Modeling of the Consumption Level of Organic Products and Strategic Directions of Increasing its Production

Hanna Kharchenko, Volodymyr Kharchenko, Svitlana Tereshchenko, Eleonora Kadebska, Hanna Doroshenko

Abstract— Nowadays traditional methods of agriculture often lead to reduction of production volumes, decrease of soil fertility, increase of content of residues of chemical fertilizers and other chemical elements in agricultural production. That is why organic production is becoming increasingly popular worldwide. It should be noted that nowadays the organic products market is one of the most dynamic and promising areas of agricultural production. Organic agricultural production is a prerequisite for the food security of the country, that provides healthy nutrition and is based on innovative developments of alternative land usage and conservation of natural resources. Organic production trends are significant in more than 170 countries, and this number is increasing annually due to the fact that organic production is demanded by many segments of the population for various objective reasons. That is why the study of the level of organic products consumption is quite topical in current conditions. The objective of this study is to determine the amount of organic production per capita by forecasting and developing strategic directions for increasing organic production that will contribute to sustainable economic growth.

Keywords: organic products, forecasting, ARIMA model, agricultural production, modeling, green economy, consumption.

I. INTRODUCTION

Today one of the main tasks of a green economy is realization of concept of sustainable socio-ecological-economic development of the countries of the world. Thus, it is not only about the quantitative increase in production of products, but first and foremost about the increase in the number of high-quality organic products per capita [1; 3]. It should be pointed out that organic agriculture is an opportunity for sustainable development of agricultural production, as it corresponds to its three components. Thus, economic sustainability of agricultural formations is achieved by improving the educational level of employees, implementing scientific and technological breakthroughs, improving the quality of products, increasing revenues of enterprises with the help of diversification of their activities. Environmental sustainability is provided by the implementation of innovative technologies for the protection and improvement of the state of natural and resource base of agricultural production. Social sustainability for consumers of organic products is achieved by increasing its consumer value due to the lower content of harmful.

It has to be noted that organic agriculture is one of the modern world trends, which is actively developing all over the world. Over the past 20 years, its area has increased fourfold, and over 2 million organic producers have been certified. These days, about 1% of the world's agricultural land is involved in organic production. As a result of the increase in the global volume of organic production, an increase in its sales has been observed. Thus, in 2006, the global sales of organic agri-food products amounted to $ 38.6 million, in 2011 - $ 64.9 million, and in 2016 - $ 89.7 million dollars USA [5].

As for Europe, in 2017, 14.6 million hectares of agricultural land were involved in organic production. Spain has the largest organic area in Europe (2.1 million hectares), the second place is occupied by Italy (1.9 million hectares) which is followed by France (1.7 million hectares) [8]. Not only do organic farmers produce products of higher value for consumers, but they also demonstrate social responsibility, ensuring food security and preserving the ecological state of agroecosystems [7]. Therefore, there is a need for implementation of necessary economic and organizational measures to increase the level of production and consumption of organic products per capita, which is impossible without the use of economic-mathematical modeling.

II. METHODOLOGY

Methodological basis of the study is mathematical mechanism of system analysis, economic-mathematical modelling and multidimensional statistical analysis. In order to study the dynamics of organic products consumption per person the model of the Auto Regressive Integrated Moving Average (ARIMA) was used. This technique does not foresee any structure of the time series data, but only applies an iterative approach to determine the admissible model from

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the aggregate of the models under study. Next, it is needed to compare the selected model with the data sources and to verify the correctness of the time series description. The investigated model was considered adequate if the residuals were small enough and didn't contain useful information.
Otherwise, with not appropriately chosen model, it was necessary to repeat the selection process, but with the use of the new model.

This procedure should be conducted until the adequate model is found [2]. After that, chosen model can be used for forecasting. Hence, we obtain an autoregression and moving average order model (p, q) - ARMA (p, q) containing p + q + 1 parameters (1).

$$v_n = a_n + \sum_{i=1}^{p} \phi_i v_{n-i} - \sum_{i=1}^{q} \theta_i a_{n-i} \qquad (1)$$

If the investigated row v (t) shows features of non-stationarity (deterministic trends - linear, polynomial, etc.), then the stationary process may not be an adequate model. A stationary row is a series, present behaviour of which or the future one coincides with behaviour in the past, so that, properties are not affected by the change in the time of the start. It is possible to determine whether a series is stationary by type of autocorrelation function (ACF) and partial autocorrelation function (PACF) and by conducting a Dickie-Fuller test.

