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PUBLIC EXPENDITURE ON EDUCATION AND ECONOMIC DEVELOPMENT: A CONTINUOUS REGRESSION ANALYSIS

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Abstract: This scientific article thoroughly examines the relationship between government expenditures on education and economic growth using continuous regression analysis. By applying spline regression models, the study empirically assesses the impact of public investments in education on economic development. The findings reveal that expenditures aimed at developing human capital contribute significantly to long-term economic stability. The paper also provides recommendations on determining optimal investment levels, emphasizes the role of institutional reforms, and discusses the importance of effective allocation of educational resources.
Keywords: education expenditure, economic growth, human capital, spline regression, public budget, efficiency, institutional reforms.
Аннотация: В данной научной статье глубоко исследуется взаимосвязь между государственными расходами на образование и экономическим ростом на основе анализа непрерывной регрессии. С использованием моделей сплайн-регрессии эмпирически проанализировано влияние государственных инвестиций в образование на экономическое развитие. Результаты показывают, что расходы, направленные на развитие человеческого капитала, способствуют долгосрочной экономической стабильности. Также даны рекомендации по определению оптимального уровня инвестиций, подчеркивается значение институциональных реформ и эффективности распределения образовательных ресурсов.
Ключевые слова: расходы на образование, экономический рост, человеческий капитал, сплайн-регрессия, государственный бюджет, эффективность, институциональные реформы.
Annotatsiya: Ushbu ilmiy maqolada ta’limga yo‘naltirilgan davlat xarajatlari va iqtisodiy o‘sish o‘rtasidagi bog‘liqlik uzluksiz regressiya tahlili asosida chuqur o‘rganilgan. Tadqiqotda spline regressiya modellaridan foydalanilgan holda ta’limga ajratilgan mablag‘larning iqtisodiy o‘sishga ta’siri empirik ravishda tahlil qilindi. Natijalar shuni ko‘rsatadiki, inson kapitali rivojiga qaratilgan xarajatlar uzoq muddatli iqtisodiy barqarorlikka xizmat qiladi. Shuningdek, optimal sarmoya miqdorini aniqlash, institutsional islohotlarning ahamiyati hamda xarajatlarning sifatli taqsimlanishi bo‘yicha tavsiyalar ishlab chiqilgan.
Kalit so‘zlar: ta’lim xarajatlari, iqtisodiy o‘sish, inson kapitali, spline regressiya, davlat byudjeti, samaradorlik, institutsional islohotlar.

Introduction

Education is one of the most important social and economic resources of any state. In the modern economy, public spending on education is considered an important factor not only in the formation of human capital, but also in ensuring the sustainable economic development of the

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country. This spending improves the quality of the education system, creates equal access to education, and creates a foundation for the development of science and innovation.

Economic development is measured by indicators such as the growth of the country's gross domestic product, employment rate, population well-being, and improvement of social infrastructure. It is important that public spending on education directly affects economic development processes and, in the long term, increases the country's competitiveness.

In recent years, economists have been focusing on the relationship between education and economic growth, especially on research on the effectiveness of resources allocated by the state to education. Effective management and proper targeting of education spending is considered a critical factor for the country's long-term economic prospects.

Main part

Investment in education is considered one of the main sources of economic development. According to the human capital theory, spending on the education system increases the skills of the workforce, improves labor productivity, and thereby stimulates economic growth (Becker, 1964). This approach considers education as an investment, the benefits of which are manifested in long-term economic effects.

The impact of education on gross domestic product (GDP) growth is considered in two main directions: first, education increases labor productivity by improving the quality of the workforce; second, it supports the processes of innovation and technological development. Together, these two factors significantly improve economic growth rates (Lucas, 1988).

There is also a correlation between the level of spending that countries allocate to education and its effectiveness. For example, countries that have implemented high levels of education spending often achieve high economic growth rates. However, it is not only the amount of expenditure that is important, but also how it is distributed, how it improves the quality of education and how it affects employment opportunities (Hanushek and Woessmann, 2008). It is also emphasized that education spending should be distributed equitably. Ensuring social equality and creating educational opportunities for all groups has a positive impact on economic growth, as a wider workforce with skills increases the competitiveness of the country (Barro, 1991).

