{Y} = 1,398.9$ billion tenge, $\bar{X}_1 = 276.5$ billion tenge, $\bar{X}_2 = 8.4$ billion tenge, $\bar{X}_3 = 425.8$ units. For SEZ the calculated values of the regression coefficients are $\beta_1 = 1.5$, $\beta_2 = 0.2$, $\beta_3 = 0.8$, $\beta_0 = 331.2$.

The regression equation for SEZ "Khorgos - Eastern Gate" is as follows:

$$Y = 331.2 + 1.5X_1 + 0.2X_2 + 0.8X_3 \quad (11)$$

According to the regression equation, the absence of investments results in a baseline GRP in the region of 331.2 billion tenge. The regression coefficient of 1.5 indicates that an

increase of 1 billion tenge in total fixed capital investments in the Zhetisu region will lead to an increase in the region's GRP by 148.0 billion tenge. This confirms that an increase in fixed capital investments contributes to the growth of GRP volume. The regression coefficient 0.2 indicates the positive correlation between investments in SEZ "Khorgos - Eastern Gate" and region's GRP.

Figure 10 represents the graphical correlation between the region's regression equation and the volume of the fixed capital investment, investments in SEZ "Khorgos - Eastern Gate" and created jobs of both Zhetisu region and SEZ "Khorgos - Eastern Gate".

The dotted blue line represents the linear trend of Zhetisu region's fixed capital investments with a significant positive trend. At the same time, investments in SEZ "Khorgos - Eastern Gate" are increasing, but at a slower pace, which is depicted by the light blue dotted line of the trend.

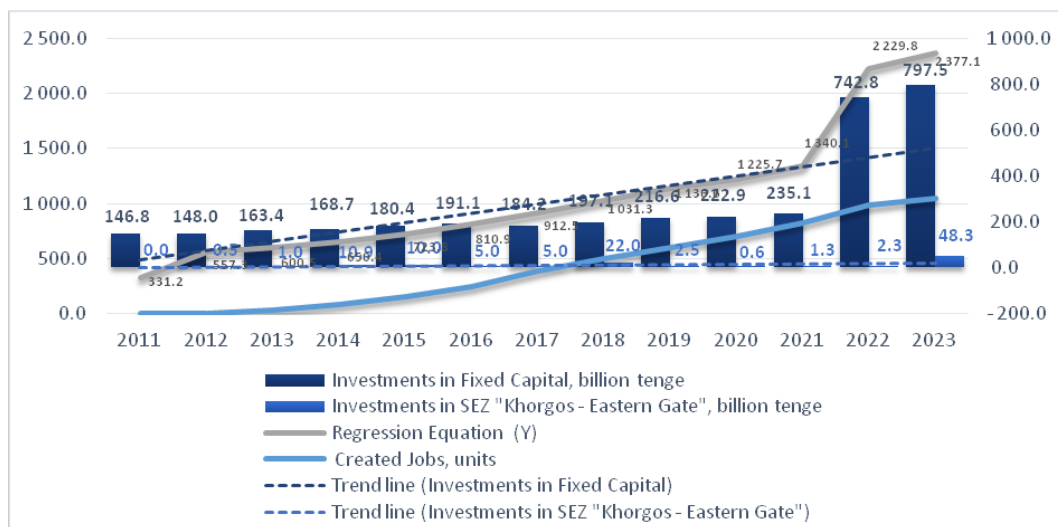


Figure 10. The relationship of the regression equation between regional GRP and the volumes of investments in fixed capital of the region and investment in the SEZ “ICBC Korgos”, and number of created permanent jobs.

Source: Bureau of National statistics, Agency for Strategic planning and reforms of the Republic of Kazakhstan 2024; authors own calculations

Thus, gray line Y represents the regression equation, which illustrates increases from 331.2 billion tenge to 2,377.1 billion tenge, and a positive forecast in perspectives, which will lead to the positive socio-economic development of Zhetisu region in the future.

For $n = 19$ the average values of the indicators for the SEZ “Ontustik” (Appendix 12) in the city of Shymkent will be equal to $\bar{Y} = 1,327.4$ billion tenge, $\bar{X}_1 = 213.1$ billion tenge, $\bar{X}_2 = 5.3$ billion tenge, $\bar{X}_3 = 108.4$ units.

Calculated values of the regression coefficients for SEZ “Ontustik”: $\beta_1 = 2.9$, $\beta_2 = 41.2$, $\beta_3 = 1.2$, $\beta_0 = 12.5$, thus, the regression equation for SEZ “Ontustik” is:

$$Y = 12.5 + 2.9X_1 + 41.2X_2 + 1.2X_3 \quad (12)$$

According to the regression equation, the baseline level of GRP in the absence of investments is projected to be 12.5

billion tenge. The regression coefficient of 2.9 indicates that for every 1 billion tenge increase in total fixed capital investments in Shymkent, the GRP is expected to rise by 2.9 billion tenge. An increase in investment in the SEZ “Ontustik” by 1 billion tenge gives an increase in GRP by approximately 41.2 billion tenge. The creation of one job in the SEZ or related industries increases GRP by approximately 1.2 billion tenge. The strongest factor is investments in SEZ (41.2), i.e. small injections into the SEZ have a multiple growth in GRP.

Figure 11 represents the graphical correlation between the region’s regression equation and the volume of the fixed capital investment, investments in SEZ “Ontustik” and created jobs of both the city of Shymkent and SEZ “Ontustik”.

