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ECONOMETRIC ASSESSMENT OF THE SOCIO-ECONOMIC DETERMINANTS OF GROSS REGIONAL PRODUCT PER CAPITA IN UZBEKISTAN

Fayziyeva Nargiza Rabimovna
Tashkent State University of Economics,
Senior Lecturer, Department of Econometrics;
nargizafayziyeva.work@gmail.ru
ORCID: 0009-0008-9642-2801

Abstract. This study empirically examines the statistical relationship between gross regional product (GRP) per capita and selected socio-economic factors in Uzbekistan. The analysis is based on annual data for 2012–2024 obtained from the Integrated System of Statistical Information (SIAT) of the National Statistics Committee of the Republic of Uzbekistan. The dependent variable is specified as the natural logarithm of GRP per capita, while the explanatory variables include the natural logarithm of fixed capital investment per capita, the employment rate, and preschool education coverage among children aged 3–6.

Keywords: gross regional product, GRP per capita, investment, employment, human capital, preschool education, housing, econometric assessment, OLS, time series, Uzbekistan.

Аннотация. В данном исследовании эмпирически анализируется статистическая взаимосвязь между валовым региональным продуктом (ВРП) на душу населения и рядом социально-экономических факторов в Узбекистане. Анализ основан на ежегодных данных за 2012–2024 годы, полученных из Интегрированной системы статистической информации (СИАТ) Национального комитета Республики Узбекистан по статистике. В качестве зависимой переменной используется натуральный логарифм ВРП на душу населения, а к объясняющим переменным относятся натуральный логарифм инвестиций в основной капитал на душу населения, уровень занятости и охват детей в возрасте 3–6 лет дошкольным образованием.

Ключевые слова: валовой региональный продукт, ВРП на душу населения, инвестиции, занятость, человеческий капитал, дошкольное образование, жилищное строительство, эконометрическая оценка, МНК, временные ряды, Узбекистан.

INTRODUCTION

Gross regional product (GRP) is one of the key macroeconomic indicators used to assess the economic performance of regions. In particular, GRP per capita makes it possible to evaluate the amount of economic value generated relative to the size of the population and is therefore widely used as an indicator of regional economic development.

In recent years, Uzbekistan has placed increasing emphasis on stimulating investment activity, creating employment opportunities, modernizing production capacities, and developing human capital. The World Bank's Country Economic Memorandum for Uzbekistan emphasizes the important role of capital investment in the country's economic growth during 2010–2022. At the same time, the report stresses that sustainable future growth will require improvements in labor productivity, human capital, technological development, and private-sector efficiency [1].

Official statistical data also indicate a long-term increase in economic activity in Uzbekistan. According to data from the Integrated System of Statistical Information (SIAT) of the National Statistics Committee of the Republic of Uzbekistan, GRP per capita increased from 4,780.4 thousand soums in 2012 to 39,131.4 thousand soums in 2024 [2].

It is important to emphasize, however, that this indicator is measured at current prices. According to the SIAT metadata, GRP per capita is calculated by dividing GDP/GRP by the average annual population and is expressed in thousand soums at current prices [2].

Therefore, the present study does not interpret the observed increase in GRP per capita as purely real economic growth. Instead, it examines the statistical relationship between GRP per capita measured at current prices and selected socio-economic indicators.

The main objective of this study is to econometrically assess the statistical relationship between GRP per capita and investment, employment, preschool education coverage, and housing provision in Uzbekistan.

The research questions are as follows:

1. Is fixed capital investment per capita statistically associated with GRP per capita?
2. Is the employment rate statistically associated with GRP per capita?
3. Does preschool education coverage demonstrate a statistically significant relationship with GRP per capita?
4. Is housing provision statistically associated with GRP per capita?
5. Does the estimated model satisfy the major econometric diagnostic requirements?

LITERATURE REVIEW

Capital accumulation is widely considered one of the important factors associated with economic growth. Investment can contribute to economic activity by expanding production capacity, developing infrastructure, introducing new technologies, and improving the efficiency of production processes.

The World Bank's Country Economic Memorandum for Uzbekistan reports that capital investment played an important role in the country's economic growth during 2010–2022 [1]. The report also emphasizes that future economic growth should increasingly depend on improvements in productivity, technological development, private-sector development, and human capital.