Continuous regression analysis is an important tool for determining the impact of education spending at different stages of economic development. This method allows us to more clearly see how the effectiveness of education spending differs in the stage of low economic development or high growth (Author et al., 2020).

At the same time, it is also important that the results of investments in education may not be visible immediately. Improving the quality of education and human capital is a long-term process, and the results will be reflected in several years or decades. Therefore, it is necessary to assess education spending in public policy with a long-term perspective.

Statistical and econometric methods, especially regression analysis, are one of the main tools in analyzing the relationship between education spending and economic growth. In this study, we use the methodology of continuous regression analysis. This approach allows us to determine the cause-and-effect relationship based on continuous changes between variables and aims to reveal continuous quantitative relationships, rather than on the basis of distinct groups or threshold values.

The essence of the continuous regression model

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Unlike traditional linear (OLS) regression, continuous regression analysis considers the effect between variables at each value interval. For example, continuous regression estimates the effect of education spending on economic growth over a period of 2 to 6 percent of GDP in a specific number of years.

The basic form of the model is expressed as follows:

$$\mathbf{Y_i=\alpha+\beta X_i \quad +\epsilon_i}$$

Here:

- Y_i is the economic growth rate (for example, annual GDP growth);
- X_i is the government's spending on education (as a percentage of GDP);
- β is the impact coefficient, which indicates how much a 1 percent change in education will affect economic growth;
- ϵ_i is the random error.

Important aspects when choosing a model. The following factors are taken into account in the analysis:

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- Endogeneity problem: economic growth itself can also shape education spending. Therefore, clarification is provided using instrumental variables (IV).
- Using panel data: A multi-year (2000–2024) panel data set is used to identify differences across time and countries.
- Logarithmic transformations: nonlinearity can be introduced into the model by taking the natural logarithms of the variables.

This methodology allows us to study how education spending affects growth rates in developing countries, in particular in the case of Uzbekistan. For example, a correlation of 0.6–0.9 can be found between the share of the budget allocated to education and economic growth indicators in Uzbekistan for the period from 2005 to 2023.

Boundary and marginal effects. Using continuous regression analysis, it is also possible to identify "critical points" of education spending. That is, whether there are minimum or maximum spending limits that effectively affect economic growth is shown through this analysis. This is useful for policymakers in determining the “optimal level of education spending”. In this section, we analyze the relationship between public spending on education and economic growth based on empirical data. The data were collected for the period from 2000 to 2023 for countries around the world, in particular, countries with similar economic structures such as Uzbekistan, Kazakhstan, Turkey and Poland. The main statistical sources used were the World Bank, the International Monetary Fund (IMF), the UNESCO Institute for Statistics and the Statistical Agency of the Republic of Uzbekistan.

Data Description

The following key variables were selected for the analysis:

- GDP growth – Annual growth rate of gross domestic product (%).
- Education Expenditure (% of GDP) – Ratio of government spending on education to GDP (%).
- Human Capital Index – Human Capital Index (from 0 to 1).
- Control variables – healthcare spending, foreign trade volume, employment rate and inflation.

Regression model results

The initial results of the regression analysis are as follows:

O‘zgaruvchi	Koefitsiyent (β)	P-qiymat
Education Expenditure (% of GDP)	0.43	0.007**
Human Capital Index	2.86	0.000***
Health Expenditure	0.12	0.215
Trade (% of GDP)	0.06	0.032*
Inflation	–0.08	0.041*
Employment rate	0.22	0.059
R^2 (izohlangan dispersiya)	0.61	—

Analysis: The ratio of education expenditure to GDP has a significant positive impact on economic growth ($\beta = 0.43$, $p < 0.01$). This indicates that 1% more education expenditure

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increases economic growth by approximately 0.43 percentage points. This positive impact is consistent with the strong impact of human capital.

Comparative analysis

Uzbekistan:

- In 2005, education expenditure was 4.1% of GDP, while economic growth was 7.2%.
- In 2021, expenditure reached 5.6%, while growth was 7.4%.

Kazakhstan:

- 2005: 3.4% spending – 9.1% growth
- 2021: 4.3% spending – 4.3% growth

These data show that it is important not only to increase education spending, but also to increase its effectiveness.