Under these conditions, some difference of the investigated order process may be stationary d : $\varpi_n = \nabla^d v_n$, where $\nabla v_n = v_n - v_{n-1}$ the first difference (analog of the differentiation operation), ∇^d means the consistent application of d times by the operator ∇. The process itself can be described using an effective ARMA model. So let's move on to the auto-regression model and the integrated moving average order (p, d, q) - ARIMA (p, d, q) (AutoRegressive Integrated Moving Average) (2, 3) [13]:

$$\varpi_n = a_n + \mu + \sum_{i=1}^{p} \phi_i \varpi_{n-i} - \sum_{i=1}^{q} \theta_i a_{n-i} \qquad (2)$$

$$\varpi_n = \nabla^d v_n \qquad (3)$$

Hereby, the forecasting of organic products consumption per capita (euro) was conducted on the basis of official international data of the Research Institute of Organic Agriculture FiBL using Box-Jenkins method [4].

In the first stage of the study, the investigated series was tested for its stationarity. For this purpose, the autocorrelation coefficients of this series were calculated using the Minitab 16 analytical package (Table 1).

Table I- Autocorrelation coefficients

Lag	ACF	TSTA	Boxing-Lung coefficients (LBQ)
1	0,649320	2,05333	5,6215
2	0,389081	0,90625	7,8923
3	0,133159	0,28745	8,1963
4	-0,071045	-0,15211	8,2972
5	-0,267268	-0,57091	10,0116
6	-0,357963	-0,74088	13,8557
7	-0,397767	-0,78149	20,1845
8	-0,344732	-0,63937	27,3149
9	-0,232784	-0,41510	33,8175
10	0,649320	2,05333	5,6215

Taking into account the found parameters, as well as the autocorrelation function, which decreases in an infinite wave (Fig. 1), we verify that this series is stationary.

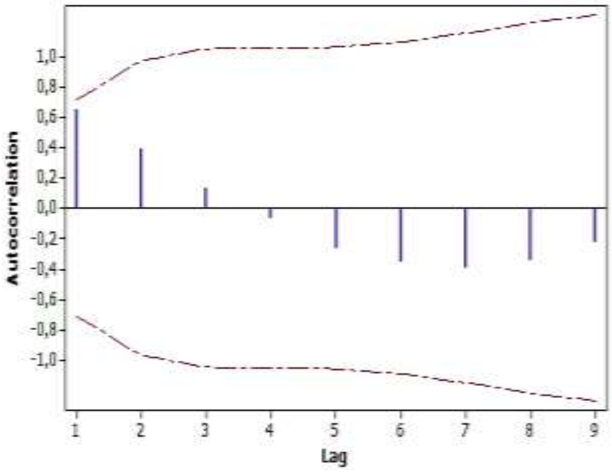

Fig. 1. Autocorrelation function of organic products consumption per 1 person, euro with 5% confidence limits for autocorrelation

The next step was to find the coefficients and graph of the partial autocorrelation function (Table 2), (Fig. 2).

Table II- Partial autocorrelation coefficients

Lag	PACF2	TSTA2
1	0,649320	2,05333
2	-0,056252	-0,17788
3	-0,168527	-0,53293
4	-0,133468	-0,42206
5	-0,204760	-0,64751
6	-0,086297	-0,27289
7	-0,109074	-0,34492
8	-0,028468	-0,09002
9	0,010924	0,03454
10	0,649320	2,05333

Analysis of the graph of the partial autocorrelation function and its coefficients indicates a break after the first lag.

