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ECONOMETRIC MODELING OF REGIONAL ECONOMIC GROWTH BASED ON THE COBB-DOUGLAS PRODUCTION FUNCTION: A CASE STUDY OF SURXONDARYA REGION



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Abstract. This study examines the key driving factors of economic growth in the Surxondaryo region using econometric modelling based on the classical Cobb-Douglas production function. To address issues related to multicollinearity and non-stationarity in the raw data, a restricted intensive form of the model, where $\alpha + \beta = 1$, was constructed using regional statistical data for the period 2010–2025.

The empirical results demonstrate high statistical significance, with an adjusted R-squared of 0.961 and an F-statistic of 379.63, confirming the reliability of the model. The estimated capital elasticity coefficient (α) is 0.6967, while the labour elasticity coefficient (β) is 0.3033. This indicates that a 1% increase in capital investment leads to an approximately 0.70% increase in regional output, whereas a 1% increase in labour resources results in only 0.30% growth.

The findings suggest that economic growth in Surxondaryo is predominantly capital-intensive and is largely driven by investment inflows. At the same time, the marginal productivity of labour remains relatively low due to an oversupply of the workforce in the region.

Keywords: economic growth, Cobb-Douglas production function, intensive form, capital elasticity, labour productivity, Surxondaryo region, econometric modelling.

Аннотация. В данном исследовании рассматриваются ключевые факторы экономического роста Сурхандарьинской области на основе эконометрического моделирования с использованием классической производственной функции Кобба–Дугласа. Для устранения проблем мультиколлинеарности и нестационарности исходных данных была построена ограниченная интенсивная форма модели при условии $\alpha + \beta = 1$ с использованием региональных статистических данных за 2010–2025 годы.

Результаты эмпирического анализа демонстрируют высокую статистическую значимость модели: скорректированный коэффициент детерминации (Adjusted R²) составил 0,961, а значение F-критерия — 379,63, что подтверждает её надёжность. Оценённый коэффициент эластичности капитала (α) равен 0,6967, тогда как коэффициент эластичности труда (β) составляет 0,3033. Это означает, что увеличение капитальных вложений на 1 % обеспечивает рост регионального выпуска примерно на 0,70 %, в то время как увеличение трудовых ресурсов на 1 % приводит лишь к росту выпуска на 0,30 %.

Полученные результаты свидетельствуют о том, что экономический рост Сурхандарьинской области носит преимущественно капиталоемкий характер и в значительной степени обусловлен инвестиционной активностью. В то же время предельная производительность труда остаётся сравнительно низкой вследствие высокой обеспеченности региона трудовыми ресурсами.

Ключевые слова: экономический рост, производственная функция Кобба–Дугласа, интенсивная форма, эластичность капитала, производительность труда, Сурхандарьинская область, эконометрическое моделирование.

INTRODUCTION

In the current context of globalisation, ensuring economic growth is one of the priority tasks for every region. Economic growth is directly linked not only to the expansion of production volumes, but also to the improvement of public welfare, the increase in employment levels, and the reduction of economic disparities between regions. Therefore, an in-depth analysis of the drivers of economic growth and their scientific evaluation remain highly relevant issues.

In modern economic research, econometric modelling methods are widely used to analyse economic growth processes. Econometric models make it possible to identify quantitative relationships between economic indicators, assess their degree of influence, and conduct forecasting. In particular, models constructed on the basis of production functions play an important role in determining the contribution of the main factors of economic growth, namely capital and labour resources.

In this research, the Cobb-Douglas production function, which is widely applied in modelling economic growth, was used. Through this model, the dependence of gross regional product (GRP) on investment, representing capital, and labour resources was econometrically evaluated. The main reason for selecting the Cobb-Douglas model is that, along with its simple and clear structure, it enables the determination of elasticity indicators for economic growth factors.

LITERATURE REVIEW

At the regional level, the impact of various factors on economic growth processes was investigated by I. Abdullayev using the Khorezm region as a case study. Although the author constructed a Cobb-Douglas model in this research, it was specifically noted that the model did not accurately reflect the economic process. Consequently, it was demonstrated that this model is not universal and has certain limitations [1].

Yu. V. Podpovetnaya [6] examined the labour factor as a specific structural component of the regional economy. The study determined that labour demand depends on product output, internal production factors, and the level of capital intensity in production. Based on data from industrial sectors of the Chelyabinsk region for the period 2008–2014, the Cobb-Douglas function was practically applied to analyse the relationship between employment and output.

M. Zecevic et al. [8] analysed agriculture and its influencing factors in the Serbian economy. Open-source agricultural data were examined, and a classical Cobb-Douglas model was constructed. The objective of the study was to identify relationships between production factors and develop forecasts.

