"Relationship between determinants of higher education and economic development: The case of Kazakhstan"

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RELATIONSHIP BETWEEN DETERMINANTS OF HIGHER EDUCATION AND ECONOMIC DEVELOPMENT: THE CASE OF KAZAKHSTAN

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Abstract

This study aims to examine the relationship between higher education and economic development determinants in Kazakhstan's regions. The paper used two sets of indicators of three-time series: 2010, 2015, and 2020. The analysis constructed a correlation using a panel dataset for 15 regions of Kazakhstan compiled by the Statistics Bureau of Kazakhstan and the National Bank. The first set reflects the determinants of higher education (number of students in colleges and universities, number of teaching staff, and the existing ICT infrastructure in universities). The second set includes indicators of regional economic development (GRP per capita and the population's income level). The results showed a causal relationship between economic development and the determinants of higher education in the regions of Kazakhstan, which depend on the period. Surprisingly, the number of university students has almost no effect on GRP per capita and the population's income level. For 2015–2020, the study observed the emergence and strengthening of correlations between economic growth and the development of innovations in universities. The findings also identified Mangystau, Atyrau, North Kazakhstan, and Pavlodar as regions with low innovation development in education. Therefore, the country's higher education development policy should encourage and strengthen knowledge management systems in these regions. The study concludes that higher education and economic indicators significantly influence the growth of the economy in Kazakhstan.

Keywords higher education system, economic growth, infrastructure, university, correlation

JEL Classification I21, I25, I26

INTRODUCTION

The transition to high-quality development is significantly based on technology and innovation. Human resources and their impact on economic growth are an essential part of innovation. Economic development requires the accumulation of adequate human capital and increasing its ability to innovate as critical to implementing strategic changes in the innovation policy of the state. In the modern world, the knowledge-based economy and the level of education development increase competitiveness. Higher education creates and spreads knowledge, linking economic development and improving the country's welfare.

When training new specialists, integration into the international educational and economic space is vital. Education undoubtedly requires a radically innovative approach to training highly qualified personnel. Therefore, it is no coincidence that when studying the factors affecting

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the socio-economic development of a country or region, business activity, economic growth, and others, it is often the higher education system that is singled out. Teachers and students are the main part of the educational system, as they play a vital and decisive role in the effectiveness of higher education institutions.

Kazakhstan tries to integrate the economy and knowledge society to accelerate its development. The effective functioning of the higher education system is a strategic task of the state, which depends on social stability and economic growth. It also increases the competitiveness of the national economy. Kazakhstan faces a particular gap between the needs of the sectors of the economy, the existing structure of higher education, and the training level of specialists. In this regard, the government and the public must consider the system of higher education in the context of high-quality training of specialists. Particular attention should be paid to the impact of economic development and the social groups involved in the educational process of universities (students and teachers). Moreover, the leading positions are occupied by countries that have understood the importance of higher education for economic development, especially when developing sustainable development strategies.

In recent decades, developed and developing countries have steadily increased spending on higher education. The creative ability of a government is determined by the development of higher education, which further affects the economic growth and the speed of the country's development. Therefore, it is vital to assess the scale and infrastructure of the higher education system and put forward targeted policy proposals to promote its sustainable development. This study considers the number of teaching staff in higher educational institutions, the number of students, and the availability of accessible information and communication (ICT) infrastructure at universities, depending on the region.

1. LITERATURE REVIEW

The impact of higher education on the overall economic growth and well-being of the population is widely covered in the scientific literature. The development potential of a modern knowledge-based economy is primarily determined by the quality of labor resources, which depends on higher education and vocational training. Therefore, the relationship between higher education and economic growth is measured by the share of higher education in economic growth.

Cohen and Levinthal (1990) introduced the concept of absorptive capacity, which is the ability to recognize the value of new, external information, assimilate it, and apply it. Education improves this ability, so absorptive capacity can explain why a nonlinear relationship between education and growth might be expected, i.e., why a country's economic growth performance might differ depending on its educational achievement. Empirical studies mainly researched the relationship between economic growth, higher education, and productivity. Thus, Pencavel (1991) defined the relationship between education, productivity, and income, paying particular attention to workers with higher education. Dudzevičiūtė and Šimelytė (2018) focused on the relationship between education and economic development and applied descriptive statistics analysis and econometric methods. The results revealed a statistically causal relationship between education and economic growth.

Further, several scientific studies analyze the relationship between education and the population's income distribution. Hill (2016) demonstrated that increasing population income could contribute to the trends in American higher education, particularly in the selective, private nonprofit, and public sectors. The paper demonstrated how income inequality increases tuition, costs, and financial aid. Chekina and Vorhach (2020) evaluated the dependence of population qualifications on the amount of higher education expenditure in Ukraine and certain foreign countries and the impact of higher education on economic growth. It is determined that the share of the population with higher education in Ukraine, reflected in official statistics, is growing yearly. Brueckner et al. (2022) found that when the population's education increases, the correlation between non-gravity trade and income inequality decreases. Non-gravity trade does not significantly affect income inequality in countries that are world leaders in education.

