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ASSESSING THE IMPACT OF HIGHER EDUCATION FACTORS ON INNOVATIVE ACTIVITY OF ENTERPRISES: AN ARDL APPROACH

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ABSTRACT

There has been an extensive amount of research devoted to innovative activity in universities and not much research is done on the factors of higher education influencing the innovative activity of enterprises. In this regard, the authors of this study have decided to fill this gap, and they trust that scholars and policymakers would consider their work to be of considerable significance for understanding the interconnection between higher education and innovation performance. This research aims to evaluate the effect of the major higher education institutional factors on the innovative activity of enterprises in the country and to illustrate how these factors are of long-run importance in realizing sustainable economic growth. The factors examined for 2003–2023 include level of innovation activity (in %), R&D expenditure (% of GDP), government expenditure on education, total (% of GDP), graduation of doctoral students, number of higher education institutions, and graduation of university students. Our econometric model is the autoregressive distributed lag (ARDL) model. The model was validated/tested by the augmented Dickey–Fuller (ADF) unit root test, Granger causality test, co-integration test, and stability tests, which are useful for model validation and robustness. Our results suggest that research and development spending and government spending on education generate short-term positive effects and long-run negative ones. On the contrary, the larger count of higher education institutions, doctoral graduates, and overall university graduates has detrimental short-run but advantageous long-run ramifications. The results can support important policy considerations for the promotion of innovation-based higher education systems and the enhancement of national innovation performance.

Keywords: *higher education, innovative activity, PhD students, ARDL model, education policy, economic growth*

1. INTRODUCTION

In the modern economy innovation is one of the two important factors in the national development. Knowledge is made innovations emerge from the accumulation, transmission, and effective use of that knowledge. Newton's (1675) metaphor of "standing on the shoulders of giants" describes this process, explaining how knowledge is passed down from generation to generation, promotes human welfare, optimizes the use of scarce resources, and underpins discoveries and innovations across disciplines in human activity. In cooperation with capital accumulation, innovation continues to be an influential determinant of long-run economic growth (Howitt &

Aghion, 1998). Education forms the basis for further social progress, and it is crucial for the transformation of innovation into an economic engine on terms of human capital accumulation and development. Human capital has been acknowledged for a long time as a key contributor to economic development (Mincer, 1958; Schultz, 1971; Dinzhanova & Bayetova, 2022, Kabylkairatkyzy et.al., 2025). In the knowledge-based context of contemporary business, education is one of the key drivers of innovation, and thus, expanding and strengthening education systems, particularly higher education, are critical aspects of nurturing innovative capacity. Higher education expansion boosts firms' innovation potential through the expansion of skilled labor pool, researchers and inventors (Kong et al., 2022). Higher education institutions serve as prominent social mechanisms of knowledge dissemination and transfer. Intentional sharing of both internal and external knowledge to stimulate innovation has been increasingly investigated in both academic and industrial circles (Jekabsone & Anohina-Naumeca, 2024). However, it is increasingly evident that higher education institutions themselves play an important role in incentivizing this sort of innovation. Many studies have investigated the importance of higher education institutions for innovation promotion and have researched effective ways to inspire students and engage them in innovative activities (Iglesias-Sánchez et al., 2019; Valencia-Arias et al., 2023; Mochnacs et al., 2024). However, there is evidence that merely having a university degree does not lead to better labor market outcomes or more widespread innovation. Graduates' job prospects are largely dictated by various other factors, and even the successful completion of advanced degrees including PhDs does not necessarily lead to increased innovation performance (Sekerbayeva et al., 2024; Satpayeva et al., 2025). In this context, the purpose of this study is to determine the effect of higher education–related characteristics on enterprises' innovative activity and to make policy-oriented recommendations for future development of enterprises. More precisely, the research questions the study aims to answer are:

Research Question 1: Which higher education factors have the greatest impact on enterprise innovation?

Research Question 2: What are the risks of promoting innovation via higher education mechanisms?

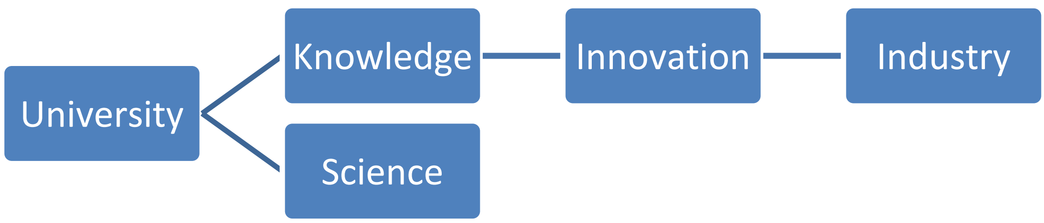
To do so, the study aims to add to the literature and enlarge its scope while contributing insights through econometric modeling by answering the above questions. Section 1 provides the introduction, followed by literature review, methodology and data description, descriptive statistics, results and discussion, and concluding remarks.