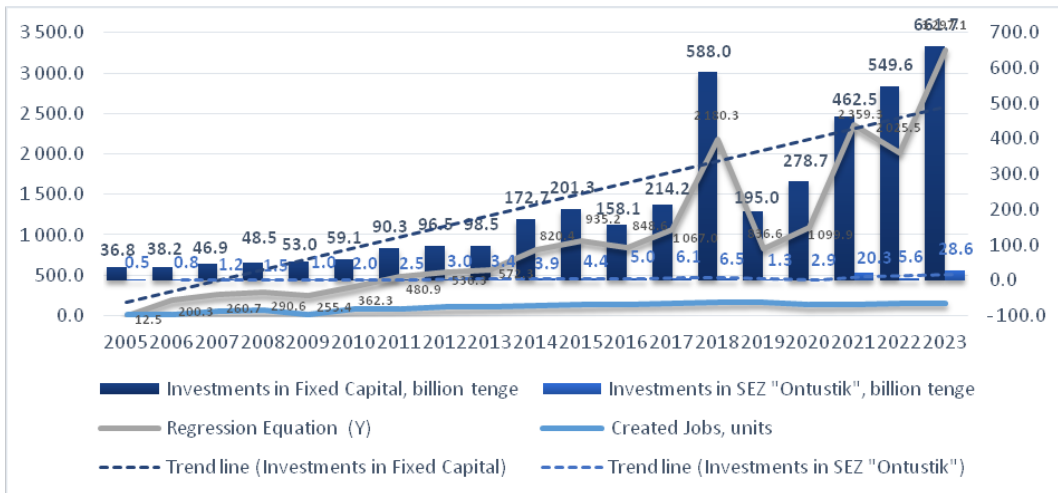


Figure 11. The relationship of the regression equation between regional GRP and the volumes of investments in fixed capital of the region and investment in the SEZ "Ontustik", and number of created permanent jobs.

Source: Bureau of National statistics, Agency for Strategic planning and reforms of the Republic of Kazakhstan 2024; authors own calculations

The dotted blue line represents the linear trend of the city of Shymkent's fixed capital investments with a positive trend with some fluctuations. At the same time, investments in SEZ "Ontustik" are increasing, but at a slower pace, which is depicted by the light blue dotted line of the trend.

Gray line Y represents the regression equation, which illustrates increases from 12.5 billion tenge to 3,297.1 billion tenge, and a positive forecast in perspectives, which will lead to the positive socio-economic development of the city of Shymkent in the future.

For SEZ "Jibek Joly" (Appendix 13) in the Zhambyl region for $n = 12$ the average values of the indicators will be equal to $\bar{Y} = 1,609.2$ billion tenge, $\bar{X}_1 = 293.4$ billion tenge, $\bar{X}_2 = 6.8$ billion tenge, $\bar{X}_3 = 150.0$ units. The regression coefficients for the SEZ "Jibek Joly" are as follows: $\beta_1 = 3.4$, $\beta_2 = 14.0$, $\beta_3 = 1.7$, $\beta_0 = 125$, the intercept term $\beta_0 = 406.7$. The regression equation can be expressed as:

$$Y = 406.7 + 3.4X_1 + 14X_2 + 1.7X_3 \quad (13)$$

The regression equation indicates that in the absence of investments in the Zhambyl region and SEZ "Jibek Joly", the GRP would be at 406.7 billion tenge. There is a positive correlation between the total volume of investments and GRP. Every 1 billion tenge investment increase leads to a GRP increase of 3.4 billion tenge.

Thus, investments in the regional economy have a positive effect on its development. The regression coefficient of 14.0 indicates that the SEZ "Jibek Joly" either uses investments effectively or investments are attracted to the most profitable projects.

Figure 12 represents the graphical correlation between the region's regression equation and the volume of the fixed capital investment, investments in SEZ and created jobs of both the Zhambyl region and SEZ "Jibek Joly".

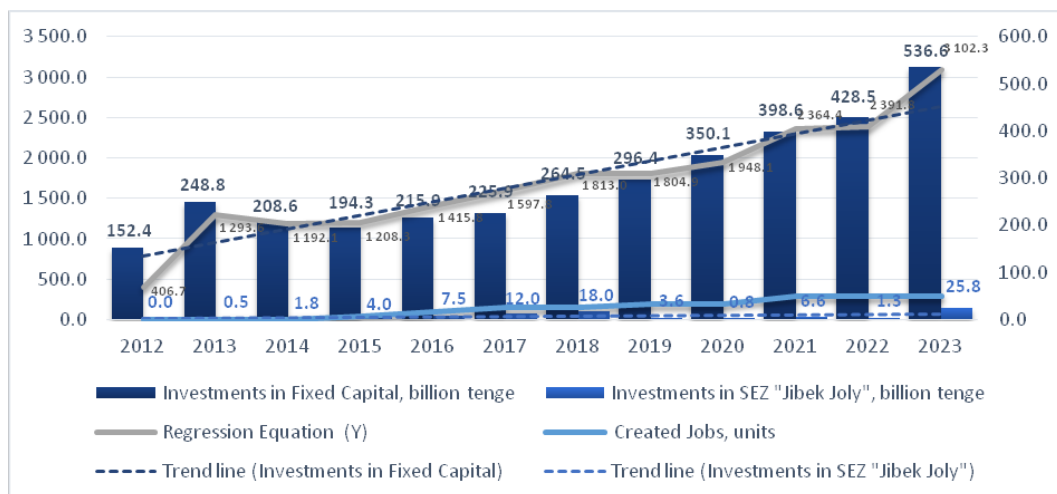


Figure 12. The relationship of the regression equation between regional GRP and the volumes of investments in fixed capital of the region and investment in the SEZ “Jibek Joly”, and number of created permanent jobs.

