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Structural Transformation of Higher Education in Kazakhstan: Educational, Economic and Social Dimensions

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Abstract
The development of the higher education system is considered one of the key factors in the formation of human capital, the increase in innovation activity, and long-term economic growth. The purpose of the article is to analyse the structural transformation of of Kazakhstan's higher education system by identifying interrelations among educational, economic, and social indicators for 2004-2024. The methodological basis of the study consists of correlation analysis and principal component analysis (PCA) with Varimax orthogonal rotation, which enables the identification of hidden structural factors and the assessment of the consistency of indicator dynamics. The empirical basis of the study was made up of annual statistical data from the Bureau of National Statistics of the Republic of Kazakhstan for 2004-2024, including such indicators as the number of students and teachers, the number of universities, the unemployment rate, household incomes, spending on science, innovation activity, the Gini index, the share of education spending in GDP and average wages. The results reveal strong structural relationships between economic development and science financing (r = 0.986) and between income and wages (r = 0.985). Principal component analysis shows that the first component explains 73.6% of the variance. In comparison, the first two components explain 88.9% of the variance, indicating a structural transformation of higher education associated with the development of the knowledge economy. Future research may extend the analysis by incorporating regional data, panel econometric models, and additional institutional indicators to assess causal relationships between higher education development, labour market outcomes, and innovation dynamics.

KEYWORDS
Education, Higher Education, Education Policy, Human Capital, Knowledge Economy, Research Funding, Science Expenditure

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1 | INTRODUCTION

In modern conditions, as the role of knowledge, technology, and intellectual resources increases, higher education is becoming one of the key factors in long-term development. Universities are increasingly viewed not only as organizations providing education, but also as important elements of the scientific, innovative and institutional system of society. Expanding access to education, increasing the number of students, changing the structure of personnel training, developing the scientific activities of universities, digitalizing the educational environment and strengthening international integration are creating new conditions for the interaction of education, economy and society. However, the quantitative expansion of the higher education system alone does not guarantee an improvement in its quality, a reduction in social inequality, or an increase in labor market efficiency.

The world's scientific literature has accumulated a significant body of research on various aspects of the functioning and development of higher education. Researchers analyze the impact of education on economic growth, social mobility, employment structure, and innovation activity (Makinde et al., 2013; Kusakabe, 2013; Márquez-Ramos et al., 2020). The expansion of the higher education system contributes to the development of professional skills, increased employment and income growth, and the formation of the economy's innovative potential (Delgado et al., 2014; Janssen et al., 2021). In the context of the knowledge economy, universities perform not only an educational, but also a research function, acting as important participants in national innovation systems. A separate area of research is devoted to accessibility of education, social inequality, and the role of universities in shaping the innovation environment (Verhofstadt et al., 2007; Yang, 2018; Rohrbacker & Weber, 2014). Despite a significant body of research, most studies analyse individual aspects of higher education's functioning, while comprehensive studies that combine educational, economic, and social indicators are much less common.

This problem is especially relevant for Kazakhstan. The need for such an analysis is further reinforced by the fact that in Kazakhstan, the development of higher education is taking place in the context of broader institutional transformations. The higher education system is involved in the processes of economic modernization, digital transformation, the development of science and innovation, as well as in solving the tasks of increasing the competitiveness of human capital. In these circumstances, it is important to understand whether the observed changes reflect only quantitative growth in the system or indicate a deeper structural transformation affecting the links among education, the labor market, economic development, and the social sphere. All this requires an analysis that allows us to consider higher education not in isolation, but in connection with broader structural processes.

As a result, there remains a research gap in the scientific literature regarding the lack of comprehensive research on the structural dynamics of the higher education system. Unlike most existing works that consider individual aspects of educational development, this study analyzes the joint dynamics of several groups of indicators, enabling the identification of structural patterns in their change and possible latent factors underlying the observed processes. Thus, the purpose of the article is to analyse the structural transformation of Kazakhstan's higher education system by identifying relationships among educational, economic, and social indicators for 2004-2024.

