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FORECASTING OF GROSS AGRICULTURAL OUTPUT OF AGRARIAN ENTERPRISES OF UKRAINE: CASE STUDY WITH STELLA SOFTWARE

The article is devoted to the forecasting of gross agricultural output of agrarian enterprises of Ukraine with an application of STELLA program. The STELLA economic modelling program, which combines mathematical differential equations with a developed graphical interface, has been used in the article. In this program a model was created and an attempt was made to forecast the gross agricultural output of agrarian enterprises of Ukraine by 2030. It has been the possible growth up to UAH 147319 mln UA of output of agricultural enterprises (PRODUCTION) with a slight reduction and further stabilization of the agricultural land (AREA) at the level of 22600 thousand hectares, a constant increase in fertilizers to 135 kg per hectare (FERTILIZATION) and a steady growth of enterprises up to 60900 (ENTERP). The most promising possibilities for applying STELLA program in economic forecasting have been outlined in the article.
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Introduction

As a result of the agrarian reform in Ukraine (1990-2010), based on collective agricultural enterprises, new economic entities, based on private ownership of property and collective forms of management, have been created. Functioning in the market conditions, characterized by a competitive environment, newly created enterprises can provide profitable activities at the expense of production in accordance with the needs of consumers. Enterprises need to ensure the production of goods, that are necessary for the target market segments. The globalization of processes and the entry of Ukraine into the WTO (the world trade organization) requires enterprises to produce goods that meet international standards.

However, in less than a quarter of a century, in most of the newly created enterprises, except large (high-value) enterprises, the necessary material and technical base for agricultural production is not yet fully formed, there are problems with obtaining land for use, due to lack of funds, there is not enough opportunity to apply progressive technology, lack of many years experience in managing enterprises in a competitive environment, not all marketing tools are used.

As a result, agricultural enterprises of Ukraine in the last years of 2012-2016 were able to provide only half of the gross output in comparison with 1990 (the base period for the beginning of agrarian transformations). Therefore, the task of increasing the gross agricultural output of agrarian enterprises of Ukraine, which concerns the agrarian sector of the economy, is extremely important. In this situation, forecasting of gross agricultural output of agrarian enterprises is relevant, and the results of the forecast can be used for further planning of agricultural activity.

The literature review

Problems of the gross agricultural output of agrarian enterprises are devoted to the scientific work of many economists (Hohulia, 2014, Andriychuk, 2002, Danylko & Kobylynska, 2014). Also, the methodological bases of calculation of production in Ukraine of gross agricultural output are being analyzed (Andriychuk, 2013, Luginin, 2007).

Gross output is considered as the final result of production activity in cash terms per year (Andriychuk, 2013, pp. 180). Gross agricultural output is expressed in comparable prices in a given year, has a material and value basis, and is represented by crop and livestock products manufactured during the year (Andriychuk, 2002). This is a statistical indicator in money, which characterizes the total amount of agricultural production per year (Great Dictionary of the Ukrainian Language, 2007), as well as the volume of agricultural and livestock products manufactured for a certain period and expressed in cost form (Economic Encyclopedia, 2000).

The gross output shows the total value of all kinds of production received by the company during a certain period (Gorbonos et al., 2010). It describes the total volume of production produced in agriculture, is part of the gross social product (Dusanovsky et al., 1997) and

acts as the initial result of the interaction of factors of production, which is represented by all products manufactured during the year by crop and livestock production.

Calculation of gross agricultural output is carried out at the expense of cost estimation of each particular type of agricultural product, regardless of place and conditions of production, and at the same price (Danylko & Kobylynska, 2014).

The peculiarity of agricultural production is the land – on which production is carried out and which is included in the production process as one of its conditions, and therefore it is the basis for the combination of all production resources (Matsybora, 2014). The achievement of the economic efficiency of land use characterizes the production of gross output per hectare of land (Dusanovsky, et al., 1997).

Forecasting gross agricultural production of agrarian enterprises in Ukraine, realized with the system dynamics modelling environment, STELLA (isee Systems, 2015) created by the American firm HPS (High-Performance Systems). The STELLA program allows the processing of original models of economic systems and their research (Kwaśniecki, 1998; Aschepkova, 2002). We chose STELLA because of its low cost, intuitive and user-friendly (no programming is required) interface, and widely recognized modelling iconography (Costanza & Gottlieb, 1998; Costanza & Voinov, 2001; Costanza et al., 1998; Richmond, 2001, Walters et al., 2016).