Source: Bureau of National statistics, Agency for Strategic planning and reforms of the Republic of Kazakhstan 2024; authors own calculations

The dotted blue line represents the linear trend of the Zhambyl region's fixed capital investments with a positive trend with some fluctuations. At the same time, investments in SEZ are increasing, but at a slower pace, which is depicted by the light blue dotted line of the trend.

Gray line Y represents the regression equation, which illustrates increases from 406.7 billion tenge to 3,102.3 billion tenge, and a positive forecast in perspective, which will lead to the positive socio-economic development of the Zhambyl region in the future.

For SEZ “Qyzyljar” (Appendix 14) in the North Kazakhstan region for $n = 6$ the average values of the indicators will be equal to $\bar{Y} = 1,764.2$ billion tenge, $\bar{X}_1 = 313.4$ billion tenge, $\bar{X}_2 = 5.5$ billion tenge, $\bar{X}_3 = 554.3$ units.

The regression coefficients for the SEZ “Qyzyljar” are $\beta_1 = 1.5$, $\beta_2 = 18$, $\beta_3 = 0.2$, $\beta_0 = 1,100.0$. The regression equation for SEZ can be expressed as follows:

$$Y = 1,100.0 + 1.5X_1 + 18X_2 + 0.2X_3 \quad (14)$$

The regression equation indicates that in the absence of investments in the North Kazakhstan region and SEZ “Qyzyljar”, the GRP would be at 1,100.0 billion tenge. There is a positive correlation between the total volume of investments and GRP. Every 1 billion tenge investment increase leads to a GRP increase of 1.5 billion tenge. Thus, investments in the region's economy positively influence its development. The regression coefficient of 18.0 indicates that the SEZ “Qyzyljar” either uses investments effectively or investments are attracted to the most profitable projects.

Figure 13 represents the graphical correlation between the region's regression equation and the volume of the fixed capital investment, investments in SEZ and created jobs of both the North Kazakhstan region and SEZ “Qyzyljar”.

The dotted blue line represents the linear trend of the North Kazakhstan region's fixed

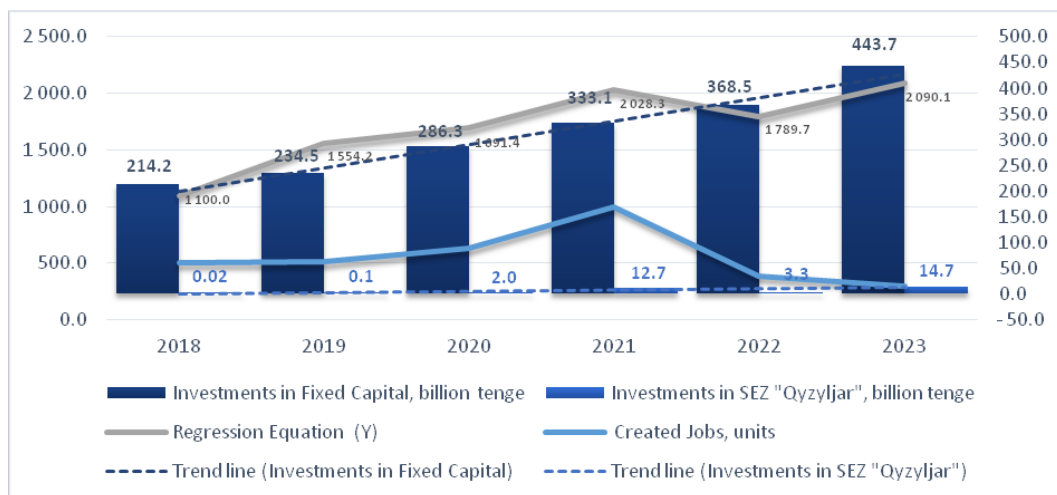


Figure 13. The relationship of the regression equation between regional GRP and the volumes of investments in fixed capital of the region and investment in the SEZ "Jibek Joly", and number of created permanent jobs.

Source: Bureau of National statistics, Agency for Strategic planning and reforms of the Republic of Kazakhstan 2024; authors own calculations

capital investments with a positive trend with some fluctuations. At the same time, investments in SEZ are increasing, but at a slower pace, which is depicted by the light blue dotted line of the trend.

Gray line Y represents the regression equation, which illustrates increases from 1,100.0 billion tenge to 2,090.1 billion tenge, and a positive forecast in perspective, which will lead to the positive socio-economic development of the North Kazakhstan region in the future.

3. Research results

Based on presented analysis results are summarized in one table (Table 1).

Table 1 demonstrates that, across all regression equations, fixed capital investment ($\bar{X}_1$) exerts a consistently positive and often substantial impact. The coefficients range from moderate values (1.3–2.4) in some SEZs to very high ones (8.0–10.5) in "Saryarka" and "PIT." This finding highlights the critical

role of capital formation in driving GRP growth: expanding physical capital enhances production capacity, stimulates demand for complementary services, and generates higher added value at the regional level.

