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# Education, Institutions, and Investment as Determinants of Economic Growth in Central Asia and the Caucasus: A Panel Data Analysis

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**Abstract:** Economic growth and development are key to societal well-being, yet emerging economies in Central Asia and the Caucasus face challenges such as labor market inefficiencies, uneven capital distribution, and weak institutions. This study examines the impact of education, institutional quality, capital investment, and labor force dynamics on economic growth in the region from 2010 to 2023. Using panel data analysis, including unit root tests, cointegration tests (Pedroni and Kao), and FMOLS/DOLS estimation, the findings reveal that while education and capital investment drive growth, institutional factors show mixed effects. Higher tertiary education enrollment correlates with long-term economic expansion, whereas weak governance and corruption hinder progress. This study contributes to the literature by providing empirical evidence on education and institutional roles in economic performance, offering policy insights for sustainable growth. The results highlight the need for governance reforms, education quality improvements, and labor market adaptability to enhance economic potential.

**Keywords:** human capital; tertiary education enrollment; panel data analysis; FMOLS and DOLS estimation; institutional frameworks; labor market dynamics; capital formation; higher education policy; sustainable economic growth

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Academic Editor: Hiroyuki Taguchi

Received: 5 February 2025
Revised: 4 March 2025
Accepted: 6 March 2025
Published: 17 March 2025

**Citation:** Tleppayev, A., Zeinolla, S., Tyulyubayeva, D., & Aben, A. (2025). Education, Institutions, and Investment as Determinants of Economic Growth in Central Asia and the Caucasus: A Panel Data Analysis. *Economies*, *13*(3), 78. https://doi.org/10.3390/economies13030078

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## 1. Introduction

Higher education is a critical factor for economic development, especially in regions with dynamic economies such as Central Asia and the Caucasus. In the context of global competition and technological progress, investments in education are becoming an integral part of a long-term growth strategy. They help to build human capital, increase labor productivity and create an innovative economy. However, the effectiveness of such investments depends not only on their volume but also on the quality of educational programs, the level of teacher training, and the institutional environment.

Research confirms that public investment in higher education can have a significant impact on economic development, but its impact is determined by many factors. For example, Solmon and Fagnano (1993) highlight that human capital growth is a key driver of economic modernization and has a stronger impact on economic growth than physical capital accumulation. The analysis of Arman et al. (2020) shows that regions with high levels of skilled labor show higher rates of economic development. However, simply increasing the number of universities does not lead to significant economic growth unless accompanied by an increase in teacher training and improved educational standards.

Global experience also shows that the mechanisms of higher education's impact on the economy may differ depending on the level of a country's development and its education policy. For example, Wang (2021), in his study of the Chinese economy, identifies three key mechanisms through which higher education contributes to economic growth: development of science and technology, optimization of human resources, and direct contribution to GDP. In turn, Lobo (2015) analyses the impact of higher education on India's economic development and concludes that low higher education enrolment rates (GERs) and inadequate teaching quality are impediments to economic growth. Unlike in China, where government support ensured rapid development of universities, in India, the increase in the number of higher education institutions was accompanied by a deterioration in educational standards, which had a negative impact on training.

Thus, the study of the impact of investment in higher education on economic development in Central Asia and the Caucasus requires a comprehensive approach. This paper makes a significant contribution by introducing a new perspective on the relationship between education, institutional quality, and economic growth. Unlike previous studies, it highlights the critical role of governance in determining the effectiveness of educational investments. Using advanced econometric techniques (FMOLS/DOLS), this study provides new empirical evidence on the long-term impact of education and institutions, offering previously unexplored insights for optimizing education policy and strengthening economic competitiveness.

The remainder of this paper is structured as follows. Section 2 reviews the relevant literature on the relationship between education, institutional quality, and economic growth. Section 3 presents an analysis of macroeconomic indicators in Central Asia and the Caucasus. Section 4 outlines the research methodology, including the econometric model and data sources. Section 5 discusses the empirical findings and their implications. Section 6 provides policy recommendations and future research directions. Finally, Section 7 concludes the study by summarizing key insights and contributions.

## 2. Literature Review

*Educational Investment and Economic Growth*

Research analysis confirms that strategies aimed at improving the quality of higher education should be aligned with national economic objectives, as emphasized by Baidybekova et al. (2022). Successful reforms, including accreditation, digitalization programs, and the integration of innovative educational technologies, demonstrate that investment in education directly contributes to increased productivity, reduced unemployment, and an improved quality of life. Higher education plays a crucial role in economic development by enhancing labor productivity, fostering innovation, and contributing to overall socio-economic performance. Recent research highlights that institutional changes and higher education reforms are key drivers of long-term economic growth (Volchik et al., 2018).

The role and impact of investment in education are significant for both developed and developing countries, but its effectiveness depends on the structure of the education market. Garcia (2014) investigates the relationship between public spending on higher education and economic growth in 50 US states for the period 1989–2006. Using a two-stage least squares (2SLS) model, the author showed that public spending on higher education has a positive impact on economic growth only in states with a small private sector for higher education. Aca-ac et al. (2020), Fahim et al (2023) explore the perception of higher education quality in an emerging economy by analyzing the perspectives of key stakeholders—students, educators, and employers. Their findings highlight that curriculum relevance, graduate employability, and institutional reputation play a critical role in

defining education quality. These insights are crucial for understanding how investment in higher education aligns with labor market needs and economic growth in developing economies.

Coronel and Díaz-Roldán (2024) investigate the impact of public expenditure on education on labor productivity, wages, and economic growth in European Union countries over the period 2009–2020. The authors applied DOLS and FMOLS estimation techniques to panel data to remove endogeneity and identify long-run relationships between variables. The main findings show that labor productivity and the size of the population with tertiary education have a positive and significant impact on economic growth. However, the relationship between public spending on education and labor productivity is not directly identified. The authors note that this effect is found indirectly through higher levels of education and technological skills. These results emphasize the importance of investing in sectors with a high technological component and the need to further analyze the structure of educational expenditures.

In addition, Ambasz et al. (2023) indicate a negative relationship between public spending on higher education and educational attainment. However, this negative effect is partially offset in states with a more developed private education sector. This study emphasizes the complex role of public expenditure in a mixed education market and the need for an integrated approach to education policy design.

Education spending and labor force quality have a significant impact on economic development. Clarke et al. (2015) examine the relationship between public education spending, educational attainment, and economic growth at the county level in Georgia for the period 2006–2008. The results show that the number of jobs and economic growth depend more on the educational attainment of the workforce than on schooling expenditures. The authors note that having a bachelor's degree in the population is positively correlated with job growth, especially in high value-added sectors such as biotechnology.