Forecasting is an important tool for agricultural policy, which offers possible alternatives for the development of agricultural enterprises taking into account the market impact and other factors while ensuring the accuracy of forecasts (Zabolotnia & Kurova, 2013). (c. 62,66).

On the basis of the forecasting of gross agricultural production of agrarian enterprises is a scenario which accumulates information on the forms and types of activity of agricultural enterprises, their financial results not only in the past, but also those that have to occur in the future (Panasiuk, 1998).

The purpose of the forecast is to investigate what agricultural holdings need to take in land use and how it will affect the future use of land resources (Tretiak, 2009).

Models of economic growth created by Ya. Tynberhen (1980) can be used in the construction of agricultural enterprise development models.

The forecast is a necessary tool for improving the efficiency of enterprises, which is especially important in the period of modern economic transformations that are taking place in Ukraine (Luchyk V., Koroliuk, 2017). This confirms the importance of forecasting as a component of planning, in developing prognostic changes in the gross agricultural output of agrarian enterprises of Ukraine.

The aim of the article was to present the results of forecasting the gross agricultural output of agrarian enterprises of Ukraine up to 2030 using STELLA software.

To achieve this goal, firstly, one needs an assessment of the state of study of the experience of effective operation of agricultural enterprises in market conditions for the period from 1990 to 2017. Secondly, ensuring the preservation of soil fertility by making the optimal

amount of fertilizers. Thirdly, to support the scientific and technical potential of the agrarian sector. And Fourthly, we have taken into account that volumes of production of gross output are formed according to demand and supply, adherence to agricultural requirements and market conditions. The above-mentioned shows that today the question of forecasting gross agricultural output of agrarian enterprises with the use of mathematical apparatus appears.

Research Methodology

The collected materials have been processed in the statistical program Statistica 13.1. In particular, the relationship between the indicators (variables) that have the strongest influence on the formation of gross agricultural output of agrarian enterprises (PRODUCTION) has been investigated. A multivariate analysis has initially been conducted between 8 indicators such as: area of agricultural lands (AREA), fertilization per 1 ha (FERTILIZATION), number of enterprises (ENTERPISE), gross agricultural output of agrarian enterprises (PRODUCTION), net income (INCOME), labor productivity per 1 employee (LABOR PRODUCTIVITY PER EMPLOYEE), perfitability level (PERFITABILITY), number of employees (NUMBER OF EMPLOYEES).

Only 4 indicators in the STELLA program have been selected for simulation, with a p value ≤ 0.05 (that is, only those rated as statistically reliable). These are such indicators as: area of agricultural lands (AREA), fertilization per 1 ha (FERTILIZATION), number of enterprises (ENTERP), the gross agricultural output of agricultural enterprises (PRODUCTION).

After statistical processing of the collected data, a mathematical equation has been obtained that characterizes the connections which appear between the selected indicators. Here we only remark that the collected data has been analyzed for the dependent indicators in order to exclude cases that could violate the established regression equation. In the final result, after eliminating non-significant samples, the regression equation is determined. All indicators have been checked for the probability test $p \leq 0.05$ in order to exclude those that showed a lack of statistical accuracy.

The resulting equation was introduced to the model created in the STELLA (Structural Thinking, Experiential learning Laboratory with Animation) program. The model is innovative for Ukraine and is based on the theory of system dynamics (Bertalanffy, 1976, Forester, 1978). The STELLA program successfully combines mathematical differential equations with a well-developed graphical interface (Kwaśniecki, 1998; Aschepkova, 2002; Kozak & Parpan 2009).

To create a model in the STELLA program, we applied the Stock element (*Stock*), to which the initial value of the gross agricultural output of agrarian enterprises (PRODUCTION) has been inserted since 1990. The second key element used in the model was the Flow element (*Flow*). The formula that was previously calculated in the Statistica 13.1 program was inserting in this element. Both elements were connected using such elements Arrows (Action *Connector*).

There converter elements (*Converter*) were created in the Model: area of agricultural land (AREA), Fertilizer per 1 ha (FERTILIZATION) and number of Enterprise (ENTERP). The Time function was used (using the Builtins configuration window).The graphical function (*Graphical Function*) was used. The graphical element of the STELLA program such as (*Graph Pad*) and tabular element (*Tabel Pad*), which show the results of the forecast were used in the model.