Employment represents another important component of economic activity. Greater participation of the working-age population in economic activity can increase the amount of labor available for production. However, employment alone does not fully determine economic performance. Labor productivity, skills, education, and the quality of human capital are also important.

Human capital begins to develop at an early age. Preschool education therefore represents one of the initial stages of human-capital formation. Improvements in access to early childhood education may contribute to better educational outcomes and the development of skills required later in life.

The inclusion of preschool education coverage in the present model is therefore motivated by the broader human-capital approach to economic development.

Housing is included as an additional socio-economic indicator reflecting living conditions and the development of construction activity. Nevertheless, its statistical relationship with GRP per capita cannot be assumed a priori and therefore needs to be tested empirically.

The contribution of this study is that investment, employment, preschool education coverage, and housing provision are examined simultaneously within a single econometric framework for Uzbekistan.

The theoretical relationship between capital accumulation and economic growth has been extensively discussed in the economic growth literature. In the neoclassical growth framework, Solow [1] demonstrated that capital accumulation and labor are fundamental components of production and economic growth, although diminishing returns to physical capital imply that long-term growth cannot be explained by capital accumulation alone.

The role of human capital was subsequently developed in greater detail by Becker [2], who emphasized that education, training, knowledge, and skills constitute forms of investment that increase individuals' productive capacity. Mincer's [3] human-capital approach further established an analytical framework for examining the relationship between education, skills, and economic outcomes.

The endogenous growth literature expanded this perspective. Romer [4] emphasized the role of knowledge accumulation and technological change in generating long-term economic growth. In this framework, investment in human capital and knowledge can generate broader economic effects beyond the individual or firm undertaking the investment.

Empirical cross-country research has also provided evidence supporting the importance of human capital. Barro [5] found that differences in human capital, measured through educational attainment, are associated with differences in subsequent economic growth. His empirical results also indicate relationships among human capital, investment, and per capita economic growth.

The quality of education may be more important than educational participation alone. Hanushek and Woessmann [6] argue that cognitive skills are strongly associated with individual earnings and aggregate economic growth and that the quality of human capital should therefore be considered alongside conventional indicators of school enrollment and educational attainment.

These theoretical and empirical findings provide a basis for including investment, employment, and an education-related indicator in the present econometric model. In particular, preschool education coverage can be viewed as an indicator of the early stage of human-capital formation rather than as a direct measure of labor productivity.

The relevance of these factors is particularly important in Uzbekistan. The World Bank's recent assessment emphasizes that human capital—including people's knowledge, skills, and health—is an important driver of productivity and economic growth in Uzbekistan [7].

Similarly, the World Bank's Country Economic Memorandum for Uzbekistan reports that the country's previous growth model relied heavily on capital investment and emphasizes the importance of productivity, human capital, private-sector development, and job creation for sustaining economic growth [8].

Earlier World Bank research on Uzbekistan also emphasized the importance of improving workforce skills and productivity for creating better employment opportunities and supporting the country's transition toward higher-income status [9].

Thus, the theoretical and empirical literature provides a strong justification for examining investment, employment, and human-capital-related indicators as potential determinants associated with GRP per capita in Uzbekistan.

RESEARCH METHODOLOGY

The empirical analysis covers the period 2012–2024, providing 13 annual observations. In preparing the manuscript, artificial intelligence tools were used to a limited extent, accounting for no more than 10% of the overall text preparation process.

The data were obtained from the Integrated System of Statistical Information (SIAT) of the National Statistics Committee of the Republic of Uzbekistan. Table 1 presents the variables included in the econometric model.

Table 1.
Variables included in the econometric model

Symbol	Symbol	Measurement
Y	Per capita GRP	thousand soums
X ₁	Per capita fixed-capital investment	thousand soums
X ₂	Employment rate	percent
X ₃	Preschool education coverage among children aged 3–6	percent

Source: Developed by the author.

The dependent variable is transformed using the natural logarithm:

$$Y_t^* = \ln(Y_t)$$

Investment and housing variables are also transformed into logarithmic form.

The following log-linear model is estimated:

$$\ln(Y_t) = \beta_0 + \beta_1 \ln(X_{1t}) + \beta_2 X_{2t} + \beta_3 X_{3t} + \varepsilon_t$$

where:

- Y_t — per capita GRP;
- X_1 — per capita fixed-capital investment;
- X_2 — employment rate;
- X_3 — preschool education coverage;
- ε_t — random error term.

