FORECASTS OF TOMATO SUPPLY AND DEMAND

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Abstract: *In the article, future forecasts of supply and demand for tomatoes grown by farmers and households in the food production chain are calculated using modern analysis methods. ARIMA model used for forecasting.*

Keywords: *ARIMA, farmers and households, food, tomato production, export, residual product, value-added, demand, and supply forecast.*

INTRODUCTION

In developing and transition economy countries, smallholders have a high role as a source of sustainable food production for consumption, high yield, and income (Wünsche & Fernqvist, 2022). According to the statistical results of the Food and Agriculture Organization (FAO), small farms account for only 12% of the world's arable land, but they produce more than 80% of the total agricultural output (Gomez y Paloma et al., 2020). Commonly, these small farms are located in rural areas, and they face many problems in economic activity, such as high transaction costs and risk in the production and sale of products (Abebe et al., 2013).

In Uzbekistan, the share of smallholders in the supply of agricultural products is high, and it is the source of income for 1/3 of the families living in rural areas. The development of the economy requires the improvement of the production system of agricultural products in smallholders and the improvement of economic relations between the entities in the production chain.

Tomatoes produced by smallholders in the country provide a significant part of the population's demand for tomato products. The natural conditions for the production of the product are favorable, and there is a high possibility of obtaining a high yield and growing a product rich in vitamins. At the same time, it is grown in almost all regions of the country, especially for consumption and sale in households, and as a second crop in areas freed from grain for income.

Today, tomato production in smallholders is based on the principles of the free market economy and is operating at high risk. According to the obtained statistics, 161 thousand tons of tomatoes were produced in Samarkand region in 2021, this figure was 184.3 thousand tons in 2020, and 158.8 thousand tons in 2019.[10] According to the statistics, in the past, the production dynamic dispersion volume was high, and such sharp changes affect the change in the price of the product over the years. Naturally, a decrease in supply leads to an increase in the price, and an increase in the supply causes the price to fall and an oversupply. Such changes put farmers in a difficult economic position in years when product prices are low.

[10] Based on the data of the Samarkand Region Statistics Department. www.samstat.uz

To improve the economic relations between entities in the tomato production chain, it is necessary to forecast the amount of production and its demand. Forecasting enables entities to provide product-related information in advance (Zhao et al., 2021), reduce product wastage (Cicculo et al., 2021), reduce risks (Nyamah et al., 2017), and implement effective collaboration (Saurabh & Dey, 2021).

Forecasting is one of the widely used analysis tasks in the economy, it plans economic relations at all links of the product production chain and provides information for decision-making. In addition, it guides the strategic planning of entities in the system and acts as an indicator of results (Eksoz et al., 2014).

The purpose of the article is to determine the future forecasts of demand and supply of tomatoes grown by smallholders in the food production chain and to provide scientific proposals and practical recommendations.

Material and methods. In the analysis, secondary data collected by the Statistics Department of Samarkand region in 2011-2021 were used. The 2015 series of STATA software was used in the analysis.

There are more than 130 methods of economic forecasting, which are generally divided into extrapolation, expert, and modeling methods. In our study, we performed an analysis using quantitative methods on time series in the extrapolation method group. The ARIMA model was chosen as the most suitable model for the analysis in this direction. The ARIMA model allows for integrated time series modeling.

The ARIMA model and its derivatives are one of the most widely used tools for time series forecasting. Time series forecasting is the process of predicting future data based on past data. A time series is a sequence of data points taken at regular intervals over a while (Box et al., 2015). The non-seasonal ARIMA(p,d,q) model consists of three components:

- The autoregressive order (AR) part is a linear combination of the previous p values of the variable;
- The moving average (MA) component is a linear combination of q prior forecast errors (not to be confused with moving averages, another concept in time series analysis);
- The order of differences is called (I) because the data differed d times to satisfy the stationarity requirement.

Below is the formula of the ARIMA model, which incorporates the above structural component:

$$Y_t^* = \Delta^d Y_t$$

$$Y_t^* = \mu + \sum_{i=1}^{p} \varphi_i Y_{t-i}^* + \sum_{i=1}^{q} \theta_i \epsilon_{t-i} + \epsilon_t \qquad (1)$$

Here, ARIMA(p,d,q) represents the model. y specifies the series of observations, the parameters φ and θ of the AR and MA parts of the model, respectively, and the prediction errors ε, m the constant value, and D the variable values. The above formula provides accurate forecasting results by taking into account the seasonality of accurate time series forecasting in the data sets. It should be noted that no model can guarantee perfect predictions for any time series, but the ARIMA model is more versatile than simpler methods (Hyndman & Athanasopoulos, 2018).

