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Secondary Education Financing in Kazakhstan: Challenges and Efficiency

Marzhan U. Daurbaeva [1] | Elmira E. Zhussipova [1] | Asem A. Dossaliyeva [1]* Sultanpatsha S. Ubaeva [2]

[1]M. Auezov South Kazakhstan University, Shymkent, Kazakhstan.
[2]Joint Belarusian-Uzbek

Intersectoral Institute of Applied and Technical Qualifications, Tashkent, Uzbekistan.

Correspondence
*Asem A. Dossaliyeva – PhD student, M. Auezov South Kazakhstan University, Shymkent, Kazakhstan.
Email: asem.0702@mail.ru

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Abstract
In the context of the transition to a knowledge economy and the increasing demands on the quality of human capital, the effectiveness of financing secondary education is becoming particularly relevant. The aim of the study is to assess the impact of financing mechanisms for secondary education on the quality of educational outcomes in Kazakhstan, considering infrastructural, human, and digital factors. The methodological basis of the research includes methods of descriptive statistics, correlation analysis, econometric modeling, and performance analysis. The empirical database is based on panel data for 17 regions of Kazakhstan for the period 2015–2025. The results of the study revealed a stable positive relationship between financing and the quality of education. Digitalization ($\beta = 3.45$) and infrastructure ($\beta = 2.63$) had the greatest impact, whereas the impact of financial expenses was more moderate ($\beta = 1.92$). The burden on teachers has a statistically significant negative impact ($\beta = -1.08$). The high coefficient of determination ($R^2 = 0.84$) confirms the model's significant explanatory power. The results of the DEA analysis demonstrate pronounced regional differentiation in efficiency, with Almaty (0.92) and Astana (0.90) occupying the leading positions, while the southern and western regions exhibit lower efficiency. The results show that financing is a necessary but insufficient condition for improving the quality of education. The research contributes to the development of the theory of educational financing by demonstrating the need to transition to an integrated resource management model focused on the effectiveness and quality of educational outcomes.

KEYWORDS
Education, education quality, secondary education, education economics, human capital, region, regional development, economic efficiency

1 | INTRODUCTION

In the context of the transition to a knowledge economy and increasing global competition for human capital, the education system is becoming a key factor in long-term socio-economic development. In this regard, the effectiveness of education financing is of particular importance, since it is through resource allocation mechanisms that conditions are created to improve the quality of educational outcomes, develop cognitive skills, and ensure social mobility. The transition to a knowledge economy increases the demands on the quality, accessibility, and effectiveness of education, making the issues of financing the educational system particularly relevant. It is through financing mechanisms that the state creates conditions for the functioning of educational institutions, infrastructure development, teacher training, and the introduction of digital technologies.

In recent years, scientific research has increasingly raised the issue that increased spending on education alone does not guarantee improved educational outcomes. Within the framework of the classical theory of human capital, education is considered an investment that increases labour productivity and income (Becker, 1964; Mincer, 1974). In the macroeconomic context, this idea has been developed in economic growth models, where human capital is considered one of the key factors determining differences in countries' levels of development (Mankiw et al., 1992).

However, recent research shows that increased education funding does not always lead to improved educational outcomes (Pritchett, 2001; Afonso, 2006). At the same time, the quality of education is of particular importance and has a more significant impact on economic growth than its quantitative characteristics (Hanushek & Woessmann, 2015; Goczek et al., 2021). Research shows that the effectiveness of an educational system is determined not only by the volume of resources, but also by the conditions of their use, including institutional mechanisms, the quality of management, and the level of development of the educational environment (Churchill et al., 2015; Psacharopoulos & Patrinos, 2018). In recent decades, the scientific agenda has shifted from analysing funding levels to researching the effectiveness and efficiency of funding. The educational system is increasingly viewed as a multicomponent structure that includes not only financial resources, but also infrastructure, human resources, and the level of digitalization. In this context, the digital transformation of education is particularly important, as it increases the availability of educational resources, optimises learning and management processes, and reduces transaction costs.

The relevance of this study to Kazakhstan lies in the country's education system, which is undergoing active transformation and is heavily dependent on government funding. In recent years, education spending has increased, but a corresponding improvement in educational outcomes has not always followed. One of the reasons is the uneven distribution of resources between regions, as well as differences in infrastructure development and access to modern educational technologies. The process of digitalising education creates additional complexity that develops unevenly and requires both a technical foundation and relevant competencies from teachers. In an environment where digital solutions are being implemented faster than the skills to use them effectively are being developed, their potential is not being fully realized.

Despite the existence of a significant number of studies on education financing, most focus on specific aspects of the problem. At the same time, the complex impact of financial, infrastructural, and digital factors on the quality of educational outcomes, considering regional specifics, remains insufficiently studied. In addition, limited attention is paid to assessing the effectiveness of resource use in the territorial context. In this regard, the purpose of this study is to assess the impact of financing mechanisms for secondary education

on the quality of educational outcomes in Kazakhstan, considering infrastructural, human, and digital factors. To achieve this goal, a comprehensive methodological approach is used, including descriptive statistics, correlation analysis, econometric modelling, and efficiency assessment based on the Data Envelopment Analysis (hereinafter – DEA) method. The empirical basis of the study is panel data on Kazakhstan's regions for the period 2015-2025, which allows us to account for both temporal dynamics and interregional differences.