The model is estimated using the Ordinary Least Squares (OLS) method.

The statistical adequacy of the model is evaluated using:

- coefficient of determination R^2 ;
- adjusted R^2 ;
- F-statistic;
- Durbin–Watson statistic;
- Breusch–Pagan test;
- Jarque–Bera test;
- Ramsey RESET test;
- Variance Inflation Factor (VIF).

ANALYSIS AND RESULTS

The OLS estimation produced the following regression equation:

$$\ln Y_t = 3.4039 + 0.6030 \ln X_{1t} + 0.0635 X_{2t} + 0.0072 X_{3t} + \varepsilon_t$$

The table below presents the diagnostic test results (table 2):

Table 2.
OLS regression results

Variable	Coefficient	p-value	Statistical interpretation
Constant	3.4039	—	—
ln(Investment)	0.6030	<0.001	Significant at 1%
Employment	0.0635	0.012	Significant at 5%
Preschool education coverage	0.0072	0.032	Significant at 5%

Source: *Estimated by the author.*

The coefficient of determination is approximately:

$$R^2 = 0.996$$

while:

$$\text{Adjusted } R^2 = 0.993.$$

The F-test is statistically significant at the 1% level ($p < 0.001$), indicating that the explanatory variables are jointly statistically significant.

The estimated coefficient of fixed capital investment per capita is 0.6030 and is statistically significant at the 1% level.

Because both the dependent variable and the investment variable are expressed in logarithmic form, the coefficient can be interpreted as an elasticity. Ceteris paribus, a 1% increase in fixed capital investment per capita is statistically associated with approximately a 0.603% higher level of GRP per capita.

This result is consistent with the World Bank's assessment of the important role of capital investment in Uzbekistan's economic growth [1].

Importantly, this coefficient should not be interpreted as proof that investment causes a 0.603% increase in GRP per capita. The estimated relationship represents a statistical association within the specified model.

The coefficient of the employment rate is 0.0635, with a p-value of 0.012.

Holding the other variables constant, a one-percentage-point increase in the employment rate is statistically associated with approximately a 6.56% higher level of GRP per capita.

Again, this result should be interpreted as a statistical relationship rather than a causal effect.

The positive sign is economically plausible because greater employment participation may be associated with more extensive utilization of labor resources and higher aggregate production.

The coefficient of preschool education coverage is 0.0072 and is statistically significant at the 5% level ($p = 0.032$).

Thus, a one-percentage-point increase in preschool education coverage is statistically associated with approximately a 0.72% higher level of GRP per capita, holding the other variables constant.

This finding is consistent with the broader human-capital perspective, according to which investment in early education can contribute to the development of skills and capabilities.

However, because of the short time series and possible correlations among the explanatory variables, this result should not be interpreted as evidence of a direct causal effect of preschool education on GRP per capita.

The coefficient of the housing variable is -0.5614 . However, its p-value is 0.106.

Therefore, the housing variable is not statistically significant at the 5% level.

Consequently, the negative coefficient should not be interpreted as evidence that an increase in housing provision reduces economic output.

Rather, the appropriate interpretation is that the model does not provide sufficient statistical evidence of a significant relationship between the selected housing indicator and GRP per capita during the analyzed period. Table 3 presents the results of the diagnostic tests.

Table 3. Diagnostic test results

Test	Result	p-value	Conclusion
R ²	0.996	—	High explanatory power
Adjusted R ²	0.993	—	High
F-test	451.8	<0.001	Model jointly significant
Durbin–Watson	≈2.005	—	No strong AR(1) autocorrelation
Breusch–Pagan	—	0.248	No evidence of heteroskedasticity
Jarque–Bera	—	0.708	Normality not rejected
Ramsey RESET	—	0.232	No evidence of functional-form misspecification

Source: *Estimated by the author.*

The Durbin–Watson statistic is close to 2, indicating no strong evidence of first-order serial correlation in the residuals.

The Breusch–Pagan test yields a p-value of 0.248, which is greater than 0.05. Therefore, the null hypothesis of homoskedasticity cannot be rejected.

The Jarque–Bera test yields a p-value of 0.708. Thus, there is insufficient evidence to reject the null hypothesis that the residuals are normally distributed.

The Ramsey RESET test yields a p-value of 0.232, indicating no statistically significant evidence of functional-form misspecification.

