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Forecasting export options for fruit and vegetable products

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Forecasting Export Options for Fruit and Vegetable Products

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Abstract. The state of fruit and vegetable exports is an important indicator of the quality of economic and social development of the economy. In this regard, in recent years, an active policy has been pursued to deepen economic reforms in the agricultural sector of the economy, create favorable conditions for increasing the production and processing of fruits and vegetables. As a result, the range of products - juices, nectars, jams, canned fruits and vegetables, marinades - is increasingly expanding in the markets and in the retail network. The main purpose of the work is to forecast options for the export of fruits and vegetables. To achieve this goal, the problems of developing a linear and non-linear regression model and a fuzzy Sugeno model for forecasting the export of fruits and vegetables were solved. The first method allows you to simultaneously tune the membership functions of the terms of the input variables and the conclusion of the rules by adjusting the coefficients of conclusions of fuzzy rules using the gradient optimization method. The collection of initial information and its preparation for calculations is the most time-consuming and responsible stage of statistical research. The success of the work largely depends on the completeness and reliability of the obtained economic information. The features of the application of the theory of fuzzy sets and neural networks are considered, which show their advantages in comparison with other existing methods when choosing a forecast model.

INTRODUCTION

Export deliveries are carried out in more than 80 countries of the world. There have been significant changes in the structure of exports, in particular, the share of exports of raw materials has decreased, and at the same time the volumes of exports of finished products, including those with a deep degree of processing, have increased.

Also, work continues on processing and exporting fruits and vegetables. As a result of the measures taken over the years of independence, the volume of exports of fruit and vegetable products by main types (apricot, persimmon, pomegranate, beans, plums, cucumbers, carrots, walnuts, etc.) increased 7 times - from 72.1 thousand tons to almost 500 thousand tons, while exports in value terms increased by more than 25 times [1].

The agricultural processing industry is among the industries that have all the basic conditions for rapid development. The country annually increases the volume of production of agricultural raw materials, there is a significant labor potential, many processing enterprises are re-equipped with modern foreign-made equipment.

One of these sources can and should be an increase in the volume of exports of fruits and vegetables, the proceeds from which can be directed to the purchase of new equipment, technology, chemicals, some of which require foreign currency. In order to increase the amount of currency, commodity producers must earn more. To do this, it is necessary to increase the range of exports of processed fruits and vegetables.

Encouragement of various forms of trade in finished products, due to which the development of export trade took place. As a result, trade in processed products will become the main driver of the country's exports.

Taking into account the growing demand in the world market, comprehensive work is being carried out to improve this industry, in particular:

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- Creation of new highly productive and competitive varieties of agricultural crops corresponding to the soil and climatic conditions of the regions;
- Development of intensive gardening;
- Introduction of modern agrotechnical methods into production;
- The creation of domestic small-sized tractors and agricultural machines for the needs of producers of horticultural products, vegetable crops;
- Creation of large retail outlets for the sale of export-oriented agricultural products to the foreign market;
- Implementation of work on advertising and targeted marketing research;
- Further increase state support for export-oriented enterprises to increase the volume of exports, expand and improve its structure, stimulate enterprises producing export-oriented and competitive products;
- Involvement of foreign investments in the development of basic industries;
- Introduce modern technology in terms of structure and management methods, actively master production, scientific and technical, design and other developments.

MATERIALS AND METHODS

Export of fruits and vegetables depends on many conditions and factors [2, 3].

Two methods for forecasting the export of fruits and vegetables are considered - using the Sugeno fuzzy knowledge base and the regression model [4, 5].

The first method allows you to simultaneously adjust the membership functions of the terms of the input variables and the conclusion of the rules by adjusting the coefficients of conclusions of fuzzy rules according to the gradient optimization method [2-4].

The collection of initial information and its preparation for calculations is the most time-consuming and responsible stage of statistical research. The success of the work largely depends on the completeness and reliability of the obtained economic information [5].

Information for economic and statistical research can be obtained in the form of a sample [6]:

- Temporal (information about the industry, for a separate period of time);
- Spatial (information on a group of homogeneous subjects of agriculture);
- Combined spatio-temporal (information on a group of homogeneous agricultural subjects for a certain period of time).

Of particular importance for studying the development of economic phenomena in time and their forecasting is information in the form of time series [7].

A time series is formed from a series of observations taken through definite and usually equal integrals of time. The individual observations of a time series are called the level of the series. Interval time series are understood as series in which the levels of the series characterize the phenomenon under study over a time interval (for example, the volume of production per year). Under the moment series understand the time series in which the levels characterize the phenomenon at a certain point in time (for example, the volume of consumption of products per year). And, finally, derivative series are understood as series of dynamics, the levels of which characterize the development of phenomena over an interval or at a certain point in time using average or relative values (for example, a series of labor productivity growth rates over a five-year period) [7-11].

The simultaneous use of information characterizing the change in phenomena has received a certain distribution. In time and space, which allows you to significantly increase the sample size.

The following requirements are imposed on the initial information in any of its forms. The information must be reliable and residually representative, homogeneous and have a certain quantitative expression.