2 | LITERATURE REVIEW

Higher education in modern scientific literature is considered one of the main institutions for the formation of human capital, increasing labor productivity and ensuring long-term

socio-economic development. Its importance goes beyond personnel training, as the higher education system is increasingly associated with the expansion of innovation potential, the development of research infrastructure and the strengthening of the knowledge economy. Thus, the transformation of higher education is of interest not only as an industry process but also as an important element of broader structural changes affecting the labor market, population incomes, and social inequality.

Existing research confirms that the impact of higher education on societal development is multidimensional. On the one hand, the growth of educational coverage and professional development of the population contributes to employment and income growth (Makinde et al., 2013; Kusakabe, 2013; Janssen et al., 2021). On the other hand, the effects of educational expansion are not unambiguous, as they depend on the quality of institutions, the scale of funding for science, the ability of universities to participate in innovation processes, as well as the nature of the social distribution of development outcomes (Delgado et al., 2014; Márquez-Ramos et al., 2019). This makes it necessary to consider higher education not in isolation, but in relation to economic, innovative and social indicators.

Higher education is considered in modern literature to be one of the key mechanisms for accumulating human capital, since investments in education increase skills, productivity, and future economic outcomes for the population. Hashimoto (1995) highlighted that investments in labor relations, including the development of professional skills and the improvement of the reliability of intra-company communications, contribute to productivity growth, strengthening cooperation and greater flexibility in employment. Makinde et al. (2013) showed that employment expansion, agricultural development, technology transfer and SME support can be considered as key measures to reduce unemployment and insecurity in Nigeria. Laird (2017) showed that after the Great Recession, the US public sector stopped fully fulfilling its levelling function, as black workers, especially women, found themselves in the most vulnerable position in terms of job loss and transition to the private sector. Theodorovicz et al. (2023) argued that companies' investments in employees' general skills, even in flexible forms of employment, can strengthen long-term cooperation and increase the value created if training is perceived as caring for employees' development.

In many countries, the development of higher education has been accompanied by a transition from an elite model to mass enrollment, which is considered one of the key stages in the transformation of university systems in the literature (Trow, 2007; Smolentseva et al., 2017; Scott, 2019). Mass growth was accompanied by increased access, greater institutional diversity, and a shift in the sector's structure, but quantitative expansion alone did not guarantee improved quality or equivalent academic performance (Mok & Jiang, 2017). The expansion of the system was often accompanied by processes of segmentation, hierarchization, and redistribution of resources among different types of universities (Carpentier, 2021). The impact of higher education on the labor market and social inequality is assessed ambiguously in the literature. Some studies show that a higher level of education is associated with better job outcomes, a higher probability of employment, and higher incomes, which confirms the importance of higher education as a tool for expanding economic opportunities (Verhofstadt et al., 2007; Rohrbacker & Weber, 2014). Some studies emphasized that increased participation in higher education can reduce inequalities in access and completion, but does not necessarily reduce differences in skills and subsequent market outcomes (Borgonovi & Marconi, 2020; Chen et al., 2025). To analyze the transformation of higher education, it is not enough to take into account only quantitative educational parameters; it is also necessary to take into account social indicators reflecting the labor market and distributional effects, including unemployment and inequality (Yang, 2018).

In the knowledge economy, universities are considered not only as educational organizations, but also as important research institutions involved in the creation and dissemination of knowledge. The contribution of higher education goes beyond personnel training and includes the development of research potential, participation in national and regional innovation systems, as well as the formation of an environment for technological and organizational innovations (Caniëls & Bosch, 2011). The literature also highlights the close relationship between the development of science, human capital, and innovative competitiveness, so the transformation of the higher education system should not be considered in isolation (Hoareau et al., 2013). The educational and research missions of universities complement each other and collectively influence economic outcomes and innovation potential (Bonaccorsi et al., 2023). Individual studies also confirm that the human capital generated by the higher education system contributes to the growth of innovation activity at the firm and regional levels (Wu & Liu, 2021).

Despite the significant body of research, the literature still predominantly consists of studies analysing separate channels through which higher education exerts its influence, primarily focusing on its relationship with income, employment, accessibility, training quality, or innovation. Even in studies on Kazakhstan, researchers more often examine either mismatches between the education system and the labor market, issues of social inequality, or the influence of individual educational factors on regional or economic development, whereas an integral analysis of these dimensions is encountered much less frequently (Busurmanov et al., 2019; Karabayev et al., 2023; Arynova et al., 2025; Zeinolla et al., 2025). Therefore, for Kazakhstan, this issue has indeed been studied in a fragmented manner, as confirmed by both the content of existing studies and recent reviews of the higher education sector, which note the fragmentation of thematic areas and the limited number of systemic empirical models.