2. LITERATURE REVIEW

The role and contributions of private enterprises toward economic development in the country and their novel activities significantly contribute to profitability and competitiveness (Sarsen et al., 2023). Now, various authors have shown that the role of higher education in developing innovation is mainly tied to the introduction and integration of innovations into higher education (Liu, 2024; Zhang, 2025; Monico et al., 2025). The roles of universities have changed and the transfer of knowledge away from the institution is crucial as it contributes knowledge commercialization as part of innovative development (Cai et al., 2020). Today's universities have placed a growing emphasis on innovation; to bring knowledge to reality in addition to new concepts (Marczewska et al., 2024). For example, Okolo et al. (2023) reviewed panel data of 79 economies from 1995-2017 and reported that higher education has a significantly positive impact on innovation performance as measured from the applications to patents and trademarks. However, a mixture of patent data and Chinese industrial enterprises and provincial education data was combined by Pan et al. (2020) and found that, although the number of elite higher education institutions has a positive effect on firm-level innovation, the number of higher education institutions has a negative impact. Kazakhstan being an oil-exporting nation has its economy heavily stimulated by technology and knowledge innovation (Mukhamediyev & Spankulova, 2020). High-quality education always brings economic prosperity to countries (Erić, 2018; Li et al., 2024; Chen & Dong, 2025). Kazakhstan's higher education institutions are currently undergoing major changes (Meldebekova et al., 2025). Financial support assistance from the government from such aid source is vital to the successful adaptation of these changes as they take place (Kushebayev & Nygymetov, 2022). It is great to have the universities enabling innovation (Adin et al., 2024), and innovation will always be driven by the scientific knowledge (Fudickar & Hottenrott, 2019). Several initiatives for transforming educational institutions into centers of innovation and science are underway (Jonbekova et al., 2020; Jonbekova et al., 2025). While concerns overpay and transformation of internal university operations abound, Mukhiyayeva et al. (2022) found that in this article, their analysis showed university teaching staff had a firm grasp on science and innovation. It can be observed from the study by Altynbekov et al. (2023) that the number of professors and teaching personnel is correlated with innovative enterprises and business innovative firms. However, there remains a disparity between the number of doctorate theses defended and the number of PhD program graduates (Yelibay et al., 2022). This is the reason teachers and scientists are aging in their middle years. Innovation and digitization are closely associated with knowledge (Bolatbek et al., 2025). Olzhebayeva et al. (2025) examine how elements of human capital graduates, postgraduate students and expenses of education, influence creative activities in Kazakhstani regions. This study is based on the quantitative time series analysis of the Kazakhstani areas from 2000 to 2023 using regression and correlation analysis with the National Bureau of Statistics. The empirical results show how significantly (and positively) the number of PhD students, and the Gross Regional Product (GRP) influence the innovative activity. When GRP increases by 1% the number of innovative businesses is up by 0.75%, whereas the number of PhD students is up by 0.23%. But there are several challenges associated with making universities centers for research and innovation:

- Defenses for the small number of PhD students (Satpayeva et al., 2025).
- Compromise of the science concept continuity, a consequence of providing incentives to participate in grants of both basic and applied sciences.
- Short-lived research projects provided by scientific grants such as the ones below:
- Faculty of the university is also to teach science together with teaching. This is because we should keep in mind that public work given to teachers, as well as paperwork, in higher education institutions take time.
- Innovation is not conveyed well or advanced in simple and comprehensible manner.
- The quality of general education as well as scientific research is being hurt by the higher education institutions focusing too much on the global rankings and quantitative metrics (Narbaev et al., 2025).

Figure 1. The functional chain of university-driven innovation development



Source: compiled by authors

High-quality education in higher education institutions provides the laboratories required for the advancement of practical work, while also aiding in the advancement of science. Integrating theory and practice requires the consideration of the quality of science and education and the settings in which these are performed as well. Moreover, there are several ways to evaluate an organization's innovative behavior (Bekzhanova et al., 2024).

3. METHODOLOGY AND MATERIALS

3. 1. DATA

The econometric model was developed and analyzed, selecting the data for the following reasons:

