ISSN 2181-8622

Manufacturing technology problems

Scientific and Technical Journal Namangan Institute of Engineering and Technology

INDEX COPERNICUS
INTERNATIONAL

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Volume 10
Issue 3
2025

ECONOMETRIC ANALYSIS OF THE ACTIVITIES OF MULTI-SECTORAL FARMS

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Abstract: Projections indicate that the global demand for food products will rise by nearly 60 percent by 2050, presenting one of the most pressing challenges for agriculture and food systems. This surge in demand must be met under conditions of climate change, finite natural resources, and shifting consumption patterns driven by demographic growth, urbanization, and income dynamics. In developing countries, the responsibility for addressing this challenge disproportionately falls on small-scale producers, who account for the majority of food production. Their role is critical not only for ensuring food security at the national level but also for sustaining rural livelihoods and contributing to broader economic resilience. However, their potential is often constrained by limited access to technology, markets, finance, and infrastructure, which amplifies their vulnerability to environmental and economic shocks. The socioeconomic impact of these developments was considerable. In rural areas, agricultural intensification generated higher demand for labor, created new employment opportunities for the rural poor, and contributed to increasing rural wages. Collectively, these dynamics strengthened food security and enhanced the resilience of local economies.

Keywords: agriculture and food systems, food security, small producers, agricultural products, animal husbandry, consumer prices.

Introduction. At the same time, global consumption patterns are expected to undergo profound change. Rising prosperity will not only increase the absolute demand for food but will also shift preferences toward **higher-quality and resource-intensive products**, such as premium crop varieties, livestock-based goods, and processed foods. Meeting this diversified demand will place additional pressure on land, water, and energy resources, which are already under strain in many parts of the world (Table 1) [2].

Table 1. The main indicators of the agricultural economy

Indicators	2000	2005	2010	2015	2016	2017	2018
Agricultural products, bln. soum	1387.2	5978.3	30856.7	99604.6	115599.2	148199,3	192699.2
Agricultural crops cultivated area, thousand hectares	3778.3	3647.5	3708.4	3694.2	3706.7	3474,5	3396.0
Agriculture, bln. soum	696.8	3323.1	18119.0	55429.2	61755.1	83303,4	102495.1
Animal husbandry, billion soum	690.4	2655.2	12737.7	44175.4	53844.1	64895.9	90204.1

From the data in Table 1, it is observed that in the year 2000, the total volume of agricultural output amounted to 1,387.2 billion soums. Of this, 50.2 percent (696.8 billion soums) was generated from crop production, while 49.8 percent (690.4 billion soums) came from livestock production. In the same period, livestock output per capita reached 3,778.3 thousand soums, reflecting the balanced contribution of both sub-sectors to overall agricultural development.

By 2018, total agricultural output had increased by 38.9 times compared to 2000, reaching 192,699.2 billion soums. Within this structure, crop production accounted for 53.2 percent (83,303.4 billion soums), whereas livestock production contributed 46.8 percent (64,895.9 billion soums).

It is important to emphasize that these significant growth rates were achieved despite a reduction of **382.3 hectares in cultivated land area** compared to 2000. This outcome demonstrates that agricultural progress in Uzbekistan during this period was driven primarily by **intensive development strategies**, particularly through improved **land reclamation practices** and the **efficient use of water resources**.

Methods. The research methodology is based on a combination of quantitative and qualitative approaches. Specifically, the study applies statistical analysis to process empirical data and reveal structural patterns, while monographic observation is employed to examine individual cases in depth. Methods of induction and deduction are used to ensure logical consistency in drawing general and specific conclusions.

In addition, the study relies on abstract reasoning to formulate theoretical generalizations, while economic and mathematical modeling allows for the identification of functional relationships and the simulation of possible development scenarios. To complement these methods, expert assessments and rating evaluations are applied, enabling the integration of professional judgments and comparative analysis of alternatives.

Together, this methodological framework ensures both scientific rigor and practical applicability of the research results.

Results. The primary factors behind the low profitability of agricultural enterprises include the reliance on self-financing and appropriated funds, the decline in investment inflows, low levels of employee remuneration, and the persistent price disparity between agricultural and industrial products. In many cases, the profitability of production is sustained at the expense of suppressed wages, making this factor decisive for the survival of most farms in the region.

