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INFORMATION SUPPORT OF VALUE-BASED MANAGEMENT OF OIL AND GAS ENTERPRISES

Introduction. *In the context of the current energy transition challenges, the management system of oil and gas enterprises requires effective information support. Predictive modeling is a key tool for developing value-based strategies aimed at the effective development of oil and gas enterprises in the new energy realities.*

Problem Statement. *Insufficient information support limits the potential for effective value-based management of oil and gas companies. The use of predictive modeling helps to predict changes in production output to improve strategic planning and to make decisions with proper awareness.*

Purpose. *To find out the possibilities of using predictive modeling as a tool to provide an information base for value-based management of oil and gas enterprises.*

Materials and Methods. *The study has been based on materials of the State Statistics Service of Ukraine. The methods include analysis, synthesis, analogy, modeling, abstraction, and specification. The software products Statistics 12 and STELLA have been employed for data processing.*

Results. *It has been established that the use of predictive modeling tools makes it possible to improve information support of value-based management at oil and gas enterprises. The regression analysis has shown that the number of employees, the number of operating business entities, and the personnel costs have the greatest influence on the growth of sales of oil and gas enterprises.*

Conclusions. *Thus, the study has shown the importance of predictive modeling to improve the efficiency of value-based management of oil and gas enterprises, to formulate effective strategies for their development in the context of the energy transition, to provide information support, and to increase their ability to adapt and innovate in a dynamic external environment.*

Keywords: information support, value-based management, oil and gas enterprises, forecasting, modeling.

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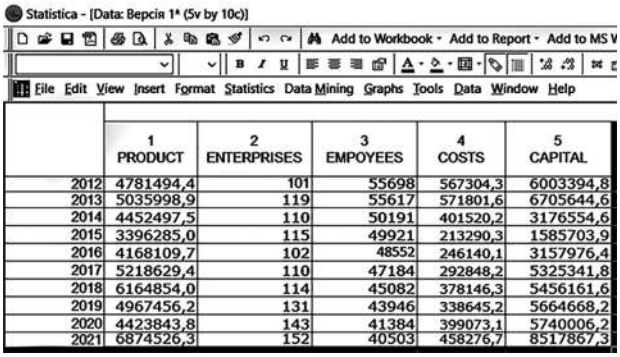
In the present-day conditions, oil and gas enterprises play an important role in the formation of public welfare and energy security of many countries of the world, as they provide the necessary raw materials for the energy, chemical, transport and other industries. Because of the necessity to uninterruptedly satisfy the national and global demand for energy resources, oil and gas enterprises have been facing the problems related to the geological conditions of hydrocarbon extraction, a decrease in oil and gas reserves in conventional deposits, changes in the market conditions for crude oil and natural gas, high requirements for environmental safety and sustainable development, geopolitical instability. The strategic potential of the social importance of oil and gas enterprises is associated with the massive use of hydrocarbons to ensure modern technological processes of industrial production of fuel, plastics, mineral fertilizers, and other material goods, in household consumption. All these factors have caused an increase in the demand for crude oil and natural gas in conditions of limited natural resources and, at the same time, posed challenges to oil and gas enterprises. Among them, there is the need for effective management of oil and gas enterprises given the value-based approach.

The concept of value-oriented management is based on the axiological doctrine of organizational development of oil and gas enterprises, ethical principles and interests of stakeholders, including shareholders, employees, partners, contractors, representatives of government authorities and self-government, and other representatives of an open society [1]. The information support systems play a leading role in the value-oriented management of oil and gas production enterprises, as it provides access to important data for decision-making. The functionality of this system covers the collection, analysis, and interpretation of large amount of information reflecting technological processes, risks, the state of competition and other oil-and-gas production specific factors. Predictive modeling allows oil and gas companies to make forecasts and predict possible scenarios of the development of the situation based on the available data, which becomes a useful tool for their managers. However, it is important to keep in mind that the use of predictive modeling tools is effective in stable conditions where there are no factors that can radically change the external environment. In the current conditions, such factors that introduce significant unpredictability into modeling and analysis are the aggression and acts of terrorism by Russian army against oil and gas enterprises of Ukraine. These factors require additional investigation and adaptation of approaches to predictive modeling to take into account the possibility of sudden changes, emergency situations, and war-caused accidents. This emphasizes the need to develop new methods and tools that allow effective management of oil and gas enterprises in conditions of high uncertainty and risk. Constant monitoring of the situation, adaptation to changes and search for appropriate tools are the key components of value-oriented situational management of oil and gas enterprises [2].

