



ECONOMETRIC ASSESSMENT OF FACTORS AFFECTING AGRICULTURAL PRODUCTION IN SURKHANDARYA REGION

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ABSTRACT

This study aims to estimate how labour and capital determine agricultural production in Surkhandarya region, Uzbekistan, and whether the relationship changed after 2018. A quantitative explanatory design based on secondary time-series data was used. The population is the agricultural sector of the region; the sample covers all annual observations for 2010–2024 ($n = 15$) published by the Statistics Agency under the President of the Republic of Uzbekistan. Gross agricultural output was converted into constant 2010 prices with the official volume indices, employment in agriculture, forestry and fishery measured labour, and the capital stock was constructed from real investment in fixed capital by the perpetual inventory method. A log-linear Cobb–Douglas production function was estimated by ordinary least squares, after ADF unit root tests, and checked with Breusch–Godfrey, Breusch–Pagan, Jarque–Bera, RESET, VIF and Engle–Granger tests. In the preferred model (adjusted $R^2 = 0.991$) the output elasticity of labour is 0.716 and that of capital is 0.342 (both $p < 0.001$), the hypothesis of constant returns to scale is not rejected ($p = 0.481$), and output after 2018 is about 12% lower than input levels predict. In the short run, output growth responds to employment growth but not to capital growth. Agricultural growth in the region therefore remains labour-driven while the return on the recent investment boom is still limited. Policy should target investment more directly at agriculture and raise labour productivity in farms and dehqon households.

Keywords: Agricultural production; Cobb–Douglas production function; labour; capital; Surkhandarya region.



INTRODUCTION

Agriculture is a strategic sector of Uzbekistan's economy, providing food security, raw materials for industry and employment for a large share of the rural population. The Strategy for the Development of Agriculture of the Republic of Uzbekistan for 2020–2030 sets the goals of raising productivity, diversifying production and attracting investment into the sector (President of the Republic of Uzbekistan, 2019). Achieving these goals at the regional level requires reliable quantitative evidence on which production factors actually drive output.

Surkhandarya, the southernmost region of the country, has a favourable climate for early vegetables, fruit, cotton and grain as well as livestock. In 2022 crop production accounted for 53.4% and livestock for 46.6% of the region's agricultural output (Statistics Agency, 2023), and by 2024 the total volume reached 35,234.1 billion soums (Statistics Agency, 2026). At the same time, the region faces water scarcity, land degradation and climate risks typical of Central Asia (Hamidov, Helming, & Balla, 2016; Mirzabaev et al., 2016).

International studies show that long-run agricultural growth depends increasingly on capital, technology and total factor productivity rather than on expanding land and labour (Fuglie, 2018), while climate change has already slowed productivity growth worldwide (Ortiz-Bobea, Ault, Carrillo, Chambers, & Lobell, 2021). For Central Asia, Swinnen, Burkitbayeva, Schierhorn, Prishchepov and Müller (2017) highlight a large unrealised production potential, and research on Uzbekistan emphasises the role of land reforms, farm restructuring and risk (Djanibekov & Finger, 2018; Lombardozzi, 2020). Regional studies of Surkhandarya have analysed price fluctuations (Kenjayev, 2026), the macroeconomic effects of agricultural investment using a VAR model (Badalov, 2026), food industry output (Khursanov, 2026) and the dynamics of fruit and vegetable production (Majidova, 2024).

However, these studies focus on a single product group or a single factor, and a production-function assessment of the joint contribution of labour and capital to agricultural output in Surkhandarya, which also accounts for the farm restructuring of 2018, is still lacking. The purpose of this study is to estimate the output elasticities of labour and capital in the region's agriculture and to derive policy recommendations. It is hypothesised that (H1) labour and (H2) capital have positive and significant effects on agricultural output, and (H3) the relationship shifted after 2018.



METHOD

The study uses a quantitative explanatory design based on secondary time-series data. The object is the agricultural sector of Surkhandarya region (agricultural enterprises, farms and dehqon households). All annual observations for 2010–2024 ($n = 15$) were taken from the open datasets of the Statistics Agency under the President of the Republic of Uzbekistan (SIAT). Output (Y) was converted into constant 2010 prices by chaining the official volume index of agricultural production. Labour (L) is the number of people employed in agriculture, forestry and fishery. Because investment in agriculture alone is published for the region's districts only from 2016, when it formed 8–14% of the regional total, the capital stock (K) was built from total investment in fixed capital in the region, deflated by its official volume index, using the perpetual inventory method with a 5% depreciation rate and an initial stock equal to $I_{2010}/(g + \delta)$, where $g = 12.7\%$ is the average real growth of investment. A dummy S18 equals 1 from 2018, the year when output fell by 2.8%, the share of farms in output dropped from 23.8% to 18.3% and the farm sector was reorganised. Table 1 describes the variables.