The conducted literature review enables several conclusions to be drawn. First, higher education is a multidimensional institution whose impact extends beyond workforce training to encompass human capital formation, labor productivity, income, and innovation activity. Second, the expansion of the higher education system is not always accompanied by comparable improvements in quality and reductions in inequality, and therefore should be considered not only a quantitative but also a structural process. Third, the impact of higher education on the labor market and social inequality is ambiguous and depends on the institutional context. Fourth, in the knowledge economy, universities perform not only an educational but also a research function, acting as important participants in innovation systems.

Despite the significant body of research, most studies analyze separate channels of higher education's influence, such as employment, income, accessibility, training quality, or innovation. For Kazakhstan, this gap is especially evident, since the existing studies are mainly fragmented in nature and focus on individual aspects of the interaction between higher education, the labor market, social inequality, and economic development. Therefore, the purpose of the article is to analyze the structural transformation of Kazakhstan's higher education system by identifying the relationships between educational, economic, and social indicators for 2004–2024.

Taking into account the purpose of the study and the logic of the empirical analysis, the following hypotheses are proposed.

H1. There are stable and statistically significant relationships among educational, economic, and social indicators for 2004–2024, reflecting the system's general structural dynamics.

H2. The joint variability of the indicators under study is determined by a dominant latent factor that integrates transformations in higher education, economic development, expenditures on science, and innovation activity.

H3. Indicators of social inequality and the labor market constitute a separate structural dimension, partially autonomous of the economic and innovation factors.

H4. The identified changes reflect a transition from the quantitative expansion of the higher education system to a model of institutional consolidation associated with the development of the knowledge economy.

3 | RESEARCH METHODS

The present study aims to identify the interrelationships among educational, economic, and social indicators in Kazakhstan for the period 2004-2024. The methodological logic of the analysis is based on the assumption that the transformation of the higher education system does not occur in isolation, but in close connection with changes in employment, income, scientific financing and innovation activity. For empirical verification, hypotheses H1–H4 were proposed regarding the existence of stable relationships among educational, economic, and social indicators within the institutional consolidation model. In this regard, the study focuses on identifying both the observed statistical relationships among indicators and the latent factors that govern their joint dynamics.

The analysis was carried out in several successive stages. In the first stage, a correlation analysis was performed to determine the degree and direction of linear relationships among the indicators. In the second stage, Principal Component Analysis (hereinafter – PCA) was applied to reduce the data size and identify underlying structural dimensions. The use of PCA is due to the variables under consideration being closely interrelated and potentially reflecting more general latent factors of structural transformation rather than individual, autonomous processes. In the third stage, Varimax orthogonal rotation was used to increase the interpretability of the selected components, enabling the distinction of factor loadings and the identification of relatively independent groups of indicators corresponding to different dimensions of the system under study. At the final stage, factor maps of observations in the space of the initial and rotated components were constructed, which provided a visual interpretation of the temporal dynamics and allowed us to trace the distribution of observation years in the coordinates of the identified latent factors.

A more detailed sequence of research steps, analytical procedures and interpretation of the results is shown in Figure 1.

The empirical base of the study was made up of annual statistical data for 2004-2024, taken from the annual data of the Bureau of National Statistics of the Republic of Kazakhstan (Bureau of National Statistics, 2025). For the analysis, we selected indicators that allow us to trace the relationship between the institutional parameters of higher education and broader socio-economic processes. The study includes the number of students, the number of teaching staff, the unemployment rate, the number of higher education institutions, the average income of the population, spending on science, the level of innovation activity, the Gini index, the share of education spending in GDP and average wages. The variables are shown in more detail in Table 1.