This study confirms that spending on education alone does not guarantee economic growth. The most important factor is the quality of education and the ability of regions to attract and retain highly qualified specialists (Legčević, 2014). This underlines the need to create a balanced education policy aimed at improving the level of education and adapting the labor force to the requirements of high-tech industries (Narmania et al., 2023).

Investment in education has a significant impact on economic development, especially in emerging economies. Abu Alfoul et al. (2024a) emphasize that institutional quality plays a key role in amplifying the effect of education on economic growth. Applying a panel ARDL model for 18 countries in the sub-Saharan Africa region over the period 2000–2020, the authors find that the long-run effect of education on economic growth is insignificant without the presence of institutional support. In particular, factors such as corruption control and political stability reinforce the positive effect of education on economic growth. Fahim et al. (2023) confirm the positive relationship between investment in higher education and economic growth, highlighting that while education contributes to economic expansion, economic growth itself has played a limited role in promoting further investments in higher education. This underscores the need for strategic policy interventions to ensure sustainable educational development.

Importantly, investment in education is closely linked to sustainable economic development. Sherry and Zeaiter (2024) investigate the impact of International Monetary Fund (IMF) conditionalities on public spending on education in the Middle East and North Africa (MENA). Using panel data for 1990–2020 and fixed effects models, the authors show that strict IMF lending conditions (so-called binding conditions) boost education spending by freeing up fiscal space and attracting international aid. These results highlight the importance of aligning education priorities with macroeconomic stabilization programs. The

authors emphasize that, despite positive effects, potential trade-offs between fiscal stability and social spending can have a dampening effect on long-term investment in human capital. Under conditions of weak governance, the effectiveness of increased educational spending may be limited, which requires a more balanced approach to economic and social policy.

There are also studies that have found that investment in digital technology and education has a significant impact on economic development. Abu Alfoul et al. (2024b) emphasize that the use of ICT (information and communication technology) can have a positive impact on economic growth, but this impact depends largely on the level of education of the population. This study, covering 15 countries in the MENA region over the period 2000–2020, finds that higher education enhances the effect of ICT on economic development, while insufficient training and brain drain significantly reduce the effectiveness of digital initiatives. The authors also draw attention to the need to modernize infrastructure and create a favorable institutional environment to improve the interaction between ICTs and the economy.

It is interesting that the positive impact of increased spending on education also has a positive effect on the economic growth of the region, maintaining this effect from the transition from the macrolevel to the mesolevel of the economy. Thus, investment in higher education and effective university budget management are of key importance for regional socio-economic development. Chinnakum et al. (2024) investigated the impact of Chiang Mai University on the economy of Northern Thailand using Input–Output (IO) and Social Return on Investment (SROI) models. The results show that the university creates about 700 agricultural jobs, 241 service jobs, and 113 industrial jobs annually over the 2023–2025 period.

In addition, every million Thai baht invested in the university generates a significant socio-economic impact. The use of the SROI forecasting model identified key areas for optimizing budget expenditure and offered recommendations for improving the effectiveness of university financial management. This study emphasizes the importance of supporting SDG 4 (quality education) through investment in higher education and regional economic development.

Current research shows that quality education and strategic investment in digital technologies can be crucial for economic growth. However, countries with low-quality education and high levels of skilled emigration have seen diminishing returns on investment in technology, highlighting the importance of integrating education policies and digital strategies. In contexts with weak institutions, educational efforts are often ineffective. The results confirm the importance of integrating education policy with broader economic reforms, including greater transparency and better governance.

## 3. Analysis of Macroeconomic Indicators

*An Empirical Study Based on Data*

This section will analyze the impact of educational investment on economic development and offer recommendations for improving the effectiveness of higher education development strategies in Central Asia and the Caucasus. By analyzing GDP growth (annual change in gross domestic product) and the structure of education spending, it is possible to identify the relationship between the long-term development of human capital and the level of economic activity. The development of effective strategies requires a detailed consideration of these factors, taking into account regional specifics and the dynamics of economic indicators.

The Figure 1 presents an analysis of the dynamics of gross domestic product (GDP) per capita (in current US dollars) across eight countries in the region—Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, Mongolia, Tajikistan, and Uzbekistan—over

the period from 2011 to 2023. The data provide insights into the disparities in economic development among these nations and allow for an assessment of the sustainability of their economic growth.

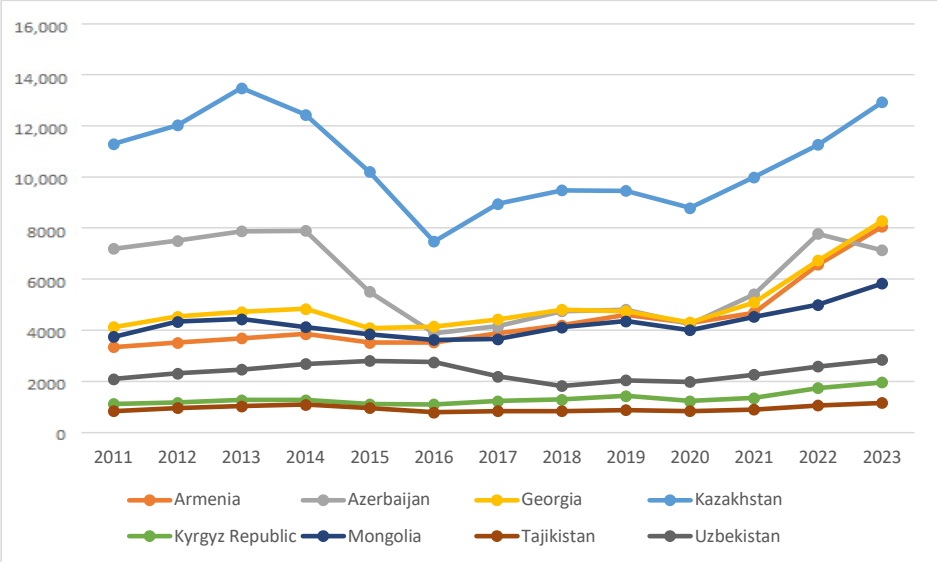



**Figure 1.** Dynamics of GDP per capita in the countries of Central Asia and the Caucasus (prepared by the authors using World Bank data).

Kazakhstan exhibits the highest GDP per capita among the analyzed countries, with a steady increase from 2011, peaking in 2014 at over USD 14,000 (Figure 1). Following this peak, a decline is observed, but from 2018 onwards, the trend reverses, leading to a recovery and reaching approximately USD 13,000 by 2023. Azerbaijan, which initially maintained a relatively high GDP per capita, experienced a notable decline after 2014, likely due to its economic dependence on the oil sector and fluctuations in global energy prices. A recovery trend emerges in 2021–2023. Georgia and Mongolia display moderate and relatively stable GDP per capita growth throughout the period, with minor fluctuations. Kyrgyzstan and Tajikistan remain at the lower end of the spectrum in terms of GDP per capita but exhibit slow yet consistent growth, particularly in recent years. Uzbekistan maintains a GDP per capita below the regional average for most of the period; however, a significant upward trend is observed after 2020. Armenia has demonstrated a gradual increase in GDP per capita since 2017, which may be attributed to economic reforms and the expansion of international economic cooperation.