SEZ-specific investments ($\bar{X}_2$) also exhibit a strong positive effect in a number of cases ("Astana – Technopolis" – 12.1; "Astana - New City" – 19.9; "Ontustik" – 41.2; "Jibek Joly" – 14.0). These results suggest that targeted investments within SEZs - supported by preferential regimes and dedicated infrastructure - may generate higher returns compared to general fixed capital investment. This effect is largely explained by clustering, agglomeration dynamics, and institutional support mechanisms that foster structured growth of regional value added. Conversely, some SEZs reveal either negligible coefficients ("Khorgos-Eastern Gate" – 0.2; "ICBC Khorgos" – 0.6) or extremely large, likely anomalous ones ("PIT" – 250.0), indicating possible data or specification issues.

Table 1. Average value of the indicators (GRP, fixed capital investment and SEZ, created jobs) until 2023 and regression equation (function of dependence of GRP on investments and jobs)*

Name of SEZ	$\bar{Y}$	$\bar{X}_1$	$\bar{X}_2$	$\bar{X}_3$	β_1	β_2	β_3	Regression Equation
SEZ "Astana – Technopolis"	8 686,9	1 201,6	13,0	45,0	5,2	12,1	7,8	$Y = 1.200.0 + 5.2X_1 + 12.1X_2 + 7.8X_3$
SEZ "Astana - New City"	3 966,4	663,5	81,3	227,4	1,6	19,9	0,9	$Y = -179.6 + 1.6X_1 + 19.9X_2 + 0.9X_3$
SEZ "TURAN"	2 739,9	635,6	168,7	989,2	2,0	0,4	0,3	$Y = 1,375.1 + 2.0X_1 + 0.4X_2 + 0.3X_3$
SEZ "Seaport Aktau"	2 129,0	431,8	32,3	218,0	2,4	4,2	0,9	$Y = 150.4 + 2.4X_1 + 4.2X_2 + 0.9X_3$
SEZ "Saryarka"	4 282,0	523,8	29,9	396,9	8,0	8,2	1,3	$Y = -301.5 + 8.0X_1 + 8.2X_2 + 1.3X_3$
SEZ "Pavlodar"	2 621,4	460,1	19,8	148,1	5,9	1,7	-1,4	$Y = 2,621.4 + 5.9X_1 + 1.7X_2 - 1.4X_3$
SEZ "PIT"	8 287,5	643,4	11,3	173,3	10,5	250	5,2	$Y = 200.0 + 10.5X_1 + 250.5X_2 + 5.2X_3$
SEZ "ICBC Khorgos"	1 244,9	243,5	26,4	285,7	2,1	0,6	0,5	$Y = 539.2 + 2.1X_1 + 0.8X_2 + 0.5X_3$
SEZ "Khorgos - Eastern Gate"	1 398,9	276,5	8,4	425,8	1,5	0,2	0,8	$Y = 331.2 + 1.5X_1 + 0.2X_2 + 0.8X_3$
SEZ "Ontustik"	1 327,4	213,1	5,3	108,4	2,9	41,2	1,2	$Y = 12.5 + 2.9X_1 + 41.2X_2 + 1.2X_3$
SEZ "Jibek Joly"	1 609,2	293,4	6,8	150,0	3,4	14,0	1,7	$Y = 406.7 + 3.4X_1 + 14X_2 + 1.7X_3$
SEZ "Qyzyljar"	1 764,2	313,4	5,5	554,3	6,5	-17,4	0,0	$Y = 1,100.1 + 1.5X_1 + 18X_2 + 0.2X_3$
SEZ "NINT"	3 279,2	2 005,4	97,2	66,8	1,3	19,9	-0,8	$Y = 1,622.8 + 1.3X_1 + 19.9X_2 - 0.8X_3$

Note: * - excluding SEZ "Alatau", established in 2024

Source: Bureau of National statistics, Agency for Strategic planning and reforms of the Republic of Kazakhstan 2024; National Report on the State of Industry of the Republic of Kazakhstan 2023, Regression equation formed by the authors

Employment creation ($\bar{X}_3$) generally contributes positively, with coefficients in the range of 0.3–1.7. This reflects the conventional pathway through which job creation boosts household incomes, stimulates consumption, increases tax revenues, and indirectly enhances GRP. Nevertheless, exceptions are observed: negative coefficients in Pavlodar ($\beta_3 = -1.4$) and NINT ($\beta_3 = -0.8$) suggest structural distortions, where new jobs may be concentrated in low-productivity or temporary occupations, thereby limiting their contribution to regional output and potentially diverting resources from more productive sectors.

From a policy perspective, the relative magnitudes of the coefficients are highly relevant. In SEZs where β_2 substantially

exceeds β_1 (e.g., "Astana-New City," "Ontustik," "Jibek Joly"), government support and targeted infrastructure investment deliver a higher GRP multiplier, emphasizing the importance of reinforcing investment incentives and sectoral clustering. By contrast, in zones characterized by a strong β_1 ("Saryarka," "PIT"), policies should focus on strengthening fixed capital formation - infrastructure, production facilities, and modernization - thereby ensuring rapid economic gains. In zones where the employment coefficient is small or negative, strategies should prioritize improving the quality of jobs, enhancing workforce skills, and aligning new employment with higher value-added sectors through stronger links between

business development and vocational training systems.