2 | LITERATURE REVIEW

Studying the mechanisms of financing secondary education in modern conditions requires a comprehensive theoretical and methodological approach that integrates classical economic concepts with contemporary institutional and empirical research. The evolution of scientific thought demonstrates a gradual transition from viewing education as a factor in human capital accumulation to considering it a complex system encompassing financial, institutional, infrastructural, and digital components. In this context, education financing is considered not only a tool for providing resources, but also a key mechanism for generating long-term economic growth, social mobility, and sustainable development.

The classical starting point for the analysis of education financing is the theory of human capital, formed in the works of Gary Becker and Theodore Schultz. According to this theory, investments in education are a form of investment that brings economic returns in the form of increased labor productivity and income (Becker, 1964; Schultz, 1961). Empirical studies confirm that education is one of the most stable factors explaining income differences at both the individual and macroeconomic levels (Mincer, 1974).

In the macroeconomic context, economic growth models have integrated human capital into the production function, demonstrating its key role in explaining cross-country differences in levels of development (Mankiw et al., 1992). However, subsequent studies have shown that increases in education levels and related costs are not always accompanied by proportional increases in economic and educational outcomes (Devarajan et al., 1996; Krueger, 1999). Afonso (2006) showed that, at the same level of funding, countries and regions exhibit different efficiencies in converting resources into educational outcomes. An increase in costs leads to a decrease in the marginal effect, especially when a certain level of the education system's resource provision is reached (Barro and Lee, 2013). This indicates that the effectiveness of investments is determined not only by their volume, but also by the quality of the educational environment.

However, subsequent studies have significantly clarified this relationship. In particular, it has been shown that quantitative indicators of education are less significant than qualitative characteristics, particularly students' cognitive skills (Checchi, 2006; Rao and Jani, 2008; Hanushek and Woessmann, 2012). Moreover, research shows that the quality of education, rather than its duration, has a statistically significant impact on economic growth (Goczek et al., 2021; Hanushek and Woessmann, 2015). This indicates the need to rethink the role of education financing, shifting the focus from the number of resources to their effectiveness.

The next stage in the development of scientific thought concerns the analysis of the role of government spending in education. The results of empirical and generalizing studies show that increased spending on education does not always lead to improved educational outcomes or accelerated economic growth (Easterly, 2001; Pritchett, 2001). However, the key issue is not only the amount of funding, but also its effectiveness. A meta-analysis of empirical research shows that increased spending on education does not always lead to improved educational outcomes or economic growth (Benos, 2014). Thus, the quality of education is of key importance not only in terms of macroeconomic effects, but also at the

level of behavior of economic agents (Koning and Wiel, 2013).

This phenomenon is explained by the influence of institutional factors. In particular, it has been shown that the effectiveness of educational expenditures depends on the quality of management, the structure of resource allocation and the institutional environment (Churchill et al., 2015; Psacharopoulos and Patrinos, 2018). More recent research confirms that countries with comparable levels of funding exhibit significant differences in educational outcomes, pointing to the key role of institutional mechanisms and educational policies (Aghion et al., 2009; Woessmann, 2016; Schwerdt et al., 2020).

An important area of research is the analysis of the nonlinear nature of the impact of educational expenditure. Recent studies suggest that the relationship between spending and educational outcomes is heterogeneous and context-dependent, with additional investments not always leading to proportional improvements in performance (Schleicher, 2019; Carnoy et al., 2016). Moreover, recent cross-country analyses highlight that improvements in outcomes occur primarily when financial inputs are complemented by institutional reforms and system-level efficiency gains (Barrett et al., 2015; Kraft, 2019).

Modern research also highlights the role of infrastructure as one of the key factors of educational effectiveness. A well-developed material and technical base provides conditions for the implementation of educational programs and improving the quality of education (Goczek et al., 2021). Recent studies demonstrate that digital tools can significantly improve educational outcomes, especially in contexts with limited traditional resources, while also increasing flexibility and personalization of learning (Selwyn, 2019; Tran-Duong, 2022). Research showed that digitalization has a significant impact on educational outcomes, especially in conditions of limited traditional resources (Bulman and Fairlie, 2016; Winthrop et al., 2020). Moreover, contemporary empirical evidence suggests that digital technologies can amplify the impact of educational investments by serving as an efficiency multiplier when effectively integrated into teaching and learning processes (Reimers and Schleicher, 2020; Escueta et al., 2020; Zhao et al., 2021).