Overall, the analysis highlights significant variations in the economic development of the countries in the region and differing degrees of economic growth sustainability, which are shaped by macroeconomic factors, structural characteristics of national economies, and external economic conditions. The dynamics of GDP per capita emphasize the importance of strategies aimed at diversifying the economy, increasing the level of investment in human capital and education. In countries with stable GDP per capita growth and consistent investment in education (e.g., Kazakhstan), economic development measures have shown greater effectiveness in improving overall quality of life. However, sharp fluctuations in Azerbaijan and stability at low levels in Kyrgyzstan and Tajikistan indicate the need to develop long-term economic strategies oriented towards balanced growth and improving the well-being of the population.

The Figure 2 presents data on the share of public expenditure on education as a percentage of GDP across eight countries in the region—Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, Mongolia, Tajikistan, and Uzbekistan—over the period from

2011 to 2023. The data reveal significant differences in how countries finance their education systems and the sustainability of these expenditures, meaning their long-term consistency, reliability, and ability to support education without causing fiscal imbalances or budgetary constraints.

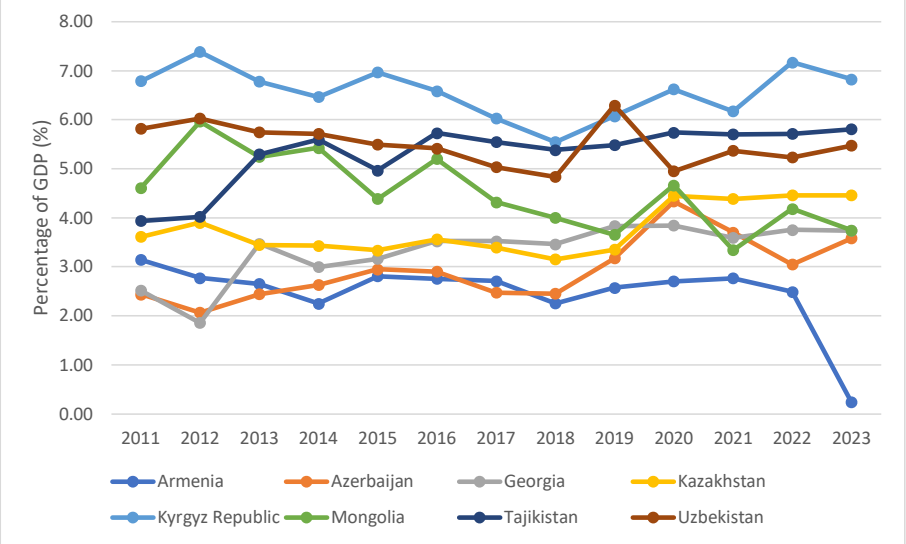



**Figure 2.** Education expenditure dynamics (% of GDP) in Central Asia and the Caucasus (prepared by the authors using World Bank data).

Kyrgyzstan allocates the highest share of public expenditure on education, exceeding 7% of GDP at the beginning of the period. Although a decline is observed by 2023, the values remain above the regional average, indicating a continued commitment to education funding. Tajikistan and Uzbekistan maintain relatively stable expenditures in the range of 5–6% of GDP throughout the period, reflecting permanent governmental support for the education sector. Mongolia exhibits fluctuations within the 4–5% range, with peaks in 2015 and 2020, likely attributable to shifting budgetary priorities. Kazakhstan maintains a stable allocation of approximately 3–4% of GDP, suggesting a balanced and consistent approach to education expenditure. In contrast, Armenia experiences a sharp decline, with public expenditure on education dropping below 1% of GDP by 2023, potentially signaling a reduction in funding or a reallocation of budgetary priorities. Azerbaijan and Georgia demonstrate fluctuations between 2 and 4%, indicating a moderate level of education spending relative to other fiscal demands.

The observed differences in the share of education expenditure underscore the variability in national education policies and priorities across the region. The (European Training Foundation (ETF), 2011) and Aperyan (2021) examine the impact of lower public allocations to education in Armenia, highlighting their long-term implications for economic growth, human capital development, and the country's competitiveness and innovation capacity. Similarly, Abasova (2023) highlights the role of increased investments in ICT techniques in Azerbaijan's higher education system during the pandemic, emphasizing both opportunities and challenges for sustainable educational development. Additionally, an analysis of gross capital formation as a percentage of GDP provides further insights into the scale and direction of economic policies across these countries. Graphical trends enable the identification of key patterns and inform recommendations aimed at enhancing the effectiveness of investment strategies, ensuring that education financing contributes to sustainable economic development.

The Figure 3 presents data on the share of gross capital formation in GDP across eight countries in the region—Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan,

Mongolia, Tajikistan, and Uzbekistan—over the period from 2010 to 2023. The data highlight differences in economic strategies and the sustainability of capital investment across these nations.

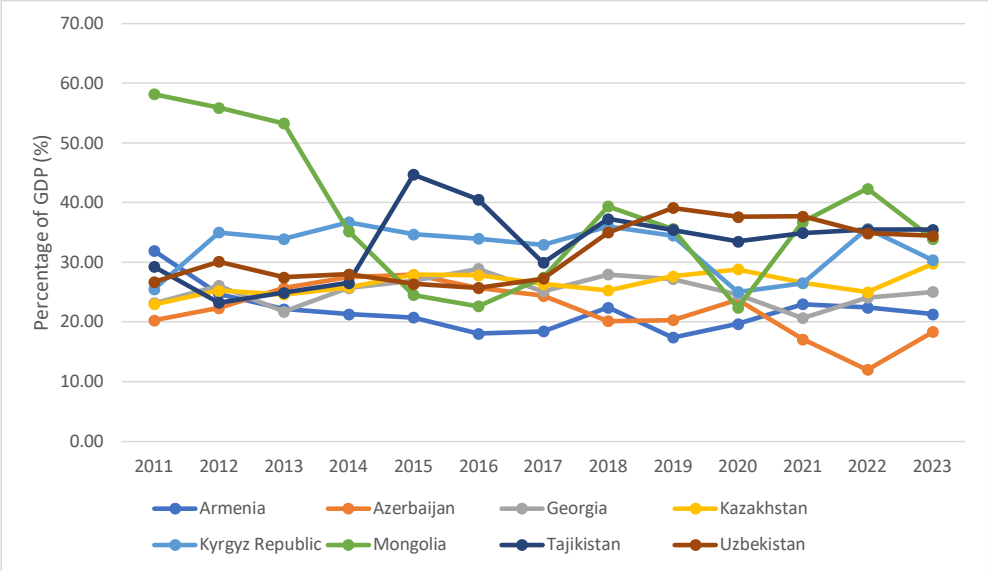



**Figure 3.** Dynamics of gross capital formation (% of GDP) in the countries of Central Asia and the Caucasus (prepared by the authors using World Bank data).