Overall, the results confirm that fixed capital investment, SEZ-targeted investment, and employment creation are all critical to GRP growth, yet their relative contributions differ across zones. To ensure sustainable socio-economic development, policy measures should be differentiated: reinforcing physical capital where β_1 is dominant, promoting cluster-based SEZ investments where β_2 is stronger, and enhancing the quality of employment so that β_3 evolves into a genuine source of income and consumption growth rather than a mere statistical indicator.

4. Discussion

Our empirical results - identifying a local rather than systemic effect of SEZs - are consistent with the existing literature by testing and specifying the hypotheses formulated in the literature review. The hypothesis about the positive impact of investments on GRP in general terms is partially confirmed: in our case, the effect exists, but it is spatially limited, whereas in studies focusing on successful cases (e.g., China), the effect is broader and systemic (Wang, 2013; Zeng, 2011), which is consistent with the idea that the return on investment in SEZs depends on the initial conditions of the region and is not uniform across territories. Our study does not so much refute general **conclusions** about the potential benefits of SEZs as it clarifies that SEZs can contribute to growth, but their effectiveness is highly dependent on initial conditions and institutional integration; without mechanisms for “extending” benefits beyond the perimeter of the zone and without a proper assessment of the budgetary effectiveness, SEZs risk remaining localized and expensive initiatives; Kazakhstan needs monitoring tools

and indicators that allow linking investments in SEZs with real changes in GRP and measuring them against long-term public expenditures - thus we close a methodological and applied gap in the literature by proposing a quantitatively based approach to assessing the effectiveness of zones.

Conclusion

The conducted correlation-regression analysis of the special economic zones (SEZs) of Kazakhstan from their creation up to 2023 has revealed key trends and problematic aspects of their development. Overall, it has been established that the impact of SEZs on regional economies is uneven and depends on sectoral specialization, infrastructure development, and the quality of governance.

The analysis showed that the growth of the gross regional product (GRP) is directly linked to investments in fixed capital in most regions, which confirms the importance of capital investment for accelerating economic development. At the same time, the impact of investments directly into the SEZs varied: in special economic zones such as “Astana – New City”, “Pavlodar”, “Ontustik” and “Seaport Aktau”, their role in GRP growth was significantly stronger. In other cases, such as “Qyzyljar”, “PIT” and “Jibek Joly”, the effect of investments was limited, indicating a territorial disparity in SEZ performance.

Regarding employment, it was found that job creation does not always have a positive impact on economic growth. Sometimes employment growth even has a negative effect, as it often refers to low-productivity jobs. This highlights that for the economy, the quality of jobs - such as wage levels, labor productivity and technological intensity - is more important than their sheer quantity. Overall, it can be concluded that there is no

universal SEZ model for all regions. Their success depends on regional specificities: special economic zones with developed infrastructure generate a stable multiplier effect, while in agricultural and depressed areas, results are often limited.

Based on the analysis, the following recommendations were developed. In industrial regions, it is advisable to continue increasing investments in manufacturing and high-tech industries. In agricultural zones, the focus should be on agricultural product processing and logistics development. In SEZ operations, emphasis should be shifted from the number of jobs to their quality, including labor productivity, wage levels, and the implementation of innovations.

In addition, interregional linkages between SEZs should be strengthened so that multiplier effects spread more widely, and the specialization of each zone should be clarified to avoid sectoral duplication. In regions, where SEZs show low effectiveness, alternative support mechanisms should be used, such as subsidies for processing, development of cooperatives, and support for small and medium-sized enterprises.

In conclusion, it can be noted that Kazakhstan's SEZs exert diverse impacts on the socio-economic development of the regions. To achieve strategic goals, the country needs to move from a unified model to a regionally oriented approach, where the main priorities will be innovation, productivity growth, competitiveness, and investment attractiveness.

In general, special economic zones in Kazakhstan possess the potential for significant growth and possible influence on socio-economic development; however, to maximize results, a more systematic and

focused approach to their management and monitoring is required.

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Appendices

Appendix 1. SEZs in the Republic of Kazakhstan

	Name	Specialization	Location	Validity period
1.	SEZ “Astana - New City”	Food production, chemical industry, pharmaceuticals and machine building	Astana city	2001-2027
2.	SEZ “Seaport Aktau”	Warehousing and logistics, chemical and petrochemical industries, light industry, pharmaceuticals and machine building	Mangistau region	2003-2028
3.	SEZ “Park of Innovative Technologies (SEZ “PIT”)	New engineering and communication technologies, research and development (R&D) and machine building	Almaty	2003-2028
4.	SEZ “Ontustik”	Light and chemical industries, oil refining, production of construction metal structures and machinery manufacturing	Shymkent	2005-2030
5.	SEZ “National Industrial Petrochemical Technopark” (SEZ “NINT”)	Chemical and petrochemical industries as well as the light industry	Atyrau region	2007-2032
6.	SEZ “Khorgos – Eastern Gate”	Warehousing and logistics, food, light, and chemical industries, production of construction materials, finished metal products, machinery manufacturing and fish farming	Zhetisu region	2011-2035
7.	SEZ “Saryarka”	Mechanical engineering, metallurgy and chemical industry	Karaganda region	2011-2036
8.	SEZ “Pavlodar”	Chemical and petrochemical industries	Pavlodar region	2011-2036
9.	SEZ “Jibek Joly”	Chemical industry, production of construction materials, and machinery and equipment for chemical industries	Zhambyl region	2012-2037
10.	SEZ “International Centre for Cross-Border Cooperation “Khorgos” (SEZ “ICBC “Khorgos”)	Development of cross-border trade and economic cooperation, activation of the entrepreneurial and investment environment, development of transport infrastructure, and tourism		2017-2041
11.	SEZ “Astana-Technopolis”	Production of foodstuffs, pharmaceuticals, glass and glass products, construction materials, finished metal products, and mechanical engineering	Astana	2017-2042
12.	SEZ “Turan”	Construction of Turkestan International Airport, tourist accommodations, sanatorium and recreational facilities, social infrastructure, administrative and residential complexes, and the production of construction materials	Turkestan region	2018-2043
13.	SEZ “Qyzyljar”	Food industry, production of construction materials, furniture, electronics and electrical equipment, and mechanical engineering	North Kazakhstan region	2019-2044
14.	SEZ “Alatau”	Mechanical engineering, metallurgy, food production, and the production of construction materials	Almaty region	2024-2048