At the same time, the effectiveness of digitalization depends on the level of its integration and the availability of appropriate competencies among teachers. With insufficient training and infrastructure, digitalization may not lead to the expected results, which underscores the need for an integrated approach to reforming the educational system. A separate area of research is related to the analysis of educational inequality. It has been established that differences in access to educational resources lead to the reproduction of socio-economic inequalities (Blanden et al., 2022). Empirical evidence shows that unequal access to digital technologies and educational resources contributes to the persistence and reproduction of socio-economic disparities (Werfhorst et al., 2022). This is especially true in countries with economies in transition, where there is significant regional differentiation in funding levels, infrastructure, and the quality of education.

In the context of Kazakhstan, these problems are becoming particularly relevant. Modern research shows that the education financing system is characterized by high dependence on the state budget, as well as the presence of structural imbalances in the allocation of resources (Aryn and Issakhova, 2018; Zamirbekkyzy et al., 2024). At the same time, an increase in funding is not always accompanied by an increase in the quality of educational outcomes, which corresponds to the conclusions of international research. The effectiveness of the education system largely depends on the quality of implementation, the level of management practices and the institutional environment, which is especially typical for countries with economies in transition (Potluri and Mukashev, 2024). At the same time, research on the Kazakh education system highlights the influence of behavioral and structural factors,

including the choice of educational institutions and perceptions of their quality, which also reflect the system's heterogeneity and differences in access to educational resources (Jumasseitova et al., 2025).

Thus, modern scientific literature helped identify several key areas of analysis: (1) the role of education financing in the formation of human capital; (2) resource efficiency and institutional constraints; (3) the importance of infrastructure and digitalization; (4) the non-linear nature of the relationships; (5) regional differentiation of educational systems. Despite significant progress in the study of these issues, a scientific gap remains in the insufficient integration of financial, infrastructural, and digital factors into a single empirical model, especially in countries with economies in transition. In addition, there is a limited number of studies that take into account the spatial differentiation of the effectiveness of educational systems. Thus, the present study aims to fill this gap through a comprehensive analysis of the financing mechanisms of secondary education in the Republic of Kazakhstan using econometric methods, efficiency assessment and spatial approach.

3 | RESEARCH METHODS

In the context of the increasing burden on the secondary education system and the need to improve the efficiency of public resource use, a quantitative analysis of financing mechanisms is becoming particularly relevant. Unlike traditional approaches, which primarily focus on estimating budget expenditures, the modern scientific agenda focuses on the effectiveness and efficiency of allocating financial resources, as well as on identifying the relationship between investments in education and their final results.

The present study employs a comprehensive methodological approach that combines descriptive statistics, correlation analysis, econometric modeling, and performance evaluation. This approach makes it possible to account for both the temporal dynamics of indicators and interregional differences, and to identify structural relationships between financing and the quality of education.

The study's empirical base is panel data for 17 regions of the Republic of Kazakhstan for the period 2015–2025, yielding a balanced sample of 187 observations. Each observation is a region–year combination, which allows simultaneous analysis of temporal and spatial effects.

Within the framework of the study, the system of financing secondary education is considered a set of interrelated elements, including the number of financial resources, staffing, infrastructure, and the level of digitalization. Based on this concept, a system of variables has been developed to reflect the key characteristics of the educational system.

The dependent variable is an integral indicator of education quality, calculated as a composite index based on normalized components reflecting key educational outcomes by formula (1):

$$EduQuality_{\text{it}} = \frac{1}{n}\sum_{k=1}^{n} Z_{\text{kit}} \tag{1}$$

where:

$EduQuality_{\text{it}}$ – integral indicator of education quality in region i at time t;

Z_{kit} – normalized value of the k-th indicator included in the index;

n – number of indicators used to construct the index.

The constructed system of variables makes it possible to proceed to the analysis of their statistical properties and to assess the degree of variation. At this stage, descriptive statistics are applied to evaluate the range of indicator values, their dynamics, and interregional

differences. The results of the analysis indicate a steady increase in education expenditures and the level of digitalization, accompanied by a reduction in teacher workload and a gradual improvement in education quality. At the same time, significant regional disparities persist, indicating the heterogeneity of the secondary education system.

The correlation analysis is based on aggregated data for the period 2015–2025, which makes it possible to identify stable dependencies between financing, infrastructure, digitalization and the quality of education. However, this approach does not allow quantifying the impact of factors, which requires the use of econometric modeling.

To assess the impact of these factors on the quality of education, the following econometric model is specified by formula (2):

$$EduQuality_{it} = \alpha + \beta_1 EduExp_{it} + \beta_2 PTR_{it} + \beta_3 Infra_{it} + \beta_4 Digital_{it} + \mu_i + \varepsilon_{it} \quad (2)$$

where:
$EduQuality_{it}$ – education quality indicator;
$EduExp_{it}$ – education expenditures;
PTR_{it} – teacher workload (pupil–teacher ratio);
$Infra_{it}$ – infrastructure level;
$Digital_{it}$ – the level of digitalization;
μ_i – region-specific effects;
ε_{it} – stochastic error term.

The model parameters are estimated using panel data regression techniques based on the least squares method for the period 2015–2025. The use of panel data allows controlling for unobserved regional heterogeneity and capturing both temporal dynamics and cross-regional differences, which improves the robustness of the estimates. At the same time, regression analysis mainly reflects average relationships and does not allow assessing the efficiency of resource utilization. Therefore, the study additionally employs DEA, which enables the evaluation of the relative efficiency of regions.