The choice of these variables is due to the need to cover several interrelated dimensions of the system under study. Firstly, the educational dimension reflects the scale and institutional configuration of the higher education system through indicators such as the numbers of students, faculty, and universities. Secondly, the economic and innovation dimension characterizes the processes related to income growth, financing of science, in-

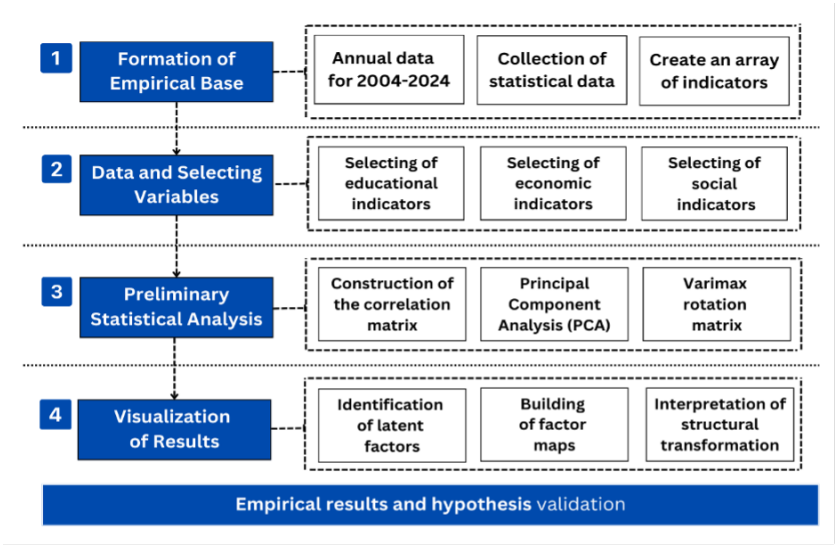


Figure 1 Logic of research, stages of analysis and hypothesis testing

novation activity and the role of education in the economy. Thirdly, the social dimension enables consideration of the state of the labour market and the distributional aspects of development, as reflected in indicators of unemployment and social inequality. Taken together, these indicators enable a comprehensive assessment of how the transformation of the higher education system correlates with changes in society's economic, innovative, and social structures.

Descriptive statistics for the study variables, including mean values, standard deviations, and minimum and maximum values, are presented in Table 2.

Table 1 Coding of study variables

Variable	Unit of measurement	Description of variable
Year	year time	Observation period (2004–2024)
STUDENTS	person	The total number of students in the higher education system
FACULTY	person	Total number of teaching staff
UNEMPL	%	The share of the unemployed in the total workforce
HIGHER_EDU	units	Total number of higher education institutions
INCOME	KZT	Per capita monetary income of the population
EXP_SCIENCE	million KZT	Government spending on research and development
INNOV_ACTIV	%	The share of organizations engaged in innovative activities
GINI_INDEX	coefficient	An indicator of the level of social inequality
GDP_EDU	% of GDP	Government spending on education as a percentage of GDP

Note: compiled by the author

It should be borne in mind that the study is based on aggregated annual data, which limits the possibilities of a strict causal interpretation of the identified relationships. High correlation coefficients and factor loadings may partially reflect the general trend movement of variables over time. In this regard, the results of PCA and correlation analysis should be interpreted primarily as a tool for identifying the structural consistency of indicators, rather

Table 2 Descriptive statistics

Variable	Medium (Mean)	Min	Max	Standard deviation
STUDENTS	603 879	459 369	775 762	92 984
FACULTY	39 189	36 307	43 382	2 061
UNEMPL	5,62	4,7	8,4	1,05
HIGHER_EDU	142	112	181	22,8
INCOME	141 253	23 128	364 295	98 964
EXP_SCIENCE	63 543	11 643	172 586	41 965
INNOV_ACTIV	7,13	2,1	11,7	3,16
GINI_INDEX	0,289	0,267	0,315	0,013
GDP_EDU	3,48	2,26	4,63	0,69
MED_SALARY	159 810	60 000	450 000	118 778

Note: compiled by the author

than as evidence of the direct causal influence of some variables on others.

To ensure comparability of indicators measured in different units, all variables were standardized using the z-transform before the multidimensional analysis was performed by formula (1):

$$z_i = \frac{x_i - \bar{x}}{s} \tag{1}$$

where:

x_i – the observed value of the indicator;

$\bar{x}$ – the observed value of the indicator;

s – the standard deviation.