Mongolia initially had the highest investment share at 60% in 2011, declining to around 30% by 2015 and stabilizing thereafter. This suggests a shift in priorities rather than a sharp drop. Kazakhstan and Uzbekistan maintained stable investment levels of 25–30%, while Tajikistan fluctuated, peaking at 40% in 2015 before declining to 33% by 2023, likely due to policy and economic changes. Armenia, Azerbaijan, and Georgia showed steady trends within 20–32%, indicating gradual economic development.

Overall, some countries pursued aggressive investment strategies, while others maintained stability. Economic shifts, policies, and external factors significantly influenced investment levels.

The observed dynamics of gross capital formation emphasize the importance of long-term investment planning for sustainable economic growth. Countries demonstrating relatively stable investment patterns, such as Kazakhstan and Uzbekistan, appear to have established a balance between capital formation, education, and other key economic factors. Mongolia provides an example of rapid increases in capital investment, yet such strategies necessitate further evaluation of their long-term effectiveness. These findings underscore the need for a balanced approach to education funding and capital investment to maximize long-term benefits for the region.

Additionally, the Figure 4 below presents data on the total labor force in Central Asian and Caucasus countries (Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, Mongolia, Tajikistan, and Uzbekistan) over the period from 2011 to 2023. The data illustrate variations in labor force size and growth patterns, offering further insights into regional economic trends and workforce dynamics.

Uzbekistan has the largest labor force among the analyzed countries, exhibiting stable and significant growth throughout the period. By 2023, the labor force will surpass 14 million, reflecting continuous demographic expansion and workforce participation. Kazakhstan ranks second in terms of labor force size, also demonstrating steady growth, with the number exceeding 9 million by the end of the period. Azerbaijan and Kyrgyzstan exhibit moderate labor force growth characterized by gradual increases over time. In contrast,

Georgia, Mongolia, and Tajikistan display relative stability with minimal changes, which is likely attributed to their smaller populations and demographic constraints. Armenia has the smallest labor force among the countries analyzed, with only a marginal increase by 2023.

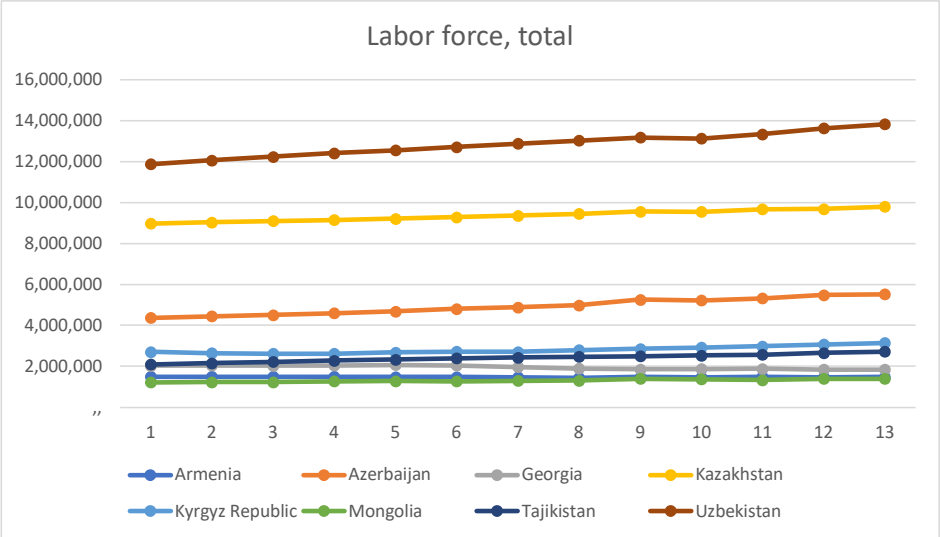



**Figure 4.** Labor force dynamics in the countries of Central Asia and the Caucasus (prepared by the authors using World Bank data).

The observed labor force growth in Uzbekistan and Kazakhstan may be linked to favorable demographic trends and an increasing share of the working-age population. In contrast, the more stable figures in other countries suggest an absence of significant population shifts or structural changes in labor market dynamics. According to the World Bank (2018), countries experiencing labor force expansion, such as Uzbekistan and Kazakhstan, have the potential to enhance economic productivity and efficiency by equipping their workforce with the necessary skills and investing in education.

A crucial determinant of the impact of educational investment on economic growth is the quality of higher education. One of the significant indicators is tertiary education enrollment, which measures participation rates in higher education. This metric provides insights into the accessibility of education for the population and the extent of youth engagement in the educational process.

The Figure 5 presents the dynamics of higher education enrollment in the countries of Central Asia and the Caucasus from 2000 to 2022 demonstrate the following trends. The growth leaders are Armenia, where the indicator reached 60% by 2022, and Georgia, which reached 55%. Steady growth is observed in Kazakhstan (35% by 2022) and Kyrgyzstan (30%). Despite the positive dynamics, the indicators in Uzbekistan (20%) and Tajikistan (15%) remain relatively low. Overall, the region is showing positive changes in the development of higher education, but differences between countries remain significant.

The effectiveness of public administration in education depends on organization and control, ensuring resource efficiency, accountability, and systematic management. Corruption control reflects transparency in financial flows, preventing the misuse of funds and fostering public trust, which is crucial for sustainable development. Political stability creates favorable conditions for educational institutions, enabling long-term planning, consistent policy implementation, and institutional security. The quality of regulation determines how effectively educational reforms are designed and enforced, ensuring that policies lead to real improvements rather than remaining theoretical. A strong legal system protects property rights, enforces laws, and ensures fairness, stability, and integrity

in education. Together, these factors shape a resilient and effective educational system, capable of adapting to societal needs and fostering progress.