Time series should correctly reflect the dynamics of the phenomenon and therefore consist of homogeneous comparable values. This comparability is achieved as a result of the same principle of formation of the equations of the series in different time intervals. The levels of the time series should be expressed in the same units, the methodology for their calculation for all time periods covered by the time series should be the same.

When using spatial sampling, the populations included in the sample should also be comparable and their range should not change significantly over time.

Regression dependency equations are of the following types:

- Linear equation:

$$Y = a_0 + a_1 x_1 + a_2 x_2 + ... + a_n x_n \quad (1)$$

- Nonlinear equation:

$$Y = a_0 + a_1 x_1 + a_2 x_2 + ... + a_n x_n + a_{n+1} x_1^2 + ... + a_m x_n^2 \quad (2)$$

- And etc.

Here a_i, $i = 1,2,...$ are called regression coefficients.

Most of the economic and statistical models are built with the aim of studying the dependencies in the sphere of production. The economic-statistical model adequately describes the relationship between the result of production activity (for example, the volume of output) and the amount of production resources involved in production.

Formally, the Sugeno algorithm proposed by Sugeno and Takagi can be defined as follows [4, 5]:

- Fuzzification of input variables. Same as above;
- Aggregation of subconditions in fuzzy production rules;
- Defuzzification of output variables [9-11].

RESULTS

Formalization of the export of fruits and vegetables in the form of an economic and statistical model that describes the relationship between the export of fruits and vegetables and the production, consumption, processing of fruits and vegetables leads to the construction of a general relationship:

$$Y = f(X_1, X_2, ...X_n), \quad (3)$$

Where Y is the volume of exports of fruits and vegetables.

Linear equation: $Y = -3127372 + 0.6918x_1 - 0.6687x_2 + 0.0435x_3$.

Nonlinear equation:

$Y = 954.0649 - 0.7313x_1 + 0.5723x_2 + 0.4822x_3 + 0.0001x_1^2 - 0.0001x_2^2 - 0.0003x_3^2$.

Based on the Sugeno model, a neuro-fuzzy model of a linear and non-linear regression model, the results of forecasting the export of fruit and vegetable products were obtained and a comparative analysis was carried out (Table 1). The results of the forecast for the export of fruits and vegetables are shown in Figures 1-3.

TABLE 1. Comparative table of forecast data for fruit and vegetable exports.

Export of fruits and vegetables	Production	Consumption	Recycling	Forecast using fuzzy set theory	Prediction using neural networks	Forecast using linear ression model	Prediction using a non-linear stress model	Fuzzy model error	Neural model error	Linear regression model error
4776.9	3732.7	550.3	473.9	473.9	472.7	520.0	488.3	0.0	1.16	46.1
5108.4	4219.5	834.5	513.2	513.2	513.3	436.2	482.5	0.0	0.14	76.9
6241.6	5147.4	1096.8	535.0	535.0	535.6	611.1	556.7	0.0	0.58	76.1
6819.3	5909.2	991.0	561.0	561.0	561.9	496.8	524.9	0.0	0.90	64.2
7411.2	6767.1	1118.0	303.4	303.4	304.7	338.2	350.7	0.0	1.28	34.8
8147.2	7459.8	1204.3	361.5	361.5	363.4	387.9	366.5	0.0	1.88	26.4
9044.2	8182.0	1270.1	562.1	562.1	563.2	528.4	534.7	0.0	1.09	33.7
9955.0	8947.2	1365.2	689.1	689.1	691.8	651.0	720.8	0.0	2.69	38.1
11023.7	10247.7	1463.6	512.2	512.2	511.8	525.1	485.8	0.0	0.36	12.9
11485.0	10723.0	1447.1	520.8	520.8	520.6	525.6	505.9	0.0	17	4.8
12259.3	11520.7	1462.5	522.9	522.9	522.9	528.6	520.7	0.0	0.01	5.7
13033.6	12318.4	1463.2	524.9	524.9	524.8	530.9	542.5	0.0	0.02	6.1
11485.0	10723.0	1447.1	520.8	520.8	520.6	525.7	505.9	0.0	0.17	4.9
12259.3	11520.7	1462.5	522.9	522.9	522.9	528.6	520.7	0.0	0.01	5.7
13033.6	12318.4	1463.2	524.9	524.9	524.8	530.9	542.5	0.0	0.02	6.1