Allen and van der Velden (2001), Bilbao-Osorio and Rodríguez-Pose (2004), Dickson and Harmon (2011), and Davila et al. (2016) considered the macroeconomic perspective explaining the impact of investments in higher education on economic growth. Nevertheless, cross-country approaches to evaluating higher education and economic well-being often show contradictory results when using growth rates to indicate economic development. Such rates require consistency over time and may not accurately measure long-term economic success over relatively short periods. It is crucial to overcome this issue to assess the relationship between the critical variables of higher education and the ratio of capital to physical labor (Knabb & Stoddard, 2005).

Universities and the number of graduates positively affect the educational process at the appropriate levels, such as industry, region, and infrastructure. Thus, different levels of higher education significantly affect the overall growth of factor productivity and are mainly reflected in the spatial distribution effect (Sun & Ning, 2016). Liu and Bi (2019) argued that undergraduate and doctoral studies (especially doctoral studies) demonstrated a significant positive effect, while technical school and master's degrees had a significant negative impact. Some articles focused on a major active data infrastructure project in higher education in the United Kingdom (Williamson, 2018). The research examined the technical networks of organizations, software programs, standards, dashboards, and visual analytics technologies that constitute the infrastructure and how these technologies are fused to governmental imperatives of market reform. Perrota (2021) proposed a case study of platforms and predictive frameworks emerging in higher education.

Accordingly, the second area of research in this sphere is assessing education as an element of human capital development. Specific studies are devoted to higher education as a personal decision to invest in human capital and assess these private investments' profitability (Hartog, 2000; Heijke et al., 2003; Harmon et al., 2003). Hanushek (2016) considered how human capital and its main variables affect the pace of economic growth. An essential part of this is thinking about how to measure human capital. As a result, the higher the level of education of the population, the more economic activity increases, and the higher the demand for educated people on the labor market.

In different countries, human capital affects economic growth from different perspectives. Mamuli (2020) focused on the role of higher education as a tool for improving the country's human capital development. His analysis focuses on how the country's higher education institutions can be refocused on human capital development. Herinoto et al. (2021) analyzed the relationship between economic growth and human resources, such as the number of teachers and students and population density. Lentjushenkova (2021) showed that the most critical elements of the university's human capital are the professional competence of the teaching staff, namely its scientific competence. Thus, knowledge management and human capital affect an organization's competitiveness, especially in higher education institutions.

Rauch (1993) and Adams (2002) observed a significant impact of educational policy on workers' average productivity, indicating the economic consequences of decentralization for regional development. Ricoy and Fernandez-Rodriguez (2013) investigated the contribution and challenges caused by using ICT in higher education based on a sample of variables. Peric (2011) examined the impact of ICT and new generations of users to determine the use of ICT by students in the educational process, their basic requirements, and the level of satisfaction with the existing website of the faculty. The results provided recommendations to other countries that seek to improve their ICT skills.

Fauville et al. (2014) studied the impact of ICT on environmental education based on data from two new schools. The main conclusion is that thanks to ICT's introduction into environmental education, students gain access to new experiences and research areas that were previously unavailable. Further, Bostan and Akman (2015) examined the impact of the level of higher education on the awareness of users about security when using ICT products.

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Selwyn (2008), Ottestad (2010), Ott and Pozzi (2011), and Ozmen (2013) found a link between innovation and competitiveness, as well as highlighted the importance of higher education for innovation and competitiveness. ICT affect many of the mechanisms commonly used to normalize the available supply of educational services. Selwyn (2008) investigated the technological transformation of the British higher education system. This study emphasizes that the interest in educational ICTs was primarily due to improved competitiveness in a global economy. Ozmen (2013) investigated virtual communities of practitioners to ensure innovation in universities. The results showed that most administrators value virtual communities of practitioners to ensure improvements and innovations.

Feng et al. (2006), Zeng et al. (2015), and Sahoo (2019) examined the relationship between higher education quality management, organizational effectiveness, and innovation. Mehta et al. (2014), Tari and Dick (2016), and Segarra-Cipres et al. (2020) analyzed the quality management of engineering education, the effectiveness of innovation, and higher education institutions. In general, quality management contributes to the innovative strategies for products and processes within the production enterprise, which positively affects various aspects of companies' activities.

The research activity of the teaching staff is a significant driver for changes that rationalizes the directions and effectiveness of the educational process. Similarly, academic freedom for universities is crucial to ensure academic quality. Customer satisfaction depends on quality, which contributes to improving the educational environment. Manarbek et al. (2020) noted that all departments, the administration of the university and faculty, and the teaching staff should strive to achieve organizational missions and goals to ensure the quality of higher education in a harmonious and relaxed working environment.

Particular emphasis is placed on the directions of socio-economic science as an innovative approach to effective internal management in higher education institutions. For example, Turlubekova and Bugubayeva (2021) studied the trends in the development of inclusive education in Kazakhstan, which showed the relevance of promoting and developing access to inclusive education, social integration, and non-discriminatory treatment of persons with special educational needs. In addition, methods for assessing digital readiness and ICT are used at various business management levels to formulate digital transformation strategies (Kireyeva et al., 2022).

Based on the literature review, the study identified several vital points. First, some studies assessed the impact of education indicators on economic growth. Others determined the relationship between education and the population's income distribution. Finally, some assessed the importance of the population's labor resources and vocational training, which affect the development of the country's economy. Research also focused on the impact of regional differences and elements of technological infrastructure on education, including the availability of accessible ICT infrastructure. Therefore, this paper combined two sets of indicators to determine the relationship between the higher education system and economic growth. No prior studies have examined this topic in the example of Central Asian countries.