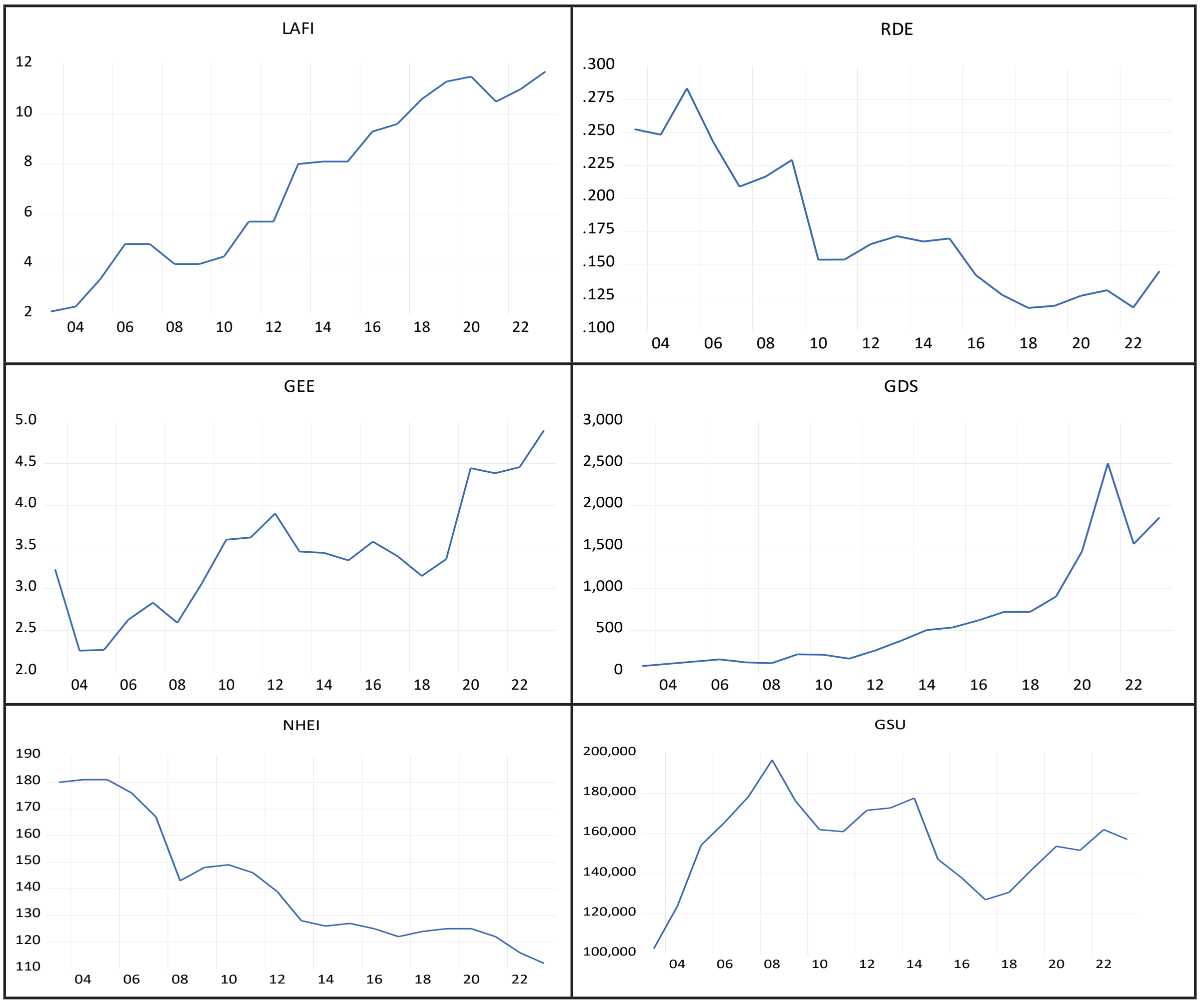
- Long-term availability of quantitative data, specifically over 20 years.
- The frequently noted items in the research of other researchers who have theoretical and methodological analysis on this or comparable topic.
- Related government policies surrounding higher education and innovation-features and measures closely related in nature. Data for the years 2003–2023 in the study were provided by the World Bank (WDI) and National Bureau of Statistics of the Republic of Kazakhstan (https://stat.gov.kz/en/), Trading Economics official website. The dependent variable is Level of activity in the field of innovation, while the explanatory variables for the study are Research and development expenditure, Government expenditure on education, graduation of doctoral students, number of higher education institutions and graduation of students from the universities. All the indicators and measurement units used in our study are defined in Table 1 below.

Table 1. Model Variables and sources

Variables	Definitions	Sources
LAFI	Level of activity in the field of innovation, in %	Bureau of National statistics Agency for Strategic planning and reforms of the Republic of Kazakhstan
RDE	Research and development expenditure, (% of GDP)	World Development Indicators (WDI) (2025)
GEE	Government expenditure on education, total (% of GDP)	Bureau of National statistics Agency for Strategic planning and reforms of the Republic of Kazakhstan, World Development Indicators (WDI) (2025), and Trading Economics
GDS	The number of graduations of doctoral students	Bureau of National statistics Agency for Strategic planning and reforms of the Republic of Kazakhstan
NHEI	The number of higher education institutions	Bureau of National statistics Agency for Strategic planning and reforms of the Republic of Kazakhstan
GSU	The number of graduation of students from the universities	Bureau of National statistics Agency for Strategic planning and reforms of the Republic of Kazakhstan

Source: compiled by authors

Figure 2. Evolution of all variables for Kazakhstan (2003–2023)



Source: compiled by authors

It is evident from the examination of the graph in Figure 2 that the variables being studied are appropriate for analysis. The graph's distinct, steady, and consistent time patterns suggest that variations in the variables are appropriate for additional research.