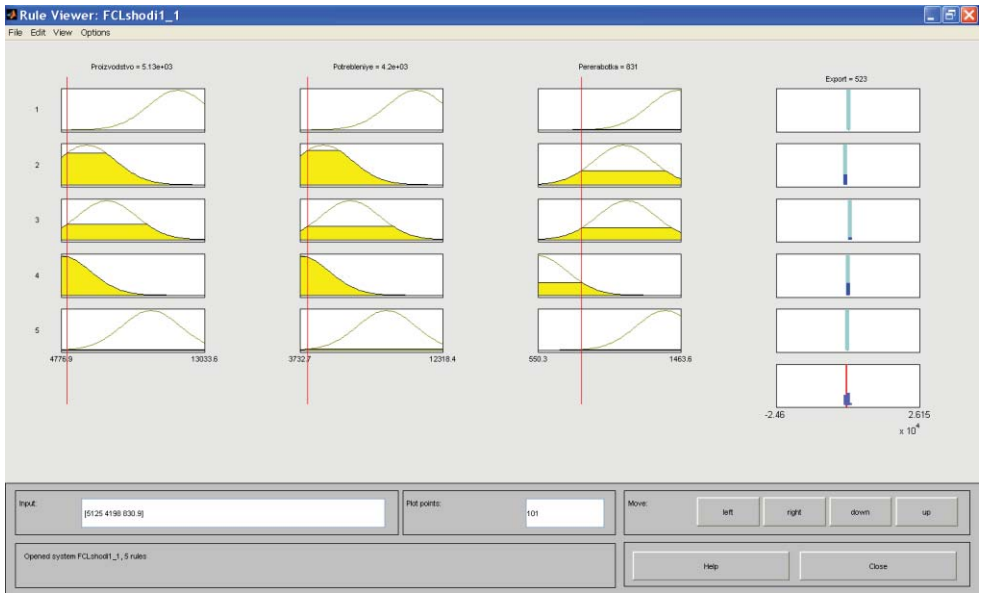

FIGURE 1. Fruit and vegetable export forecast model.

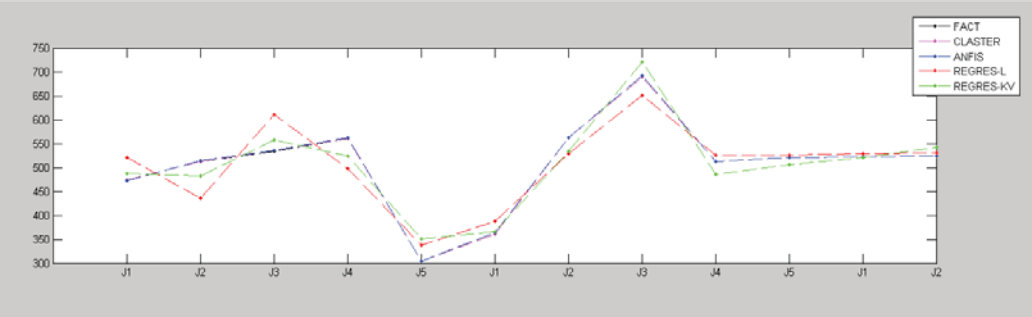

FIGURE 2. Forecast results of fruit and vegetable exports.

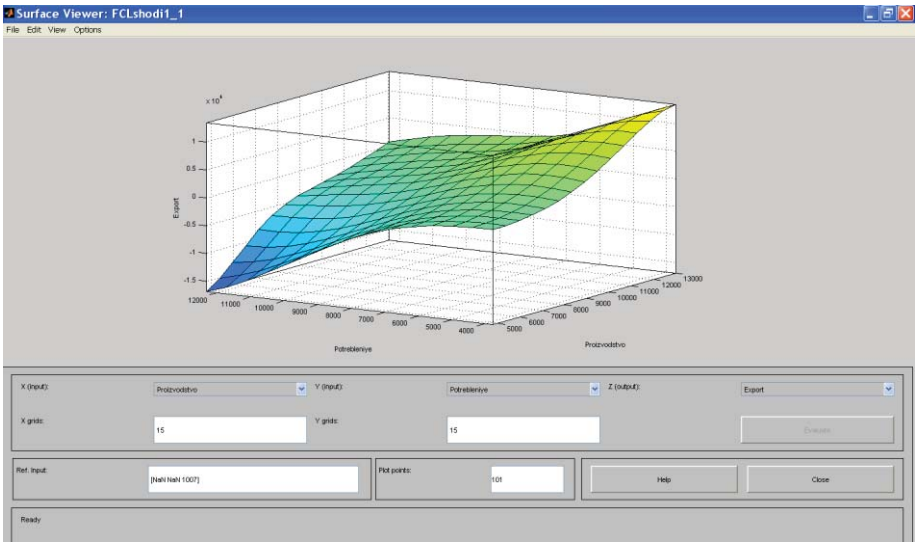

FIGURE 3. Graph of dependence of the forecast of export of fruits and vegetables.

DISCUSSION

The features of the application of the theory of fuzzy sets and neural networks are considered, which show their advantages over other existing methods when choosing a forecast model [13]:

- Efficiency in solving non-formalized or poorly formalized tasks;
- Resistance to frequent changes in the environment;
- Efficiency when working with a large amount of conflicting information.

CONCLUSION

Forecasting indicators of options for the export of fruits and vegetables was carried out using the technology of fuzzy sets and neural networks

Based on the proposed method, an approximating forecast model was created using two methods for identifying a nonlinear dependence - using the Sugeno fuzzy knowledge base and a regression model. The forecast error for the first model was - (0.1-4.35)%, and for the second model (3-21.5)%.

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