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ECONOMIC ASSESSMENT OF AGRICULTURAL ENTERPRISES IN IVANO-FRANKIVSK REGION, UKRAINE - IDENTIFICATION OF FACTORS THAT INFLUENCE PERFORMANCE

Tetiana KUZMIN[1], Ivan BALANIUK[1], Diana SHELENKO[1], Oleksandr SHPYKYLIAK[2], Myshailo SMUSHAK[1]

[1]Vasyl Stefanyk Precarpathian National University, 57, Shevchenko Str., Ivano-Frankivsk, 76010, Ukraine, Phone/Fax: +380987617616; +380503733282; +380990662326; +38509418476, E-mails: tetiana.ivaniuk@pnu.edu.ua, ivan.balaniuk@pnu.edu.ua, diana.shelenko@pnu.edu.ua, myshailo.smushak@pnu.edu.ua
[2]National Scientific Centre "Institute of Agrarian Economics", 10, Heroiv Oborony Str., 03127 Kyiv, Ukraine, Phone/Fax:+380679386887, E-mail: shpykuliak@ukr.net

Corresponding author: diana.shelenko@pnu.edu.ua

Abstract

As part of the study, the methodological toolkit for the functioning of land relations is substantiated. Using the software product STELLA, a system analysis was conducted to forecast trends in the development of indicators of agricultural enterprises. The gross output of agricultural enterprises was selected as an effective indicator, and the size of land plots was one of the influencing factors. It has been proven that forecasting is an important direction in the development of land relations in agricultural enterprises in modern competitive conditions. On the basis of the system analysis, modeling was carried out using the STELLA software product. The forecast of the production of gross agricultural products by enterprises of the Ivano-Frankivsk region until 2030 was carried out. The study shows, that among the main factors affecting the dynamic of the production of the gross products by agricultural enterprises according to its volume, the amount of mineral fertilizers applied per 1 hectare of land, the number of employees in enterprises and the number of animals in conditional expression are singled out.

Key words: *modeling, land relations, agricultural enterprises, gross production*

INTRODUCTION

The volume of production of gross products in its value expression is currently the basis for the formation and identification of the effectiveness of the functioning of agricultural enterprises, as well as increasing their competitiveness. Information support reinforces these processes and helps to model and forecast the future development of agriculture through the use of special software products. One of the main components of the development of agricultural enterprises is the production of agricultural products through the effective use of land. In order to determine the development trends of a certain process for the future, it is necessary to apply the methods of scientific forecasting.

D. Medovz [17], a researcher of the art of thinking systematically, believes that a system is a set of things that are connected to each other in such a way that they produce their own pattern of behavior as an interconnected, coherently ordered set of elements that achieves a specific goal. In her understanding, the system largely determines its own behavior. I. Kozak and V. Parpan [14] also consider system dynamics in their work, where they separate the concept of a system and prove that it actually acts through the interrelationships of its elements and functions in time and space, and the concept of a model, which is a simplified representation of this real system to understand its behavior as a concrete system. L. Cornwell, R. Costanza, [10] justify market mechanisms for environmental management under different degrees of uncertainty and use the STELLA diagram. H. Balali and D. Viaggi [2] studied STELLA models and their impact on the system and what its results are. The system dynamics approach using the STELLA model was proposed to analyze and forecast the activities of agricultural enterprises [3], [5], [16], private

enterprises [19], farms [9], agricultural cooperatives [20].

The main tools for assessing the ratio of global and local indices as performance indicators that can be used for analysis are proposed in works [7], [8]. Other researchers gave recommendations related to the preservation of land in ownership, which contribute to sustainable development in rural areas [18], [24] [25].

With the help of STELLA and Statistica software, we conducted an analysis of the purpose of the work to provide a deeper understanding of the current state of justifications and the protection of justifications in the specific context of our country.

Based on the results of the research, we have collected data that should serve as a resource for researchers and managers of agricultural enterprises, in particular all those stakeholders of the agricultural system who are interested in new organizational and managerial approaches to increasing the efficiency of entrepreneurial activity and ensuring optimal development of the agricultural sector of Ukraine.

The purpose of the article is to conduct an economic assessment and forecast the activity of agricultural enterprises in the region. This is achieved through the identification, with the help of the STELLA software, of the factors that affect the efficiency of the business.

The hypothesis of the study is to confirm the assumption that the main objective factors that affect the efficiency of agricultural enterprises are such indicators as the area of agricultural land, the amount of applied mineral fertilizers, the number of employees and the number of animals.

MATERIALS AND METHODS

With the help of the regression analysis method, it is best to implement the research ability of establishing the nature of the joint and separate influence of various factors on the characteristics ENTERPRISES, FERTILIZATION, EMPLOYEES and LIVESTOCK

Using the software product Statistica, the influence of factors on the magnitude of the effects of economic transactions in the sector of land relations of agricultural enterprises was determined.

The application of the system analysis method is a defined methodology, the order of sequential actions that ensure the establishment of structural inter-element or inter-variable relationships in the system of institutionalization of land relations. Based on the tools of the STELLA software product, a system analysis was carried out to forecast promising trends in the performance indicators of the implementation of land relations in enterprises.

The proposed model for forecast estimates of the volume of production of gross products by enterprises is built on the basis of the STELLA software product toolkit. Such factors as: the area of agricultural land used by enterprises for the production of products, the number of business entities (enterprises), the amount of mineral fertilizers applied per 1 ha of agricultural land, the number of workers employed in production and the conditional number of animals. It is a priority to use the data of this model for planning the volume of production in agricultural enterprises, according to the methodology of determining and taking into account the nature of the relationship between the dependent and independent variables.