2. AIMS AND HYPOTHESES

This study analyzes the relationship between higher education and economic development determinants in regions of Kazakhstan. Therefore, to assess the causal relationship between economic growth and higher education, this paper combined two sets of indicators of three-time series – 2010, 2015, and 2020 – to identify changes in correlation levels. The paper proposes two hypotheses:

H1: *There is a positive relationship between higher education and economic development determinants in the regions of Kazakhstan.*

H2: *There is no difference or relationship between higher education and economic development determinants in the regions of Kazakhstan.*

3. METHODS

The study used a linear approach to analyze the relationship between higher education and economic growth indicators. Thus, this paper assessed determinants that could explain the parameters of changes in the relationship between higher education and economic growth over time. Following the literature review, the economy may behave differently depending on the population's education level.

To assess the contribution of the higher education system to regional development, the paper differentiated the regions of Kazakhstan. That is why the optimal solution is to choose indicators that consider the features of the higher education system associated with the data collection characteristics. Two sets of determinants are the main blocks for assessing higher education's impact on regions' economic development. Thus, the first block comprises six determinants: (1) the number of students in colleges; (2) the number of students in universities; (3) the number of teaching staff; (4) the number of interactive equipment in colleges and universities; (5) the number of computers in colleges and universities; and (6) the number of ICT equipment with Internet access. The second block includes two determinants: (1) gross regional product (GRP), which is traditionally used as an indicator of the economic activity of the region; and (2) an indicator of the income level of the population in the region. The sample covers the period from 2010 to 2020.

Table 1 presents brief descriptive statistics to provide an overview of the two blocks of selected variables.

The trend toward the growth of GRP and the indicator of the population's income level is accompanied by a tendency to influence the rest of the variables. Therefore, to assess the causal relationship between economic growth and higher education, this paper used two sets of indicators of three-time series: 2010, 2015, and 2020.

Descriptive statistics were derived for the indicators under consideration: mean, standard error (SE), and confidence interval (CI). Mean is the indicator that reflects the average value and is calculated using the arithmetic mean method. The standard error is calculated using the square root of the given chi-square statistic. In other cases of regression calculation, an error is calculated for a particular regression coefficient. The presented data show that in 2010, 2015, and 2020, the average GRP was 1.712003, and the average number of university teachers for these three periods was 2369.

Next, the study determined the standard error (SE). This indicator reflects the standard deviation of the sample distribution. In this study, the most significant deviation is in the number of students in colleges and universities: 1286.038 and 3034.381, respectively.

From the general population of elements, there is often a range of unknown parameters. Therefore, this study considered a 95% confidence interval. A narrower range (99%) would give a higher confidence level, but this interval is more commonly used in medical research.

However, after studying the selected parameters, the model undergoes an extension or spatial mod-

Table 1. Selected measurement variables used in the correlation analysis

Source: Authors' compilation.

Indicator	Code	Definition	Mean	Std. deviation
Economic development determinants	GRP	Gross regional product per capita, bln. KZT	4,31859	2,68029
	Inc_per	Income of population, average per capita, KZT	783783,00	120786,592
Higher education determinants	Col_Stud	The number of students in colleges	8582,373	3788,6919
	Uni_Stud	The number of students in universities	7179,967	7401,7446
	Teach_Staf	The teaching staff of higher educational institutions	428,600	496,9819
	C_InterA	The number of interactive equipment in colleges and universities	4841,800	6852,4262
	C_Comp	The number of computers in colleges and universities	4542,933	6313,6170
	C_C_Int	The number of ICT equipment with Internet access	2336,600	3191,1566

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ification, and as a result, SAR, SEM, or SLX models are obtained. All models test the impact of factors on the dependent variable. The paper employs a three-time series approach to assess the causal relationship between economic growth and higher education. SPSS, STATISTA, Stata, R package, Python, Smart PLS, AMOS, and G*Power software were used to analyze the data. For the analytical part of the research, the current paper used the Stata analytics package.

The correlation-based dependence of the indicators was calculated using the formula (1):

$$r_{xy} = 1 - \frac{6\Sigma d^2}{n\,(n^2 - 1)}, \tag{1}$$

where d^2 – the sum of squared variations between ranked levels; n – the number of function arguments in the ranking; x – unmeasured variable (independent); y – measured variable (dependent).

Additionally, the current paper collected secondary data. The analysis will allow an understanding of the region's current economic situation and the relationship between the education field and the ICT skills of the population receiving higher education. Next, the data are checked for normal distribution using a visual method. P-Plots charts help to determine which of the methods for constructing the correlation matrix is the most appropriate in the current case. The Stata software predicts correlation matrix construction using the command 'correlate' => 'selected variables.

The data include two sets of indicators explaining the region's economic growth and the regional higher education system. There are 17 regions in Kazakhstan, but information on some areas is limited. As a result, this study conducted data collection, operation, and analysis for 13 regions: Akmola, Aktobe, Almaty, Atyrau, West Kazakhstan, Zhambyl, Karaganda, Kostanay, Kyzylorda, Mangystau, Pavlodar, North Kazakhstan, and East Kazakhstan. Moreover, the analysis included two cities of republican significance: Astana city and Almaty city. The determinants were taken from official statistics data compiled by the Statistics Bureau of Kazakhstan and the National Bank.