The data from 1990 have been introduced to the model. Data from 2016 were used only for verification of the created model. That is, the model was verified (results of the forecast for 2016 were compared with real data from 2016). A forecast of possible changes in the studied indicators by 2030 has been conducted after verification of the model.

The statistic data on volumes of the gross agricultural output of agrarian enterprises for the under-investigated period are given in constant prices in 2010.

Results of Analysis

Statistically significant results with $p \leq 0.05$ have been obtained for all 4 analyzed parameters. We see almost zero values of p in the results of regression analysis for the dependent variable PRODUCTION (Table 1).

Table 1

Results of regression analysis for PRODUCTION

	Test SS dla pełnego modelu względem SS dla reszt (3)										
Zależna Zm.	Wielokr. R	Wielokr. R2	Skorygow R2	SS Model	df Model	MS Model	SS Reszta	df Reszta	MS Reszta	F	p
PRODUCTION	0,985751	0,971704	0,963216	2,868860E+10	6	4,781433E+09	835398531	20	41769927	114,4707	0,000000

Source: Authors.

Based on *Beta*, it is estimated that the most significant contribution to the development of agricultural products (PRODUCTION) is such variables as the number of enterprises (ENTERP), and also the variable as the area of agricultural land (AREA) (Table 2).

The analysis of the standardized endpoints for the dependent variable showed a lack of values of greater than ± 3 sigma (Picture 1), indicating a lack of significant data deviations.

Created in Statistica 13.1. the formula has the following form:

*Productivity = 587404.312987-10.9398081604 *AREA+0.000203891387468 *AREA^2+278.500706483 *FERTILIZATION-1.52987453931*FERTILIZATION^2-29.8471051593*ENTERP+0.000409659858454*ENTERP^2*

This formula was inserted into the *Inflows Production* element (Picture 2) in the model. The figure shows the block diagram of the model. Links between variables are designed as graphic functions in the STELLA program. The convenience of this method is that the appearance of the function can be changed directly on the computer screen with the mouse cursor. We see the production rectangle created in the model as stock *(Stock)* for agricultural products (UAH mln.). This stock is replenished with Inflows Production with a

feedback arrow. The *Flow* is influenced by 3 *Convectors* (Fertilization, Area, Enterprises). On the right, there is a graph element (*Graph Pad*) and a table element (*Tabel Pad*).

Table 2

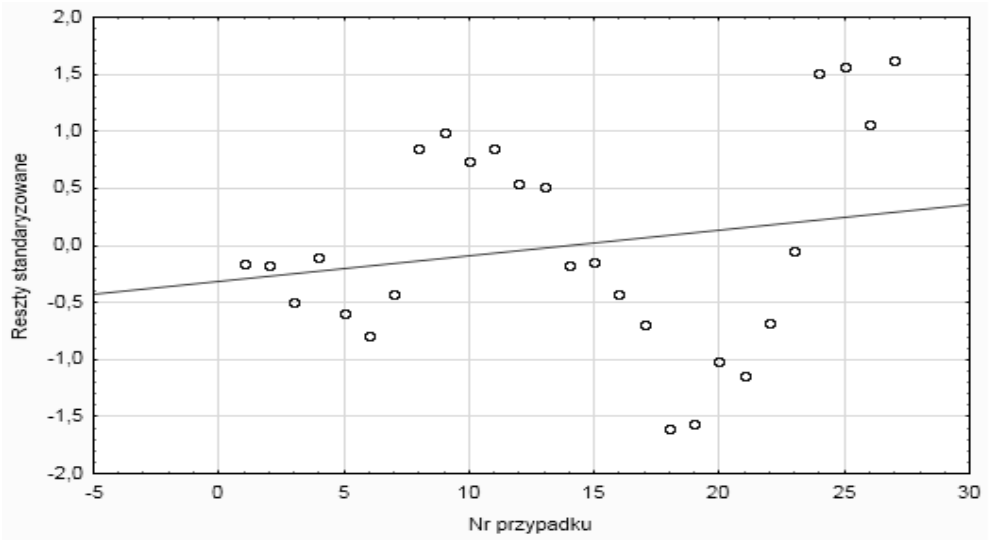
Essential results for AREA, FERTILIZATION, ENTERP