Forecasting the production of gross agricultural products by enterprises of the Ivano-Frankivsk region was carried out using the special software product STELLA. STELLA modeling software was developed by the American company High Performance Systems (HPS) [21, p. 13]. It is a simulation software that helps organizations create simulations, publish models, design presentations, analyze results based on variables, and more on a single platform. The STELLA program functions on two levels: graphical and mathematical. This software product allows you to use built-in mathematical, logical and statistical operations to create interactive models and simulations [11, p. 3].

The application of the modeling method in the STELLA software proved the practicality, transparency and accessibility of using this

program when building models and creating forecasts. The conducted modeling makes it possible to assess the significance of the use of various computer programs and technologies. With the help of special support, it becomes possible to evaluate the relationships between variables, discard factors that do not affect the performance indicator, form a prognostic equation and determine directions for increasing the effective development of agricultural activity in the Ivano-Frankivsk region.

It should be noted that the use of the polynomial regression method is effective in many cases. After all, the relationship between independent and dependent variables is not always linear. The use of polynomial regression has the advantages of modeling non-linear relationships between variables, as well as the availability of a large number of functions that are useful for the study of economic phenomena and processes, and the freedom to choose data sets and situations. With the help of visualization, it is possible to evaluate the relationships between the variables of the performed analysis.

RESULTS AND DISCUSSIONS

To carry out predictive analysis, it is necessary, first of all, to single out the effective indicator and correctly determine the factors that have the greatest influence on its development. The next requirement will be the collection of real statistical data of selected indicators for past periods and determination of the need for forecasting. The use of informative forecast data enables agricultural enterprises to determine the future trajectory of their activity. The main four elements, with the help of which the forecast is carried out, are shown in the upper left corner (Fig. 1). The rectangle mark represents the stock (Stock), the circle mark (Converter) denotes the factors affecting the stock, the valve with two arrows in different directions denotes the movement of the flow (Flow), which can be both input and output, the arrow (Action Connector) denotes relationships between model elements. When building a predictive model, the above elements (rectangle, arrows, circle, flow) are used in the order necessary to effectively express the performance indicator, factors affecting it, connections, input and output flows.

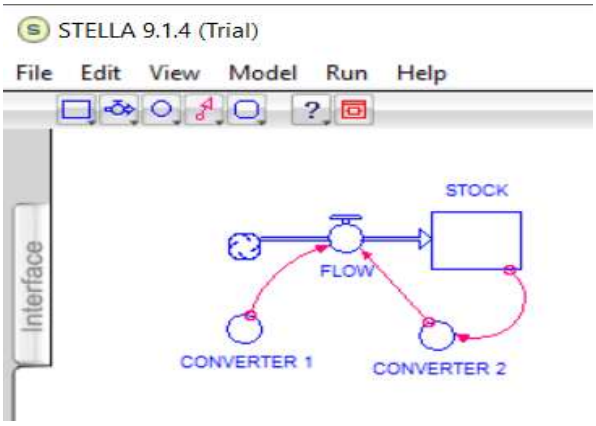

Fig. 1. Sample structure of the model in STELLA
Source: Author's computations.

Fig. 2. Function selection window in the STELLA program
Source: Author's computations.

When using the method of system dynamics in the program and building a forecast for the specified indicators, you can change the format of the model parameters with the help of built-in Bultins functions (Fig. 2).

These include mathematical, tribometric, statistical, logical, financial, time, massive, discrete and special functions. For example, to use the change of data over time, the TIME function is used, to express the MIN and MAX functions in their minimum and maximum values, to generate a system of random numbers with the minimum and maximum values, the RANDOM function is used, to calculate the arithmetic mean, the MEAN function is selected, to determine the natural expression of the LOGN logarithm, the calculation of simple extrapolation trends is

performed by the FORCST function, the HISTORY function and others are used to determine the values of variables in the past using simulation.

The user, building a model with the STELLA software application, creates only the model designer, and the prediction algorithm is formed independently using the DT step. First of all, in order to start working with the STELLA software and build a forecast using it, data from the Ivano-Frankivsk region for the period 1990-2020 were selected.

The selected indicators were first processed using the statistical analysis program Statistica, where special procedures and visualization were performed data. Next, the correlational influence between dependent and random variables was considered, in particular, the influence of random factors on the change in the gross output of agricultural enterprises in the Ivano-Frankivsk region (PRODUCT) has been studied. A regression analysis was conducted, which took into account 6 variables, including the area of agricultural land of enterprises (AREA), the number of agricultural enterprises (ENTERPRISES), the amount of applied mineral fertilizers per 1 ha of land (FERTILIZATION), the number of employees of agricultural enterprises (EMPLOYEERS), conditional livestock animals of enterprises of the Ivano-Frankivsk region (LIVESTOCK) and gross products (PRODUCT). Thus, the initial stage is entering data into the cells of the statistical program (cases) or importing them from other files (Fig. 3).

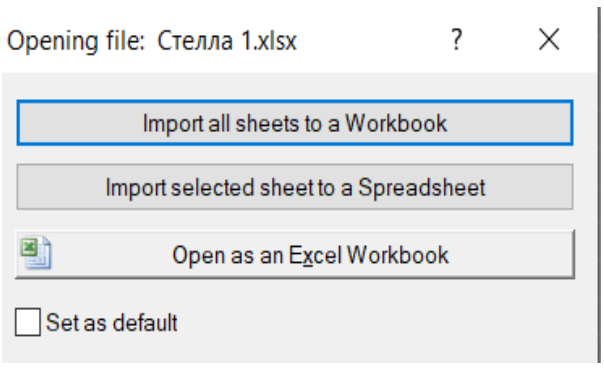

Fig. 3. Scheme of entering data into the cells of the statistical program (cases)
Source: Author's computations.