3. 2. METHODS

This The data for this study covers the period from 2003 to 2023. This period was chosen because available data for some of the variables used only cover this period. The study uses six variables: Level of activity in the field of innovation as the dependent variable, Research and development expenditure, Government expenditure on education, graduation of doctoral students, number of higher education institutions, and graduation of students from universities as explanatory independent variables. Detailed information on the variables used in this study is presented in Table 1.

This study examines the relationship between the Level of Activity in the Innovation Field and explanatory factors for the period 2003–2023, taking into account the results of the literature review in the previous section. The following formula determines the LAFI:

$$LAFI = f\,(RDE, GEE, GDS, NHEI, GSU) \qquad (1)$$

Table 1 lists all of the indicators' definitions and measures.

The study's approach was selected because it was deemed appropriate for examining the intricate connections between LAFI and significant elements influencing Kazakhstan's innovative and educational advancement. The autoregressive distributed lag (ARDL) model was considered suitable due to the dynamic nature of these variables and the requirement to take into consideration both short-term and long-term impacts. When working with time series data that has mixed orders of integration, as is frequently the case in economic research, the ARDL model performs exceptionally well.

The generalized model of autoregressive distributed lag ARDL($p,q_1,q_2,\ldots,q_k$) proposed by Pesaran (2001) is described below.

$$\Delta y_t = \alpha_0 + \sum_{i=1}^{P} \alpha_{1i}\Delta y_{t-i} + \sum_{i=0}^{q_1} \alpha_{2i}\Delta x_{1t-i} + \sum_{i=0}^{q_1} \alpha_{3i}\Delta x_{2t-i} + \ldots + \sum_{i=0}^{q_k} \alpha_{k+1i}\Delta x_{kt-i} + \beta_0 y_{t-1} + \beta_1 x_{1t-1} + \beta_2 x_{2t-1} + \ldots + \beta_k x_{kt-1} + \varepsilon_t \quad (2)$$

Below is shown how the ARDL structure based on equations 1-2 is transformed for the variables relevant to our study:

$$\Delta LAFI_t = \beta_0 + \sum_{k=1}^{m} \beta_1 \Delta LAFI_{t-k} + \sum_{k=0}^{n} \beta_2 \Delta RDE_{t-k} + \sum_{k=0}^{p} \beta_3 \Delta GEE_{t-k} + \sum_{k=0}^{q} \beta_4 \Delta GDS_{t-k} + \sum_{k=0}^{r} \beta_5 \Delta NHEI_{t-k} + \sum_{k=0}^{s} \beta_6 \Delta GSU_{t-k} + \gamma_0 LAFI_{t-i} + \gamma_1 RDE_{t-i} + \gamma_2 GEE_{t-i} + \gamma_3 GDS_{t-i} + \gamma_4 NHEI_{t-i} + \gamma_5 GSU_{t-i} + \varepsilon_t \quad (3)$$

4. EMPIRICAL RESULTS AND DISCUSSION

4. 1. DESCRIPTIVE STATISTICS

Descriptive statistics are commonly used to explain collected data. Table 2 presents the descriptive statistics for each variable. The properties of mean, median, skewness, kurtosis, Jarque-Bera, and probability were used in the study to analyze the variables.

Table 2. Values of descriptive statistics of the displayed series

Values	LAFI	RDE	GEE	GDS	NHEI	GSU
Mean	7.181	0.175	3.420	628.905	141.048	154876.1
Median	8	0.165	3.391	373	128	157106
Maximum	11.700	0.284	4.900	2503	181	196685
Minimum	2.100	0.117	2.256	70	112	102681
Std. Dev.	3.273	0.052	0.713	671.542	23.025	22003.120
Skewness	-0.033	0.623	0.281	1.449	0.705	-0.455
Kurtosis	1.540	2.105	2.560	4.206	2.078	3.007
Jarque-Bera	1.869	2.057	0.445	8.626	2.484	0.723
Probability	0.393	0.357	0.801	0.013	0.289	0.697
Sum	150.800	3.684	71.824	13207	2962.0	3252399
Sum Sq. Dev.	214.232	0.053	10.180	9019384	10602.950	9680000000

Source: Author` s calculation

The average values of LAFI, RDE, GEE, GDS, NHEI, and GSU are 7.181%, 0.175% of GDP, 3.420% of GDP, 628.905, 141.048, and 154876.1, respectively. The standard deviations of LAFI, RDE, GEE, GDS, NHEI, and GSU are 3.273%, 0.052% of GDP, 0.713% of GDP, 671.542, 23.025, and 22003.120. The standard deviation value shows that RDE has low variability. GSU has very high variability. RDE, GEE, GDS, and NHEI show positive skewness, while LAFI and GSU have negative skewness, meaning the distribution leans toward lower values with a long-left tail.

4. 2. UNIT ROOT TEST

Ensuring the stationarity of the time series is essential before looking at the long-term link between them. The augmented Dickey-Fuller (ADF) unit root test was used to determine the levels or differences of the variables that were deemed stable in this investigation, namely the existence of unit roots. Table 3 displays the findings. This test states that the presence of a unit root is indicated by a p-value larger than 0.05. There is no unit root following first-order differencing. If the variables have I(1), the ARDL bounds cointegration test can be run. Thus, these variables are used to estimate the ARDL model for our situation.