Table 1. Variables and Descriptive Statistics, 2010–2024

Variable	Unit	Mean	Std. dev.	Min	Max
Y – agricultural output (2010 prices)	bln soums	3,384.4	604.6	2,286.8	4,257.8
L – employment in agriculture	thsd persons	341.9	20.7	298.8	363.5
K – capital stock (2010 prices)	bln soums	11,624.1	7,331.3	3,707.1	25,476.8
S18 – dummy, 1 from 2018	0/1	0.47	0.52	0	1

(Source: author's calculations based on SIAT data of the Statistics Agency, 2026)

Following Cobb and Douglas (1928), the production function is specified in log-linear form:

$$\ln Y_t = \beta_0 + \beta_1 \ln L_t + \beta_2 \ln K_t + \beta_3 S18_t + \varepsilon_t \quad (1)$$

where β_1 and β_2 are the output elasticities of labour and capital. Model 1 omits S18 and Model 2 includes it; both were estimated by OLS. Stationarity was checked with the Augmented Dickey–Fuller test (lag length by AIC, critical values of MacKinnon, 2010) and the long-run relationship with the Engle–Granger residual test (Engle & Granger, 1987). The models were tested for serial correlation (Breusch–Godfrey), heteroskedasticity (Breusch–Pagan), normality (Jarque–Bera), functional form (Ramsey RESET) and multicollinearity (VIF), heteroskedasticity-robust standard errors were used as a check, and constant returns to scale ($\beta_1 + \beta_2 = 1$) was tested with



a Wald test (Wooldridge, 2020). A first-difference model was estimated to examine short-run effects. Calculations were done in Python (NumPy, SciPy). The procedure is shown in Figure 1.

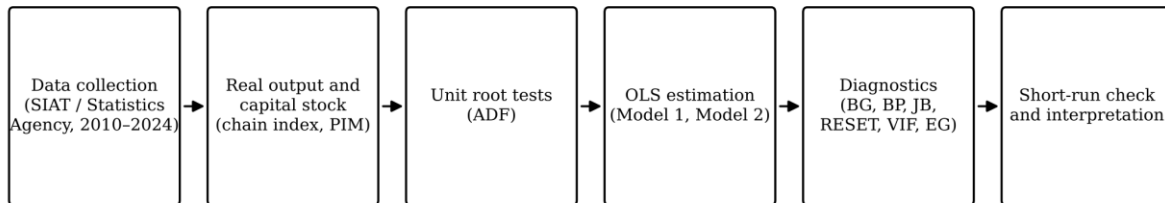


Figure 1. Research Procedure

RESULTS AND DISCUSSION

Over 2010–2024 real agricultural output of the region rose by 86%, from 2,286.8 to 4,257.8 billion soums in 2010 prices, with a single decline in 2018. Employment in the sector grew until 2017 (363.5 thousand) and then fell to 324.0 thousand in 2024, while real investment increased more than fivefold, mostly after 2017. The ADF results are reported in Table 2.

Table 2. Unit Root and Cointegration Tests

Series	ADF, level (const. + trend)	ADF, first difference (const.)
ln Y	–2.36	–2.38
ln L	–0.52	–1.57
ln K	–1.48	–1.82
5% critical value	–3.79	–3.12
Engle–Granger, Model 2 residuals	–3.90 (5% c.v. –4.41; 10% c.v. –3.91)	

(Source: author's calculations; lag length 0 selected by AIC)

The unit root hypothesis is not rejected for the levels, and with only 14 observations the test also fails to reject it for the first differences. The Engle–Granger statistic of Model 2 lies at the 10% critical value. Because ADF tests have low power in such short samples, the level estimates are interpreted as a long-run association and are complemented by a first-difference model. The estimation results are given in Table 3.



Table 3. Estimation Results (dependent variable: ln Y)

Variable	Model 1: β p (SE)	Model 2: β p (SE)	Model 2: robust p
Constant	0.997 (0.892) 0.285	0.861 (0.455) 0.085	0.071
ln L	0.833 (0.160) <0.001	0.716 (0.084) <0.001	<0.001
ln K	0.246 (0.015) <0.001	0.342 (0.018) <0.001	<0.001
S18	– –	–0.128 (0.022)	<0.001 0.004
R ² / adj. R ²	0.971 / 0.966	0.993 / 0.991	
F (p)	202.03 (<0.001)	531.43 (<0.001)	
Durbin– Watson	0.771	1.996	

Note: n = 15; robust p uses HC1 standard errors. (Source: author's calculations)