Within the DEA framework, regions are treated as decision-making units (DMUs) that transform inputs into educational outcomes. The input variables include education expenditures, the pupil–teacher ratio, and infrastructure level, while the output variables are education quality and the level of digitalization.

An input-oriented DEA model with variable returns to scale (BCC model) is applied, and it is formulated by formula (3):

$$\min_{\theta,\lambda} \theta \quad (3)$$

where:
θ – the level of technical efficiency;
λ – intensity variables.

Thus, the combination of econometric and DEA approaches makes it possible to obtain a comprehensive assessment of the secondary education financing system, including both quantitative relationships and the efficiency of resource use. The minimization problem is solved subject to a system of constraints that ensure proportional reduction of inputs while maintaining at least the observed level of outputs and satisfying the convexity condition, as shown in (4):

$$\sum_{j=1}^{n} \lambda_j x_{ij} \le \theta x_{io}, \quad \sum_{j=1}^{n} \lambda_j y_{rj} \ge y_{ro}, \quad \sum_{j=1}^{n} \lambda_j = 1, \quad \lambda_j \ge 0 \quad (4)$$

where:

θ – the level of technical efficiency;

λ_j – intensity variables (weights) assigned to peer regions in the reference set;

x_{ij} – amount of the i-th input used by region j;

x_{io} – amount of the i-th input used by the evaluated region o;

y_{rj} – amount of the r-th output produced by region j;

y_{ro} – amount of the r-th output produced by the evaluated region o;

n – number of regions (decision-making units).

Despite the advantages of the proposed approach, several limitations should be noted. The use of aggregated regional data may mask intra-regional heterogeneity. In addition, the construction of composite indicators involves a degree of subjectivity. Furthermore, the model does not fully account for potential endogeneity and omitted variables, including institutional and behavioral factors that may influence educational outcomes. Nevertheless, the proposed methodological framework provides a consistent and empirically grounded basis for analyzing the financing of secondary education and can be extended in future research through the application of more advanced econometric techniques.

4 | RESULTS

An empirical analysis of the system of financing secondary education in the Republic of Kazakhstan for the period 2015–2025 indicates the formation of a stable development trajectory, accompanied by a structural transformation of the educational system and a change in the role of key factors determining the quality of educational outcomes. During the period under review, the development of the education system took place in the context of rising budget expenditures, accelerated digitalization and a gradual improvement in infrastructure provision, which together led to an improvement in the quality of education.

In this context, financing should be considered not only as a resource base for the functioning of the educational system, but also as an element of a more complex mechanism, in which its effectiveness is determined by the conditions of resource use and interaction with infrastructural and technological components. At the first stage of the analysis, the dynamics of key indicators of the education system was investigated. The results are presented in Table 1.

In 2015-2020, there has been a comprehensive improvement in both the quantitative and qualitative characteristics of the educational system. The integral indicator of the quality of education (Educality) shows a steady increase from 0.60 in 2015 to 0.82 in 2025, corresponding to a 36.7 p.p. increase. This indicates a gradual increase in the effectiveness of the educational system and an improvement in learning outcomes. At the same time, the per-pupil education expenditure (EduExp) has more than tripled, from 450 to 1,450, indicating a significant expansion of financial support for the education system. The most intensive growth in spending occurs after 2019, which may be due to the intensification of public education policy and investments in infrastructure modernization and digital solutions.

Table 1 Dynamics of secondary education indicators in Kazakhstan for 2015–2025

Year	EduQuality Index	EduExp (thousand KZT/student)	PTR	Infra Index	Digital (%)
2015	0.60	450	18.5	0.45	48
2016	0.62	500	18.0	0.48	52
2017	0.64	560	17.5	0.52	57
2018	0.66	620	17.0	0.56	62
2019	0.68	700	16.5	0.60	68
2020	0.70	820	16.0	0.64	75
2021	0.72	950	15.5	0.68	82
2022	0.74	1100	15.0	0.72	87
2023	0.76	1250	14.5	0.76	91
2024	0.79	1350	13.8	0.80	94
2025	0.82	1450	13.2	0.85	96

Note: compiled by the authors based on the Bureau of National Statistics (2025)

The Teacher workload indicator (PTR) shows a steady decrease from 18.5 to 13.2 students per teacher. This trend reflects an improvement in staffing in the educational system and a potential increase in teaching quality by reducing teachers' workload. The level of infrastructure provision (Infra) has also increased significantly, from 0.45 to 0.85, indicating a significant improvement in the material and technical base of educational institutions, including school facilities and learning conditions. The most dynamic growth is observed in the digitalization of education indicator (Digital), which increased from 48 p.p. to 96 p.p., that is, doubled. This indicates the large-scale introduction of digital technologies and the expansion of access to electronic educational resources.