Table 3. ADF unit root tests

Variables	Intercept			Trend and intercept			None		
	Level	First diff.	Order of Integration	Level	First diff.	Order of Integration	Level	First diff.	Order of Integration
LAFI	-0.785 (0.802)	-4.45*** (0.003)	I(1)	-2.230 (0.449)	-3.212** (0.014)	I(1)	2.061 (0.987)	-3.308*** (0.002)	I(1)
RDE	-1.546 (0.490)	-4.692** (0.002)	I(1)	-2.215 (0.457)	-5.823** (0.001)	I(1)	-1.377 (0.151)	-4.551*** (0.000)	I(1)
GEE	-0.476 (0.877)	-4.99*** (0.000)	I(1)	-2.815 (0.208)	-4.810* (0.006)	I(1)	0.772 (0.872)	-4.548*** (0.000)	I(1)
GDS	3.518 (1.000)	-5.697** (0.000)	I(1)	-2.421 (0.359)	-3.419* (0.082)	I(1)	0.148 (1.000)	-5.380*** (0.000)	I(1)
NHEI	-4.774** (0.002)	-3.385** (0.026)	I(0)	-1.603 (0.755)	-4.207** (0.021)	I(1)	-2.64** (0.011)	-3.029** (0.004)	I(0)
GSU	-2.814* (0.074)	-2.953* (0.058)	I(0)	-3.332* (0.091)	-2.926* (0.177)	I(0)	-0.101 (0.636)	-3.029** (0.004)	I(1)

Notes:1) *, **, *** denote statistically significant at the 10%, 5% and 1% levels, respectively
p-value is inside brackets

Source: Author` s calculation

Since the results of the unit root tests are in line with the initial hypotheses, the ARDL model should be used to examine whether there is a long-term relationship between the level of activity in the field of innovation and the primary explanatory variables of higher education and innovation suggested in the study.

4. 3. GRANGER CAUSALITY TEST

The Granger test is employed to examine the causal link between the chosen variables and LAFI. Before making recommendations, it is crucial to understand the causal link between the basic factors.

Table 4. Noncausality tests in the sense of Granger for the vector autoregressive (1) (2003-2023)

Direction of causality	F-statistic	Prob.
LAFI		
RDE does not Granger Cause LAFI	0.169273	0.9188
GEE does not Granger Cause LAFI	0.258045	0.8790
GDS does not Granger Cause LAFI	0.256525	0.8796
NHEI does not Granger Cause LAFI	0.752139	0.6866
GSU does not Granger Cause LAFI	1.643552	0.4397

Source: Author` s calculation

The test results are shown in Table 4. These findings show that RDE, GEE, GDS, NHEI, GSU, and LAFI are not causally related. They do not show that the regressors are interdependent, which means that changes in one variable can not have a big impact on another.

4. 4. SELECTION ORDER CRITERIA

The ARDL model was used to analyze the long-term connection between variables because of the small sample size. This study examines the long-term relationship between a few chosen factors and the LAFI using the ARDL bounds testing approach in order to evaluate the influence of higher education and innovation factors on the Level of Innovation Activity in the Republic of Kazakhstan. It is essential to ascertain the lag period prior to performing the cointegration test. The LR, FPE, AIC, SC, and HQ are used to calculate the lag length criterion. The results for the chosen lag are shown in Table 5, which indicates that since it has more stars and is utilized in the study, the lag length of 2 should be picked.

Table 5. Selection order criteria

ARDL(2, 2, 1, 1, 1, 2)						
Lag	LogL	LR	FPE	AIC	SC	HQ
0	-422.9147	NA	1.63e+12	45.14892	45.44716	45.19939
1	-341.3998	102.9663	1.69e+10	40.35787	42.44558	40.71119
2	-207.1578	84.78443*	2737828.*	30.01661*	33.89378*	30.67278*

Source: Authors' analysis results

* Indicates lag order selected by criterion. LR: Likelihood ratio criterion. FPE: Final Prediction Error. AIC: Akaike information criterion. SC: Schwarz infor mation criterion. HQ: Hannan-Quinn information criterion.

Based on the LogL, LR, FPE, AIC, SC, HQ criteria presented in Table 5 above, the lag order for the autoregressive distributed lag (ARDL) model can be determined to be 2. This is due to the fact that the values calculated for lag 2 for all these criteria are the smallest compared to the values calculated for the remaining lags.

4. 5. CO-INTEGRATION TEST

The results of the ARDL (2, 2, 1, 1, 1, 2) test for cointegration boundaries are presented in Table 6. The general F-bounds test, which tests the null hypothesis of no relationship between the levels, yields an F-statistic of 4.661470. This value significantly exceeds the critical boundaries at all significance levels and indicates the rejection of the null hypothesis, therefore, cointegration exists.