After data standardisation, the PCA method was applied to identify the latent structure of the relationships among the studied indicators. This method allows you to transform the original set of interrelated variables into a system of new uncorrelated components, each of which is a linear combination of the original variables by formula (2):

$$PC_k = a_{k1}X_1 + a_{k2}X_2 + \cdots + a_{kp}X_p \tag{2}$$

where:

PC_k – the principal component;

a_{kj} – factor loads;

X_j – standardized source variables.

To increase the interpretability of the factor structure after extracting the main components, orthogonal Varimax rotation was applied, enabling clearer differentiation of variables across the selected components. To visually represent the distribution of observations in the component space, factor maps were constructed. Nevertheless, the use of correlation analysis, PCA, and Varimax rotation allows us to identify stable latent dimensions of the system under study and gain a holistic understanding of how the transformation of higher education correlates with changes in income, employment, inequality, scientific financing, and innovation activity.

The empirical analysis was conducted in Python, including correlation analysis, variable standardization, PCA, Varimax rotation, and factor map visualization.

4 | RESULTS

The empirical analysis aims to identify the structural relationships among educational, economic and social indicators for the period 2004-2024. The current institutional restructuring

and the transition to a knowledge-economy model are accompanied by a changing role of higher education in shaping employment, income, and the distribution of resources. In this regard, it is necessary to determine whether changes in the higher education system constitute a single structural factor alongside economic development, or whether the social consequences of transformation develop independently.

In this regard, according to the research methodology, a correlation analysis was initially carried out, which makes it possible to assess the nature and direction of statistical relationships between variables. The correlation matrix provides a general idea of the degree of consistency in changes across indicators over time and allows us to identify potential blocks of interrelated indicators that require further factorial and econometric analyzes. The results of the correlation analysis are presented in Table 3.

Table 3 Correlation matrix

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
STUDENTS	1.000	0.598	0.799	0.838	−0.459	−0.500	−0.634	0.744	−0.543	−0.328
FACULTY	0.598	1.000	0.690	0.799	−0.769	−0.732	−0.739	0.426	−0.700	−0.724
UNEMPL	0.799	0.690	1.000	0.948	−0.720	−0.735	−0.837	0.730	−0.735	−0.603
HIGHER_EDU	0.838	0.799	0.948	1.000	−0.814	−0.833	−0.893	0.674	−0.749	−0.714
INCOME	−0.459	−0.769	−0.720	−0.814	1.000	0.986	0.882	−0.283	0.841	0.985
EXP_SCIENCE	−0.500	−0.732	−0.735	−0.833	0.986	1.000	0.875	−0.331	0.820	0.962
INNOV_ACTIV	−0.634	−0.739	−0.837	−0.893	0.882	0.875	1.000	−0.356	0.726	0.812
GINI_INDEX	0.744	0.426	0.730	0.674	−0.283	−0.331	−0.356	1.000	−0.358	−0.167
GDP_EDU	−0.543	−0.700	−0.735	−0.749	0.841	0.820	0.726	−0.358	1.000	0.804
MED_SALARY	−0.328	−0.724	−0.603	−0.714	0.985	0.962	0.812	−0.167	0.804	1.000

Note: compiled by author

The correlation results indicate strong relationships among indicators of economic development, research funding, and innovation activity. Strong positive correlations were identified between indicators of economic development and the scientific and innovation sphere. Thus, the relationship between average income and science expenditure is r = 0.986, while the relationship between average income and average wages is r = 0.985, indicating that these indicators change almost synchronously. The strong positive correlation between science expenditure and the level of innovation activity (r = 0.875) confirms that increased funding for the scientific sphere is associated with an expansion of innovation processes. At the same time, social indicators also demonstrate significant relationships. The unemployment rate has a high positive correlation with the number of universities (r = 0.948) and the Gini index (r = 0.730). These coefficients reflect the joint structural dynamics of the higher education system and socio-economic conditions at different stages of the period under consideration. In particular, a greater institutional presence of the higher education system was characteristic of the early stage of the analysis and was simultaneously associated with higher levels of unemployment and inequality.