Taken together, the data presented demonstrate a positive relationship between increased funding, infrastructure development, digitalization, and improvements in the quality of education. At the same time, the observed changes are complex, which confirms the need to analyze the education system as a multicomponent structure in which not only the number of resources, but also the effectiveness of their use plays a key role.

For a more complete characterization of the variables studied, their descriptive statistics are presented in Table 2.

Table 2 Correlation matrix of variables

Variable	Average	Std. Dev	Min	Max	
EduQuality	1.00	0.72	−0.61	0.75	0.81
EduExp	0.72	1.00	−0.55	0.78	0.84
PTR	−0.61	−0.55	1.00	−0.63	−0.59
Infra	0.75	0.78	−0.63	1.00	0.82
Digital	0.81	0.84	−0.59	0.82	1.00

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Note: compiled by the authors based on panel data

The average value of the integral indicator of the quality of education (Educality) is 0.70 with a relatively low standard deviation (0.07), which indicates the stability of this indicator

and moderate interregional differentiation. The cost of education per pupil (EduExp) is characterized by a higher variability (σ = 350) with an average value of 886, which indicates significant differences in the level of funding. The teacher workload indicator (PTR) averages 15.9 students per teacher with moderate variation, while the level of infrastructure provision (Infra) and digitalization (Digital) show a more significant variation in values. In particular, the average level of digitalization is 73% with a standard deviation of 17, reflecting the heterogeneity of digital technology adoption. Generally, the data indicate differences in the provision of resources and the level of development of the educational system, confirming the need for further analysis of the impact of these factors on the quality of education.

The correlation analysis was performed in Table 3.

Table 3 Correlation matrix

Variable	EduQuality	EduExp	PTR	Infra	Digital
EduQuality	1.00	0.72	–0.61	0.75	0.81
EduExp	0.72	1.00	–0.55	0.78	0.84
PTR	–0.61	–0.55	1.00	–0.63	–0.59
Infra	0.75	0.78	–0.63	1.00	0.82
Digital	0.81	0.84	–0.59	0.82	1.00

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Note: compiled by the authors based on panel data

The results of the correlation analysis confirm the existence of stable relationships between key variables. The positive correlation between education costs and the quality of education ($r = 0.72$) underscores the importance of financial support as a basic condition for the system's functioning. At the same time, the strongest relationship is observed between digitalization and the quality of education ($r = 0.81$), reflecting the educational system's structural transformation and the growing role of technological factors. The high correlation between digitalization and education costs ($r = 0.84$) indicates their complementary nature and the formation of a technology-oriented model for the development of the educational system. The negative correlation of the PTR index ($r = -0.61$) indicates a negative impact of teacher overload, confirming the importance of the personnel factor as a key limitation to effectiveness. Thus, correlation analysis allows us to make an important clarification: the quality of education is shaped by a complex of interrelated factors, whose interaction is systemic.

An econometric approach based on a multiple regression model was applied to quantify the impact of the factors. The results are presented in Table 4.

The results confirm the statistical significance of all variables included in the model. Digitalization exhibits the strongest effect ($\beta = 3.45$), indicating its system-forming role in shaping educational outcomes. It functions not only as an independent determinant but also as a factor enhancing the efficiency of other resources, including financial investments and infrastructure.

Infrastructure also demonstrates a substantial impact ($\beta = 2.63$), providing the fundamental conditions for the effective functioning of the education system. In contrast, the effect of financial expenditures ($\beta = 1.92$) is more moderate, suggesting that the effectiveness of investments depends on the quality of the institutional and technological

Table 4 Regression results (OLS)

Variable	Coefficient (β)	Std. Error	p-value
EduExp	1.92	0.44	0.000
PTR	–1.08	0.35	0.001
Infra	2.63	0.61	0.000
Digital	3.45	0.72	0.000
$R^2 = 0.84$, Adjusted $R^2 = 0.83$, $N = 187$			

Note: compiled by the authors based on panel data

environment in which these resources are utilized. The negative coefficient on the pupil–teacher ratio ($\beta = -1.08$) indicates an adverse impact of teacher overload, underscoring the importance of optimizing human resource allocation within the education system.

The findings further indicate a synergistic effect, whereby the impact of financial resources increases with higher levels of digitalization and infrastructure development. This suggests that the effectiveness of the education system is determined by the interaction of factors rather than their isolated influence. In addition, the results point to a threshold effect, whereby increases in funding lead to significant improvements in educational quality only after a certain level of infrastructural and digital development has been achieved. The high value of the coefficient of determination ($R^2 = 0.84$) confirms the model's strong explanatory power and the robustness of the estimated relationships.

The estimated coefficients demonstrate stability, as their signs and levels of statistical significance remain consistent across alternative model specifications, confirming the robustness of the identified relationships. Thus, the regression results make it possible to identify a hierarchical structure of factors influencing education quality, in which digitalization acts as the principal driver, infrastructure provides the basic operational conditions, and financing serves as a necessary but insufficient resource whose effectiveness depends on the environment in which it is deployed.