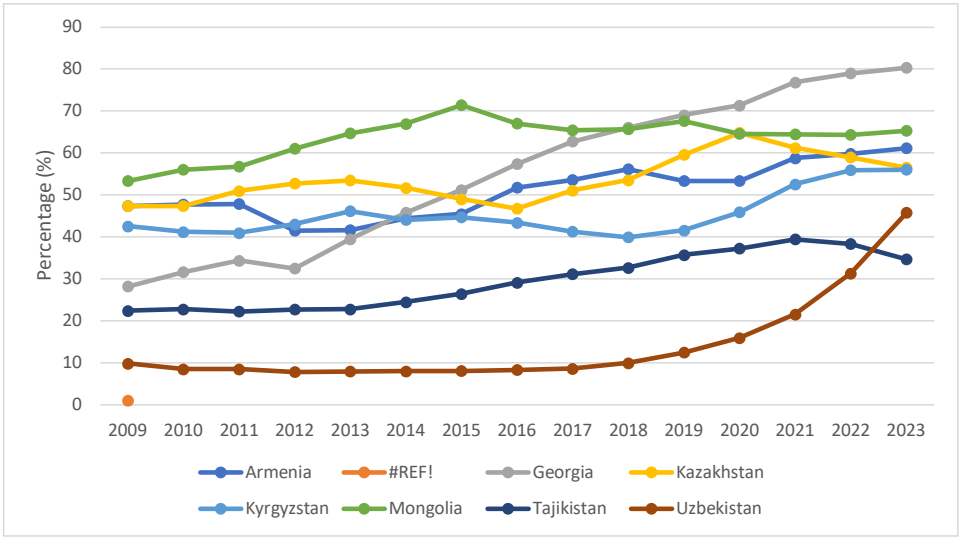



**Figure 5.** The dynamics of higher education enrollment (in %) in Central Asia and the Caucasus (prepared by the authors using World Bank data).

Thirdly, economic indicators that affect the quality of higher education include the following: the share of government spending on education in GDP, which reflects the level of financing of the educational system, and gross capital accumulation, which serves as an indicator of investments in the infrastructure of higher education institutions and their technical equipment.

The Figure 6 below shows the dynamics of the average values of six institutional factors.

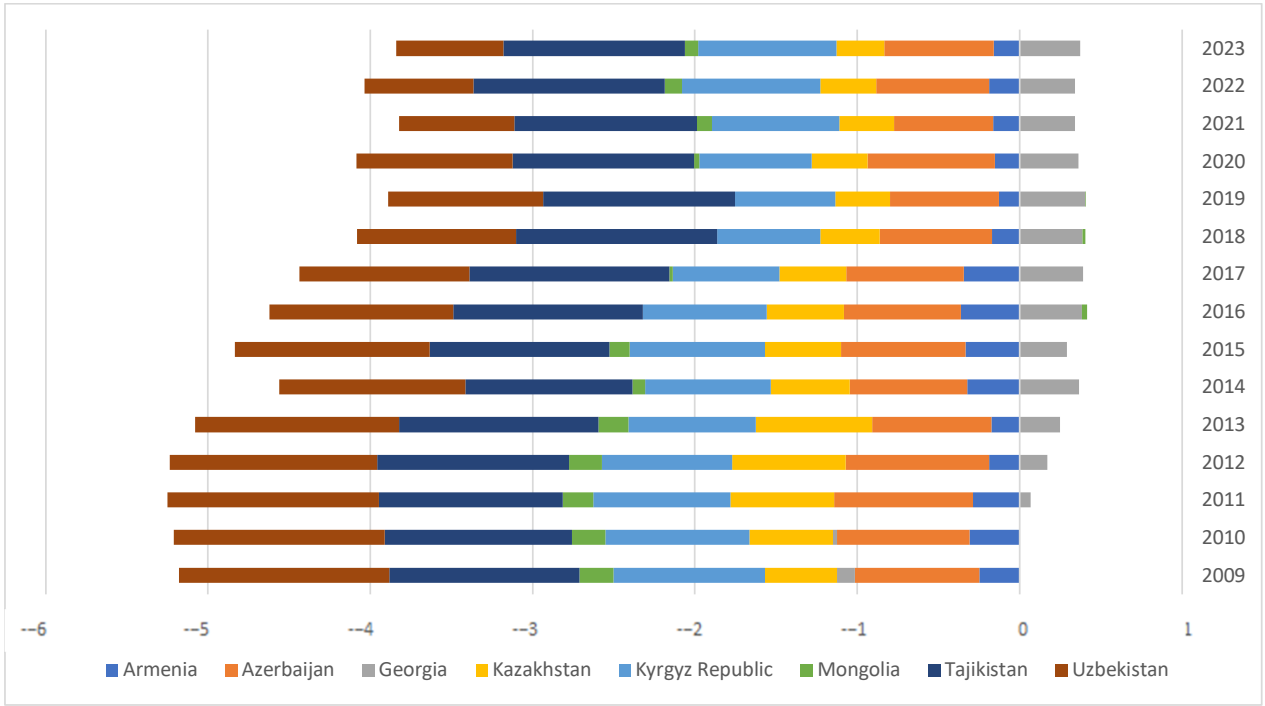



**Figure 6.** Dynamics of average indicators for 6 institutional factors in Central Asia and the Caucasus (prepared by the authors using World Bank data).

The Figure 6 presents data on the institutional factors in Central Asia and the Caucasus from 2009 to 2023 reveals a picture of heterogeneous development and limited progress in the region. The data, presented in the form of values from −1 to 1, where −1 corresponds to the worst indicators and 1 corresponds to the best, demonstrate that most of the countries in the region have negative or close to zero values, indicating that there are problems in the development of the institutional environment.

Armenia shows relatively stable results with small fluctuations during the period under review. By 2023, there will be a slight improvement in performance compared to 2009. In Azerbaijan, on the contrary, there is a tendency for indicators to deteriorate, especially noticeable in recent years, which leads to one of the lowest values in the region by 2023. Georgia stands out from the general background, demonstrating the most positive dynamics. Throughout the period, there has been a steady improvement in indicators, especially significant in 2014–2019. By 2023, Georgia will achieve the best results among all the countries represented.

In Kazakhstan, the indicators are relatively stable, with small fluctuations. By 2023, there will be a slight improvement compared to 2009. Kyrgyzstan also shows a relatively stable situation, but with a slight deterioration in recent years, leading to one of the lowest values in the region by 2023. Mongolia is showing positive dynamics, especially in the period from 2016 to 2019. However, by 2023, the improvements are proving to be negligible. In Tajikistan, the situation remains difficult, with small fluctuations in indicators. By 2023, there will be a slight improvement compared to 2009, but the indicators remain low. Noticeable changes are taking place in Uzbekistan, where there has been a significant improvement in performance between 2018 and 2023. This may indicate the implementation of reforms aimed at improving the institutional environment.

In general, the data analysis shows a significant difference in the level of development of the institutional environment between the countries of the region. Georgia is the clear leader, while Azerbaijan and Kyrgyzstan show the lowest rates. Despite some improvements in individual countries, progress in the development of the institutional environment in the region remains limited, and most countries need to continue their efforts to strengthen institutions, ensure the rule of law, and fight corruption.