It should be noted that no model can guarantee perfect predictions for any time series, but the ARIMA model is more versatile than simpler methods:

In the first step, it is necessary to determine the values of p, d, and q suitable for the model;

In the second step, the parameters of the selected model are estimated;

In the third step, choosing an ARIMA model is one of the more complicated tasks. When determining it, it is necessary to pay attention to the residual values of the model. If the residual values have a uniform distribution concerning zero on the coordinate axis, it means that the selected model can be used for analysis.

In the last stage, a forecast is made for the expected periods. A statistical description of the data used in the analysis is presented in Table 1 below.

Table 1. Descriptive statistics*

Variable	Obs	Mean	Std. Dev.	Min	Max
Истеъмол талаби, %	11	42.084	4.354	33.461	47.371
Қайта ишлаш корхоналари талаби, %	11	10.013	1.448	7.287	11.923
Экспорт, %	11	26.585	2.285	23.235	29.989
Қолдиқ маҳсулот, %	11	21.318	6.868	11.994	35.876
Ишлаб чиқариш, минг тонна	11	160.237	17.896	138.058	185.418
D Истеъмол талаби	10	.044	.144	-.237	.242
D Қайта ишлаш корхоналари талаби	10	.064	.179	-.191	.368
D Экспорт	10	.006	.119	-.168	.188
D Қолдиқ маҳсулот	10	.04	.597	-.423	1.528
D Ишлаб чиқариш	10	.008	.186	-.191	.343

* Source: Based on the data of the Statistics Department of Samarkand region.

During the observed period, the average consumption of tomatoes by the population of the region was 42.1% of the total produced product. From the point of view of food safety, the norms established in decision No. 0007-20 of the Sanitary-Epidemiological Peace and Public Health Service of the Republic of Uzbekistan entitled "Standards of average daily rational nutrition aimed at ensuring a healthy nutrition for age, gender and occupational groups of the population of the Republic of Uzbekistan" the amount of tomato consumption of the population is provided concerning the medical norm. The change in the amount of consumption was 4.4%. The average amount of production during this period is 160.2 thousand tons, and the deviation from the average is 17.9 thousand tons. Of this, processing enterprises accounted for 10%, total export (together with neighboring regions) accounted for 26.6%, and residual products accounted for 21.3%.

When forecasting, the time series was checked for stationarity by choosing a statistical model that was appropriate for the data used for analysis. We used the Augmented Dickey-Fuller test (Table 2).

Looking at the results of the test, all the observed variables are stationary, when testing the significance of the null hypothesis, the p-value is 1-5% when tested at the 95% interval, indicating that the data used are stationary in the time series.

Table 2. Augmented Dickey-Fuller test result.

Variable	Test statistics	1% critical value	5% critical value	10% critical value	Test type
Production**	-3.374	-2.896	-1.860	-1.397	Drift regression
Processing***	-5.046	-2.998	-1.895	-1.415	Drift regression
Export**	-3.066	-2.896	-1.860	-1.397	Drift regression
Rest product***	-4.667	-2.896	-1.860	-1.397	Drift regression
Consumption***	-4.005	-2.896	-1.860	-1.397	Drift regression

* p<0.1, ** p<0.05, *** p<0.01

Models were chosen to make predictions for each variable observed in the tomato production chain (Table 3). According to the results of the AIC and BIC tests, the selected models were used for production forecasts (2,2,2), processing (3,2,2), exports (3,3,3), residual product determination (3,3,0) and when determining consumer demand (3,2,0) was found to be the most optimal.

Table 3. Selected ARIMA models.

	Production (2,2,2)	Processing (3,1,3)	Export (3,3,3)	Rest product (3,2,3)	Consumption (3,2,0)
Cons	.64	.05	.13	-.45	.51
L1.ar	-.83	-1.92***	-.35	-1.88***	-1.61***
L2.ar	-.83**	-1.91***	-.90***	-1.86***	-1.59***
L3.ar		-.95***		-.97***	-.71
L1.ma	-1.79*	.28	-2.39	.81	
L2.ma	1.00	-.28	2.39	-.81	
L3.ma		-1.00	-1.00	-1.00	
AIC	56.1	33.01	45.42	65.90	59.36
BIC	56.5	34.19	45.82	66.38	59.75

* p<0.1, ** p<0.05, *** p<0.01

Results. According to the models, the forecast results for each observed indicator until 2026 were calculated (Figure 1). The results indicated that tomatoes produced by smallholders will reach 173.9 thousand tons by 2026. Production is expected to grow over the forecast years, with an annual growth rate of 1.4%.