	Oceny parametrów (3) Parametryzacja z sigma-ograniczeniami									
Efekt	PRODUCTION Param.	PRODUCTION Bł. std.	PRODUCTION t	PRODUCTION p	-95,00% Gr.ufn.	+95,00% Gr.ufn.	PRODUCTION Beta (ß)	PRODUCTION Bł.Std.ß	-95,00% Gr.ufn.	+95,00% Gr.ufn.
Wyraz wolny	-1845626	351517,6	-5,25045	0,000039	-2578879	-1112373				
AREA	-38	8,9	-4,23619	0,000405	-56	-19	-8,1242	1,917816	-12,1247	-4,1237
AREA^2	0	0,0	5,37677	0,000029	0	0	12,0204	2,235613	7,3570	16,6838
FERTILIZATION	632	214,2	2,95307	0,007863	186	1079	0,6811	0,230651	0,2000	1,1623
FERTILIZATION^2	3	1,2	2,19313	0,040288	0	5	0,4610	0,210204	0,0225	0,8995
ENTERP	330	50,2	6,58462	0,000002	226	435	22,6490	3,439683	15,4739	29,8240
ENTERP^2	-0	0,0	-6,97419	0,000001	-0	-0	-27,8599	3,994712	-36,1927	-19,5270

Source: Authors.

Picture 1

Results of regression analysis, variable dependent Production

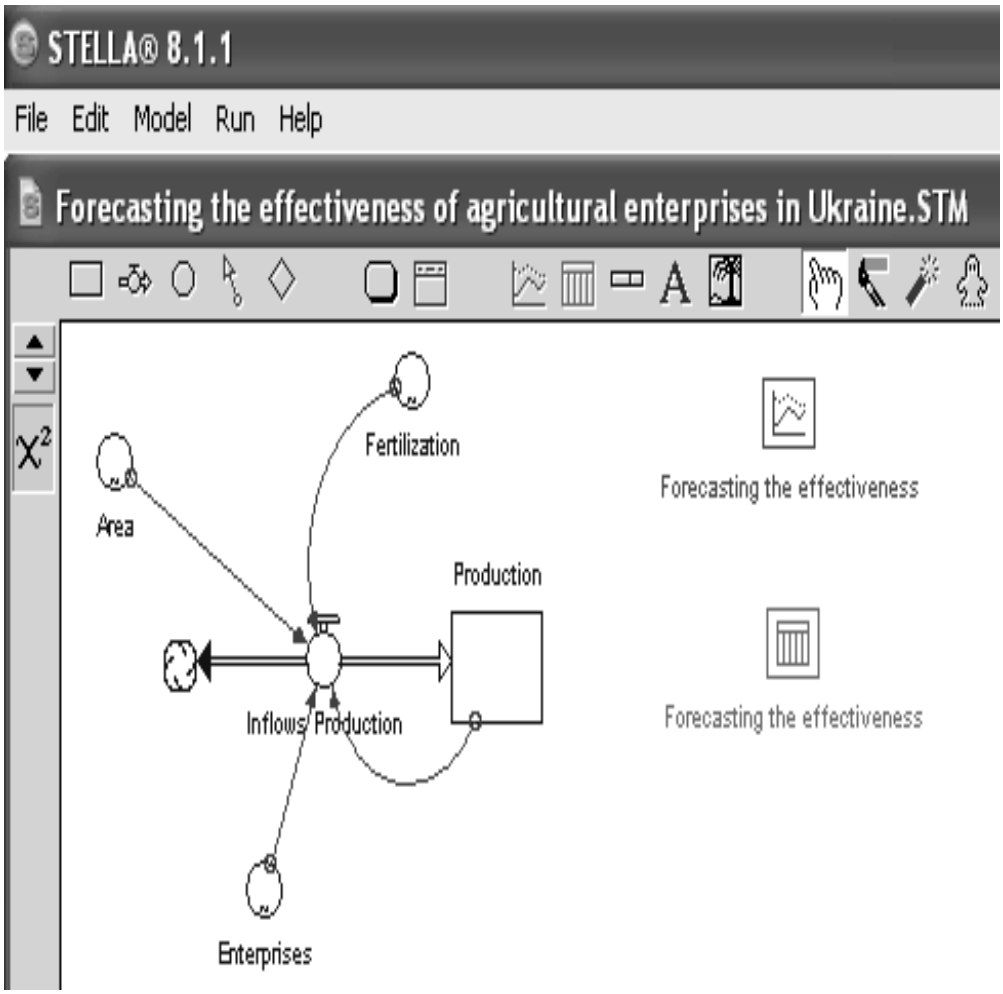


Source: Authors.