Overall, the diagnostic tests suggest that the model does not exhibit major problems related to heteroskedasticity, residual non-normality, functional-form misspecification, or first-order autocorrelation.

One of the main limitations of the estimated model is indicated by the VIF results presented in Table 4.

Table 4.
Variance Inflation Factor results

Variable	VIF
ln Investment	17.03
Employment	1.14
Preschool education coverage	13.85

Source: *Estimated by the author.*

The VIF values for investment and preschool education coverage exceed 10, indicating a substantial degree of multicollinearity.

This may reflect the fact that both variables followed similar upward trends over the analyzed period.

High multicollinearity does not necessarily imply that the model as a whole is invalid. However, it can make individual coefficient estimates less stable and complicate the interpretation of the marginal effects of correlated explanatory variables.

To further examine this issue, a first-difference specification was additionally estimated:

$$\Delta \ln Y_t = \alpha + \beta_1 \Delta \ln X_{1t} + \beta_2 \Delta X_{2t} + \beta_3 \Delta X_{3t} + u_t$$

In the first-difference specification, (R²) was approximately 0.925, while the adjusted (R²) was approximately 0.897. At the same time, the VIF values declined to below 3.

This suggests that part of the high multicollinearity observed in the level model may be related to common time trends among the variables.

The empirical results indicate that GRP per capita in Uzbekistan is statistically associated with three major explanatory factors: investment, employment, and preschool education coverage.

Investment exhibits a strong positive statistical relationship with GRP per capita. The estimated coefficient of 0.6030 indicates that changes in investment are significantly associated with changes in GRP per capita within the specified model.

This finding is broadly consistent with the World Bank's assessment that capital investment has played an important role in Uzbekistan's economic growth [1].

The positive and statistically significant coefficient of employment is also economically plausible. Higher employment may correspond to greater utilization of available labor resources and increased production activity.

The statistically significant coefficient of preschool education coverage provides additional evidence that human-capital-related variables may be associated with economic performance. However, the interpretation should remain cautious because the available time series contains only 13 observations.

An important methodological issue is that the dependent variable—GRP per capita—is measured at current prices. Therefore, the estimated model captures not only changes in real economic activity but also the effects of changes in prices.

Consequently, the results should not be interpreted as evidence that investment, employment, or preschool education causes changes in real economic output.

Instead, the appropriate conclusion is that these variables are statistically associated with the level of GRP per capita over the analyzed period.

CONCLUSION AND SUGGESTIONS

This study examined the statistical relationship between GRP per capita and selected socio-economic indicators in Uzbekistan using annual data for 2012–2024.

The main findings can be summarized as follows.

First, fixed capital investment per capita demonstrates a positive and statistically significant relationship with GRP per capita. The estimated elasticity is approximately 0.603.

Second, the employment rate is positively and statistically significantly associated with GRP per capita.

Third, preschool education coverage also demonstrates a positive and statistically significant relationship with GRP per capita, supporting the relevance of human-capital-related indicators in empirical studies of economic development.

Fourth, the selected housing indicator is not statistically significant in the estimated model.

Fifth, the Breusch–Pagan, Jarque–Bera, and Ramsey RESET tests do not provide evidence of major problems related to heteroskedasticity, residual non-normality, or functional-form misspecification. The Durbin–Watson statistic is also close to 2, indicating no strong evidence of first-order serial correlation.

Sixth, the VIF results reveal substantial multicollinearity between investment and preschool education coverage. Therefore, the coefficients of these variables should be interpreted with caution.

From a policy perspective, the results suggest that investment promotion, job creation, and human-capital development can be considered complementary components of Uzbekistan's long-term economic development strategy.

The findings are consistent with the World Bank's view that future economic growth in Uzbekistan will increasingly depend on improvements in productivity, human capital, private-sector development, and the more efficient use of capital [1].

Nevertheless, the study has several limitations. The most important limitation is the small number of annual observations. In addition, GRP per capita is measured at current prices, which makes it difficult to distinguish changes in real output from price effects.

Future research should therefore employ real, inflation-adjusted GRP, real investment indicators, and, preferably, regional panel data. A panel dataset covering 14 regions over the period 2012–2024 would substantially increase the number of observations and make it possible to account for region-specific characteristics.

Such an approach would provide a more robust basis for assessing the determinants of regional economic development in Uzbekistan.

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