To provide a more detailed assessment of the contribution of individual factors and to strengthen the study's analytical rigor, a sequential specification of econometric models was conducted. This approach allows for evaluating the incremental explanatory power of each group of variables. The corresponding results are presented in Table 5.

Table 5 Comparison of model specifications

Model	Variables included	R^2
Model 1	EduExp	0.52
Model 2	EduExp + PTR	0.61
Model 3	EduExp + PTR + Infra	0.73
Model 4	EduExp + PTR + Infra + Digital	0.84

Note: compiled by the authors based on panel data

The results show that the model's explanatory power gradually improves with the addition of new factors. In the first model, where only education costs are taken into account, the coefficient of determination is 0.52. When the teacher workload indicator (PTR) is added,

the R^2 value increases to 0.61, suggesting that the personnel factor also plays an important role in explaining differences in the quality of education. In the third model, where the infrastructure level is additionally taken into account, R^2 increases to 0.73. The greatest improvement is observed in the full model (Model 4), which accounts for digitalization. The R^2 value reaches 0.84, indicating that digitalization is a key factor significantly enhancing the effectiveness of the educational system. Generally, the results show that the quality of education is shaped by several factors simultaneously, and the greatest effect is achieved when they are combined.

To address this limitation, DEA was applied at the subsequent stage of the study. The corresponding results are presented in Table 6.

Table 6 DEA results

Region	Efficiency
Almaty	0.92
Astana	0.90
Northern	0.86
Central	0.83
Eastern	0.81
South	0.76
Western	0.73

Note: compiled by the authors

The results indicate that the highest efficiency scores are observed in Almaty (0.92) and Astana (0.90), which may be associated with higher levels of infrastructure development, digitalization, and the concentration of human capital. In contrast, the southern and western regions show lower efficiency scores (0.76 and 0.73, respectively), suggesting structural and institutional constraints that limit the effective use of resources. Overall, the results reveal noticeable regional disparities in the efficiency of the education system, highlighting the importance of considering spatial differences in education policy and resource allocation.

For a more detailed interpretation of spatial differences, the regions were ranked by efficiency level (Figure 1).

The highest performance indicators are observed in Almaty (0.92) and Astana (0.90). This means that resources are used most efficiently in these cities compared to other regions. Next are the Northern region (0.86), the Central region (0.83), and the Eastern region (0.81). They have an average level of efficiency, meaning the system is working quite well, but there is potential for improvement. The lowest values were recorded in the Southern (0.76) and Western (0.73) regions. This suggests that resources are being used less efficiently in these regions and that there are problems in the education system.

To provide additional insight into regional differences and identify structural patterns, a clustering of regions was conducted (Table 7).

The clustering results indicate spatial asymmetry in the development of the education system. For a more visual analysis, the regions were divided into three groups (clusters) based on efficiency levels. The first group includes Almaty and Astana, which are the most efficient regions. Infrastructure and digitalization are better developed here, so resources are used most efficiently. The second group includes the Northern, Central, and Eastern regions.

They have an average level of efficiency. This means that the education system is operating fairly stably, but there is room for improvement. The third group includes the Southern and Western regions, where efficiency is lowest. This is due to certain limitations, such as underdeveloped infrastructure and inefficient use of resources. Thus, this distribution shows that there are noticeable differences between regions, and the development of the education system is uneven.

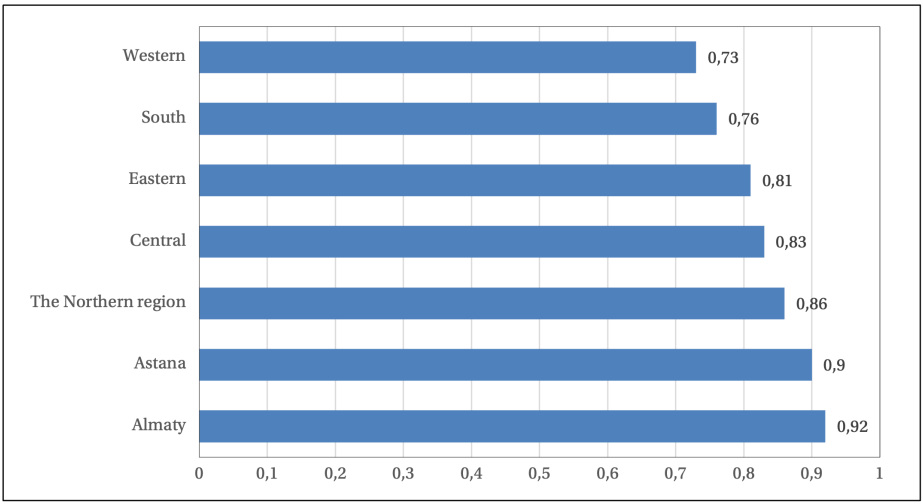

Figure 1 Distribution of regional performance based on the results of the DEA analysis

Table 7 Clustering of regions

Cluster	Region	Characteristics
High efficiency	Almaty, Astana	High levels of digitalization and infrastructure development
Medium efficiency	Northern, Central, Eastern regions	Relatively balanced development of key indicators
Low efficiency	Southern, Western regions	Relatively balanced development of key indicators

Note: compiled by the authors

5 | DISCUSSION

The empirical findings of this study provide robust evidence that the effectiveness of secondary education financing in Kazakhstan is determined not merely by the volume of allocated resources, but by the structural conditions under which these resources are utilized. The results demonstrate that the quality of education is determined by the interaction among financial, infrastructural, human, and digital factors, rather than by their isolated influences. This confirms the multidimensional nature of the educational system and its transformation in the context of the knowledge economy.

