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G.Zh. Doskeyeva[1], A.O. Ongdash[1]*,
A.K. Boranbayeva[2], V.N. Seitova[3]

[1]Narxoz University, Almaty, Kazakhstan
[2]Al-Farabi Kazakh National University, Almaty, Kazakhstan
[3]M. Auezov South Kazakhstan University, Shymkent, Kazakhstan
*e-mail: ainur.ongdash@narxoz.kz

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.

Г.Ж. Доскеева[1], А.О. Оңдаш[1]*,
А.К. Боранбаева[2], В.Н. Сейтова[3]

[1]Нархоз университеті, Алматы, Қазақстан
[2]Әл-Фараби атындағы Қазақ ұлттық университеті, Алматы, Қазақстан
[3]М. Әуезов атындағы Оңтүстік Қазақстан университеті, Шымкент, Қазақстан
*e-mail: ainur.ongdash@narxoz.kz

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 сарапануын зерттеу үшін пайдаланылады.

Нәтижелер мемлекеттік бағдарламалар мен өңірлік экономикалық өсім арасындағы оң, алайда әркелкі байланысты көрсетеді және бағдарламалардың тиімділігі қаржыландыру көлемімен қатар институционалдық жағдайларға, бағдарламалардың дизайнына және өңірлік экономиканың құрылымына тәуелді екенін айқындайды. Зерттеудің ғылыми үлесі өңірлік әркелкілік 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 әркелкілік, Қазақстан Республикасы.

Г.Ж. Доскеева[1], А.О. Оңдаш[1]*,
А.К. Боранбаева[2], В.Н. Сейтова[3]

[1]Университет Нархоз, Алматы, Казахстан
[2]Казахский национальный университет имени аль-Фараби, Алматы, Казахстан
[3]Южно-Казахстанский университет имени М. Ауэзова, Шымкент, Казахстан
*e-mail: ainur.ongdash@narxoz.kz

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, ensuring 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 different 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.

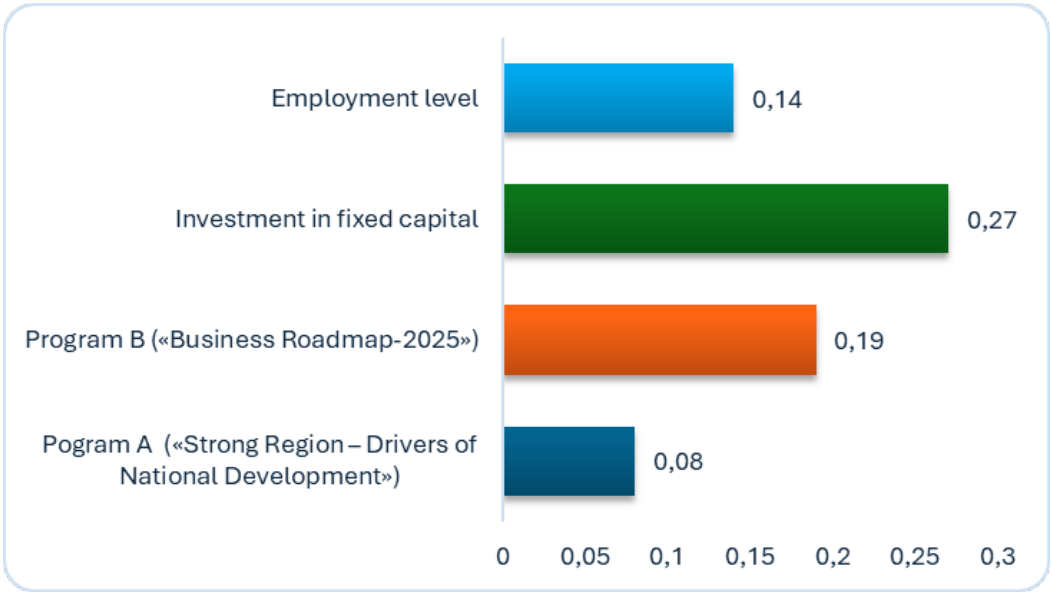
Overall, the regression results indicate that the effectiveness of state regional development programs varies across policy instruments. Program outcomes depend not only on the volume of public expenditures but also on the design of program mechanisms and their alignment with regional economic structures. 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-

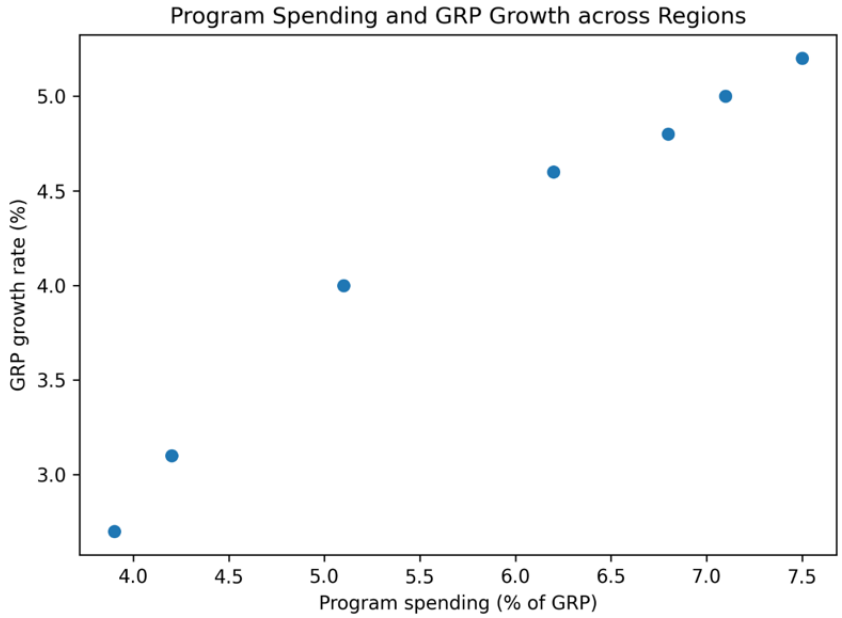
plays a more moderate influence. The relative positioning of coefficients in the figure underscores that growth outcomes are driven by a combination of investment dynamics, labor market conditions, and program design rather than by public expenditures alone.