Appendix 2. Macroeconomic indicators of Atyrau region and SEZ “NINT” for the years 2007-2023

Year	Y (GRP, billion tenge)	X ₁ (Fixed capital investment, billion tenge)	X ₂ (Investments in SEZ “NINT”, billion tenge)	X ₃ (Created jobs, units)
2007	1 234,0	764,4	0,8	0
2008	1 798,5	826,4	1,0	23
2009	1 969,9	1 094,4	1,7	11
2010	2 843,6	1 105,4	2,3	42
2011	3 791,6	1 077,0	5,4	15
2012	3 613,4	1 034,0	10,0	64
2013	3 977,4	1 038,4	18,2	39
2014	4 340,6	1 129,6	25,0	98
2015	4 216,8	1 470,3	35,1	47
2016	5 200,7	2 036,9	55,6	182
2017	5 947,7	2 468,6	80,3	73
2018	7 818,8	3 691,4	110,0	24
2019	9 327,3	4 328,2	149,2	0
2020	7 738,2	3 179,0	250,6	252
2021	10 627,6	2 910,1	297,5	12
2022	13 725,4	3 003,5	167,5	106
2023	14 327,3	2 934,8	441,5	148

Appendix 3. Macroeconomic indicators of Astana and SEZ “Astana-Technopolis” for the years 2017-2023

Year	Y (GRP, billion tenge)	X ₁ (Fixed capital investment, billion tenge)	X ₂ (Investments in SEZ “Astana-Technopolis”, billion tenge)	X ₃ (Created jobs, units)
2017	5 775,6	956,9	0,0	0
2018	6 706,0	1 067,5	34,06	5
2019	7 834,8	919,1	0,3	20
2020	7 975,3	1 125,2	1,1	15
2021	8 923,7	1 225,0	9,9	45
2022	10 672,5	1 462,5	17,2	30
2023	12 875,0	1 655,0	28,6	200

Appendix 4. Macroeconomic indicators of Astana city and SEZ “Astana - New City” for the years 2001-2023

Year	Y (GRP, billion tenge)	X ₁ (Fixed capital investment, billion tenge)	X ₂ (Investments in SEZ “Astana - New City”, billion tenge)	X ₃ (Created jobs, units)
2001	204,4	89,5	0,0	0
2002	230,7	102,6	5,2	50
2003	302,2	137,9	12,8	70
2004	468,8	220,6	18,5	80
2005	711,6	274,7	24,7	110
2006	957,1	354,6	31,3	140
2007	1 134,2	424,2	39,6	150
2008	1 291,8	454,5	48,1	180
2009	1 373,2	368,2	56,7	200
2010	1 774,2	396,6	65,4	220
2011	2 145,9	572,2	74,3	250
2012	2 646,4	617,5	83,5	280
2013	3 483,3	547,5	93,0	290
2014	4 019,6	646,6	103,2	310
2015	4 809,6	782,3	150,0	320
2016	4 865,3	858,7	178,5	230
2017	5 775,6	956,9	210,0	250
2018	6 706,0	1 067,5	245,0	150
2019	7 834,8	919,1	280,0	99
2020	7 975,3	1 125,2	320,0	251
2021	8 923,7	1 225,0	370,0	300
2022	10 672,5	1 462,5	420,0	400
2023	12 875,0	1 655,0	480,0	900

Appendix 5. Macroeconomic indicators of Turkestan region and SEZ “Turan” for the years 2018-2023

Year	Y (GRP, billion tenge)	X ₁ (Fixed capital investment, billion tenge)	X ₂ (Investments in SEZ “Turan”, billion tenge)	X ₃ (Created jobs, units)
2018	1 660,0	314,1	525,6	1 630
2019	2 016,1	443,5	10,1	1 083
2020	2 384,2	705,7	147,3	608
2021	2 808,0	659,1	207,0	619
2022	3 517,3	742,6	57,4	690
2023	4 054,0	948,8	64,6	1 305

Appendix 6. Macroeconomic indicators of Mangistau region and SEZ “Seaport Aktau” for the years 2003-2023