Table 6. Results of cointegration test

Model	F Statistics	Signif.	Critical Bounds		Decision
			I(0)	I(1)	
ARDL (2, 2, 1, 1, 1, 2)	4.661470***	10%	1.81	2.93	Cointegration
		5%	2.14	3.34	
		2.5%	2.44	3.71	
		1%	2.82	4.21	

Critical bounds are reported at 1% (***) and 10% (**) level of significance

Source: Authors' analysis results

This finding supports the notion that the results obtained from all dynamic methodologies used in this study are robust, indicating a consistent long-term relationship between the chosen variables in the case of Kazakhstan.

4. 6. RESULTS OF LONG- AND SHORT RUN RELATIONSHIP

In the ARDL (2, 2, 1, 1, 1, 2) model, the explanatory variables together explain 0.986518% of the systematic variation in the growth of the Level of activity in the field of innovation D(LAFI) over the study period. The coefficients of the long-term and short-term relationships are presented in Table 7. All coefficients of the independent variables that affect the Level of innovation of Kazakhstan in the long term are significant. GDS, NHEI, GSU have a positive and significant effect on the growth of the Level of activity in the field of innovation of Kazakhstan, ceteris paribus. The growth of GDS, NHEI, GSU leads to an increase in D(LAFI) of Kazakhstan (coefficients of 0.015104, 0.310914, 0.000173, respectively). And RDE, GEE have a negative and significant effect on D(LAFI), with corresponding coefficients of -173.7203, -13.32922.

Table 7. Results of ARDL Estimation (2003-2023)

Model 1- results of ARDL(2, 2, 1, 1, 1, 2)
estimation D(LAFI)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Short Run				
LAFI(-1)*	0.328827	0.169406	1.941057	0.1099
RDE(-1)	57.12385*	25.33451	2.254785	0.0738
GEE(-1)	4.383002**	1.233851	3.552295	0.0163
GDS(-1)	-0.004967**	0.001442	-3.444016	0.0184
NHEI(-1)	-0.102237*	0.048164	-2.122664	0.0872
GSU(-1)	-5.69E-05**	1.82E-05	-3.120084	0.0262
D(LAFI(-1))	-1.091178**	0.418457	-2.607621	0.0478
D(RDE)	-12.74260	11.58395	-1.100022	0.3214
D(RDE(-1))	-23.90008	14.65354	-1.631011	0.1638
D(GEE)	1.375787	0.730592	1.883112	0.1184
D(GDS)	-0.002610**	0.000777	-3.361022	0.0201
D(NHEI)	0.047789	0.039586	1.207233	0.2813
D(GSU)	5.74E-05	3.51E-05	1.633389	0.1633
D(GSU(-1))	7.09E-05*	2.78E-05	2.545703	0.0515
ECT(-1)	-0.824117	0.066062	-12.47491	0.0002
Long Run				
RDE	-173.7203**	63.76951	-2.724191	0.0416
GEE	-13.32922*	5.518047	-2.415569	0.0604
GDS	0.015104**	0.004981	3.032108	0.0290
NHEI	0.310914**	0.120248	2.585613	0.0491
GSU	0.000173*	7.79E-05	2.222007	0.0769

Diagnostic	F-statistics	P-value
Serial correlation	2.444953	0.1366
Heteroskedasticity	0.718007	0.7131
Jarque-Bera	1.570457	0.4560

1) coefficients are statistically significant at ***1%, **5%, *10% level of significance.

2) compiled by the authors

Source: Authors' analysis results

In the short run, Kazakhstan's degree of innovation declines as the GDS difference rises (coefficient -0.002610).

Additionally, all other things being equal, the coefficients for the lagged variables RDE(-1) and GEE(-1) were positive (with coefficients of 57.12385 and 4.383002, respectively) in the short term, whereas the coefficients for the lagged variables GDS(-1) and NHEI(-1) confirmed negative effects on D(LAFI) (coefficients of -0.004967 and -0.102237, respectively).

The change in the lagged variables D(GSU(-1)) is positively and significantly correlated with D(LAFI) in the short run (7.09E-05), which is consistent with the long-run result.

Finally, diagnostic tests of the model were performed, including the Jarque-Bera normality test, the Breusch-Godfrey (LM) serial correlation test, and the Breusch-Pagan-Godfrey heteroscedasticity test (Table 7). For the ARDL(2, 2, 1, 1, 1, 2) model, the null hypotheses of homoscedasticity, normality, and absence of serial correlation in the ARDL model cannot be rejected.

The results in Table 7 show that the F-statistic of the test is 2.444953, and the probability value is 0.1366, indicating the absence of serial correlation. Given that the F-statistic is 0.718007 and the P-value is 0.7131, which exceeds the 5% significance level, the model is homoscedastic. Given that the F-statistic is 1.570457 and the probability value is 0.4560, which exceeds the 5% significance level, the null hypothesis of the normality test is accepted, indicating that the residuals are normally distributed.