4. RESULTS

Before focusing on the relationship between economic growth and higher education, the study analyzed the collected statistical data, namely, the primary indicator that considers the peculiarities of regional economic development. Thus, GRP is traditionally used as an indicator of the economic activity of each region per capita. In addition, the analysis of statistical indicators shows which regions need to be financially stimulated to improve higher education quality. Finally, this paper analyzes the development of GRP in thirteen regions of Kazakhstan within the framework of three ordered arrays of statistical data: 2010, 2015, and 2020.

Figure 1 shows a positive trend during the analyzed period. There are four regions showing high indicators (regions with resource-producing and export-oriented specifics – Atyrau and Mangystau) and regions with high economic activity (Almaty city and Astana city, which produce 19.5% of GRP). The high indicators of these regions reflect their economic activity and a high level of investment in fixed assets and financial security. Interestingly, the distribution of regions by GRP size with average per capita indicators is presented asymmetrically. Thus, differentiation in East Kazakhstan and Akmola increased in 2010 and decreased in 2020.

According to the dynamics of GRP changes, two regions – Zhambyl and Almaty – belong to regions with a low level of development. These regions are characterized by lower economic indicators per capita, low values of financial security, and insufficient levels of development of income distribution. These regions are significantly inferior in all indicators to the average Kazakh values, and this gap tends to increase further.

Next, this study analyzed the number of university students as an essential component of the higher education system. Astana city and Almaty city are Kazakhstan's financial business and intellectual centers. Therefore, the main part of higher educational institutions is concentrated in these two cities; young people mostly come to get a higher education here. Table 2 shows the dynamics of changes in the number of university students for 2010–2015 and 2016–2020.

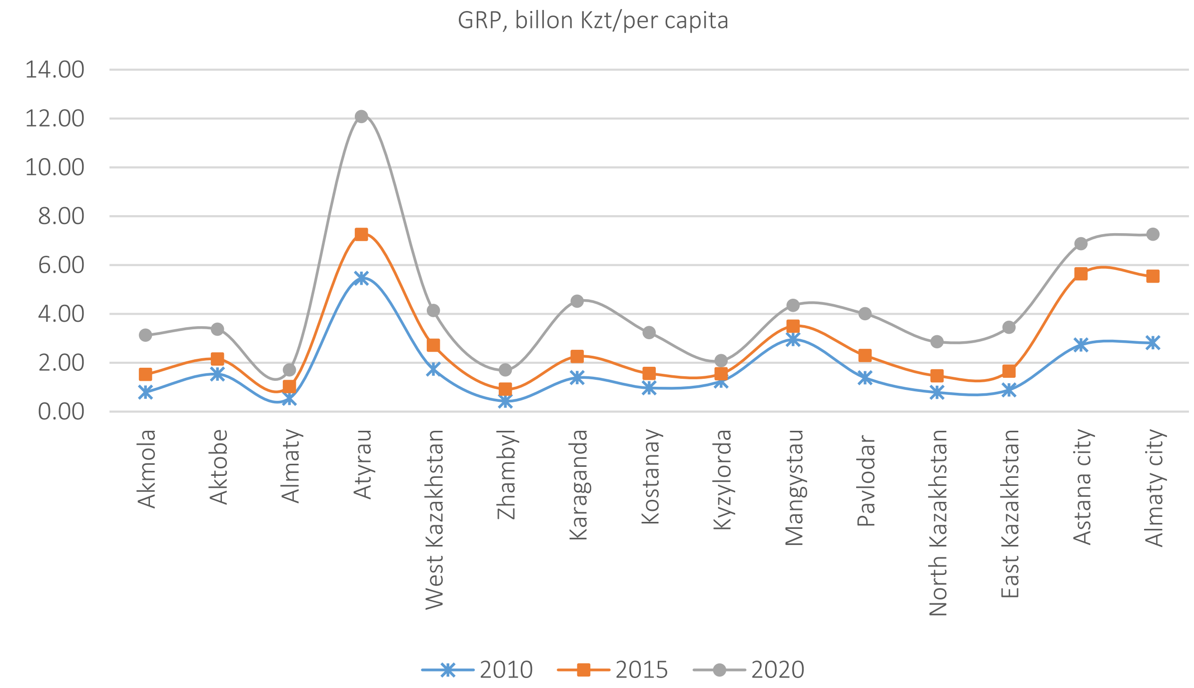

Figure 1. Dynamics of GRP development in the regions of Kazakhstan for 2010, 2015, and 2020

During the analyzed periods, the number of students in Kazakhstan is reducing due to some objective and subjective reasons. The objective reasons include the impact of negative demographic and migration processes. The subjective reasons are low academic performance of students, the lack of popularity of higher education, and the deterioration of the financial situation. Thus, for 2010–2015 and 2016–2020, the worst indicators were recorded in four regions: Kostanay (–32% and –30%), Karaganda (–39% and –32%), East Kazakhstan (–45% and –34%), and Kyzylorda (–42% and –35%).

On the contrary, the next period (2016–2020) is characterized by an increase in the number of university students. Thus, there was an increase in three regions: Aktobe (+7%), Almaty (+7%), and Astana City (+46%). There is a significant increase in the number of students in Astana city because about a third of universities are in this region. Objective reasons are connected with the migra-

Table 2. Dynamics of changes in the number of university students for 2010–2020

Source: Authors' elaboration based on Bureau of National Statistics (2022).