The model's verification consisted of a comparison of real data from 2016 (as data from 2017 were absent) with data forecasted in the model for 2016. We see that the model for 95-100% hit the real data in 2016. So in 2016, real data for the variable Production was UAH 145,119 million, for Fertilization 96 kg per 1 hectare, for Area 20,746 thousand hectares. Accordingly, the model showed in 2016 – for the Production variable 143475,77 million UAH, for Fertilization 95,5 kg of fertilizers per 1 hectare, for the variable Area 22100 thousand hectares.

Picture 2

The interface of the created model in STELLA program

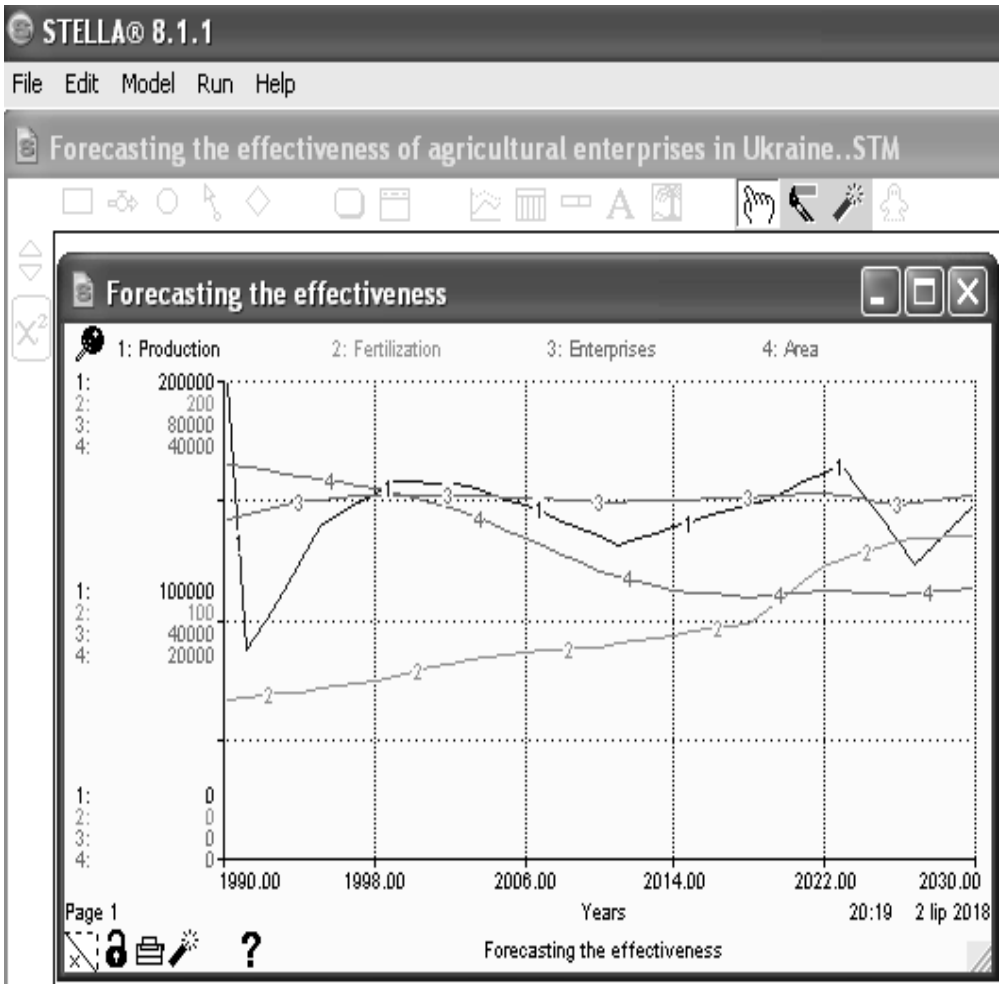


Source: Authors.

The results of the forecast (Figure 3) showed the possible increase in the gross agricultural output of agrarian enterprises (Production) with an increase in the amount of fertilizers applied per ha (Fertilization). At the same time, the increase predicted and stabilization of the number of enterprises (Enterprises) and the agricultural land area (Area) especially at the end of the forecast (in the figure, each variable has its own number which is highlighted in the left part of the picture and on the lines).