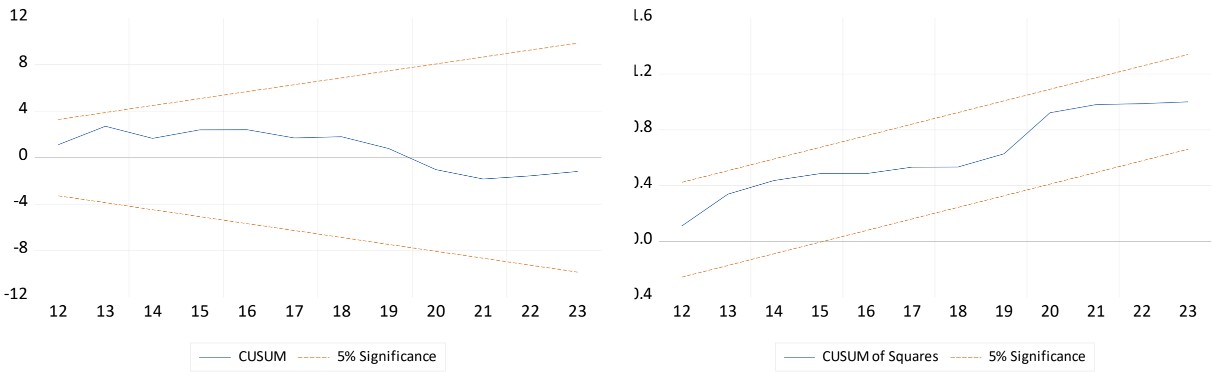
Thus, diagnostic testing confirmed the absence of serial correlation and heteroscedasticity. Similarly, the data used are normal, as confirmed by the value and probability of the Jarque-Bera test.

The error correction coefficient, equal to -0.824117, is negative and statistically significant at the 1% significance level, indicating a long-run relationship between the variables. The error correction term ranges from 0 to -1, indicating convergence to equilibrium. This suggests that 82.4% of short-term shocks can be eliminated, thus demonstrating the possibility of a more rapid adjustment of disequilibrium in the long run in the presence of any previous-year shocks in the explanatory variables.

4. 7. STABILITY TESTS

To determine whether the coefficients of the built model stay constant over time, Figure 3 displays the findings of the CUSUM and CUSUM-squared tests, which are markers of model stability. The reliability of the model is demonstrated by the tests' failure to surpass the critical threshold values at the 5% significance level. The long-term dynamics of the regression are also examined using this test.

Figure 3. CUSUM and CUSUM squares tests



Source: Author` s calculation

4. 8. MULTICOLLINEARITY TEST

In this study, the VIF tool was used to test for multicollinearity. The results of the VIF test are presented in Table 8, which show that no multicollinearity was detected.

Table 8. VIF multicollinearity test results

Variable	Centered VIF
RDE	6.236780
GEE	3.703177
GDS	3.028223
NHEI	6.774369
GSU	1.247066

Source: Authors' analysis results

The VIF test is used in this study to identify multicollinearity amongst independent variables. Table 8 displays the findings. The VIF assesses the level of variance inflation in the computed regression coefficient if the independent variables are correlated.

Paying attention to the Centered VIF is crucial. Generally speaking, multicollinearity problems are indicated by a VIF result larger than 10. A VIF rating of less than 10 indicates that collinearity is not an issue (Chavent et al., 2006)

According to the test results, every VIF value is less than 10, which is in line with the empirical rule. As a result, we may deduce from the model findings that there are no significant multicollinearity problems, which permits us to keep all of the variables in our subsequent research.

5. DISCUSSION

The findings of this study are comparable to those of other investigations.

While Government expenditure on education and Research and development expenditure has a short-term beneficial effect, the number of university students and PhD student graduates has a short-term negative effect. Government expenditure on education and R&D expenditures have long-term negative effects, the number of university students and PhD student's graduates has long-term favorable effects. These results are in line with several researchers. Research and development expenditure has a favorable effect on innovation, as shown by studies by Akcali & Sismanoglu (2015), Pegkas et al. (2019), Dritsaki & Dritsaki (2023). However, research and development expenditure have a short-term detrimental effect on innovation, according to Dritsaki & Dritsaki's (2023) study. The findings of the Tan et al. (2023) study is in line with the short-term beneficial effects of government expenditures on education on innovation. Additionally, we concur with Tan et al. (2023) that improving cooperation between academic institutions, institutes of research, and businesses is essential. Studies by Morais et al. (2022), Zhang (2024), Resta et al. (2024) have also shown a long-term correlation between innovation and doctoral student graduation.

The following graph displays the dynamic change in each of the indicators provided in the table for the years 2003–2023. Using the following formula, we display the percentage changes in statistics from 2003 to 2023 in Table 8.

$$Percent\ Chage = \frac{V_{2023} - V_{2003}}{V_{2003}} \cdot 100\% \quad (3)$$

where V_2003 and V_2023 are the values of the indicators for 2003 and 2023, respectively.

The information provided indicates that between 2003 and 2023, the amount of activity in the sector of innovation rose by about 457 percent. The amount of innovative activity has increased globally over the years of research, as evidenced by the rise in the number of innovative products and the introduction of new technologies and processes. These developments result in economic growth, the creation of new jobs, and an improvement in societal well-being.