Moreover, multi-sectoral farms demonstrate relatively stronger financial positions, as their accounts contain larger amounts of available funds compared to single-sector farms. This financial flexibility provides them with broader opportunities to allocate resources purposefully and invest in productive development.

Discussions. Raising wages in the agricultural sector plays a crucial role in motivating employees, strengthening their commitment to work, and enhancing the competitiveness of agricultural products. Higher incomes also contribute to the improvement of rural living standards, the expansion of human capital, and the social stability of the rural population.

At the same time, higher wages inevitably increase production costs and tax liabilities, which can reduce profitability—particularly in regions with unfavorable agricultural conditions. Research findings indicate that the formation of multi-sectoral farms has created opportunities to balance this trade-off. Such farms are better able to compensate for the rising labor costs by diversifying revenue streams, thereby mitigating the potential negative effects of lower profitability and preserving competitiveness in agricultural production.

Based on the organization of multi-sectoral farms, it will be possible to organize agricultural products processing, cooperation with neighboring agricultural enterprises and other additional complex structures managed by agricultural producers.

To enhance the activities of multi-sectoral farms, it is necessary to establish marketing services that connect production with urban markets and business structures. The integration of such services within the framework of public–private partnerships provides several advantages:

- **Increased profitability and income** of multi-sectoral farms through expanded market access;
- **Strengthened cooperation** between multi-sectoral farms, household plots, and peasant (farmer) farms, thereby enlarging the overall sales volume;
- **Growth of rural employment and real incomes**, contributing to improved living standards and social stability.

Effective development of rural areas—particularly in terms of raising household incomes and ensuring employment—can therefore be achieved through the efficient organization of multi-sectoral farms. In this context, priority should be given to the training of highly qualified specialists and the continuous improvement of farm managers' skills.

Based on the research analysis, the following **priority measures** are required to increase the efficiency of multi-sectoral farms:

1. **Balanced use of agricultural land** to ensure long-term sustainability;
2. **Improving the productivity of agricultural products** through intensive and innovative methods;
3. **Maximizing export opportunities** to strengthen the competitiveness of agriculture in global markets;
4. **Enhancing the efficiency of budgetary support** for agricultural financing;
5. **Ensuring secure land ownership rights** for farms to strengthen investment incentives;

Developing and implementing modern management methods, thereby improving governance mechanisms and institutional capacity of multi-sectoral farms.

Along with the growth of gross domestic product (GDP), the development of its sectoral network structure remains one of the most urgent issues of the current era. Within the scope of this research, it is particularly important to assess the impact of socio-economic and demographic factors on the dynamics of the gross agricultural output of farms in the Republic of Uzbekistan.

For this purpose, the following explanatory variables were selected as factors influencing farm output (**Y**):

- X_1 – volume of investment in agriculture (billion soums);
- X_2 – real total income per capita (thousand soums per year);
- X_3 – number of people employed in the agricultural sector (thousand persons);

• X_4 – population density in the country (persons per square kilometer per year).

On this basis, an econometric regression equation was constructed and analyzed to identify the quantitative influence of each factor on the change in the gross agricultural product (see Table 2).

Table 2. Correlation coefficient between the selected factors of the gross output of farms of the Republic of Uzbekistan

	Y	*X1*	*X2*	*X3*	*X4*
Y	1	-	-	-	-
X1	0,752336	1	-	-	-
X2	0,98506	0,787484	1	-	-
X3	0,897593	0,515908	0,79501	1	-
X4	0,957394	0,81823	0,954609	0,979945	1

Table 3. Criteria-based testing of regression equation coefficients and reliability

Dependent Variable: LNY
Method: Least Squares
Date: 12/03/20 Time: 12:32
Sample: 2000 2019
Included observations: 20

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNX1	0.442429	0.402704	1.098645655	0.0120
LNX2	2.192569	0.940448	2.331409073	0.0329
LNX3	0.039426	0.682030	0.057806841	0.0462
C	-13.44545	10.01737	-1.342123177	0.0094
			t_{jad}=2,119905285	