Based on the above, we propose the following hypotheses to be tested in this study:

- The economic growth of a country depends not only on the amount of capital and labor but also on government investments in education. Public spending on education enhances human capital by improving skills, knowledge, and innovation potential. This, in turn, increases labor productivity and economic competitiveness, ultimately contributing to sustained economic growth. Investments in education also lead to technological advancements and higher adaptability of the workforce to economic changes.
- Increasing the share of higher education coverage is crucial for economic development. Higher education coverage refers to the proportion of the population that has access to and successfully completes higher education. A higher share of higher education graduates leads to a more skilled and competitive workforce, fostering innovation, improving labor market efficiency, and attracting foreign and domestic investments. Countries with a well-educated workforce are better positioned to transition to knowledge-based economies, which drive technological progress and sustainable economic growth.
- Institutions play a key role in ensuring sustainable economic development. Sustainable economic development refers to a long-term growth model that balances economic expansion with environmental protection and social well-being. It ensures that economic progress does not come at the expense of future generations by promoting responsible

resource use, reducing inequality, and fostering institutional stability. Institutions, including legal frameworks, regulatory bodies, and governance structures, shape economic outcomes by ensuring transparency, protecting property rights, enforcing contracts, and minimizing corruption. In the observed countries, strong institutions contribute to economic stability, investment security, and efficient governance, which, in turn, stimulate long-term growth. Conversely, weak institutions hinder economic progress by increasing risks, reducing investor confidence, and fostering inefficiencies.

The analysis of macroeconomic indicators in the previous section has highlighted significant disparities in GDP growth, education expenditure, capital formation, and labor force dynamics across Central Asia and the Caucasus. These variations suggest that economic development in the region is shaped by a complex interplay of human capital investment, institutional quality, and financial allocation. To further explore these relationships, the following section outlines the methodological framework used to quantify the impact of these factors on long-term economic growth, employing panel data analysis and econometric modeling techniques.

## 4. Methodology

The purpose of this article is to examine how education, institutional quality, capital investment, and labor force dynamics influence economic growth in the Caucasus (Azerbaijan, Armenia, Georgia) and Central Asian countries (Kazakhstan, Kyrgyzstan, Uzbekistan, Tajikistan, Mongolia) over the period 2010–2023. Using panel data analysis, including unit root tests, cointegration tests, and FMOLS/DOLS estimation, this study aims to provide empirical insights into the roles of human capital and institutional quality in shaping economic performance and to offer policy recommendations for sustainable growth.

The econometric model used in this study builds upon prior empirical frameworks analyzing the relationship between education quality and economic development. Recent research suggests that traditional university ranking methodologies fail to fully capture the economic impact of higher education institutions, highlighting the need for new evaluation models (Vasilevska & Tomovska-Misoska, 2024).

The methodology of this study consists of the following steps.

Step 1. Define the purpose and hypotheses of modeling, a set of factors and indicators involved in the model.

Step 2. Collect the necessary statistical information.

Step 3. Perform a statistical analysis of the model and, above all, a statistical evaluation of the model parameters.

Step 4. Check the adequacy of the model, interpret the resulting model, and describe the results.

The econometric model, which was built based on the purpose of this research paper, can be represented as follows:

$$GDP = f(L, K, H, I) \quad (1)$$

Based on this equation, let us consider the dependence of the annual growth rate of GDP on factors such as labor (L), capital costs (K), human capital (H), and institutional factors. Similar approaches, including the Cobb-Douglas production function, have been used to evaluate the relationship between education spending and GDP growth in developing economies (Otieno, 2016; Tleppayev et al., 2024).

Capital costs (K)—gross capital formation (% of GDP); L—labor force participation rate, total (% of total population ages 15+); human capital through GovExp—government expenditure on education, total (% of GDP); and Enroll—school enrollment, tertiary (% gross). Institutional factors are measured through the arithmetic mean of the following indicators: control of corruption, government effectiveness, political stability and absence

of violence/terrorism, regulatory quality, rule of law, voice, and accountability. For the institutional factor, data were taken from the Worldwide Governance Indicators (WGI) provided by the World Bank. This index includes key indicators that assess the quality of governance and the institutional environment in countries.

Taking the log-linear form of both sides of Equation (1), we obtain the following equation:

$$\ln GDP = \beta 0 + \beta 1 \ln L + \beta 2 \ln K + \beta 3 \ln GovExp + \beta 4 \ln Enroll + \beta 5 \ln Inst + \varepsilon_{it} \quad (2)$$

where ln stands for the natural logarithm. The parameters β1, β2, β3, and β4 represent the long-term elasticities of GDP per capita relative to labor, capital, and government expenditure on education (measured as a percentage of GDP).

In our study, we use panel data analysis for a group of countries. Panel data consist of observations of the same economic unit or objects that are implemented in consecutive time periods. Panel data combine both a spatial data type and a time series data type. At each point in time, data are available for a spatial type of economic entities, and for each of its corresponding objects, the data forms one or more time series.

A feature of panel data is a large number of observations, which increases the number of degrees of freedom and reduces the collinearity between explanatory variables and, as a result, increases the effectiveness of estimates. Panel data allows you to analyze many important economic issues that cannot be studied when studying time series, as well as spatial data, separately. By combining data by country and over time, it is possible to increase the number of degrees of freedom and thus the test power, using information about the dynamic behavior of a large number of countries simultaneously (Baltagi, 2005; Hsiao, 2014).

In the present study, LLC and IPS tests were used to test the single root hypothesis in panel data.

The next step after the unit root tests is the cointegration tests. In this study, residue-based cointegration tests are used. Well-known residue-based tests are the tests proposed by Pedroni (Pedroni, 1999; Pedroni, 2004) and Kao (McCoskey & Kao, 1998; Kao, 1999). Pedroni proposed several test statistics that can be categorized into two groups: within-dimension (panel) statistics (Panel v-statistic, Panel rho-statistic, Panel PP-statistic, Panel ADF-statistic) and between-dimension (group) statistics (Group rho-statistic, Group PP-statistic, Group ADF-statistic). All these statistics revolve around testing whether the residuals from a hypothesized long-run relationship are stationary. Kao also tests for panel cointegration, but his methodology imposes some more assumptions about homogeneity (for example, the same cointegration vector across cross-sections).

If the presence of cointegration is confirmed by residue-based tests such as Pedroni and Kao, the next step is to select panel cointegration assessment tools. Since the estimation by the usual least squares method has a second-order asymptotic bias with unacceptable standard errors (Kao & Chen, 1995), alternative methods such as the fully modified least squares method (FMOLS) and the dynamic least squares method (DOLS) were used in this study to estimate panel cointegration. The purpose of FMOLS and DOLS is to evaluate the long-term equilibrium relationship between variables after conducting cointegration tests. The advantage of FMOLS is that it corrects problems related to correlation within the series and the endogeneity error (Pedroni, 2001). Hamit-Haggar (2012) and Khan et al. (2019) believe that FMOLS is the most suitable method for analyzing panel data, as it is the most suitable method for use in the presence of heterogeneous cointegrated panels and allows for consistent and effective assessments of long-term relationships.