Picture 3

Graphical representation of forecasting results in STELLA program



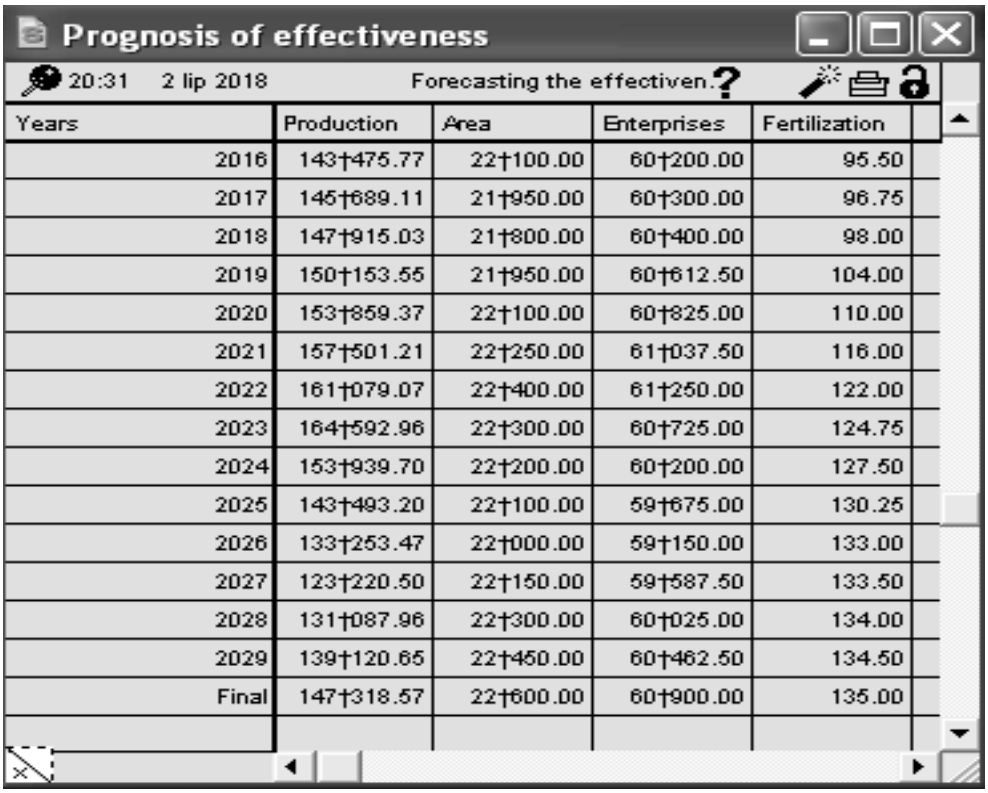
Source: Authors.

The specific values of the predicted analyzed variables by 2030 can also be seen (Table 3) in the table (the special character separates the millions and thousands of values).

As we see (Figure 3, Table 3), the model predicts that at stabilization of the number of agricultural enterprises (Enterprises) at the level of 60900 and Area (Area) lands at the level of 22600 thousand hectares, as well as with the increase in the amount of fertilizer per ha (Fertilization) to 135 kg of fertilizers per 1 hectare in Ukraine there can be positive changes in the gross agricultural output of agrarian enterprises (agricultural products can reach the level of 147318 million UAN).

Table 3

Table view of forecasting results in STELLA program



Years	Production	Area	Enterprises	Fertilization
2016	143†475.77	22†100.00	60†200.00	95.50
2017	145†689.11	21†950.00	60†300.00	96.75
2018	147†915.03	21†800.00	60†400.00	98.00
2019	150†153.55	21†950.00	60†612.50	104.00
2020	153†859.37	22†100.00	60†825.00	110.00
2021	157†501.21	22†250.00	61†037.50	116.00
2022	161†079.07	22†400.00	61†250.00	122.00
2023	164†592.96	22†300.00	60†725.00	124.75
2024	153†939.70	22†200.00	60†200.00	127.50
2025	143†493.20	22†100.00	59†675.00	130.25
2026	133†253.47	22†000.00	59†150.00	133.00
2027	123†220.50	22†150.00	59†587.50	133.50
2028	131†087.96	22†300.00	60†025.00	134.00
2029	139†120.65	22†450.00	60†462.50	134.50
Final	147†318.57	22†600.00	60†900.00	135.00

Source: Authors.

Discussion

The results of the study showed that after 2018, the forecasting increase in gross agricultural production may increase to 164593 mln. UAH. in 2023, showing growth compared to the size in 2016. The forecast, taking into account agricultural products, fertilization per 1 hectare of the area of agricultural crops, the number of enterprises and the area of agricultural land, showed perspective changes that may occur in the agricultural sector of Ukraine. Growth in gross agricultural production may indicate an increase in crop yields and an increase in livestock production (Danylko, & Kobylynska, 2014).