Table 4. Diagnostic Tests

Test	Model 1: statistic (p)	Model 2: statistic (p)
Breusch–Godfrey LM, 1 lag	4.97 (0.026)	0.10 (0.747)
Breusch–Godfrey LM, 2 lags	7.41 (0.025)	1.23 (0.540)
Breusch–Pagan	1.74 (0.418)	8.00 (0.046)
Jarque–Bera	0.75 (0.688)	1.89 (0.389)
Ramsey RESET	10.08 (0.009)	7.08 (0.024)
Maximum VIF	1.16	6.11
Wald, $\beta_1 + \beta_2 = 1$	1.079; F = 0.26 (0.621)	1.058; F = 0.53 (0.481)

(Source: author's calculations)

Model 1 fits the data well, but its residuals are strongly autocorrelated (DW = 0.771, BG p = 0.026), which signals an omitted structural change. Adding the 2018 shift (Model 2) removes the autocorrelation (DW = 1.996, BG p = 0.747), raises the adjusted R² to 0.991 and keeps all VIFs below 10. Residuals are normal; the Breusch–Pagan test shows mild heteroskedasticity (p = 0.046), but robust standard errors leave every coefficient significant at the 1% level. The RESET test (p = 0.024) suggests some remaining nonlinearity, which is a limitation of the small sample. Model 2 is therefore preferred, and Figure 2 shows how closely it tracks actual output.

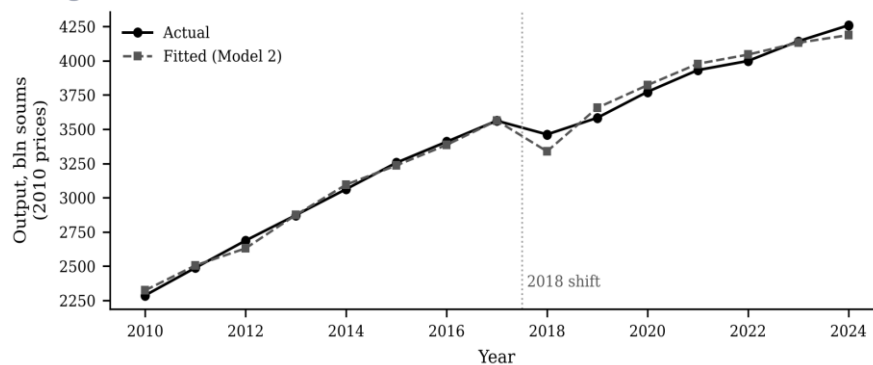


Figure 2. Actual and Fitted Agricultural Output, 2010–2024

The labour elasticity of 0.716 means that a 1% increase in agricultural employment is associated with a 0.72% increase in real output, which supports H1. Labour is the dominant factor because production in the region is concentrated in labour-intensive dehqon households and small farms, which produced about two-thirds of output in 2024, a structure also described for Uzbekistan by Lombardozzi (2020) and Djanibekov and Finger (2018). The first-difference model confirms this in the short run: output growth responds to employment growth ($\beta = 0.505$, $p = 0.003$).

The capital elasticity of 0.342 ($p < 0.001$) supports H2 and is consistent with Badalov (2026), who found a positive effect of agricultural investment on the regional economy, and with Fuglie (2018), who links agricultural growth to capital and technology. However, the short-run effect of capital growth is not significant ($\beta = -0.045$, $p = 0.644$), so investment raises output only gradually. The sum of the elasticities (1.058) does not differ significantly from one ($p = 0.481$), indicating constant returns to scale.

The S18 coefficient of -0.128 ($p < 0.001$) supports H3: since 2018 output has been about 12% lower than the levels of labour and capital alone would predict. This coincides with the 2018 production decline and the reorganisation of farms, and with the fact that most of the post-2017 investment boom went to non-agricultural sectors, since agriculture received only 8–14% of regional investment. In line with Swinnen et al. (2017) and FAO (2021), this points to an unrealised potential that can be used by directing investment to irrigation, machinery and storage, while climate pressure makes such investment more urgent (Ortiz-Bobea et al., 2021).

CONCLUSION

The econometric assessment for 2010–2024 shows that agricultural output in Surkhandarya region is determined by labour, with an elasticity of 0.72, and by capital, with an elasticity of 0.34, under constant returns to scale, and that after 2018



output has been about 12% below the level predicted by these inputs; all three hypotheses are therefore supported. Agricultural growth in the region still relies mainly on labour, while the effect of the large investment inflow on agriculture is limited and delayed. Regional policy should therefore channel a larger share of investment directly into agriculture, especially water-saving irrigation, machinery and storage, and support the productivity of dehqon households and farms through training, credit and cooperation. Future research should use agriculture-specific capital, land, water and climate variables and district-level panel data to obtain more precise estimates.

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