By construction, FMOLS yields estimates of the long-run parameters that are super-consistent under cointegration and free of the small-sample bias that plagues simple OLS

in cointegrated settings. It also provides valid asymptotic inference (t-statistics, etc.) by addressing serial correlation and endogeneity jointly.

Similarly, DOLS also takes into account the serial correlation and endogeneity characteristic of the standard least squares method by including cross-section-specific lags and leads of the first differentiated regressors in the panel cointegration equation (Othman & Masih, 2015). The DOLS method solves the problem of endogeneity and eliminates the serial correlation present in the standard least squares (OLS) method.

According to Kao and Chiang (2001), the DOLS estimator can be derived from the following equation:

$$y_{it} = \alpha_i + x'_{i,t}\beta + \Sigma_{j=-q}^{q} c_{ij}\Delta x_{it+j} + \upsilon_{i,t} \quad (3)$$

Equation (3) precisely shows how DOLS extends a simple cointegrating regression by adding differenced terms in leads and lags ($\Delta x_{i,t}$). This design is what allows DOLS to produce robust estimates of the long-run parameter β in the presence of endogeneity and serial correlation—two major issues in cointegration analysis.

DOLS often surpasses the FMOLS (fully modified OLS) method in accuracy and stability, especially in finite samples. According to Kao and Chiang (2001), DOLS is preferred in cases where it is important to minimize bias and avoid the complexities associated with non-parametric corrections, especially in heterogeneous panels.

By incorporating corrections for endogeneity and autocorrelation, both FMOLS and DOLS deliver superconsistent parameter estimates and valid t-statistics grounded in the long-run variance of the residual process.

## 5. Results

### *5.1. Panel Unit Root and Cointegration Tests*

#### 5.1.1. Panel Unit Root Test

Table 1 illustrates that most of the variables are not stationary at level, with the exception of the economic growth rate and gross capital formation. The results of the LLC and IPS tests showed that all variables are stationary at first difference.

**Table 1.** Panel unit root tests.

| | LLC | | | | IPS | | | |
|---|---|---|---|---|---|---|---|---|
| | **Levels (Statistic)** | **Prob.** | **First Differences (Statistic)** | **Prob.** | **Levels (Statistic)** | **Prob.** | **First Differences (Statistic)** | **Prob.** |
| GDP growth (%) (annual change in gross domestic product) | −3.76726 | 0.000 | −7.23075 | 0.000 | −3.63619 | 0.000 | −6.45514 | 0.000 |
| Government expenditure on education | −0.51598 | 0.303 | −4.85615 | 0.000 | 0.36155 | 0.641 | −4.21360 | 0.000 |
| Labor force participation rate | −2.10251 | 0.018 | −2.84557 | 0.002 | −0.43738 | 0.331 | −2.32675 | 0.010 |
| Gross capital formation | −3.79231 | 0.000 | −6.94885 | 0.000 | −2.41679 | 0.008 | −5.08642 | 0.000 |
| Institutional indicator | −2.39601 | 0.008 | −4.63663 | 0.000 | −0.82429 | 0.205 | −3.35998 | 0.000 |
| School enrollment, tertiary (% gross) | 1.40802 | 0.920 | −4.87027 | 0.000 | 1.61014 | 0.946 | −3.52962 | 0.000 |

Source: Authors' calculations in Eviews.

From Table 1, it can be seen that all variables are stationary at first difference. In this case, the next step is to test whether there is a long-run equilibrium relationship between these variables using a cointegration test.

5.1.2. Panel Cointegration Test

To analyze the long-run equilibrium between the variables of interest, two tests are used: panel and group Pedroni statistics and Kao's t-statistic. The tests are based on different assumptions and approaches to calculating statistics. The null hypothesis of the tests is that there is no cointegration; the alternative hypothesis assumes cointegration of the series. The results of the panel cointegration test based on the Pedroni statistics and Kao's t-statistic are shown in Table 2.

**Table 2.** Pedroni Cointegration Test.

| | **Statistic** | **Prob.** |
|---|---|---|
| Panel v-Statistic | −1.126870 | 0.8701 |
| Panel rho-Statistic | 1.287874 | 0.9011 |
| Panel PP-Statistic | −6.415790 | 0.0000 |
| Panel ADF-Statistic | −4.858742 | 0.0000 |
| Group rho-Statistic | 2.162466 | 0.9847 |
| Group PP-Statistic | −8.315995 | 0.0000 |
| Group ADF-Statistic | −5.634981 | 0.0000 |
| Kao Residual Cointegration Test (ADF) | −7.829541 | 0.0000 |

Source: Authors' calculations in Eviews.

It can be seen that the cointegration between variables is significant at the level of 1% (for five out of eight tests). The Kao Residual Cointegration Test showed that the null hypothesis of the absence of a cointegration relationship was rejected. Therefore, the null hypothesis about the absence of cointegration can be rejected. These results strongly confirm the existence of long-term equilibrium relationships between economic growth, education, capital, and the size of the labor force. That is, the existence of cointegration in the sample panel is confirmed.

*5.2. FMOLS and DOLS Results*

According to the results of Table 3, it is obvious that the coefficients estimated using the two FMOLS and DOLS models are very close and have the same signs.

**Table 3.** Results of FMOLS and DOLS analysis.

| | **FMOLS** | **DOLS** |
|---|---|---|
| Government expenditure on education | −0.875020<br>(0.446410) | −1.019641<br>(1.025495) |
| Labor force participation rate | 0.076977<br>(0.143419) | −0.117674<br>(0.226639) |
| Gross capital formation | 0.215605<br>(0.042253) | 0.095613<br>(1.069720) |
| Institutional indicator | −9.057518<br>(2.438211) | −11.47791<br>(4.605956) |
| School enrollment, tertiary (% gross) | 0.092926<br>(0.034965) | 0.168234<br>(0.069771) |

Source: Authors' calculations in Eviews.

Our empirical research shows that institutional factors, school enrollment, and classrooms have an impact on economic growth. Indeed, the school enrollment coefficient shows that an increase of 1% will increase economic growth by between 0.09 and 0.17% in the

long term through FMOLS and DOLS, respectively. On the other hand, the improvement of institutional factors has a negative impact on economic growth (by 0.87 and 1%, respectively), which requires consideration in future models. The FMOLS model also shows the impact of capital growth—economic growth increases by 0.21%, but the DOLS model does not have this effect. The influence of the government expenditure on education variable, measured as a percentage of GDP, is weakly significant only in the FMOLS model (it causes a decrease in growth by 0.87%). The size of the workforce does not affect the variables, requiring consideration in future models.