Year	Y (GRP, billion tenge)	X ₁ (Fixed capital investment, billion tenge)	X ₂ (Investments in SEZ “Seaport Aktau”, billion tenge)	X ₃ (Created jobs, units)
2003	218,0	75,4	0,5	12
2004	295,8	100,5	0,5	17
2005	432,2	143,1	0,5	23
2006	594,0	229,8	1,0	31
2007	756,6	251,4	2,0	42
2008	1 095,8	383,2	1,0	56
2009	1 108,5	314,7	2,0	63
2010	1 484,8	372,0	2,0	78
2011	1 867,9	369,6	2,5	91
2012	1 764,8	396,4	5,5	127
2013	2 075,1	440,0	6,0	153
2014	2 418,2	532,2	7,6	198
2015	2 123,8	459,0	223,0	1 827
2016	2 463,4	405,6	40,0	347
2017	3 274,5	434,4	35,0	309
2018	3 476,7	504,6	25,0	263
2019	3 685,4	556,6	49,0	412
2020	3 074,4	582,3	15,0	123
2021	3 627,0	629,1	15,0	137
2022	4 401,2	785,8	10,0	141
2023	4 798,7	1 102,2	10,0	129

Appendix 7. Macroeconomic indicators of Karaganda region and SEZ “Saryarka” for the years 2011-2023

Year	Y (GRP, billion tenge)	X ₁ (Fixed capital investment, billion tenge)	X ₂ (Investments in SEZ “Saryarka”, billion tenge)	X ₃ (Created jobs, units)
2011	2 387,7	253,0	25,0	200
2012	2 446,5	323,8	10,0	300
2013	2 621,9	405,0	15,0	500
2014	2 900,0	411,9	3,1	350
2015	3 107,1	343,4	36,5	200
2016	3 712,1	317,6	73,1	500
2017	4 284,4	363,3	20	400
2018	4 734,4	489,0	30	689
2019	5 388,3	811,4	1,6	100
2020	6 099,9	692,3	1,9	645
2021	7 446,3	796,9	12,6	800
2022	7 278,1	724,9	6,2	200
2023	8 128,8	876,5	154,1	276

Appendix 8. Macroeconomic indicators of Pavlodar region and SEZ “Pavlodar” for the years 2011-2023

Year	Y (GRP, billion tenge)	X ₁ (Fixed capital investment, billion tenge)	X ₂ (Investments in SEZ “Pavlodar”, billion tenge)	X ₃ (Created jobs, units)
2011	1 520,5	207,7	0,5	0
2012	1 520,6	263,5	2,0	50
2013	1 758,1	276,2	4,0	70
2014	1 746,8	353,1	6,0	100
2015	1 736,2	451,7	9,0	130
2016	1 975,5	439,8	12,0	150
2017	2 369,3	483,8	50,2	220
2018	2 746,7	412,0	65,6	230
2019	3 029,6	494,6	9,0	250
2020	3 120,1	487,2	4,4	150
2021	3 883,8	571,9	4,6	100
2022	4 296,9	742,8	3,8	100
2023	4 371,0	797,5	86,7	375

Appendix 9. Macroeconomic indicators of Almaty city and SEZ “PIT” for the years 2003-2023

Year	Y (GRP, billion tenge)	X ₁ (Fixed capital investment, billion tenge)	X ₂ (Investments in SEZ “PIT”, billion tenge)	X ₃ (Created jobs, units)
2003	808,8	166,2	0,5	50
2004	1 102,2	278,5	0,8	30
2005	1 497,4	334,2	2,0	40
2006	2 272,7	417,4	3,0	60
2007	2 675,9	492,8	4,5	90
2008	2 949,6	485,1	3,8	70
2009	3 175,2	382,7	5,0	100
2010	3 923,4	398,4	6,5	50
2011	4 860,2	415,4	8,0	100
2012	5 715,9	458,3	9,5	100
2013	7 127,9	482,9	10,5	150
2014	8 143,6	511,6	12	150
2015	9 100,0	533,4	14,0	150
2016	10 601,3	581,6	16,0	200
2017	11 893,2	644,4	18,5	300
2018	12 132,60	732,9	18,5	400
2019	13 547,0	820,4	20,0	200
2020	13 459,8	976,8	21,0	200
2021	15 000,1	1 187,6	23,0	300
2022	19 154,6	1 408,0	25,0	500
2023	24 895,9	1 803,2	28,0	400

Appendix 10. Macroeconomic indicators of Zhetisu region and SEZ “ICBC “Khorgos” for the years 2017-2023

Year	Y (GRP, billion tenge)	X ₁ (Fixed capital investment, billion tenge)	X ₂ (Investments in SEZ “ICBC “Khorgos”, billion tenge)	X ₃ (Created jobs, units)
2017	846,3	184,2	0,0	0
2018	952,0	197,1	55,0	600
2019	1 086,2	216,6	100	400
2020	1 218,8	222,9	20,0	200
2021	1 476,8	235,1	2,0	300
2022	1 426,9	292,0	0,0	300
2023	1 707,4	356,7	7,7	200

Appendix 11. Macroeconomic indicators of Zhetisu region and SEZ “Khorgos – Eastern Gate” for the years 2011-2023

Year	Y (GRP, billion tenge)	X ₁ (Fixed capital investment, billion tenge)	X ₂ (Investments in SEZ “Khorgos – Eastern Gate”, billion tenge)	X ₃ (Created jobs, units)
2011	486,8	146,8	0,0	0
2012	558,3	148,0	0,5	5
2013	660,0	163,4	1,0	30
2014	711,2	168,7	10,9	80
2015	726,4	180,4	10,0	150
2016	791,5	191,1	5,0	240
2017	846,3	184,2	5,0	380
2018	952,0	197,1	22,0	500
2019	1 086,2	216,6	2,5	600
2020	1 218,8	222,9	0,6	700
2021	1 476,8	235,1	1,3	820
2022	1 426,9	292,0	2,3	980
2023	1 707,4	356,7	48,3	1 050