After completing the formation of the table with informative data, it is necessary to choose the correspondence of the modeled object Advanced Linear / Nonlinear Models, namely General Regression Model (Fig. 4).

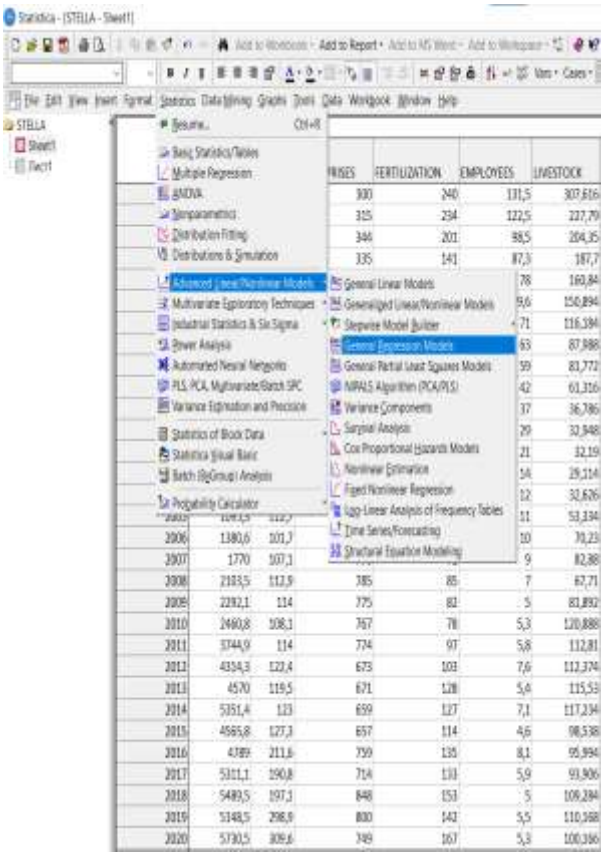

Fig. 4. Selecting an option in the Statistica software menu
Source: Author's computations.

The next step is to choose the type of regression analysis, namely Polynomial regression and variable variables (Fig. 5).

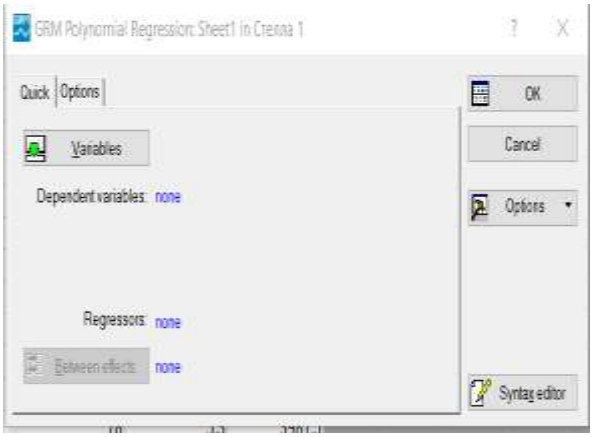

Fig. 5. Statistica software variable selection window
Source: Author's computations.

Polynomial regression contains nonlinear relationships, but it can be formulated as a

statistical estimate of nonlinear parameters [20, p. 505]. This makes it possible to apply the method of multivariate linear regression in order to find coefficients in the presence of non-linear variables.

In place of the dependent variable, the gross output of agricultural enterprises of the Ivano-Frankivsk region (PRODUCT) is indicated. AREA, ENTERPRISES, FERTILIZATION, EMPLOYEES and LIVESTOCK indicators are defined as independent variables (Fig. 6).

Fig. 6. "All effects" option
Source: Author's computations.

The obtained results of polynomial regression are displayed using the "All effects" option (Fig. 6).

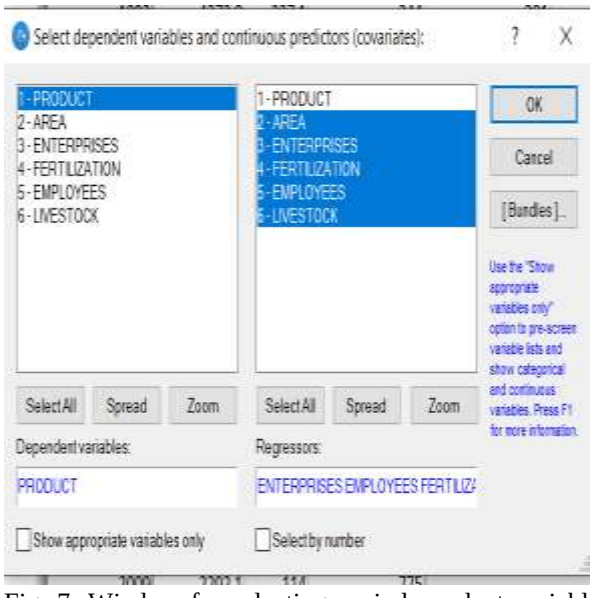

Fig. 7. Window for selecting an independent variable and dependent variables in the Statistica program
Source: Author's computations.

With the application of the function of this tab, as a result, a regression analysis has been performed on the dependent variable PRODUCT (Fig. 7).