Region	2010	2015	Growth rate, %	2016	2020	Growth rate, %	Growth rate, %
Akmola	16736	9267	–45	8455	12111	43	–28
Aktobe	25336	20336	–20	21004	27090	29	7
Almaty	10057	9051	–10	9422	10753	14	7
Atyrau	15481	10014	–35	11012	12407	13	–20
West Kazakhstan	28260	26856	–5	29919	27121	–9	–4
Zhambyl	29426	18950	–36	19662	24953	27	–15
Karaganda	61105	36976	–39	41738	41650	0	–32
Kostanay	28079	19014	–32	20057	19574	–2	–30
Kyzylorda	17244	10055	–42	10070	11169	11	–35
Mangystau	8436	3976	–53	5081	7574	49	–10
Pavlodar	21755	12703	–42	13566	17144	26	–21
North Kazakhstan	9405	4560	–52	5235	8016	53	–15
East Kazakhstan	48381	26842	–45	27969	32104	15	–34
Astana city	40817	51235	26	51800	59425	15	46
Almaty city	186499	128707	–31	130761	163357	25	–12

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tion of young people to large cities. Subjective reasons may be a change in the social attitudes of people who associate the growth of well-being with education and qualifications.

When studying the relationship between the higher education system and economic growth, some studies generally recognize the limiting influence of technological infrastructure. At the same time, only a few studies considered computers, interactive equipment, and ICT infrastructure as essential components of higher education. Thus, indicators of accessible digital infrastructure are essential components of the higher education system, on which the quality of knowledge and teaching directly depends. Furthermore, the assessment of the level of digitalization makes it possible to identify the strengths and weaknesses of this process and justify the necessary management decisions that can provide the prerequisites for economic development.

This study conducted a detailed comparative analysis of the existing ICT infrastructure of colleges and universities in the context of regions. In addition, it was necessary to provide data reflecting the state at certain points: 2010, 2015 and 2020 (Table 3).

The indicator number of sets of interactive equipment in universities shows overall dynamics not only to increase in some regions but also to decrease. In 2010, the largest number of sets of interactive equipment at universities was in Almaty city (689), Karaganda (227), and Astana city (133); the smallest number was in Kyzylorda (21), Akmola (22), and Atyrau (23). In the next five years, the situation changed a little. Regions and cities leaders in 2015 are Kyzylorda (1303), Almaty city (1067), and East Kazakhstan (512). Regions with low indicators are Atyrau (55), Almaty (95), and Akmola (104). In 2020, the largest number of interactive equipment in universities was recorded in Almaty city (2432), Astana city (1272), and East Kazakhstan (912).

Further, the indicator of computers used in the educational process in universities in dynamics shows an increase over time. For example, a decrease in the equipment of universities by 2020 compared to 2010 is observed in Mangystau (124), Atyrau (951), and Pavlodar (1755). In other regions, the number of computers increased in 2020 compared to previous years. Such a massive increase in computers resulted from the COVID-19 pandemic, as the higher education system switched to a remote format and computers began to be purchased for online classes. The reason for the significant increase in ICT equipment with Internet access in 2020 was also the COVID-19 pandemic. Contact classes (offline) were banned at the beginning of

Table 3. Indicators of accessible ICT infrastructure at colleges and universities by regions

Source: Authors' elaboration based on Bureau of National Statistics (2022).

Region	The number of interactive equipment in colleges and universities			The number of computers in colleges and universities			The number of ICT equipment with Internet access		
	2010	2015	2020	2010	2015	2020	2010	2015	2020
Akmola	22	104	152	1680	2008	2380	816	1940	2380
Aktobe	64	233	532	2179	2987	4759	631	2359	4188
Almaty	43	95	160	626	1795	2315	175	1795	2315
Atyrau	23	55	64	1406	1164	951	618	850	931
West Kazakhstan	28	103	165	2058	2911	3357	1513	2644	3355
Zhambyl	48	178	220	1595	2244	1979	1263	2244	1947
Karaganda	227	433	652	6244	8097	10105	4687	7584	9965
Kostanay	103	251	379	2785	4834	5652	2479	4576	5596
Kyzylorda	21	1303	171	101	1371	2381	128	1786	2320
Mangystau	34	118	125	611	916	124	480	916	124
Pavlodar	21	130	156	2004	2384	1755	1787	2337	1755
North Kazakhstan	94	138	188	1569	1588	2528	900	1406	1612
East Kazakhstan	95	512	912	4793	5598	7117	2702	4273	5584
Astana city	133	459	1272	4915	9331	16617	2975	8724	16179
Almaty city	689	1067	2432	23322	30843	35656	15215	26993	32609
Medium	22	104	152	1680	2008	2380	816	1940	2380

2020 and were minimized in its second half. As a result, cameras, modems, interactive equipment, and software for conducting classes and monitoring during the session became necessary. The number was the maximum in Almaty city and Astana city since the concentration of students and teachers in these two cities is the maximum (32609 and 16179). On the other hand, an insignificant increase is observed in Atyrau (931), and Mangystau (124) faced a decrease in this indicator.