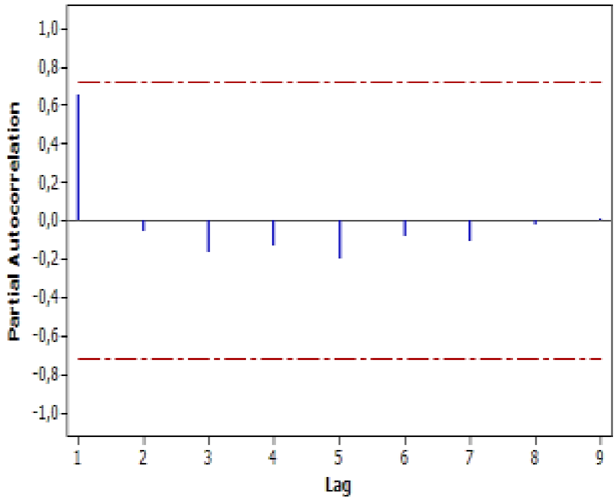

Fig. 2. Partial autocorrelation function for organic products consumption per 1 person, euro with 5% confidence limits for autocorrelation

After that, a series of stationarity tests were performed. Applying Dickie-Fuller's test to the investigated series using the least-squares method revealed its non-stationarity [4]. Therefore, in order to transform this series, it is necessary to go to the first difference of events and obtain a stationary series, in which it acts as a unit of observation (4).

$$\Delta Y_t = Y_t - Y_{t-1} \qquad (4)$$

After the analysis of autocorrelation and partial autocorrelation coefficients and their graphs the Box-Jenkins model for forecasting was accepted, namely ARIMA (2,1,2).

The following step was to carry out the evaluation of model parameters.

To ensure the accuracy of forecast such indicators were used: MAD (Mean Absolute Derivation), MSE (Mean Squared Error), MAPE (Mean Absolute Perceptible Error), which are used for comparing and evaluating different investigated models [9].

Mean Absolute Derivation (MAD) measures the accuracy of a prediction by averaging the magnitudes of the prediction errors (the absolute meanings of each value). This error is calculated using (5). MAD = 0.013. That is, this value indicates the average absolute error.

$$MAD = \frac{1}{n}\sum_{t=1}^{n}\left|Y_t - \hat{Y}_t\right| \qquad (5)$$

MSE (Mean Squared Error) is another way of evaluating the prediction method. Each error or fallibility is squared. These values are then summed up and divided by the number of observations (6). MSE is 0.026.

$$MSE = \frac{1}{n}\cdot\sum_{t=1}^{n}\left(Y_t - \hat{Y}_t\right)^2 \qquad (6)$$

MPE (Mean Percentage Error) is an average error (in percentage) which measures deviations. MPE is 6,46 (7):

$$MPE = \frac{1}{n}\sum_{t=1}^{n}\frac{\left(Y_t - \hat{Y}_t\right)}{Y_t} \qquad (7)$$

Sometimes it is better to calculate not the absolute magnitudes of errors, but their percentage ratio. Mean Absolute Percentage Error (MAPE) is calculated by finding the absolute error at each time point and dividing it by the actual observed value (at this point in time), followed by averaging the absolute percentage errors obtained.

The indicator is 9.86% and shows the relative accuracy of the found forecast result. Thus, for high accuracy forecasts, MAPE is <10%, for ones of good accuracy it lies within the range 10% <MAPE <20%, for satisfactory forecasts it is in the range of 20% <MAPE <50%, and for unsatisfactory forecasts MAPE is > 50% (8).

$$MAPE = \frac{1}{n}\sum_{t=1}^{n}\frac{\left|Y_t - \hat{Y}_t\right|}{Y_t} \qquad (8)$$

Subsequently, the investigated model is adequate and acceptable for further forecasting.

III. RESULTS

Results of the research showed that in 2020 the amount of organic products consumed per capita (euro) is forecasted to increase in average by 30%, that will enable agricultural enterprises to strengthen the production potential level. This increase in organic products consumption per capita will allow the effective formation and development of the resource potential of agricultural formations, which in turn will contribute to the increase in the level of efficiency of production and economic activity of agricultural formations and to the ensuring of food security in the country.

Figure 3 graphically depicts realistic, pessimistic and optimistic results of forecasting of organic products consumption per capita (euro).