As a result: the multiple correlation coefficient (R), ENTERPRISES, FERTILIZATION, EMPLOYEES and LIVESTOCK is characterized by a tight linear relationship between the dependent variable PRODUCT and the independent variable AREA; the dependence of the data in the obtained regression shows the coefficient of determination (R^2), because it is close to 1. Also, with an increase in the number of variable data, the value of the coefficient of determination changes, which does not always mean an improvement in the quality of forecasting. For this purpose, the adjusted coefficient of determination (adjusted R^2) is used in the regression model [12, p. 57].

All 5 isolated factors were tested for statistical significance $p \leq 0.05$. Fisher's F-coefficient is 46.31017, and its degree of significance (p-level) is almost zero in the results of the regression analysis of the dependent variable PRODUCT.

The indicator of multiple correlation between the dependent variable PRODUCT and the five independent variables is statistically significant, and the model itself is adequate and can be meaningfully displayed.

Standardized βeta coefficients can be compared with each other, which will make it possible to rank regressors by the strength of their influence on the regressor [23, p. 354]. That is, the standardized βeta indicator describes the weight of the influence of each independent variable on the dependent variable.

During the regression analysis, the βeta coefficient shows that the variable AREA – the area of agricultural land – has the greatest influence on the increase in the output of gross agricultural products of enterprises. In second place is the variable FERTILIZATION (amount of applied mineral fertilizers per 1 ha of land), in third place – EMPLOYEES (number of employees of agricultural enterprises), in fourth place – ENTERPRISES (number of agricultural enterprises) and in fifth place – LIVESTOCK (conditional livestock

enterprises) (Fig. 8).

Fig. 8. Results of using the Statistica software for regression analysis of the dependent variable PRODUCT*
Source: Author's computations.

In order to evaluate the standardized deviations, the Residuals 1 tab was selected and the "Caseno&res" option was chosen (Fig. 9).
Analysis of the standardized residuals for the dependent variable PRODUCT established a shortage of values higher than ±3 sigma, which demonstrates the absence of significant deviations (Fig. 10).

Fig. 9. Residuals 1 tab with "Caseno & res" option
Source: Author's computations.

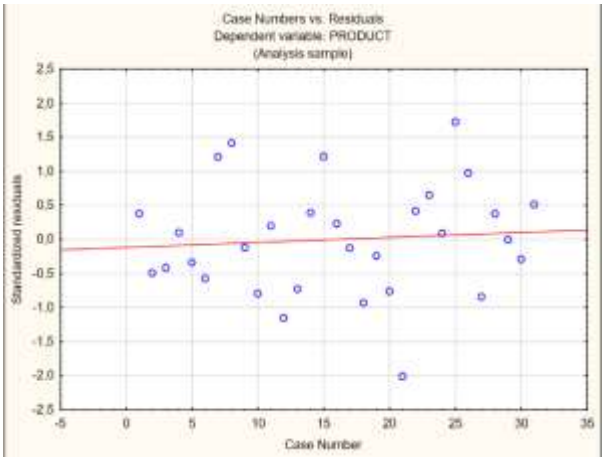

Fig. 10. Display for the dependent variable PRODUCT of standardized deviations
Source: Author's computations.

In the figure, the red regression line reflects the linear relationship between the variables: if the points are located close to this line, it can be assumed that there is a linear relationship between the variables [3, p. 33].
The use of visual methods during the systematic modeling of phenomena and management processes will provide an opportunity to illustrate the processes of agricultural enterprises.
In particular, with the help of the Pareto diagram, cause-and-effect relationships between the dependent and independent variables were established (Fig. 11). This method serves for a visual display (in the form of bar charts) of factors that have an impact on the object of research. The Pareto diagram is a graphic representation of the degree of importance of the influence of factors on the results of economic activity [15, p. 125]. It was established that the selected influencing factors on the change in PRODUCT are appropriate and can ultimately be used to form a regression equation.

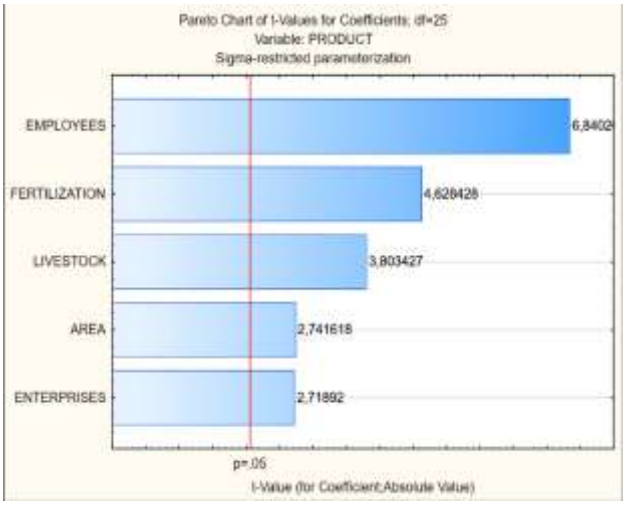

Fig. 11. Cause and effect relationships between dependent and independent variables of the Pareto diagram
Source: Author's computations.

In order to create a prognostic equation of the regression analysis, it is necessary to select the option shown in Fig. 12.
Carrying out a set of actions with the help of the Statistica software product makes it possible to carry out further analysis and research of the selected object. The formed

prognostic equation in the software product looks like this (Fig. 13).