From a theoretical perspective, the results obtained are generally consistent with both classical and modern approaches to human capital theory. While education remains a key investment in increasing productivity and long-term economic growth (Becker, 1964; Mincer, 1974; Mankiw et al., 1992), the findings of this study confirm that the effectiveness of such investments is highly heterogeneous and context-dependent. In particular, the relatively moderate effect of financial expenditures compared with infrastructural and digital factors supports the argument that the marginal returns to education spending decrease when institutional and systemic conditions are underdeveloped.

The results are also consistent with contemporary empirical literature emphasizing that increased funding does not automatically lead to improved educational outcomes (Pritchett, 2001; Afonso, 2006; Hanushek and Woessmann, 2015). In line with these studies, the findings confirm that the quality of education is more strongly influenced by the effectiveness of resource use rather than by their absolute volume. In this regard, the model's high explanatory power ($R^2 = 0.84$) indicates that structural factors play a decisive role in shaping educational outcomes.

A key contribution of this study is the identification of the hierarchical structure of determinants that influence educational quality. The results clearly indicate that digitalization performs a system-forming function within the educational system. Its dominant effect suggests that digital technologies act not only as an independent factor but also as an efficiency multiplier, enhancing the productivity of other inputs, including financial resources and infrastructure. This finding is consistent with recent studies highlighting the transformative role of digital technologies in education systems (Escueta et al., 2020; Reimers and Schleicher, 2020; Zhao et al., 2021).

At the same time, infrastructure emerges as a fundamental condition for the effective functioning of the education system. The significant impact of infrastructural development indicates that access to educational facilities, learning environments, and material resources remains a critical prerequisite for achieving high-quality outcomes. This confirms the conclusions of previous studies emphasizing the importance of the physical and technological bases of education systems (Goczek et al., 2021).

The negative impact of the pupil–teacher ratio further emphasizes the importance of human resource allocation. The results indicate that excessive teacher workload significantly reduces the quality of educational outcomes, confirming the role of human capital in both quantitative and qualitative terms. This is consistent with research demonstrating that teacher-related factors are among the most important determinants of educational performance (Hanushek and Woessmann, 2015).

An important finding of the study is the presence of a synergistic effect among key variables. The results indicate that the impact of financial investments increases significantly in regions with higher levels of digitalization and infrastructure development. This suggests that the effectiveness of education financing is conditional upon the overall level of system development, supporting the concept of complementarities between inputs in complex socio-economic systems.

The results of the DEA analysis further reinforce these conclusions by highlighting significant regional disparities in resource utilization efficiency. The leading positions of major urban centers such as Almaty and Astana reflect the concentration of human capital, advanced infrastructure, and higher levels of digitalization. In contrast, the lower efficiency observed in the southern and western regions indicates structural and institutional constraints that limit the transformation of financial resources into educational outcomes.

From a spatial perspective, the clustering results confirm the existence of a core–

periphery structure within the educational system of Kazakhstan. Highly efficient regions serve as centers of human capital accumulation and innovation, while peripheral regions face limitations in infrastructure, digital access, and institutional capacity. This finding is consistent with broader literature on regional inequality and uneven development in transition economies.

At the same time, the results suggest that Kazakhstan is currently at an intermediate stage of educational system transformation. While significant progress has been made in increasing funding and expanding digital infrastructure, the integration of these components into a coherent, efficient system remains incomplete. This partially explains the observed gap between resource allocation and educational outcomes.

From a broader institutional perspective, the findings confirm that education financing should be considered within the framework of systemic governance. The effectiveness of resource allocation depends on the quality of management, institutional design, and the ability to integrate financial, technological, and human components into a unified system. This supports the argument that institutional factors play a critical role in determining the returns to educational investments (Psacharopoulos and Patrinos, 2018). Thus, the main theoretical implication of this study is that education financing represents a necessary but insufficient condition for improving educational outcomes. The highest effectiveness is achieved when financial resources are complemented by developed infrastructure, advanced digitalization, and efficient institutional mechanisms.

Overall, the results contribute to the existing body of literature by providing empirical evidence on the integrated nature of education financing in a transition economy context. The findings highlight the need to move beyond traditional approaches focused on increasing expenditures toward a more comprehensive model of educational system development that prioritizes efficiency, integration, and institutional quality.

6 | CONCLUSION

The present study provides a comprehensive assessment of the mechanisms of financing secondary education in Kazakhstan and identifies the key factors determining the quality of educational outcomes under conditions of systemic transformation. The results demonstrate that the development of the education system over the period 2015–2025 has been accompanied by a significant increase in financial resources, expansion of infrastructure, and rapid digitalization, which together contributed to an overall improvement in the quality of education.