The comparative analysis offers several significant conclusions. First, the total number of available infrastructure in colleges and universities has grown in almost all regions of Kazakhstan. Second, a sharp increase in the number of equipped computers, interactive equipment, and ICT infrastructure was recorded in two regions (Kyzylorda and Almaty region) and two cities (Astana city and Almaty city). Third, the study results show a large proportion of regions with a low level of digitalization of the educational process. These regions include Mangystau, Atyrau, North Kazakhstan, and Pavlodar.

In almost all the regions and cities, there was an increase in the number of computers, interactive equipment, and ICT equipment with Internet access. At the same time, the studied indicators were higher in regions where the contingent of students was larger. The economic orientation of the regions is also affected. In particular, there are fewer colleges and universities in industrial regions. In 2020, a massive transition to digital technologies took place in Kazakhstan during the pandemic. The pandemic forced teachers to master remote technologies to improve their digital skills.

4.1. Correlation analysis

Before calculating the correlation coefficients, the study checked the data for normal distribution. Testing for normality has evolved historically, and scientists are still finding new ways and improving previously discovered methods (Jelito & Pitera, 2021). Some use the Fisher F-test, the Kolmogorov-Smirnov test (Lytvynenko et al., 2020), the Shapiro-Wilk test (Wilk & Shapiro, 1965), Chi-square, or Durbin. This study uses a graphical method – P-plots (Figure 2).

The direction of the lines allows for checking if the frequency distribution of the data is normal. If there are no lines, then the data are not normally distributed. This study uses the Spearman method to assess the relationships between the data. Conversely, if straight lines are observed, there is a normal distribution. In this case, all indicators were checked at once. Table 4 shows the correlation matrix results for 2010.

In 2010, there was a strong significant relationship between the indicators of the number of teachers (Teach_Staf) and the number of digital equipment

Table 4. Spearman's rho Correlation matrix – 2010 / Sig. (2-tailed)

Source: Authors' compilation.

Indicator	GRP	Inc_per	Col_Stud	Uni_Stud	Teach_Staf	C_InterA	C_Comp	C_C_Int
GRP	1	.811**	–.161	.021	–.032	.070	.200	.136
		.000	.567	.940	.909	.805	.475	.630
Inc_per	.811**	1	.100	–.004	.239	.359	.482	.411
	.000		.723	.990	.390	.188	.069	.128
Col_Stud	–.161	.100	1	–.014	.436	.542*	.657**	.575*
	.567	.723		.960	.104	.037	.008	.025
Uni_Stud	.021	–.004	–.014	1	.129	.329	.093	.132
	.940	.990	.960		.648	.231	.742	.639
Teach_Staf	–.032	.239	.436	.129	1	.810**	.807**	.775**
	.909	.390	.104	.648		.000	.000	.001
C_InterA	.070	.359	.542*	.329	.810**	1	.752**	.717**
	.805	.188	.037	.231	.000		.001	.003
C_Comp	.200	.482	.657**	.093	.807**	.752**	1	.929**
	.475	.069	.008	.742	.000	.001		.000
C_C_Int	.136	.411	.575*	.132	.775**	.717**	.929**	1
	.630	.128	.025	.639	.001	.003	.000	

Note: * Correlation is significant at the 0.05 level (2-tailed); ** Correlation is significant at the 0.01 level (2-tailed).

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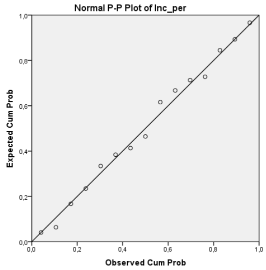
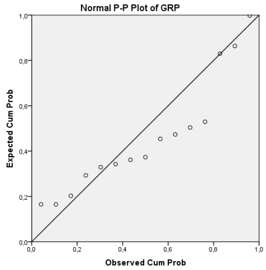
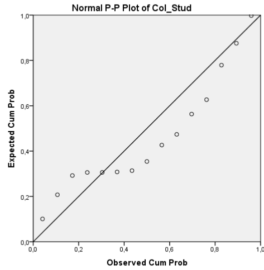
Source: Compiled by the authors.



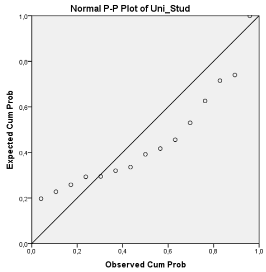
a) Cash income, average per capita, Kzt



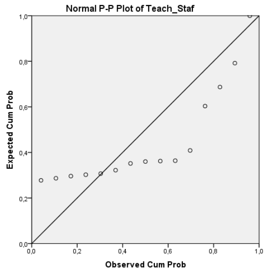
b) Gross regional product per capita, bln. Kzt



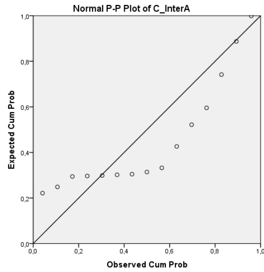
c) College students, people



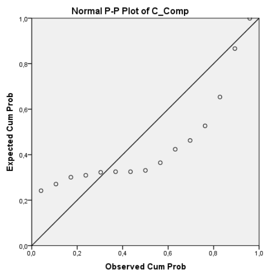
d) Students in universities, people



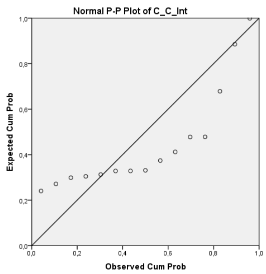
e) Staff of higher educational institutions, people



f) Number of sets of interactive equipment in universities, unit



g) Number of computers used in the educational process in universities, unit



h) Number of computers with Internet access in universities, unit

Note: The figure checks the indicators for the normality of the distribution.