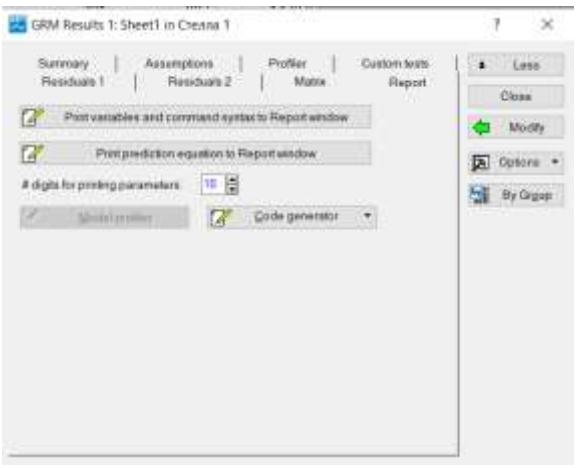

Fig. 12. Predictive equation of regression analysis
Source: Author's computations.

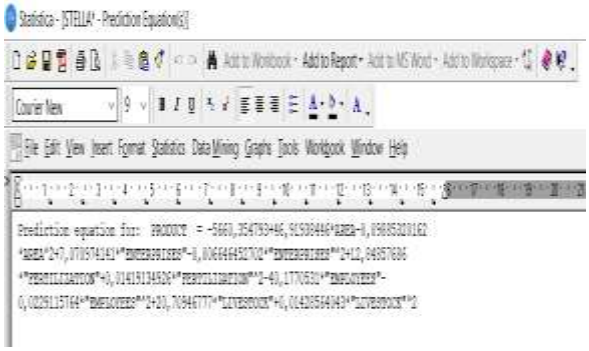

Fig. 13. Predictive regression equation created in Statistica
Source: Author's computations

In order for this equation to be used in further analysis, it must be transformed, namely: replace the comma symbol with a dot and remove the quotation marks next to the name of each variable. After these changes, the following formula was obtained:

Prediction equation for: PRODUCT = -5660.354793+46.91938446*AREA-0.09885320162*AREA^2+7.070974141 *ENTERPRISES-0.006646452702*ENTERPRISES^2+12.84857686 *FERTILIZATION+0.01419134926*FERTILIZATION^2-40.1770531* EMPLOYEES-0.0229115764*EMPLOYEES^2+20.70946777 *LIVESTOCK +0.01428564043*LIVESTOCK^2 (1)

Next, the transformed regression prognostic equation was placed in the value of the flow indicator FLOW PRODUCT (Fig. 14).

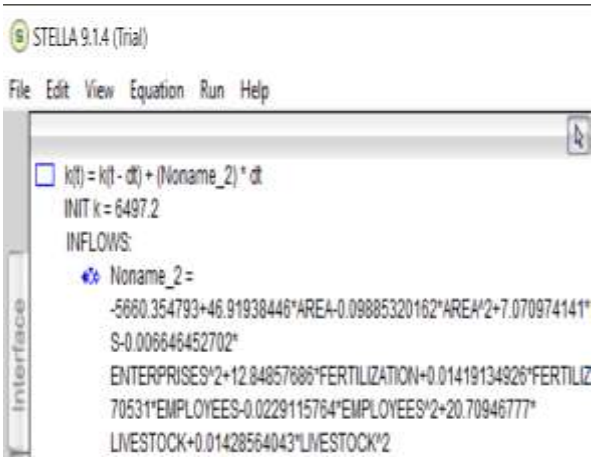

Fig. 14. Fragment of the prognostic equation in STELLA for the variable PRODUCT with the input flow FLOWPRODUCT and under the influence of factors
Source: authors' own calculations from STELLA program.

That is, the further forecast in the STELLA software will be based on the formula that was previously obtained in the Statistica program using the above-described method.

In the STELLA program, the model provides for the creation of a PRODUCT rectangle (Stock), which will display data on the production of agricultural products in million UAH. The specified stock is replenished due to the operation of the FLOWPRODUCT flow and the converter with the reverse arrow of the PRODUCTRATE. According to the formed model, 6 converters influence the PRODUCT stock through the FLOWPRODUCT flow, namely: AREA, ENTERPRISES, FERTILIZATION, EMPLOYEES, LIVESTOCK and PRODUCTRATE. The block diagram of the model can be seen in Fig. 15.

In the STELLA software, relationships between variables are expressed in the form of arrows. The possibility of building component elements of the model and graphic display is a feature of the application of this software. Also, the convenience is that all connections, formed stocks, input and output flows and converters can be changed at any time during the simulation of economic phenomena directly with the help of the user's working mouse cursor. Also, on the right of the figure, the signs of the graph (Graph 1) and table (Table 1) are visually displayed, which allow you to illustrate the obtained forecasting results in the form of graphs and tables.

The model includes information about agricultural enterprises of the Ivano-Frankivsk region in the period 1990-2019. Data from 2020 was used only to verify the veracity of the constructed model. Thus, the model was tested for reliability (forecast results as of 2020 were simulated and compared with real statistical data for this period).