## 6. Policy Implications and Future Directions

Based on the results of data analysis and regression model based on FMOLS and DOLS methods, it is recommended to pay attention to the following conclusions.

Education priority: due to the consistent positive impact of education coverage on economic growth, government policy should be aimed at increasing the proportion of the educated population (Khitarishvili, 2010; Kumar et al., 2020). This may include investments in educational infrastructure, improving the quality of education at all levels, creating conditions for access to education for all segments of the population, and developing professional retraining and advanced training programs.

Reassessment of the role of institutions and public spending on education: Due to differences in the assessment of the impact of these factors using FMOLS and DOLS methods, additional analysis is needed to clarify their role. Perhaps institutional factors require a rethink of measurement methods or are related to specific aspects of the institutional environment that need to be improved. With regard to expenditures, it is important to evaluate their effectiveness and identify priority investment areas to maximize their impact on economic growth. The state's spending directions should be analyzed here but should also take into account their low share of the budget.

Given the specificity of the sample and the limited sample size, it should be borne in mind that FMOLS and DOLS results may differ. In this case, FMOLS may be preferable for analyzing long-term relationships, whereas DOLS may be useful for studying short-term dynamics. It is recommended to check the stability of the results using alternative methods, such as FE, RE, or ARDL, and choose the method that best suits the properties of the data and the objectives of this study.

The negative impact of institutional factors requires further study. It is essential to determine the specific mechanisms through which these factors influence economic growth and to develop measures for improving institutional quality. Additionally, the weaknesses of institutions, the underdevelopment of civil society, and the impact of corruption must be considered. The effectiveness of educational investment depends not only on the volume of funding but also on governance quality, institutional frameworks, and alignment with labor market demands. This finding aligns with European studies on the modernization of higher education, which emphasize the importance of institutional reforms and academic mobility (van der Hijden, 2014).

It is also necessary to take into account the limitations of this study related to the sample size, the choice of analysis methods, and possible problems with measuring institutional factors. This will avoid misinterpretation of the results and highlight the need for further research in this area.

In general, the government is recommended to focus on policies aimed at increasing the share of education coverage and rethinking the role of institutions and the qualitative allocation of public spending, taking into account the specifics of the sample and analysis methods. It is important to note that this study of the countries under consideration is

debatable and primary in nature and requires further in-depth study in order to develop more accurate and informed policy recommendations.

## 7. Conclusions

This study examined the impact of investments in higher education on the economic development of Central Asian and Caucasus countries, emphasizing the interplay between education quality, institutional frameworks, and macroeconomic indicators. The findings provide strong evidence that strategic investment in education significantly contributes to long-term economic growth by enhancing workforce productivity and fostering innovation. However, the effectiveness of such investments is contingent upon the strength of national institutions and governance mechanisms.

A key insight from this analysis is that while increased funding for higher education correlates with economic expansion, financial allocation alone is insufficient to drive sustainable growth. Instead, the quality of education—measured through institutional effectiveness, governance, and accessibility—plays a decisive role in shaping economic outcomes. Countries such as Kazakhstan and Uzbekistan, which have maintained relatively stable investment patterns in education and capital formation, demonstrate stronger economic performance compared to nations with inconsistent or declining education expenditures. Conversely, Tajikistan and Kyrgyzstan allocate a higher percentage of GDP to education, yet their economic impact remains constrained due to weaker institutional structures and lower enrollment rates in higher education.

This study also highlights contrasting dynamics in the Caucasus region. Armenia boasts the highest tertiary education enrollment (~60%), yet economic challenges persist due to political instability and limited capital formation. In contrast, Georgia has successfully leveraged education investments alongside institutional improvements, resulting in a more dynamic labor market and enhanced innovation potential. Similarly, Azerbaijan and Mongolia present unique cases where fluctuating education spending—often influenced by external economic factors such as natural resource revenues—affects the sustainability of education-driven economic benefits.

Moreover, this study underscores the critical role of institutional factors—such as government effectiveness, regulatory quality, and control of corruption—in translating educational investments into tangible economic benefits. Weak institutional environments hinder the efficient utilization of public spending on education, preventing proportional improvements in human capital development. Addressing these governance challenges requires comprehensive reforms to strengthen education management, enhance financial transparency, and align educational policies with labor market demands.

Disparities in higher education enrollment across the region further reinforce the need for targeted policy interventions. Armenia and Georgia lead in participation rates, whereas Uzbekistan and Tajikistan lag behind, limiting their ability to cultivate a skilled workforce for technological advancement and economic diversification. To bridge this gap, governments must focus on expanding access to tertiary education, modernizing curricula to meet industry demands, and investing in digital learning infrastructure.

From an economic perspective, the findings affirm the necessity of balancing investments in education with broader economic policies, particularly in gross capital formation and labor market development. Countries experiencing labor force expansion, such as Uzbekistan and Kazakhstan, have a unique opportunity to maximize economic efficiency by equipping their workforce with advanced skills and fostering knowledge-based industries. However, realizing this potential requires sustained investments in human capital, policies that incentivize innovation and entrepreneurship, and a commitment to long-term institutional strengthening.

Ultimately, this study underscores that higher education is not merely an expenditure but a strategic investment in national development. The economic benefits of education are maximized when coupled with effective governance, institutional stability, and policies that foster an innovative and skilled workforce. Future research should further explore the interplay between education policies, labor market dynamics, and technological advancements to develop a comprehensive framework for sustainable economic growth in the region.

**Author Contributions:** Conceptualization, S.Z. and A.T.; methodology, S.Z.; software, A.T..; validation, S.Z., A.T. and D.T.; formal analysis, S.Z.; investigation, A.A.; resources, A.A.; data curation, A.T.; writing—original draft preparation, A.A.; writing—review and editing, S.Z.; visualization, S.Z.; supervision, S.Z.; project administration, D.T.; funding acquisition, A.A. All authors have read and agreed to the published version of the manuscript.

**Funding:** This research was funded by Ministry of Science and Higher Education of the Republic of Kazakhstan grant number IRN BR21882434 on the topic "A systematic approach to monitoring, analysis and assessment of the quality of higher education in Kazakhstan".

**Informed Consent Statement:** Not applicable.

**Data Availability Statement:** Data reported in this work are available at https://databank.worldbank.org/source/world-development-indicators.

**Conflicts of Interest:** The authors declare no conflicts of interest. The funders had no role in the design of the study; in the collection, analysis or interpretation of data; in the writing of the manuscript or in the decision to publish the results.

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