R-squared	0.959137	Mean dependent var	8.512908
Adjusted R-squared	0.951476	S.D. dependent var	2.030439
S.E. of regression	0.447270	Akaike info criterion	1.405550
Sum squared resid	3.200814	Schwarz criterion	1.604696
Log likelihood	-10.05550	Hannan-Quinn criter.	1.444425
F-statistic	125.1851	Durbin-Watson stat	1.845037
Prob(F-statistic)	0.000000	F_{jad}=3,238871522	

According to the data of Table 2, it was found that all the factors are strongly connected with the resulting factor agricultural output, however, the country's population density (population per 1 sq. km per year) – X4 factor with other factors (r_(x1,x4) =0.81823,r_(x2,x4)=0.9546 and r_(x3,x4)=0.9799) r_(〜_n,x_(n+1))>0.8 because it creates multicollinearity , in order to ensure the reliability and adequacy of the model, we exclude the factor of population density in the country in the study. Now, based on the selected indicators, we move from the variation of the measurement units to the logarithm and continue the process by defining the regression equation and using the Ewievs program to check its reliability and adequacy (Table 3).

Based on the data of Table 3, it should be noted that the determined regression equation (1) is expressed as follows:

$$LnY=0,44LnX1+2,19LnX_2+0,04LnX_3-13,454445 \quad (1)$$

We can exponentiate this logarithmic equation (1) to bring it to a linear equation, and according to it, the logarithmic equation (1) will look like this:

$$Y=\frac{X1^{0,44}*X2^{2,19}*X3^{0,04}}{e^{13,454445}} \quad (2)$$

We check the significance of the determined equation (2) ∝=0.05 for the case Fjad=3,239 when k1=3, k2=16. According to the data in the table, the regression equation (2) determined by the fact that Fhis=125.2 and Fhis>Fcondition is fulfilled is significant, but (tjad=2.12>tx1=1.0986; tx3=0.058) according to tjad>this condition MAPE this parameter We check with the criteria <10 and TIC<1 (Fig. 1).

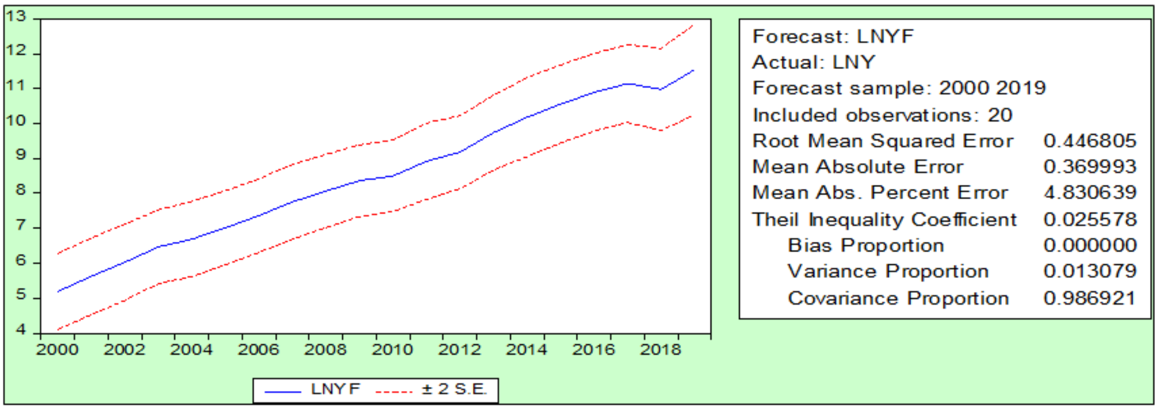

Figure 1. Assessing the retrospective predictive quality of a variable.

According to the condition, - due to the good accuracy of the forecast and using MAPE=4.83<10 and TIC=0.026<1, parameters X1 and X3 were also proved to be significant, and model (2) determined from DW=1.85≤2 was reliable and adequacy arises.