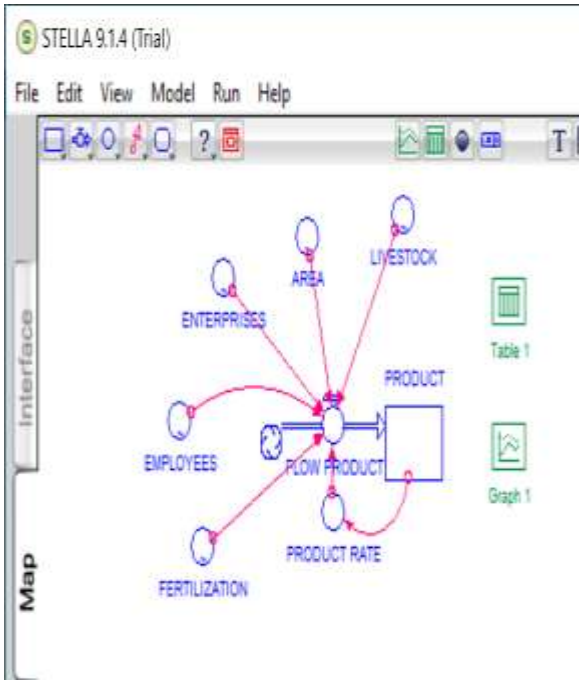

Fig. 15. Block diagram of the model created using the STELLA software product
Source: authors' own calculations from STELLA program.

After verification of the received data, a forecast of probable transformational changes of the selected indicators was made until 2030. In the process of forecasting, the STELLA program used a special TIME function, which makes it possible to simulate data changes over a certain period and determine the simulation step.

In order to simulate at the mathematical level using a system of finite difference formulas, it is necessary to use a certain algorithm and an integration scheme using the Run Specs option (Fig. 16). This tab of the program allows you to create a time step, specify the integration method (Euler or Rungu-Krut), determine the time limits of the forecast and set the initial information. The Euler`s Method option used is one of the methods of system dynamics and is implemented using cause-and-effect relationships diagrams that determine the relationship between the selected variables.

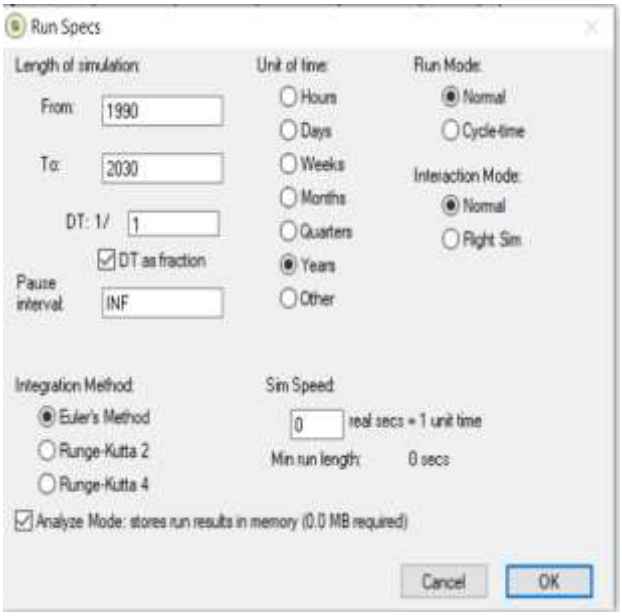

Fig. 16. Fragment of the STELLA program with setting of simulation parameters according to the Euler method
Source: authors' own calculations from STELLA program.

Thus, during the verification of the predictive model, it was found that the results it displays are 90-99 % consistent with real data as of 2020. According to real statistical data, in 2021 the data for the independent variable PRODUCT amounted to UAH 6,231.7 million, for AREA – 309.6 thousand hectares, for FERTILIZATION – 167 kg per 1 ha, for ENTERPRISES – 749 units, for EMPLOYEES – 3.18 thousand persons, for LIVESTOCK – 99.9 thousand heads.

According to the model obtained in STELLA, the value of the dependent variable PRODUCT in 2020 was UAH 7,598.89 million. The values for independent variables were determined as follows: for AREA (area of agricultural land) – 308.13 thousand ha, for FERTILIZATION (amount of applied mineral fertilizers per 1 ha of land) – 166.2 kg per 1 ha of land, for ENTERPRISES (number of agricultural enterprises) – 778.95 units, for EMPLOYEES (the number of employees of agricultural enterprises) – 5.64 thousand persons, for LIVESTOCK (conditional livestock of enterprises) – 97.8 thousand heads. The specified data for the productive indicator PRODUCT are shown in Fig. 17, and the

factors affecting it are shown in Fig. 18, where the results of projected changes as of 2020 are underlined with a vertical line, if necessary, other data can be underlined using additional lines and other parameters.

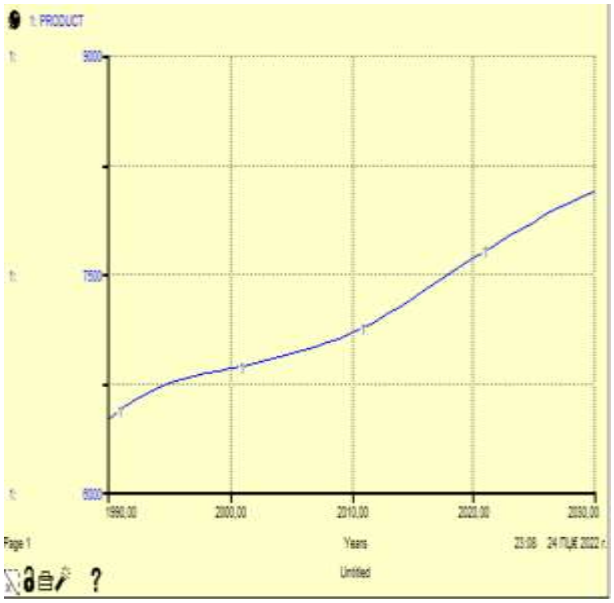

Fig. 17. Visualization of the predicted results for the PRODUCT variable using the STELLA
Source: authors' own calculations from STELLA program.