RESEARCH METHODOLOGY

It is well known that the Cobb-Douglas model, which explains gross domestic product and its growth rates through capital and labour factors, makes it possible to study the efficiency of using capital and labour inputs, as well as the results of their influence on economic growth when their volumes increase or decrease. The Cobb-Douglas model was proposed in 1928 by Ch. Cobb and P. Douglas in their work "A Theory of Production". The model expresses the dependence of production volume (Y) on its structural factors, namely capital inputs (K) and labour inputs (L) [7; 2]. Its general form is as follows [3]:

$$Q=A \cdot K^{\alpha} \cdot L^{\beta} \quad (1)$$

where Q represents total production volume or gross regional product; A is the coefficient representing the level of technological progress, also known as total factor productivity; K represents capital inputs; L represents labour inputs; and α and β are the output elasticities of capital and labour, respectively.

The α coefficient of the model is the elasticity coefficient indicating that a 1% increase in capital inputs leads to an $\alpha\%$ increase in production volume [5]. The β coefficient is interpreted in the same way for labour. If these parameters satisfy the condition $\alpha + \beta = 1$, it implies that an n-fold increase in capital and labour inputs will increase output by the same proportion, indicating constant returns to scale. Likewise, if the condition $\alpha + \beta > 1$ holds, it means that a 1% increase in capital and labour inputs results in a proportionally higher percentage increase in production, indicating increasing returns to scale [3].

As a result of the empirical analysis, a log-linear Cobb-Douglas model was initially constructed. However, the estimated parameters of the model did not fully correspond to real economic conditions, since the elasticity of the labour factor (L) appeared to be excessively high. In fact, in the context of the Surxondaryo region, there is an oversupply of labour resources. Under such conditions, economic theory suggests that an additional increase in labour supply contributes less to total production. This anomaly may be explained by differences in

the units of measurement of the variables, differences in scale, multicollinearity, or the non-stationarity of the data. Consequently, it was not possible to interpret the initial results accurately.

Therefore, it was decided to impose a restriction on the model parameters, where $\alpha + \beta = 1$, and to estimate the production function in its ratio, or per capita, form, that is, through the intensive form. In scientific literature, this type of model is usually referred to as a restricted production function or an intensive form of the production function. Since $\alpha + \beta = 1$ in this specification, it implies constant returns to scale, meaning that when all production factors increase in the same proportion, output increases by the same proportion.

By transforming the variables into Q/L , representing labour productivity, and K/L , representing the capital-labour ratio, the data are normalised. This reduces the influence of time trends and helps eliminate multicollinearity. As a result, the estimated parameters become more stable, statistically robust, and structurally comparable from the perspective of economic interpretation.

The Cobb-Douglas model with the constant returns to scale constraint is expressed as follows:

$$\frac{Q}{L} = A \left(\frac{K}{L} \right)^{\alpha} \quad (2)$$

After logarithmic transformation, the model takes the following linear form:

$$\ln \frac{Q}{L} = \ln A + \alpha \ln \frac{K}{L} \quad (3)$$

ANALYSIS AND RESULTS

For the empirical analysis, data obtained from the regional Statistics Department were used to assess the impact of investment and labour factors on the gross regional product (GRP) of the Surxondaryo region (Table 1).

Table 1
The volume of Gross Regional Product of the Surxondaryo region
and the values of influencing investment and labor factors [4]

Year	Gross regional product	Investments (billion UZS)	Labour resources (thousand people)	Year	Gross regional product	Investments (billion UZS)	Labour resources (thousand people)
2010	3 394,7	655,3	1 174,1	2018	21 229,4	7 240,6	1 442,7
2011	5 217,1	802,9	1 245,4	2019	25 473,1	11 835,1	1 462,6
2012	6 436,4	980,3	1 282,7	2020	27 571,6	10 068,2	1 452,2
2013	7 436,4	1 371,0	1 320,2	2021	33 591,1	12 037,8	1 463,5
2014	9 213,2	1 509,1	1 353,0	2022	39 201,8	11 569,4	1 468,9
2015	11 114,4	1 843,6	1 379,2	2023	46 999,2	18 307,7	1 489,6
2016	12 179,6	2 142,4	1 403,1	2024	54 354,1	16 593,1	1 509,6
2017	16 354,4	3 551,0	1 425,0	2025	66 186,5	22 758,4	1 511,4

Based on the data presented in Table 1, labour productivity and the capital-labour ratio were calculated. These indicators make it possible to visually analyse the efficiency of production volume (Figure 1).