Table 8. Key statistics

Variables	2003	2023	Change
Level of activity in the field of innovation, in %	2,1	11,7	457,1429
Research and development expenditure, percent of GDP	0,25246	0,14472	-42,6761
Government expenditure on education, total (% of GDP)	3,230482	4,9	51,68015
The number of graduations of doctoral students	70	1 854	2548,571
The number of higher education institutions	180	112	-37,7778
The number of graduation of students from the universities	102 681	157 106	53,00396

Source: Author` s calculation

Additionally, it is mentioned that while expenditure on research and development has increased to 172.6 billion tenge during the last 21 years, its percentage of GDP has dropped by 42.68 percent. According to current data, government spending on education will account for 4.9% of GDP in US dollars in 2023. It has been discovered that it has surged by almost 51 percent. The decrease in Kazakhstan's educational spending as a share of GDP over the past 20 years may be the result of a change in budget priorities, a global drop in the proportion of public spending on education, and an increase in total public spending in absolute terms, which may cause the relative share to fall even with more funding. The number of PhD students who graduate has increased by 26.4 times, or 2,548.571%. Statistics indicating a surge in researchers with advanced degrees, including PhDs and doctors of science, reveal that Kazakhstan has seen a rise in doctoral graduates over the last 20 years. Nonetheless, during the course of the study, Kazakhstan's higher education institution count has decreased. Based on statistical data, the number of institutions decreased by a considerable 37.8% from 180 in 2003 to 112% in 2023. The universities have seen a notable improvement in their student graduation rate, which has risen by almost 53%.

6. RESULTS AND CONCLUSION

Numerous studies have demonstrated that state innovation activity is influenced by significant elements in higher education institutions. This research paper's purpose is to evaluate how various elements in Republic of Kazakhstan's higher education institutions affect innovative activity of enterprises. In order to accomplish this, authors used ARDL to assess the link between the following metrics for the years 2003–2023: level of activity in the field of innovation (in %), research and development expenditure (% GDP), government expenditure on education, total (% of GDP), graduation of doctoral students, number of higher education institutions, graduation of students from the universities. According to the model results, the lag variable of graduation of doctoral students and itself and the lag variable of number of higher education institutions have a negative impact on innovative activity in the short term. And graduation of doctoral students, graduation of students from universities, number of higher education institutes have a positive impact in the long term. Similarly, research and development expenditure, government expenditure on education have a positive impact in the short term, but a negative impact in the long term.

The research's findings allow us to respond to the aforementioned research topics in the following ways:

RQ1 - Every explanatory variable has a considerable impact on the Level of activity in the field of innovation outcome factor. The number of higher education institutions explanatory variable has a stronger impact on the Level of activity in the field of innovation dependent variable than the others, as indicated by the comparatively biggest elasticity coefficient (-0.7603) and correlation coefficient (-0.893).

RQ2 - Tough precautions are necessary due to the high danger of corruption in the field of higher education and science (Singh et al., 2025). Understanding the scenario from the perspective of internal risk, we think that the short-term negative effects of government spending on R&D are linked to the misappropriation of funds. Given their crucial role in training experts who join the labor market each year, technical and vocational education (TVE) and higher education development are especially vital. All residents have the option to get their first working profession at no cost because to the government's proactive approach to TVE development. Underfunding in this area, however, results in a lower employment rate for graduates than in OECD nations, as well as outdated infrastructure in educational institutions and poor teaching personnel. Since per capita funding was introduced, higher education has become more autonomous on both a financial and intellectual level, with universities creating their own curricula on their own. The inadequate gross enrollment in higher education, which is made possible by the state grant distribution system, is one of the major issues facing this industry. Additionally, the nation's capacity to produce R&D is constrained by low research expenditures, which, when combined with the lack of communication between government agencies and universities about advisory work and research for policymaking, seriously undercuts the potential of higher education in the nation. The state budget and student fees are the two main sources of funding for universities, while private investor capital and contributions from other groups and people make up a sizable portion of global funding. The risk of corruption is still significant. In addition to costing the budget billions of tenge, the many schemes and illicit activities plaguing Kazakhstan's educational system also damage the country's reputation and diminish the efficiency of public spending.

Current situation and some policy implications

These days, the state's economic development and the expansion of its own production depend on inventive development. Thus, more money must be spent on research and development, and their budget must be closely watched. We consider that actions like focusing on patents and increasing the duration of scientific grants will greatly aid in the commercialization of science. Universities should not receive as much emphasis as scientific research institutes. Furthermore, it is important to keep a close eye on the quality of education provided in colleges since, as we should not forget, educating the next generation is a top priority. As the model findings demonstrate, research does not yield a return in the short term, but it will yield a high and consistent return over the long run. The study's findings unequivocally demonstrate that science has no immediate financial advantages, but its long-term benefits greatly exceed this. Funding research organizations and universities that conduct research with strategic purposes is crucial.

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