The use of graphical display of data provides an opportunity to assess the accuracy of the constructed verified model. The lines on the graphs are numbered accordingly, for example, if a single element is plotted on the graph, as shown in Fig. 18, then it is automatically assigned an ordinal value of 1. In the case that several components of the forecast are presented on the graph, they are automatically numbered according to the following format: 1. area of agricultural land (AREA); 2. number of agricultural enterprises (ENTERPRISES); 3. amount of applied mineral fertilizers per 1 ha of land (FERTILIZATION); 4. conditional livestock of agricultural enterprises (LIVESTOCK); 5. number of employees of agricultural enterprises EMPLOYEES. It should be noted that no more than five factors and no less than one can be displayed graphically on one graph at the same time.

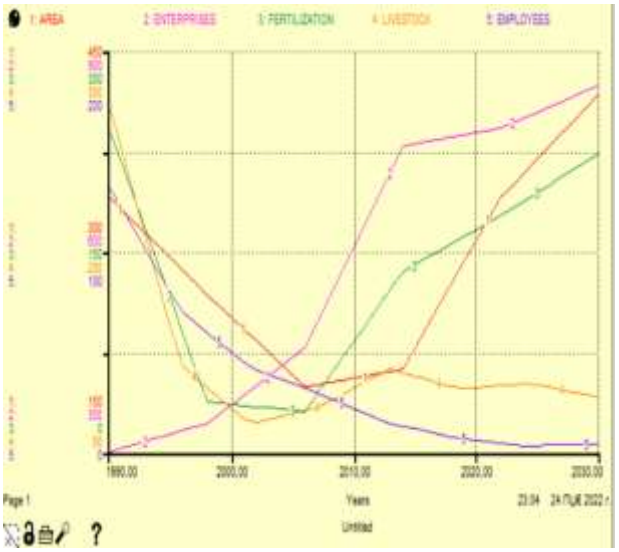

Fig. 18. Visual display of predicted results for the variables AREA, ENTERPRISES, FERTILIZATION, LIVESTOCK, EMPLOYEES using the STELLA*
1. Agricultural land area AREA
2. Number of agricultural enterprises ENTERPRISES
3. Amount of applied mineral fertilizers per 1 ha of FERTILIZATION land
4. Conditional stock of agricultural enterprises LIVESTOCK
5. The number of employees of agricultural enterprises EMPLOYEES
Source: authors' own calculations from STELLA program.

Fig. 18 shows the measurement scale for each evaluated indicator. Thus, the value can vary for the indicators: PRODUCT from 6,000 to 9,000 million UAH, AREA – from 150 to 450 thousand ha, ENTERPRISES – from 0 to 900 enterprises, FERTILIZATION – from 0 to 300 kg of mineral fertilizers per 1 ha of land, LIVESTOCK – from 50 to 350 thousand heads, EMPLOYEES – from 0 to 200 thousand people [16].

Also, the STELLA software allows you to evaluate the forecast results by displaying the obtained results in tabular form.

In Fig. 19 presents the results of the probable growth of the gross output of agricultural enterprises (PRODUCT) taking into account the change in factors over time that affect it, such as: AREA, ENTERPRISES, FERTILIZATION, LIVESTOCK and EMPLOYEES.

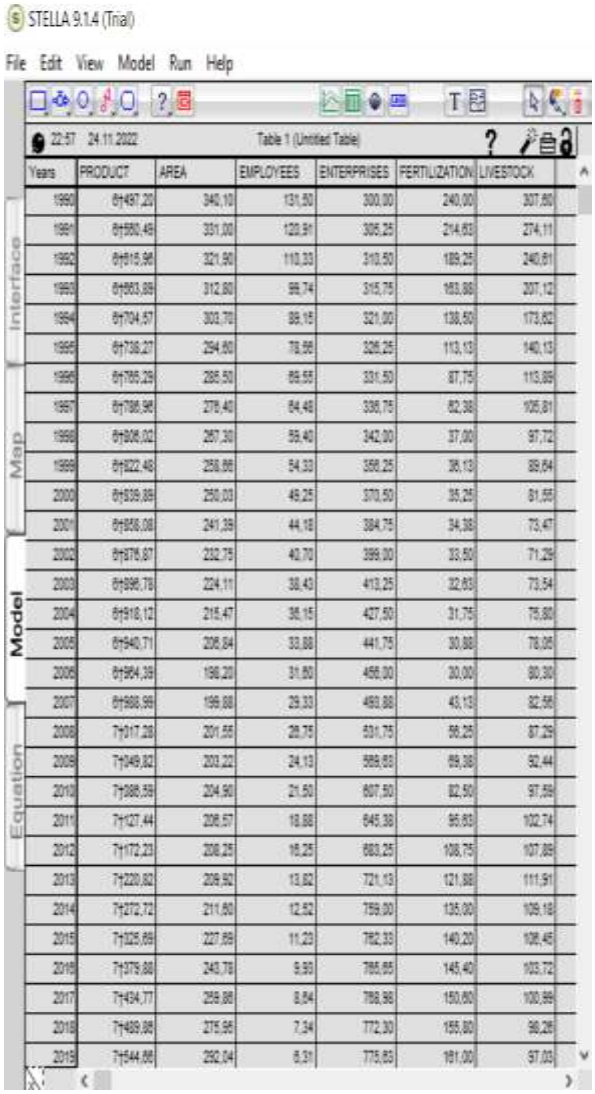

Fig. 19. Visualization in the STELLA program of essential data until 2019
Source: authors' own calculations from STELLA program.