The rate of processing has averaged 10% annually over the past 10 years, and its rate will increase to 12% by 2026. This indicator is in an upward trend according to the forecast results, and it was found to be equal to 0.25%.

The export amount of the product made an average of 26.6% of the total product. According to the result of the forecast model, export products are in a decreasing trend, and by 2026, its level is equal to 22.4%, showing a decreasing trend of 0.4%.

The rest tomatoes produced by smallholders were significantly high. This indicator has averaged 21% of total output over the last 10 years.

The small value of the dispersion by periods was 11.9 and the large value was 35.8%. From this, it can be understood that in the observed years, the dispersion range of the residual product is very large, and the product is not produced evenly concerning the demand. Real demand information for the product is asymmetric, and the product is produced at high risk.

Condition-by-case residual product forecasts were also calculated. By 2026, its indicator will be equal to 14.8%, and it will be in an annual decreasing trend of 0.65%.

Estimates of the population consumption of tomatoes were also calculated. Population consumption is in a parallel trend with population growth, and its annual growth rate is estimated to be 0.76%.

Conclusions and suggestions. Judging from the results of the research, the increase in the production of tomatoes in the summer season by farmers and farmers in the Samarkand region, the regular increase in the amount of consumption and processing is a positive thing. However, the residual production level remains at 21%, which harms farmers' income.

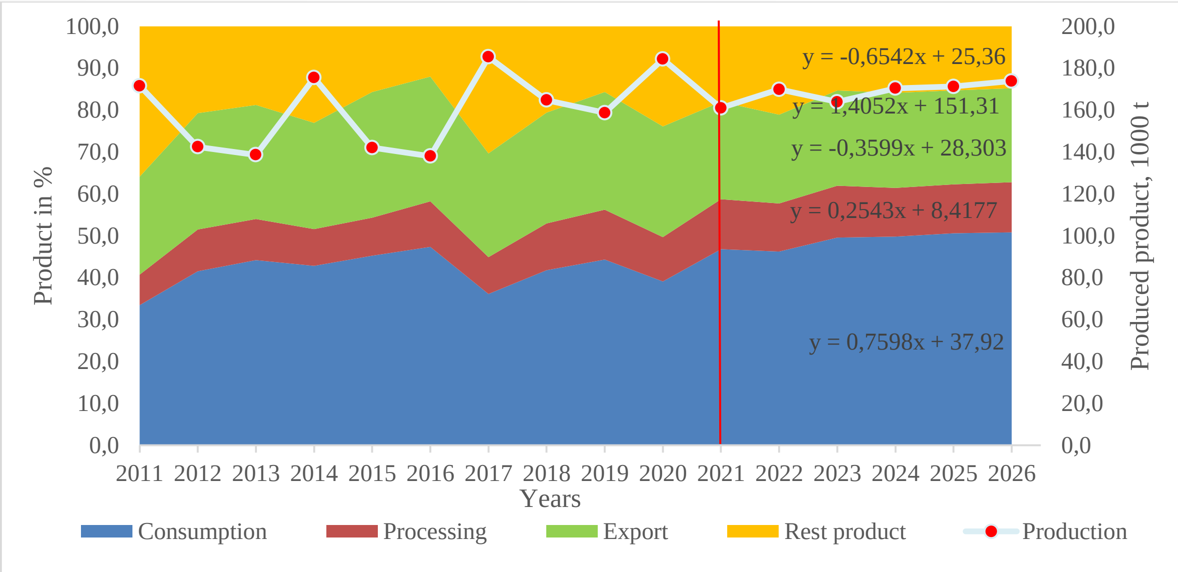

Figure 1. Forecasting results of the demand for tomatoes produced by smallholders of the Samarkand region.

Based on the results of the forecast in the conducted research, it is appropriate to consider the following measures to increase the added value in the tomato production chain in the Samarkand region:

- increasing the number of processing enterprises in districts to reduce the monopoly of processing enterprises;

- applying measures to encourage economic cooperation with processing enterprises to guarantee the income of farmers and households;

- to reduce transaction costs in the system, it is required to ensure the creation of contractual relations between the entities and thus support the implementation of exports.

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