Overall, the correlation analysis indicates the presence of stable statistical relationships among indicators of economic development, research funding, and innovation activity. Pronounced negative correlations were identified between the number of higher education institutions and indicators of economic development, as well as between the number of universities and innovation activity. This relationship may reflect the processes of structural consolidation in the higher education system and resource concentration. During the analysed period, the reduction in the number of universities occurred in parallel with rising incomes, increased research funding, and higher innovation activity, which may indicate a transition from a quantitative model of expansion to a model of qualitative concentration.

It can be concluded that the high values of several correlation coefficients may be partially due to the general time trend of the indicators. The joint trend movement of variables increases the likelihood of spurionic (false) correlations. In this regard, the high correlation of most variables with the time factor indicates the need for further econometric analysis (in particular, eliminating the trend component and checking the stationarity of the series) for the correct interpretation of cause-and-effect relationships.

To identify hidden (latent) factors that determine the joint variability of social, economic, and educational indicators during 2004-2024, the PCA method was applied. Before performing PCA, the initial variables were standardized (z-transform), which ensures comparability of indicators measured in different units. The results of the analysis showed the dominance of the first principal component (PC1), which accounted for the bulk of the explained variance. PC1 loadings have positive signs for income, science spending, innovation activity, the share of education spending in GDP, and average wages, and a negative sign for the number of students, teachers, universities, the unemployment rate, and the Gini index. In general, the PCA results confirm the presence of a dominant structural factor characterizing the transformation of higher education in the context of the development of the knowledge economy, and also identify a separate socio-distributional dimension related to the dynamics of inequality (Table 4).

Table 4 Principal component loadings for social, economic and educational indicators

Variable	PC1	PC2
STUDENTS	−0.754	0.590
FACULTY	−0.865	−0.040
UNEMPL	−0.929	0.321
HIGHER_EDU	−0.989	0.217
INCOME	0.948	0.371
EXP_SCIENCE	0.950	0.313
INNOV_ACTIV	0.944	0.118
GINI_INDEX	−0.575	0.758
GDP_EDU	0.883	0.180
MED_SALARY	0.875	0.503

Note: compiled by the author

The results demonstrate a clear dominance of the first principal component (PC1), which accounts for the largest share of the total variance of the indicators and constitutes the system's key structural dimension. PC1 is characterised by high positive loadings on economic and innovation indicators: science expenditure (0.950), average income (0.948), innovation activity (0.944), the share of education expenditure in GDP (0.883), and average wages (0.875). At the same time, pronounced negative loadings are observed for the number of higher education institutions (-0.989), the unemployment rate (-0.929), the number of academic staff (-0.865), the number of students (-0.754), and the Gini index (-0.575).

The configuration of the loadings indicates the presence of a systemic structural shift. The reduction in the number of universities, students, and academic staff coincided with rising household incomes, increased science expenditure, and stronger innovation activity over time. The particularly large absolute values of the loadings for the number of universities (-0.989) and the unemployment rate (-0.929) suggest that the processes of consolidation in the higher education system were accompanied by a decline in the unemployment rate. Thus, PC1 reflects a transition from a mass model of higher education to a more concentrated system oriented towards the knowledge economy, in which resources become more

focused and economic indicators improve.

The second principal component (PC2) forms a separate socio-distributive dimension. The highest loading on PC2 is observed for the Gini index (0.758), indicating the relative autonomy of social inequality dynamics from the innovation-economic factor represented by PC1. Additional positive loadings are observed for the number of students (0.590) and average wages (0.503). Thus, PC2 shows that changes in the education system and wage levels are accompanied by changes in the level of social inequality.

Overall, the PCA results confirm the existence of a dominant factor of economic and innovation transformation accompanied by the institutional consolidation of higher education, while also identifying a separate social dimension related to the dynamics of inequality. To refine the interpretation of the factor structure and to achieve a clearer separation of the latent dimensions, an orthogonal Varimax rotation was applied after the initial extraction of the principal components. The use of Varimax rotation redistributes factor loadings so that each variable is more strongly associated with a single component, facilitating the interpretation of the factors. RC1 combines indicators associated with economic growth and the development of science (income, wages, science expenditure, innovation activity, and the share of education expenditure in GDP). RC2 combines indicators reflecting the social and educational structure of society (number of students, number of universities, unemployment rate, and the Gini index).

Table 5 presents the results of the orthogonal Varimax rotation for the two extracted components, RC1 and RC2.