The forecast of the analysis of informative data from 2020 to 2030 is shown in fig. 20. It is obvious that the predicted indicators in the STELLA program indicate an increase in the gross output of agricultural enterprises of the Ivano-Frankivsk region to UAH 8,062.3 million in 2030. Nevertheless, positive changes can be achieved by adjusting the area of AREA agricultural land at the level of 417.2 thousand hectares, the number of agricultural enterprises at the level of 848.7 units, the amount of applied mineral fertilizers per 1 ha of land up to 223.2 kg, the presence of conditional livestock. of agricultural enterprises up to 91,000 heads and the number of enterprise employees in the amount of 3,700 persons.

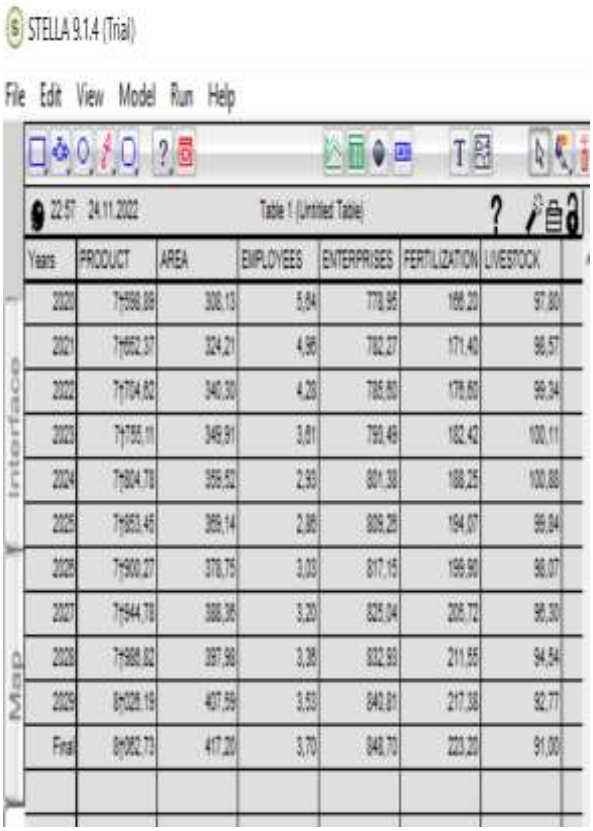

Fig. 20. Results of forecasting 2020-2030 in STELLA software
Source: authors' own calculations from STELLA program.

The volume of production of gross agricultural products of enterprises changes under the influence of such factors as the area of agricultural land, the number of agricultural enterprises, the amount of applied mineral fertilizers per one hectare of land, the conditional number of animals and the number of employees of agricultural enterprises [16]. However, the results of the study confirmed that the main factor affecting the production of agricultural products is the area of agricultural land. Both of these indicators, according to the forecast, tend to increase.

Both variables tend to increase according to the obtained forecast. In order to achieve the predicted values of the model in 2030, the activities of agricultural producers should be oriented towards the following:

– preservation of fertility and other characteristics of soils;
– compliance with norms and technologies of soil fertilization;
– effective use of material, technical, financial and other types of resources [1];

– increasing the labor productivity of agricultural workers;
– the use of means and results of information support in economic activity and the development of the Ukrainian economy [13], cross-border relations [6];
– carrying out a scientific analysis of the sales market;
– involvement of modern technologies and methods of production [19].
The built model in the STELLA software shows a forecast of indicators for the future, which affect the output of gross products by enterprises. The obtained results of forecasting the effective indicator and the factors affecting it can be applied in practice during the development of future production plans by agricultural enterprises of the Ivano-Frankivsk region.

CONCLUSIONS

When carrying out a forecast of the production of gross agricultural products, enterprises need to build models of the main performance indicators with the help of special programs. Accordingly, the possible trend of their development is determined, which in turn should be geared to the informational data of the forecast.
In the course of the research, it has been established that the forecasting of the production of gross agricultural products of enterprises in the Ivano-Frankivsk region was carried out using the specialized software STELLA and the statistical package Statistica. During the analysis, the dependent variable was determined – the gross output of agricultural enterprises of the Ivano-Frankivsk region (PRODUCT) and independent variables: the area of agricultural land of enterprises (AREA), the number of agricultural enterprises (ENTERPRISES), the amount of applied mineral fertilizers per 1 hectare of land (FERTILIZATION), the number of employees of agricultural enterprises (EMPLOYEES), conditional livestock of enterprises of Ivano-Frankivsk region (LIVESTOCK).
The predictive values of the model suggest that by 2030, it will be advisable for agricultural enterprises to build trajectories of their activities geared in the direction of achieving effects related to: the improvement of soil fertility, technological parameters of land fertilization, rational and economically efficient use of material as well as technical, financial, human and other types of resources. They also should focus on increasing the labor productivity of agricultural workers, the use of means and results of information support in economic activity, the implementation of scientific analysis of the sales market, involvement of modern technologies and methods of production.
During the forecasting of the volumes of gross agricultural products, it was found that one of the main influencing factors is the agricultural land of enterprises. The prognostic model created with the help of the STELLA program proved that the volume of gross output by agricultural enterprises of the Ivano-Frankivsk region in 2030 will increase to UAH 8,062.3 million when the amount of AREA agricultural land is adjusted to 417.2 thousand hectares, the number of agricultural enterprises by 848.7 units, the amount of applied mineral fertilizers per 1 ha of land up to 223.2 kg, the availability of conditional livestock of agricultural enterprises up to 91 thousand head and the presence of enterprise employees in the amount of 3.7 thousand persons.

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