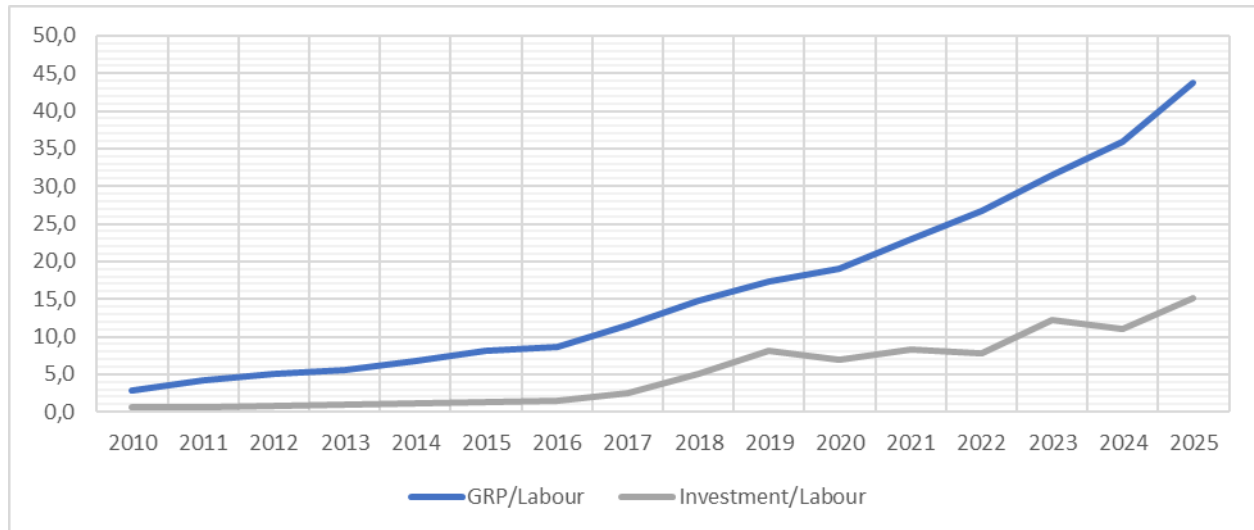


Figure 1. Labor productivity and capital-labor ratio levels in the Surxondaryo region¹

According to the data presented in Figure 1, gross regional product per unit of labour resources increased from 2.9 billion to 43.8 billion between 2010 and 2025, indicating a significant improvement in labour productivity. The investment-to-labour ratio, referred to as the capital-labour ratio, increased from 0.6 to 15.1. Notably, during the New Uzbekistan period, that is, after 2017, a sharp increase was observed in both indicators. This demonstrates that the growth in investment volume had a positive impact on labour productivity. During the pandemic period in 2020, investment declined slightly, leading to short-term fluctuations.

By transforming the capital and labour factors into ratio forms, the risk of multicollinearity was reduced. Furthermore, the analysis revealed a strong correlation between the dependent and independent variables. The results of the regression analysis are presented in Table 2.

Table 2
Estimation results of the Cobb-Douglas model²

Model 2: OLS, using observations 2010-2025 (T = 16)					
Dependent variable: I_Q/L					
	Coefficient	Std. Error	t-ratio	p-value	
const	1.73030	0.0569158	30.40	<0.0001	***
I_K/L	0.696740	0.0357591	19.48	<0.0001	***
Mean dependent var	2.510287	S.D. dependent var		0.829028	
Sum squared resid	0.366658	S.E. of regression		0.161833	
R-squared	0.964434	Adjusted R-squared		0.961894	
F(1, 14)	379.6373	P-value(F)		1.53e-11	
Log-likelihood	7.504294	Akaike criterion		-11.00859	
Schwarz criterion	-9.463410	Hannan-Quinn		-10.92946	
Rho	0.443220	Durbin-Watson		0.918063	

¹ author's development

² author's development

From Table 2, it can be observed that the calculated value of Fisher's F-criterion is $F_{calc} = 379.63$. At a significance level of $\alpha = 0.05$, the tabulated value of Fisher's F-criterion is equal to $F_{tab} = 4.6$. Therefore, since $F_{calc} > F_{tab}$, the model is considered adequate for the economic process. Furthermore, the calculated values of Student's t-criterion for the model parameters are greater than t_{tab} at the $\alpha = 0.05$ significance level. Consequently, all coefficients of the regression equation are statistically significant.

Additionally, Breusch-Godfrey LM test (LMF) results were obtained through experimentation (test statistic: $LMF = 1.175750$, with $p\text{-value} = P(F(3,11) > 1.17575) = 0.363$). This indicates the absence of autocorrelation in the residuals.