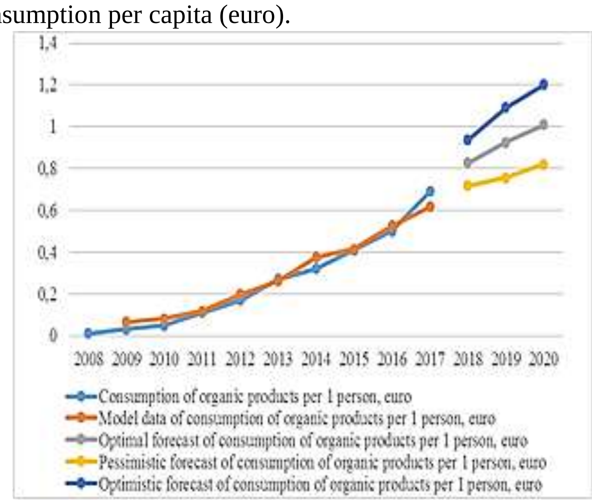

Fig. 3. Forecasting of organic products consumption per 1 person, euro

When testing the investigated model for adequacy, it is necessary to analyze the prediction errors. If they are small enough and randomly distributed, then this model is considered to be adequate.

A general test of the adequacy of the selected model was carried out by estimating the autocorrelation of residuals as well as the chi-square test ($\chi 2$) based on a modified Box-Pierce Q-statistic [4].

In this case, none of the autocorrelations coefficients are statistically significant, implying that the time series may well be completely random (white noise).

The autocorrelation function of the residuals for the investigated model is shown in Fig. 4.

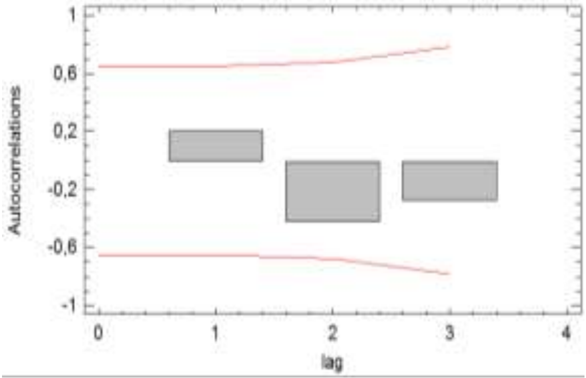

Fig. 4. Autocorrelation function of residuals for the model Furthermore, none of the partial autocorrelations coefficients is statistically significant at the 95,0% confidence level (fig.5).

Therefore, in order to check the absence of autocorrelation of the residuals of this ARIMA model, a graphical analysis of the correlogram of the residuals, the statistics of Darbin-Watson and Lung-Box were applied. They showed that the residuals were not linearly adjusted.

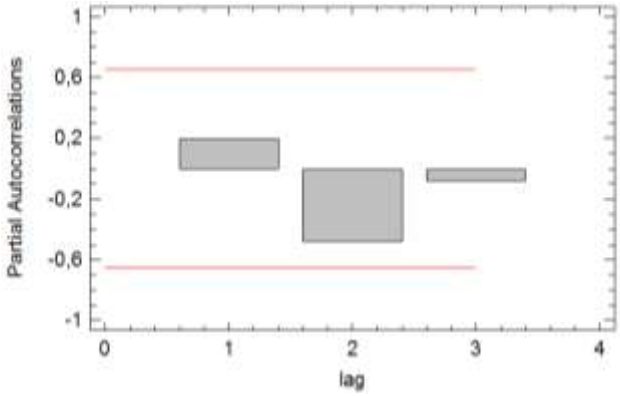

Fig. 5. Partial autocorrelation residual function for the model

The use of economic and mathematical models to predict the organic products consumption allows to perform effective management at both micro and macro levels.

For this reason, in order to increase the organic products consumption and ensure the sustainable development of agriculture, an important step is to develop strategic directions for the development of organic production. These suggestions should be based on a systematic and integrated approach (Fig. 6).

The main strategic directions should be divided into: economic, legislative, environmental (ecological), informational, productional and socially oriented ones. The legislative vector is based on the formation of a legal framework and certification system, which will guarantee the quality and safety for consumers of organic products. It is also necessary to establish a system of state support for households that are switching to organic production. The economic vector is based on the introduction of grants, attracting investments; preferential lending; insurance and reduction of energy intensity in agricultural production. Environmental vector focuses on ensuring the ecological balance of environment in the process of production, conservation and restoration of biodiversity in agricultural landscapes etc. One more important direction is informational, which spreads information about the benefits of organic production; creates information-consulting structures; ensures the protection of the rights of consumers of organic products; constantly monitors the organic market conditions, etc.