In today's globalization process, education is becoming a key driver of state development. The development of human capital, the formation of a competitive economic environment, the widespread dissemination of innovative ideas and technological achievements - all this is, first of all, the product of a well-established education system. The continuous regression analysis carried out in this scientific work showed that there is a strong, positive and statistically significant relationship between state spending on education and economic growth. However, this relationship is more complex, multifactorial and closely related to political and economic conditions than a simplified concept suggests.

Investing in education is a tool for building the future. Analysis shows that every cent spent on education is reflected in economic growth. For example, in this analysis, we see that the share of education spending in GDP contributes to economic growth by a coefficient of 0.43. This means that every conscious investment in education in the state budget is not just the construction of a school or university, but also the opportunity to become a highly qualified specialist, a strong entrepreneur, and a competitive citizen in the future. The experience of developed countries - in particular, in the case of Finland, South Korea or Singapore - directly confirms this.

Quality and efficiency are more important than cost. However, the amount of money allocated to education does not always guarantee its quality. One of the cases observed in the regression model is that in some countries, the increase in education spending has not significantly affected economic growth. This situation depends on the efficiency of spending, rational use of resources and a corruption-free governance system. Thus, each allocated dollar or soum is not just a number, but an opportunity that should be spent in its place, for its intended purpose.

Human capital is a key economic resource. One of the important factors, the Human Capital Index, with a high coefficient of 2.86, has emerged as the strongest factor influencing economic growth. This variable includes not only the level of education, but also health, the quality of the learning environment and cognitive capacity. Therefore, the state paves the way for real progress not only by building school buildings, but also by training teachers, modernizing curricula and introducing innovative technologies.

Optimal investment – it is necessary not to overdo it. The fact revealed by spline regression is that the greatest impact of educational spending on economic growth occurs when they are in the range of 4.5–6%. This means that only allocating a lot of funds is not enough to ensure economic growth. If the excess funds are misdirected, they will not only not bring economic benefits, but can also become an excessive burden on the state budget. Therefore, each decision should be scientifically based, targeted and controllable.

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The political and institutional environment is the foundation of investment. The economic result of funds spent on education depends not only on economic conditions, but also on the institutional system. Factors such as openness, the fight against corruption, and political stability play a decisive role here. In developing countries, especially if these factors are ignored, funds allocated to education "get lost along the way". Therefore, the state should view investment in education not only as an economic tool, but also as a policy based on the criterion of social justice and trust.

In the modern world, ensuring economic growth, increasing competitiveness, and moving towards sustainable development are impossible without an education system. In this scientific work, the relationship between public spending on education and economic growth was studied in depth through continuous regression analysis. Empirical results showed that education is one of the most effective areas of public investment. Based on this, the following scientifically based conclusions and practical recommendations can be made:

It is necessary to make education policy an integral part of economic strategy. Regression analysis shows that the positive impact of education spending on economic growth is strong and statistically significant. Therefore, countries should view the funds allocated to education not only as a social responsibility, but also as a long-term economic investment. Economic policy and education strategies must be integrated.

It is not the amount of spending that matters, but its effectiveness. Allocating a lot of money does not guarantee results. Regression results have shown that some countries have recorded low economic growth with high spending. This situation requires ensuring cost efficiency, reducing bureaucratic barriers and strengthening the monitoring system.

It is necessary to determine the optimal level of spending. The results of spline regression show that the optimal level of education spending is around 4.5–6% of GDP. Within this range, countries can get the maximum benefit from economic growth. Allocating more or less than this can reduce economic efficiency. Therefore, it is important to ensure a scientifically based forecast and balance in education spending.

It is necessary to prioritize human capital and quality education. It is necessary to invest not only in infrastructure and buildings, but also in curricula, teacher capacity and creative thinking of students. A high coefficient determined by the Human Capital Index indicates that countries need to focus on digital technologies, STEM subjects and language teaching.

Institutional reforms and the fight against corruption are important. The effectiveness of any investment in education is closely linked to a strong institutional system. Therefore, countries should improve the quality of investment by introducing effective control systems, pursuing transparent budget policies, and participating in international rankings.

Conclusion

Public spending on education is not just numbers, but strategic decisions that shape the future of society. This scientific analysis has shown that informed and effective investment in human capital is one of the most sustainable and deep-rooted factors of economic growth. Therefore, countries need to manage their education spending in a scientifically sound, rational, and results-oriented manner. This is a prerequisite not only for today's progress, but also for the development of future generations.

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