Figure 2. P-plots

and software in the educational process (C_InterA – .810**; C_Comp – .807** and C_C_Int –.775**). These indicators also correlate with the number of college students (Col_Stud) – C_Interra – .542*; with Class p – .657** and C_C_Int –.575*. The indicator of income population, on average per capita (Inc_per), and GRP have a high correlation coefficient .811**. There is no correlation between the indicators of the count of students in universities (In_Studio) and other indicators. Table 5 shows the results describing the correlation indicators in 2015.

In 2015, there was a relationship between the indicators of the number of teachers (Teach_Staf) and the number of digital equipment and software in the educational process (C_InterA – .632**; C_Comp – .846** and C_C_Int –.800**). Interestingly, the indicators of the number of computers (CCOMR), including those with Internet access (C_C_Int) in universities that previously had no relationship at this time correlate with the income of the population, on average per capita (.625* and .614*, respectively). Correlation between the indicators of the

Table 5. Spearman's rho Correlation matrix – 2015 / Sig. (2-tailed)

Source: Authors' compilation.

Indicator	GRP	Inc_per	Col_Stud	Uni_Stud	Teach_Staf	C_InterA	C_Comp	C_C_Int
GRP	1	.564*	–.021	–.136	.136	.014	.239	.243
		.028	.940	.630	.630	.960	.390	.383
Inc_per	.564*	1	.429	–.189	.454	.382	.625*	.614*
	.028		.111	.499	.089	.160	.013	.015
Col_Stud	–.021	.429	1	–.079	.564*	.614*	.657**	.636*
	.940	.111		.781	.028	.015	.008	.011
Uni_Stud	–.136	–.189	–.079	1	.104	.114	–.125	–.179
	.630	.499	.781		.713	.685	.657	.524
Teach_Staf	.136	.454	.564*	.104	1	.632*	.846**	.800**
	.630	.089	.028	.713		.011	.000	.000
C_InterA	.014	.382	.614*	.114	.632*	1	.579*	.589*
	.960	.160	.015	.685	.011		.024	.021
C_Comp	.239	.625*	.657**	–.125	.846**	.579*	1	.986**
	.390	.013	.008	.657	.000	.024		.000
C_C_Int	.243	.614*	.636*	–.179	.800**	.589*	.986**	1
	.383	.015	.011	.524	.000	.021	.000	

Note: * Correlation is significant at the 0.05 level (2-tailed); ** Correlation is significant at the 0.01 level (2-tailed).

count of students in universities (In_Studio) and other indicators is not observed again. Indicators of per capita income (Inc_per) and GRP also have a weak positive relationship (.564*). Further, Table 6 shows the correlation indicators for the last period under review (2020).

Table 6 shows that the income of the population, on average per capita (Inc_per), and GRP have a correlation coefficient of .636*. The number of sets of interactive equipment in universities is positively correlated with the population's income (Inc_per) .504, a weak but positive correlation. There is also a correlation between the number of students in colleges .671** and a very high coefficient between teaching staff of higher educational institutions (Teach_Staf) .907**.

There is a correlation between observed indicators that positively correlate with economic growth depending on the period. Some correlation appears and disappears during the period under obser-

Table 6. Spearman's rho Correlation matrix – 2020 / Sig. (2-tailed)

Source: Authors' compilation.

Indicator	GRP	Inc_per	Col_Stud	Uni_Stud	Teach_Staf	C_InterA	C_Comp	C_C_Int
GRP	1	.636*	.071	–.021	.271	.132	.268	.268
		.011	.800	.940	.328	.639	.334	.334
Inc_per	.636*	1	.339	–.132	.536*	.504	.593*	.521*
	.011		.216	.639	.040	.056	.020	.046
Col_Stud	.071	.339	1	–.079	.539*	.671**	.561*	.671**
	.800	.216		.781	.038	.006	.030	.006
Uni_Stud	–.021	–.132	–.079	1	.246	.125	.075	–.054
	.940	.639	.781		.376	.657	.791	.850
Teach_Staf	.271	.536*	.539*	.246	1	.907**	.900**	.814**
	.328	.040	.038	.376		.000	.000	.000
C_InterA	.132	.504	.671**	.125	.907**	1	.911**	.843**
	.639	.056	.006	.657	.000		.000	.000
C_Comp	.268	.593*	.561*	.075	.900**	.911**	1	.939**
	.334	.020	.030	.791	.000	.000		.000
C_C_Int	.268	.521*	.671**	–.054	.814**	.843**	.939**	1
	.334	.046	.006	.850	.000	.000	.000	

Note: * Correlation is significant at the 0.05 level (2-tailed); ** Correlation is significant at the 0.01 level (2-tailed).

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vation. Surprisingly, there was no correlation between the number of university students and other indicators during 2010, 2015, and 2020. The coefficients are statistically significant and positive; no negative correlation was observed.

5. DISCUSSION

Earlier studies have assessed the relationships between determinants taking into account the peculiarities of the development of the regional higher education system and economic development in Kazakhstan. For example, previous research found that the higher the level of education, the higher the productivity. Thus, higher education indicators, particularly the number of students in universities, positively impact economic indicators. Moreover, graduates with undergraduate and graduate degrees positively influence a region's productivity level (Sun & Ning, 2016; Liu & Bi, 2019).