Appendix 12. Macroeconomic indicators of Shymkent city and SEZ “Ontustik” for the years 2003-2023

Year	Y (GRP, billion tenge)	X ₁ (Fixed capital investment, billion tenge)	X ₂ (Investments in SEZ “Ontustik”, billion tenge)	X ₃ (Created jobs, units)
2005	85,1	36,8	0,47	21
2006	99,8	38,2	0,82	36
2007	143,4	46,9	1,18	53
2008	174,0	48,5	1,53	62
2009	218,8	53,0	0,97	41
2010	358,0	59,1	2,03	79
2011	423,5	90,3	2,48	87
2012	611,8	96,5	2,95	102
2013	731,4	98,5	3,42	111
2014	925,5	172,7	3,87	123
2015	1 205,3	201,3	4,41	131
2016	1 512,6	158,1	5,03	142
2017	1 868,7	214,2	6,12	151

Year	Y (GRP, billion tenge)	X ₁ (Fixed capital investment, billion tenge)	X ₂ (Investments in SEZ "Ontustik", billion tenge)	X ₃ (Created jobs, units)
2018	2 174,1	588,0	6,48	163
2019	2 203,0	195,0	7,05	171
2020	2 493,2	278,7	5,47	133
2021	2 671,5	462,5	6,03	141
2022	3 294,4	549,6	6,98	157
2023	4 079,8	661,7	7,44	156

Appendix 13. Macroeconomic indicators of Zhambyl region and SEZ "Jibek Joly" for the years 2012-2023

Year	Y (GRP, billion tenge)	X ₁ (Fixed capital investment, billion tenge)	X ₂ (Investments in SEZ "Jibek Joly", billion tenge)	X ₃ (Created jobs, units)
2012	760,4	152,4	0,0	0
2013	876,7	248,8	0,5	20
2014	979,7	208,6	1,8	30
2015	1 014,5	194,3	4,0	50
2016	1 182,8	215,9	7,5	100
2017	1 350,7	225,9	12,0	150
2018	1 532,1	264,5	18,0	150
2019	1 712,9	296,4	3,6	200
2020	1 901,4	350,1	0,8	200
2021	2 262,8	398,6	6,6	300
2022	2 685,5	428,5	1,3	300
2023	3 051,6	536,6	25,8	300

Appendix 14. Macroeconomic indicators of North Kazakhstan region and SEZ "Qyzyljar" for the years 2018-2023

Year	Y (GRP, billion tenge)	X ₁ (Fixed capital investment, billion tenge)	X ₂ (Investments in SEZ "Qyzyljar", billion tenge)	X ₃ (Created jobs, units)
2018	1 212,0	214,2	0,02	500
2019	1 382,3	234,5	0,05	2 508
2020	1 571,9	286,3	2,0	2 030
2021	1 790,8	333,1	12,7	4 000
2022	2 198,9	368,5	3,3	1 588
2023	2 429,2	443,7	14,7	1 500

Appendix 15. Correlation and regression analysis

Multiple linear regression model

$$Y = \beta_0 + \beta_1 \cdot X_1 + \beta_2 \cdot X_2 + \beta_3 \cdot X_3 + \varepsilon \quad (1)$$

where β_0 – constant term equal to the GRP when investments are zero, $\beta_0 = \bar{Y} - \beta_1 \cdot \bar{X}_1 - \beta_2 \cdot \bar{X}_2$; β_1, β_2 and β_3 – regression coefficients or coefficients indicating the impact of changes in investment volume on changes in GRP.

Matrix form: Y - vector of observations (GRP), X - matrix of factors (with a constant), β - vector of coefficients, ε - vector of errors.

$$Y = X \cdot \beta + \varepsilon \quad (2)$$

where

$$X = \begin{bmatrix} 1 & X_{11} & X_{21} & X_{31} \\ 1 & X_{12} & X_{22} & X_{32} \\ \vdots & \vdots & \vdots & \vdots \\ 1 & X_{1n} & X_{2n} & X_{3n} \end{bmatrix}, \quad \beta = \begin{bmatrix} \beta_0 \\ \beta_1 \\ \beta_2 \\ \beta_3 \end{bmatrix} \quad (3)$$

Estimation of coefficients by the method of least squares (LSM)

$$\hat{\beta} = (X^T X)^{-1} X^T \quad (4)$$

while the constant term is calculated by the formula

$$\beta_0 = \bar{Y} - \beta_1 \cdot \bar{X}_1 - \beta_2 \cdot \bar{X}_2 - \beta_3 \cdot \bar{X}_3 \quad (5)$$

where $\bar{Y}, \bar{X}_1, \bar{X}_2, \bar{X}_3$ – mean values.

For the remaining coefficients

$$\begin{bmatrix} \beta_1 \\ \beta_2 \\ \beta_3 \end{bmatrix} = \left(\begin{bmatrix} \sum X_1^2 & \sum X_1 X_2 & \sum X_1 X_3 \\ \sum X_2 X_1 & \sum X_2^2 & \sum X_2 X_3 \\ \sum X_3 X_1 & \sum X_3 X_2 & \sum X_3^2 \end{bmatrix} \right)^{-1} \cdot \begin{bmatrix} \sum X_1 Y \\ \sum X_2 Y \\ \sum X_3 Y \end{bmatrix} \quad (6)$$