At the same time, the findings reveal that education financing should not be interpreted solely as a quantitative increase in budget expenditures. Rather, it represents a complex system in which the effectiveness of resource allocation depends on the interaction of financial, infrastructural, digital, and human factors. The econometric analysis confirms a statistically significant relationship between these variables and educational outcomes and demonstrates the heterogeneous nature of their impact. In particular, digitalization emerges as the dominant driver of education quality, acting as an efficiency-enhancing factor that amplifies the returns on other resources. Infrastructure provides the foundational conditions for system functioning, whereas financial resources, although essential, exhibit a comparatively moderate effect.

The results of the study further indicate that the effectiveness of education financing is characterized by synergistic and threshold effects. This implies that additional financial investments lead to substantial improvements in educational outcomes only when supported by sufficient levels of infrastructural development and digital integration. Consequently,

the relationship between funding and education quality is nonlinear and contingent upon the overall level of system development.

The analysis of regional efficiency using the DEA method reveals significant spatial disparities in the education system's performance. Highly efficient regions, such as Almaty and Astana, benefit from a concentration of human capital, advanced infrastructure, and high levels of digitalization, while peripheral regions face structural and institutional constraints that limit their ability to transform resources into outcomes. This confirms the existence of a core–periphery structure and highlights the importance of considering regional heterogeneity in education policy design.

From a theoretical perspective, the findings support the conclusions of modern economic literature that education financing constitutes a necessary but insufficient condition for improving educational outcomes. The highest levels of effectiveness are achieved when financial resources are complemented by developed infrastructure, advanced digital technologies, and efficient institutional mechanisms.

In this context, the study's results have important policy implications. First, it is necessary to shift from an extensive model of education financing focused on increasing expenditures toward an integrated model that prioritizes efficiency and outcomes. Second, policy efforts should be directed toward the balanced development of infrastructure and digital technologies, ensuring their effective integration into the educational process. Third, particular attention should be paid to reducing regional disparities through targeted support for lagging regions, including investments in infrastructure and capacity building. Fourth, improving the quality of human resource management, including optimizing teacher workload and enhancing professional competencies, is essential for increasing system effectiveness.

An important direction for further development is strengthening institutional mechanisms to ensure the efficient allocation and utilization of resources. This includes improving governance practices, enhancing accountability, and integrating digital tools into management processes. In addition, the development of a unified digital educational ecosystem can significantly increase the education system's adaptability and resilience.

Overall, the study demonstrates that the transformation of education financing in Kazakhstan requires a systemic approach that integrates financial, technological, infrastructural, and institutional components. The transition to such a model will not only improve the efficiency of resource use but also ensure sustainable development of the education system, enhance human capital formation, and strengthen the country's competitiveness in the global knowledge economy.

AUTHOR CONTRIBUTION

Writing – original draft: Marzhan U. Daurbaeva, Elmira E. Zhussipova, Asem A. Dossaliyeva.
Conceptualization: Marzhan U. Daurbaeva, Elmira E. Zhussipova, Sultanpatsha S. Ubaeva.
Formal analysis and investigation: Elmira E. Zhussipova, Asem A. Dossaliyeva, Sultanpatsha S. Ubaeva.
Funding acquisition and research administration: Marzhan U. Daurbaeva, Sultanpatsha S. Ubaeva.
Development of research methodology: Elmira E. Zhussipova, Asem A. Dossaliyeva.
Resources: Marzhan U. Daurbaeva, Sultanpatsha S. Ubaeva.
Software and supervision: Elmira E. Zhussipova, Sultanpatsha S. Ubaeva.
Data collection, analysis and interpretation: Marzhan U. Daurbaeva, Asem A. Dossaliyeva.

CONFLICT OF INTEREST

Author(s) declare that there is no conflict of interest.

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AUTHOR BIOGRAPHIES

Marzhan U. Daurbaeva – Cand. Sc. (Econ.), Senior Lecturer, M. Auezov South Kazakhstan University, Shymkent, Kazakhstan, email: daurbaeva71@mail.ru, ORCID ID: https://orcid.org/0000-0001-7345-6648

Elmira E. Zhussipova – PhD, Associate Professor, M. Auezov South Kazakhstan University, Shymkent, Kazakhstan, email: elmira_zhusipova@mail.ru, ORCID ID: https://orcid.org/0000-0001-7363-8214

***Asem A. Dossaliyeva** – PhD student, M. Auezov South Kazakhstan University, Shymkent, Kazakhstan, email: asem.0702@mail.ru, ORCID ID: https://orcid.org/0009-0004-4000-7837

Sultanpatsha S. Ubaeva – PhD in Economics, Associate Professor, Joint Belarusian-Uzbek Intersectoral Institute of Applied and Technical Qualifications, Tashkent, Uzbekistan, email: sultanpassaubaeva@gmail.com, ORCID ID: https://orcid.org/0009-0003-7703-0064

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