Given the global experience, it should be noted that it is necessary to intensively introduce innovative information technologies to increase the level of production and consumption of organic products, to apply innovative resource-saving technologies that will ensure the production of competitive products.

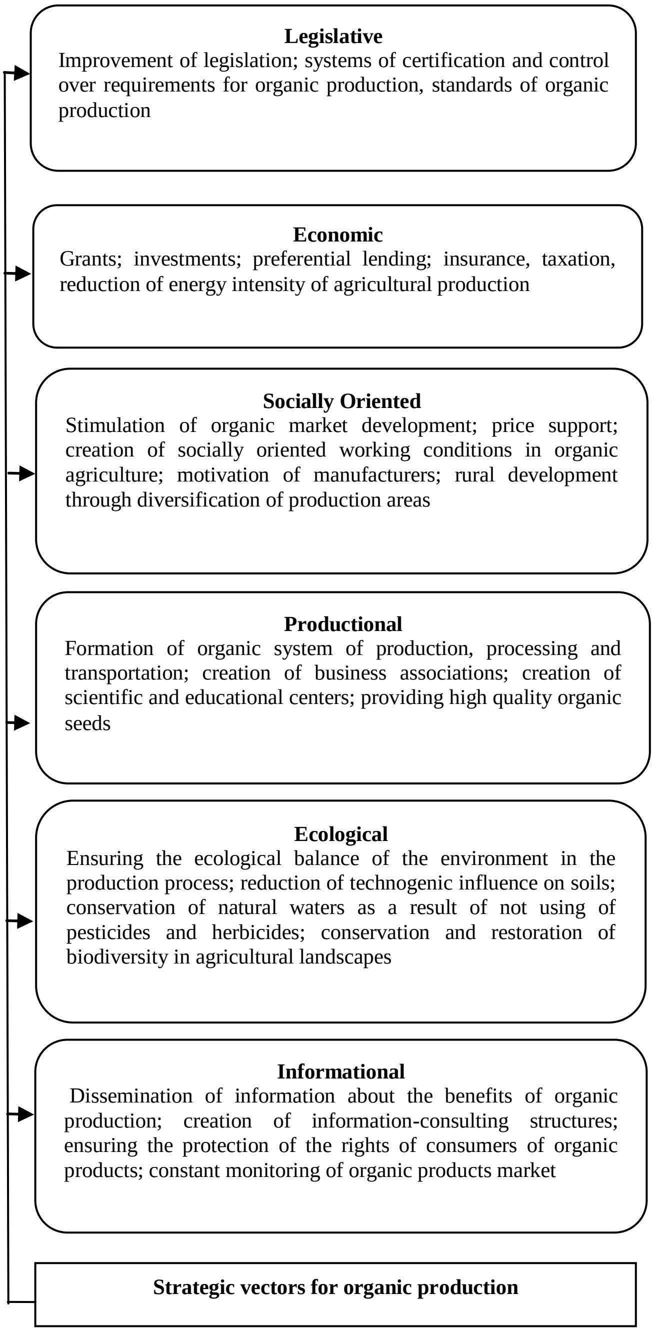

Fig. 6. Strategic vectors for organic production

All of these measures will facilitate the increase in the number of organic enterprises and growth in the consumption of organic products. In addition, the revitalization of organic production will improve soil biological activity, restore nutrient balance and, as a result, increase crop yields.

IV. CONCLUSION

Further increasing of organic products consumption requires a systematic approach. First and foremost, it is necessary and important to create the conditions for proper stimulation of agricultural producers, reducing the risks of organic production. Production should increase its areas by using land not contaminated with agrochemicals. It is important to note that the increased level of production and consumption of organic products will contribute to the improvement of social and environmental state, integrated rural development and improvement of population health.

The ecologization of international trade leads to the involvement of economic agents in “green entrepreneurship”. Following healthy lifestyles and "sustainable consumption" contributes to the development of the organic products market and increase the level of their consumption.

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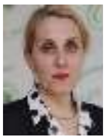

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