As we can see from the forecasting in the STELLA program from 2024 to 2027, a slight decrease in gross agricultural output can also be expected, with subsequent growth until 2030. That is, the model predicts fluctuations in the gross agricultural output of the agrarian enterprises of Ukraine.

The predicted data obtained by us using the STELLA program is confirmed by other authors' studies. In particular, Matviishin and his co-authors (Matviishin, et al., 2015) investigated trends of changes in gross production in Ukraine using the Trend Line tool. They described the equation by which one can calculate the forecast values of output and prove that its growth rate will remain at the level of average rates for previous years.

Predicted change tendencies of the analyzed indicators shown in the model are confirmed in the literature. For example, the effect of using fertilizers is increasing yields (Pidgorny, 2014). Although it should be remembered that only one effect can not be judged on the advantageous use of fertilizers. And to determine the efficiency of production it is necessary to compare the achieved effect with the costs that ensured its receipt.

The forecast of our model, the increase and stabilization of the number of agricultural enterprises at the level of 60900 may increase their share in the total production of agricultural products (Dobrunik, 2015). The optimal structure of the economy is the main factor that influences the efficiency of the production activities of agricultural enterprises. The essence of this is the rational use of natural resources, increasing the introduction of organic fertilizers, which is necessary in the production of high-quality, environmentally-friendly output (Kolos, 2013). The essence of both products and profit are the results of the enterprise (Osypov, 2016). Therefore, it is worth looking for ways to increase their number.

The literature suggests that reducing the number of agricultural enterprises may be due to the fact that most executives and specialists will be unprepared for the conditions that market economics would dictate to them (Markovych, 2011). As we see, our model predicts a slight decrease in the number of enterprises in 2023-2026. According to S. Demyanenko (1994), "... any enterprise should be based on a certain regularity in relation to its resource base", which is a stabilizing factor in increasing the number of enterprises.

The objective and subjective reasons that led to the quantitative decline of enterprises since the early 1990's include rising costs, instability of financial and credit policy and migration processes in Ukraine.

The reduction in the number of agricultural enterprises is due to the cessation of part of the farms due to difficult financial and material circumstances, the expiration of the term of lease of land and the seizure of its owners for the organization of individual farms without the creation of a legal entity, the transition to another category of farms (Shelenko, 2007). The value of gross output can be reduced due to changes in the total number of Ukrainian agricultural enterprises and land use volumes (Muzichenko, 2013). The provision of productive resources also affects the size of enterprises (Tsitska, 2012). The tendency to increase the share of agricultural enterprises in gross output is achieved by increasing the number of agro-holdings (Bogdanovych, 2016).

In Ukraine, there is no mechanism that reduces the riskiness of agricultural production due to competition from agro-holdings. This induces agricultural producers to sell products at reduced prices through intermediary structures, which in the future leads to a reduction in profits in agricultural enterprises (Kolos, 2013).

From the data obtained, we see a decrease in the area of agricultural land up to 2018. The decrease in the area of agricultural land in agrarian enterprises is affected by the fact that:

part of the village residents for various reasons did not renew the lease contracts or did not demand proper shares; others are private enterprises without the creation of a legal entity (Shelenko, 2007). Land in agriculture serves as the main means of production and the productivity of agricultural production depends on the location, the size of area and topography of agricultural land (Galushko & Berehovyi, 2011, pp. 21-22, 55).

After 2018, the model predicts a reduction in the area of agricultural land and even a slight increase in agricultural land. It is important. Increasing the amount of land resources in agrarian enterprises will ensure production growth of gross agricultural output (Yakubiv, 2014). After all, the size of land use is influenced by the gross agricultural output of the agrarian enterprises of Ukraine. The increase in cultivated land contributes to adherence agrotechnical requirements, scientifically based crop rotation, and the use of intensive technologies (Makarenko, & Melnyk, 2011).

With a pessimistic forecast, the low-level use of land resources of agricultural enterprises will lead to an increase in the cost of agricultural products (Hnydiuk, 2011)

Increase in the gross agricultural output of agrarian enterprises of Ukraine is a conscious and purposeful activity of workers on the use of natural, social and other resources concentrated in the enterprises. Accordingly, enterprises must deliberately and purposefully implement measures to ensure the achievement of a high level of economic efficiency.