However, this study revealed that the number of university students did not affect economic or education indicators throughout the considered periods. Instead, there was a correlation between the number of college students and education indicators, including technological development and availability at higher educational institutions and the teaching staff.

Many scientific studies analyzed the relationship between education indicators and the population's income distribution. In particular, an increase in the population's income affects trends in higher education, and there is a dependence on improving the population's skills (Chekina & Vorhach, 2020; Brueckner et al., 2022). However, this study revealed a correlation between observed indicators that positively correlate with economic growth, depending on the period. For example, in 2015, the average per capita income indicator (Ink_pear) and GRP had strong positive links, and in other periods, the correlation coefficient was positive, but the links had average values.

These results are consistent with previous research on the correlation between the quality of education management and innovation (Feng et al., 2006; Zeng et al., 2015; Sahoo, 2019). In addition, there is a positive influence of teaching staff development and the level of ICT development on economic growth through the development of innovation and transition to a digital mode of education (Manarbek et al., 2020; Turlubekova & Bugubayeva, 2021; Kireyeva et al., 2022). In particular, the results of the first and second periods differ considerably as a strong positive correlation was established between the availability of computers and the population's income. Moreover, there was a positive relationship between income rate and GRP throughout the three periods.

The study analyzed the GRP indicators of 13 regions and two cities of republican significance, the dynamics of the number of students and teaching staff of universities, academies, and other higher educational institutions in Kazakhstan, and the number of available ICT infrastructure. In the first stage, the GRP indicators of the regions differed several times, primarily due to the high population density. Nevertheless, during the analyzed period, there were changes in the grouping of regions of Kazakhstan, which can be considered a positive trend. This conclusion shows that the distribution of areas by GRP size with average per capita indicators is presented asymmetrically.

Next, the study assessed the available ICT infrastructure at colleges and universities in the context of regions. Knowledge of digital programs used for teaching university students is mandatory since, during the COVID-19 pandemic, university education was transferred to an online format. In almost all the regions and cities under consideration, there was an increase in the number of computers, interactive equipment, and ICT equipment with Internet access used by universities. Thus, during the pandemic in Kazakhstan, there was a massive transition to digital technologies, which forced teachers to master remote technologies and improve their skills in the field of ICT.

The correlation analysis revealed dependencies between the observed indicators that positively correlate with economic growth, depending on the period. Thus, in some periods, the study observed a significant relationship between the number of teachers and the amount of digital equipment in the educational process. Although the coefficients are statistically significant and positive, no negative correlation was observed for all periods. Therefore, the study accepts *H1* but rejects *H2*.

CONCLUSION AND LIMITATIONS

This study examined the linkage between economic development and higher education determinants in Kazakhstan regions, including the number of students in colleges and universities, the number of teaching staff, and the available ICT infrastructure.

The comparative analysis of the existing infrastructure of colleges and universities showed an increase in the number of computers, interactive equipment, and ICT equipment with Internet access in all the regions and cities. A sharp increase in the number of equipped computers, interactive equipment, and ICT infrastructure was recorded in two regions (Kyzylorda and Almaty region) and two cities (Astana city and Almaty city). Accordingly, the study identified a group of regions with a low level: Mangystau, Atyrau, North Kazakhstan, and Pavlodar. Therefore, higher education development policy should focus on encouraging and strengthening knowledge management systems in these regions.

Undoubtedly, the study found positive correlations between the main economic indicators of the regions and the level of development of the higher education system. Indicators of the number of teachers and the number of digital equipment and software showed significant positive dependencies; there is a high correlation coefficient with the number of students in colleges and a very high coefficient between teaching staff of higher educational institutions. Two solid conclusions follow. First, the number of teachers and students in colleges is significant. Second, the number of digital equipment and software is also essential. Therefore, policymakers should introduce regulatory changes to increase investment in new technologies, especially ICT.

Moreover, in Kazakhstani regions, the GRP per capita varies depending on the population density. However, improving the quality of technological infrastructure in undeveloped areas would assist in reducing the geographical limitations and gaps that prevent them from obtaining opportunities from other areas. Based on these empirical results, the study offers some policy recommendations. For example, authorities should consider a development plan to promote the penetration of innovational growth in the education process. In general, higher education is not only the main factor in the country's economic growth but also plays a fundamental role in the innovative development of the national economy.

The main limitation of this study was a partial data set for all Kazakhstani regions. This is because some areas are newly formed, and the data concerned only recent periods.

AUTHOR CONTRIBUTIONS

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Investigation: Shyngys Karabayev, Anna Kredina, Makpal Bekturganova.
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Project administration: Shyngys Karabayev, Kuralay Nurgalieva.
Resources: Anna Kredina.
Software: Makpal Bekturganova, Yerkara Aimagambetov.
Supervision: Kuralay Nurgalieva.
Validation: Yerkara Aimagambetov.
Visualization: Shyngys Karabayev, Anna Kredina, Yerkara Aimagambetov.
Writing – original draft: Shyngys Karabayev, Anna Kredina, Makpal Bekturganova.
Writing – review & editing: Shyngys Karabayev, Kuralay Nurgalieva, Makpal Bekturganova.

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