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 accompanied by favorable investment and labor market dynamics.

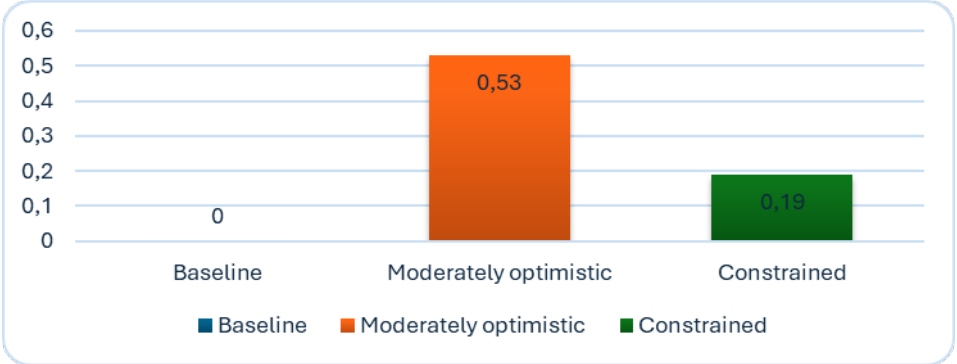
In contrast, the constrained scenario produces a markedly smaller effect of 0.19 percentage points. Despite an identical increase in program expenditures, the absence of complementary investment and employment responses limits the overall growth impact. This outcome highlights the restricted effectiveness 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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Information about the authors:

Doskeyeva Gulashar Zharmagambetovna – doctor of economic sciences, professor at the School of Law and Public Administration, Narxoz University (Almaty, Kazakhstan, e-mail: gulashar.doskeeva@narxoz.kz).

Ongdash Ainur Ongdashkyzy – PhD, Associate Professor at the School of Law and Public Administration, Narxoz University (Almaty, Kazakhstan, e-mail: ainur.ongdash@narxoz.kz).

Boranbayeva Ainur Kanatovna – PhD, Senior Lecturer at the Department of Finance and Accounting, Higher School of Economics and Business, Al-Farabi Kazakh National University (Almaty, Kazakhstan, e-mail: boranbaeva7777@gmail.com).

Vilena Nurgalievna Seitova – PhD, Associate Professor of the Department of Economic Theory, Higher School of Business and Management, M. Auezov South Kazakhstan University (Shymkent, Kazakhstan, e-mail: Vilena_11@mail.ru).

Авторлар туралы мәлімет:

Доскеева Гүлашар Жармагамбетқызы – экономика ғылымдарының докторы, Құқық және мемлекеттік басқару мектебінің профессоры, Нархоз университеті (Алматы, Қазақстан, e-mail: gulashar.doskeeva@narxoz.kz).

Оңдаш Айнур Оңдашқызы – PhD, Құқық және мемлекеттік басқару мектебінің қауымдастырылған профессоры, Нархоз университеті (Алматы, Қазақстан, e-mail: ainur.ongdash@narxoz.kz).

Боранбаева Айнур Қанатқызы – PhD докторы, «Қаржы және есеп» кафедрасының аға оқытушысы, Экономика және бизнес жоғары мектебі, Әл-Фараби атындағы Қазақ ұлттық университеті (Алматы, Қазақстан, e-mail: boranbaeva7777@gmail.com).

Сейтова Вилена Нургалиевна – PhD, Бизнес және басқару мектебі, Экономикалық теория кафедрасының қауымдастырылған профессоры, М. Әуезов атындағы Оңтүстік Қазақстан университеті (Шымкент, Қазақстан, e-mail: Vilena_11@mail.ru).

Сведения об авторах:

Доскеева Гулашар Жармагамбетовна – доктор экономических наук, профессор Школы права и государственного управления, Университет Нархоз (Алматы, Казахстан, e-mail: gulashar.doskeeva@narxoz.kz).

Оңдаш Айнур Оңдашқызы – PhD, ассоциированный профессор Школы права и государственного управления, Университет Нархоз (Алматы, Казахстан, e-mail: ainur.ongdash@narxoz.kz).

Боранбаева Айнур Канатовна – доктор PhD, старший преподаватель кафедры «Финансы и учет», Высшая школа экономики и бизнеса, Казахский национальный университет имени Аль-Фараби (Алматы, Казахстан, e-mail: boranbaeva7777@gmail.com).

Сейтова Вилена Нургалиевна – PhD, ассоциированный профессор кафедры экономической теории, Высшей школы Бизнеса и управления, Южно-Казахстанский университет им. М. Ауэзова (Шымкент, Казахстан, e-mail: Vilena_11@mail.ru).

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