Moreover, the distribution of the residuals was examined; according to the test, the Jarque-Bera statistic is $\chi^2 = 3.409$ ($p = 0.1819$), and since the p-value is greater than the 0.05 threshold, it implies that the residuals are normally distributed. At the same time, the Mean Absolute Percentage Error (MAPE) ($MAPE = 5.7362\% < 10\%$) confirms its high forecasting accuracy and adequacy to the economic process.

The final estimated form of the model is expressed as follows:

$$\ln \frac{Q}{L} = 1.73 + 0.6967 \ln \frac{K}{L} \quad (3)$$

According to the OLS (Ordinary Least Squares) estimation results of model (3), the coefficient α is equal to 0.6967, which represents the elasticity of the capital-labor ratio (K/L). This indicates that if the capital-labor ratio increases by 1%, the output per unit of labor resources (Y/L, i.e., labor productivity) will increase by approximately 0.6967%. This demonstrates that an increase in capital intensity within the model positively drives labor productivity. On the other hand, the constant term $\ln(A)$ reflects the technological level or total factor productivity of the economy.

The model can be written in linear form as follows:

$$\ln Q = 1.73 + 0.6967 \ln K + 0.3033 \ln L \quad (4)$$

According to the restriction condition ($\alpha + \beta = 1$), the elasticity of labour (β) is estimated at 0.3033. These results indicate that the capital factor plays a dominant role in the production process. Specifically, a 1% increase in investment leads to an approximately 0.70% increase in output. In contrast, a 1% increase in labour resources results in only a 0.30% increase in output. Consequently, economic growth is primarily driven by the level of capital accumulation, indicating that the model reflects a capital-intensive pattern of development.

In addition, the parameter A captures the influence of factors not explicitly included in the model, such as technological progress, management quality, infrastructure, and institutional conditions. A relatively high value of A suggests that these factors exert a significant positive impact on production within the regional economy. The estimated elasticity of labour (β) is lower than the elasticity of capital (α), which indicates the following:

- The utilisation level of labour resources is already relatively high, meaning that an additional increase in the workforce contributes only marginally to production growth;
- The marginal productivity of labour has declined;
- The growth of labour resources has not been accompanied by a proportionate increase in technology or capital;
- Capital remains a relatively scarce factor in the region and therefore serves as the primary driver of production growth.

The results show that the Cobb-Douglas model, representing the impact of investment and labour resources on the gross regional product of the Surxondaryo region, satisfies all the requirements of the verification stage.

The estimated model parameters confirm that the investment factor plays a dominant role in the production process. According to the model, a 1% increase in investment volume leads to an approximate 0.70% increase in output, whereas a 1% increase in labour resources contributes only about 0.30% to production growth. Therefore, economic growth in the region is largely determined by the level of investment provision, reflecting the capital-intensive nature of regional development.

Overall, the obtained results demonstrate that expanding capital investment is of paramount importance for increasing production volume. At the same time, achieving sustainable long-term economic growth requires further development of technological and institutional factors that enhance labour productivity and improve the efficiency of resource utilisation.

CONCLUSION AND RECOMMENDATIONS

The econometric analysis of the Surxondaryo region's economy for the period 2010–2025 demonstrates that transforming the Cobb-Douglas production function into its restricted intensive form effectively reduced

issues related to multicollinearity and non-stationarity. The model shows high statistical reliability, with an adjusted R-squared of 0.961 and an F-statistic of 379.63, confirming its suitability for representing the region's economic processes.

The empirical results reveal that the capital elasticity coefficient ($\alpha = 0.6967$) significantly exceeds labour elasticity ($\beta = 0.3033$), indicating that the regional economy has a strongly capital-intensive character. Specifically, a 1% increase in capital investment leads to an approximately 0.70% increase in regional output, whereas a 1% increase in labour resources results in only a 0.30% increase.

This difference demonstrates that regional economic growth is predominantly driven by investment inflows rather than labour expansion. The low elasticity of labour indicates structural inefficiencies and a decline in the marginal productivity of the workforce, which may be associated with an oversupply of labour in the region. Although significant reforms since 2017 have accelerated both labour productivity and the capital-labour ratio, the workforce's capacity to generate higher value remains constrained by the existing technological base.

Overall, while capital investment remains the main driver of regional economic growth, ensuring long-term sustainable development requires a gradual shift from pure capital accumulation towards improving labour productivity. In this regard, the introduction of modern technologies, the development of workforce skills, the improvement of institutional conditions, and the more efficient use of investment resources should be considered priority directions for regional economic policy.

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