Agrarian policy in Ukraine is realized through the economic and social development of each enterprise, in particular, due to the level of gross agricultural output. Here the regularity of counter-development is being shown, the state encourages the development of agricultural enterprises on the vertical where, at the end the effectiveness of agrarian policy, in general, is determined. Agrarian development of the state can be ensured directly only through the priority (primary) provision of interests of agricultural producers.

The volume of production of gross agricultural output in Ukraine with the use of the forecast model STELLA by 2030 compared with 2018 will be reduced by only 1%. It would be desirable that the further reduction of the production of gross output was realized at the state level, and by managers at both higher and lower levels, which could become the main negative factor for further reforms that will take place in agriculture of Ukraine.

The area of agricultural land, for the aforementioned period up to 2030, will be characterized by an increase of 1%. Lack of land from 1990 to 2005, in the absence of funds for the purchase of fertilizers, was an economic barrier to the effective development of agricultural enterprises. However, a general tendency to increase gross output was observed in Ukraine in the long run.

The applying of all types of fertilizers by 2030 will also tend to increase by 37.8%, which will have a positive effect on the growth of crop yields

As far as the number of agricultural enterprises is concerned, they will grow only by 1.0%, which will have low social and economic value, and it will be that by 2030 they must be organized on the basis of private ownership of land and property; to ensure the use of a single production complex; to bear complete economic and legal responsibility for the consequences of its activities.

So we can say that the current mechanism of management in agriculture in Ukraine will remain ineffective. The need for a radical change in the management system of agricultural enterprises and the provision of an economic mechanism for the development of the agrarian sector at the state level is being determined.

The main changes in the mechanism of operation of agricultural enterprises will underline in preserving the resource potential and consolidating the labour force in the countryside, creating an economic and legal environment for effective functioning in market conditions with a binding link to specific conditions of management.

The STELLA results obtained from the forecast, as well as the results of the research carried out, will contribute to the deepening of the methodological experience in the field of simulation with the use of dynamics of systems. Using STELLA's standard elements (Stock, Flow, Converter, Action Connector) allows very quickly to build your own economic model As STELLA models are inherently quantitative, it was necessary to define each of the model parameters, and normalized graphical functions. Graphical functions are useful tools within STELLA to invoke nonlinear relationships or trends between two variables (Walters et all, 2016).

Actually, our article is devoted to using STELLA as a special program of economic modeling in which we wanted to show the most promising possibilities of its application in the economy. It is worth noting that this type of model, based on the dynamics of systems and the program STELLA actively used in the United States and in European countries.

An example of the created economic model, executed with the help of the program STELLA has been considered in the article, has shown it as a quite accessible, transparent and visual. The effect of obtaining graphic results is important for the development of economic research methods with the use of modern computer programs.

Forecasting changes of the gross agricultural output of agrarian enterprises of Ukraine have been presented in the article and processed using STELLA program, which can be the basis for planning production of agricultural output.

Forecasting the production of gross agricultural output provides companies with the opportunity to focus on: improving the farming system, ensuring the growth of crop yields and animal productivity, and the rational use of resources.

Conclusions

Our research shows trends in the production of gross output, the change in the number and area of agricultural enterprises and the amount of fertilizer for the future. As the results of our research for agrarian enterprises showed, the main effective indicator of economic activity is the production of gross agricultural output. The forecasting production in the model shows cyclical changes (an increase to 2023, a further decrease to 2027 and a subsequent increase to 2030).

The total volumes of gross production in agricultural enterprises are mainly influenced by factors such as the number of enterprises, the area of agricultural land, fertilization per hectare of land area.

When forecasting the gross agricultural output of agrarian enterprises of Ukraine, an original model in the STELLA program was created, which determined the impact of the number of agricultural enterprises, the area of land and fertilizers applied on the production of gross agricultural output.

Created in STELLA program and presented in the article, the model predicts that in Ukraine, by 2030, in case of stabilization of the number of agrarian enterprises, the area of land, and with the increase of fertilizers per one hectare, it is possible to increase the production of gross agricultural output. In general, it can provide such an important for Ukraine expansion of production, increase of resource base of enterprises and development of social sphere of rural territories.

It has been proved that with the help of the developed model of forecasting of production of gross output and using calculations, agricultural enterprises will have an opportunity to predict the directions of their activities in the future.

New agricultural enterprises, created in Ukraine in the process of modern agrarian reforms, operate in market conditions. The effectiveness of their activities in a competitive environment depends on the resource provision of production in accordance with the needs of the target market segments.

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