According to regression equation (2), 1 bln. increase to 0.6 billion sums of the gross output of farms. to soums, increasing the total real income per capita by 5.6 million soums. 15.8 mln. per soum and by increasing the number of items in the network by one unit. it was found that it is possible to increase it to soum.

Now, in Namangan region, which is the object of the research, the factors affecting the gross output of farms-Y are the number of people employed on the farm - X1, the area of agricultural crops - X2, real total income per capita - X3 and the population density in the area (per year, 1 sq. .population per km)– we will continue the research on X4. According to its results, the following were determined (Table 3).

Table 3. Correlation coefficient between factors of the agricultural product of Namangan region

	Y	*X1*	*X2*	*X3*	*X4*
Y	1	-	-	-	-
X1	0,884914	1	-	-	-
X2	0,794147	0,524794	1	-	-
X3	0,894589	0,798956	0,525572	-	-
X4	0,98861	0,927926	0,881338	0,936035	1

Based on the information in the table, all the factors selected for the volume of agricultural products are strongly connected and the population density in the area (per year, population per 1 sq.km) with other factors (r_(x1,x4)=0.9279,r_(x2, x4)=0.8813 and r_(x3,x4)=0.9360) created multicollinearity under the condition r_(x_~,x_(n+1))>0.8. According to it, we continue to determine the regression equation with the remaining factors, population density (population per 1 sq. km per year)− X4. It should be noted that since the measurement units of the selected factors are different, we logarithmize all indicators, and this, in turn, determines the regression equation will not have a linear form. For the regression equation, it is first required to check the coefficients and their reliability and significance, which is done using the Ewievs program (Table 4).

Table 4. Regression equation coefficients and test results for reliability criteria

Dependent Variable: LNY				
Method: Least Squares				
Date: 12/02/20 Time: 15:15				
Sample: 2000 2019				
Included observations: 20				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNX1	1.089575	3.61693	0.301243	0.0537
LNX2	0.798733	9,14803	0.087312	0.0319
LNX3	1.241637	0.40453	3.069332	0.0075
C	-13.0831	55.7804	-0.23455	0.0452
			t_{jad}=2.119905	
R-squared	0.989727	Mean dependent var		11.32019
Adjusted R-squared	0.987801	S.D. dependent var		1.545551
S.E. of regression	0.170705	Akaike info criterion		-1.520907
Sum squared resid	0.466241	Schwarz criterion		-1.321761
Log likelihood	9.209074	Hannan-Quinn criter.		-1.482032
F-statistic	513.8349	Durbin-Watson stat		1.9292811
Prob(F-statistic)	0.000000	F_{jad}=3.006917		

According to the table, the defined regression equation (3) looks like this:

LnY=1,089575LnX1+0,798733LnX2+1,241637LnX3-13,0831 (3)

We can exponentiate this defined logarithmic equation according to the accuracy of calculations and the rule of use. Then the regression equation (3) is:

$$Y = \frac{X1^{1,0896} * X2^{0,798} * X3^{1,242}}{e^{13,083086}} \quad \textbf{(4)}$$

will have an appearance. Now we check the significance of the coefficients of equation (4) according to the Student's test. It is known that tjad=2.119905 when ∝=0.05 and df=16, and only tx3=3.069 parameter is significant in this model.

According to the condition, MAPE<10, and according to the conditions MAPE=1.236<10 and TIC=0.0067<1, all the investigated parameters were proved to be significant. Now we test the significance of this regression equation according to Fisher's test. When the result is k1=3, k2=16, Fjad=3.006917, according to the table, it is equal to Fhis=513.8 and since the condition Fhis>Fjad is fulfilled, the regression equation (4) is significant and the model determined from DW=1.929≤2 is reliable and adequate. comes out.

Conclusion. According to regression equation (4), the following marginal effects were identified for Namangan region:

• An increase in employment in farms by one person leads to an additional rise of 15.9 million soums in farm output;

• An increase in land area by one hectare results in an additional rise of 39.1 million soums in farm output;

• An increase in real per capita income by one thousand soums contributes to an additional rise of 0.15 million soums in farm output.

These findings highlight that both labor engagement and land utilization remain decisive factors in boosting agricultural productivity, while income growth also has a measurable, albeit smaller, effect.

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