Table 5 Rotated Varimax (component matrix) for social, economic and educational indicators

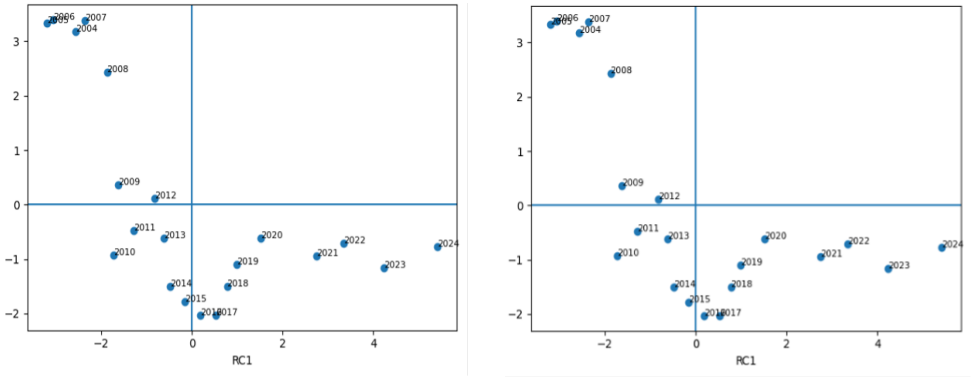
Variable	RC1	RC2
STUDENTS	−0.278	0.916
FACULTY	−0.731	0.465
UNEMPL	−0.575	0.797
HIGHER_EDU	−0.684	0.746
INCOME	0.989	−0.241
EXP_SCIENCE	0.957	−0.290
INNOV_ACTIV	0.841	−0.446
GINI_INDEX	−0.035	0.951
GDP_EDU	0.825	−0.361
MED_SALARY	1.005	−0.092

Note: compiled by the author

The results of Varimax rotation demonstrate a clear distinction between the two latent factors. The first rotated component (RC1) shows pronounced positive loadings for income (0.989), average salary (1.005), spending on science (0.957), innovation activity (0.841), loads in terms of income (0.989), average salary (1.005), spending on science (0.957), innovation activity (0.841) and the share of education spending in GDP (0.825). At the same time, negative pressures are recorded for this component in terms of the number of universities (-0.684), the number of teachers (-0.731), the unemployment rate (-0.575) and the number of students (-0.278). Thus, income growth and the development of the scientific and innovative sphere occurred in parallel with the institutional consolidation of the higher education system and the reduction of unemployment. The particularly significant module loads in terms of income, wages, and science expenditures confirm that RC1 reflects the process of strengthening the knowledge economy as the dominant direction of structural change.

The second rotated component (RC2) forms a separate socio-educational dimension. The greatest burden on RC2 falls on the Gini index (0.951), which indicates a pronounced autonomy of the dynamics of social inequality relative to the economic and innovation factors presented in RC1. Significant positive pressures are also observed in the number of students (0.916), the unemployment rate (0.797) and the number of higher education institutions (0.746). In other words, the scale of higher education, employment dynamics and the level of social inequality in the analyzed period changed consistently and form a separate structural dimension of social development.

Furthermore, to visualise the revealed factor structure in the space of the main components, factor maps of the observations are constructed (Figure 2).



Factor map (PC1–PC2) Varimax (RC1–RC2)

Figure 2 Factor score plots for social, economic and educational indicators

Factor maps showed the distribution for 2004-2024 in the space of two main components. The first component (PC1) explains 73.6% of the total data variance, while the second component (PC2) explains 15.3%. In total, they explain 88.9% of the variation, which means that the two-dimensional projection reflects the structure of the initial indicators quite well. The time dynamics can be clearly traced along the axis of the first component (PC1): 2004-2008 are located in the zone of negative values; 2020-2024 are located in the zone of positive values. This indicates the existence of a common long-term trend of social, economic and innovative development, which reflects the first main component. The axis of the second component (PC2) reflects changes that are not related to this time trend. So, to a greater extent, it is mainly related to the influence of social factors, such as the level of inequality, unemployment, and others. The graph shows especially noticeable differences along this axis in the period 2009-2016, when the most noticeable transformation processes took place in the system.

Thus, the PCA factor map shows the gradual development of the system under study — from the initial stage to a period of more sustainable economic and innovative growth. The orthogonal rotation of Varimax made it possible to make the structure of the factors more understandable, while the total proportion of the explained variance did not change. After the rotation, the factors became easier to interpret. Compared to the original PCA map, the rotated model shows a clearer separation of the two main dimensions – economic and innovative and socio-educational. This confirms that the dynamics of the studied indicators has a two-factor structure.

The factor maps also clearly show the presence of a leading factor related to socio-economic development and an additional factor reflecting the system's social and educational structure. The results obtained indicate a gradual structural transformation of the higher education system and the scientific and innovative sphere during the period under review, accompanied by an increase in income, increased funding for science and increased innovation activity. Thus, Figure 2 visually illustrates the two-factor structure of the observed dynamics, whereas Table 6 summarizes the proposed hypotheses and the results of their empirical verification.

Table 6 Summary of research hypotheses and their empirical verification

Hypothesis	Content of hypothesis	Empirical status
H1	There are stable and statistically significant relationships among educational, economic, and social indicators for 2004–2024, reflecting the system's general structural dynamics.	Confirmed
H2	The joint variability of the indicators under study is determined by a dominant latent factor that integrates transformations in higher education, economic development, expenditures on science, and innovation activity.	Confirmed
H3	Social inequality and labor market indicators form a distinct structural dimension that is partially autonomous from the economic and innovation factors.	Confirmed
H4	The identified changes reflect a transition from the quantitative expansion of the higher education system to a model of institutional consolidation associated with the development of the knowledge economy.	Partially confirmed

Thus, the results presented in Table 6 confirm the existence of stable relationships among educational, economic and social indicators, as well as a two-factor structure in the dynamics under study.Hypotheses H1–H3 are confirmed by the results of correlation and factor analysis, while hypothesis H4 has received partial confirmation and is interpreted at the level of the identified structural trend. The results indicate that the transformation of Kazakhstan's higher education system during the period under review occurred in close relation to economic, innovative, and social changes.

5 | CONCLUSIONS

The study was aimed at identifying the structural relationships between educational, economic and social indicators characterizing the transformation of Kazakhstan's higher education system in 2004-2024. The results showed that changes in the higher education sector should not be considered as an isolated sectoral process, but as part of a broader socio-economic and innovative transformation related to the development of the knowledge economy. The following conclusions were reached.

Firstly, the literature review and the study's logic indicate that higher education should be considered a multidimensional institution, whose impact is not limited to personnel training and the accumulation of human capital. In the context of the knowledge economy, it is an important element of a broader socio-economic system related to the dynamics of employment, income, scientific potential, innovation activity and social inequality. Consequently, the transformation of the higher education system should be analyzed not only through quantitative parameters of its development, but also through structural changes reflecting its place in the knowledge economy, innovation processes and the social structure of society.

Secondly, the analysis showed that the transformation of Kazakhstan's higher education system in 2004-2024 was accompanied by stable interrelations among educational, economic and social indicators. Correlation analysis, the principal component method, and Varimax rotation confirmed the presence of a dominant economic and innovation factor combining income growth, spending on science, innovation activity, and changes in the parameters of the higher education system, and identified a separate socio-educational dimension related to the dynamics of unemployment, inequality, and the scale of the sector.

The practical significance of the results lies in their potential use in the development of state policy in the fields of higher education, science, and innovation. The findings indicate that the evaluation of the effectiveness of the higher education system should not be limited to quantitative indicators of coverage or the number of organizations. A more reasonable approach is one that takes into account the relationship of higher education with the labor market, scientific financing, innovation, and social inequality.

The prospects for further research are related to the deepening of the analysis in several directions. First, it is advisable to supplement the macro-level approach with regional and institutional data, which will reveal interregional differences in the trajectories of higher education transformation. Secondly, it seems important to use econometric methods that account for time trends, stationary series, and potential causal relationships. Thirdly, further development of the topic may be related to the inclusion of additional indicators of the quality of education, digitalization, university research productivity and international academic integration.

AUTHOR CONTRIBUTION

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CONFLICT OF INTEREST

No conflict of interest/competing interest is reported by the authors.

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