Among recent studies and publications that deal with various aspects of management with a focus on values, it is worthy to single out the publications by R. Venkataraman and J. Pinto (2023), who have focused on cost optimization and management of value parameters of projects, offering for this a toolkit of cost optimization for achieving better project value in their research *Cost and Value Management in Projects* [3]. S. Ebrahimi and E. Bagheri in *Optimizing Profit and Reliability Using a Bi-Objective Mathematical Model for Oil and Gas Supply Chain under Disruption Risks* have analyzed reliability and profitability management of the oil and gas supply chain, using a predictive mathematical model for optimizing these parameters, which is based on the value aspects of risk management [4]. The team of P. Ricardiantoa, F. Baratab, S. Mardiania, E. Setiavana, H. Subagyoa, E. Saribanon, and E. Andri in *Supply Chain Management Evaluation in the Oil and Industry Natural Gas Using SCOR Model* have established the methodological principles of supply chain management in the oil and gas industry using the


Statistica - [Data: Вересн 1* (5v by 10c)]

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	1 PRODUCT	2 ENTERPRISES	3 EMPOYEES	4 COSTS	5 CAPITAL
2012	4781494,4	101	55698	567304,3	6003394,8
2013	5035998,9	119	55617	571801,6	6705644,6
2014	4452497,5	110	50191	401520,2	3176554,6
2015	3396285,0	115	49921	213290,3	1585703,9
2016	4168109,7	102	48552	246140,1	3157976,4
2017	5218629,4	110	47184	292848,2	5325341,8
2018	6164854,0	114	45082	378146,3	5456161,6
2019	4967456,2	131	43946	338645,2	5664668,2
2020	4423843,8	143	41384	399073,1	5740006,2
2021	6874526,3	152	40503	458276,7	8517867,3

Fig. 1. Display of imported data in the *Statistics* program

SCOR model that allows to evaluate the effectiveness of managing the value parameters of the sales policy for natural gas and crude oil [5]. S. Lin, A. Mazlan, S. Ismail, L. Hu, E. Kasiman, K. Yahya in *Status of Value Management Studies in Construction Projects: A Systematic Review* have analyzed the existing problems of cost optimization in construction projects, paying attention to the current status and future prospects for the development of value-oriented management in this science-intensive field of activity [6]. The analysis of the latest research and publications has confirmed that the use of predictive modeling tools is of crucial importance for optimizing the information support of management processes and making decisions with awareness. The crude oil and natural gas sales in the context of information support for value-oriented management of oil and gas enterprises have been forecasted with the use of the STELLA software application. Computer modeling with the help of this program has been used by many researchers to solve various tasks of scholarly research. The STELLA predictive modeling program is developed by the American company HPS (High Performance Systems). The specified software product has been used by J. Woodwell [7], R. Costantza and O. Voinov [8], J. Horng, R. Lee, and K. Liao [9] (for the purposes of dynamic modeling of ecological and economic systems), M. Dias De Oliveira, B. Vaughan, and E. Rykiel (for the estimates of the energy-economic and environmental efficiency of the use of a fuel product synthesized from oil and gas raw materials) [10], and by Y. Feng, Sh. Chen, L. Zhang [11] (for the modeling of system dynamics for urban consumption energy and emissions of hydrocarbon combustion products). Ukrainian researchers O. Levandivskyi, O. Shpykulyak, I. Balanyuk, I. Svinous, D. Shelenko, I. Kozak, L. Sas, M. Malik, P. Matkovskyi, and M. Gumenyuk have used the STELLA software product for various purposes of information support of management of enterprises, in particular: modeling of added value as a financial indicator of enterprise activity [12], forecasting of net profit and land area of private enterprises [13], and forecasting of the gross output of agricultural enterprises [14]. Recognizing the undeniable scientific and practical significance of the conducted research, we believe that the issue of predictive modeling in the oil and gas industry in the context of value-oriented management of crude oil and natural gas production enterprises remains understudied and requires a separate research.

The purpose of this research is to assess the possibilities of using the predictive modeling tools in the context of information support for value-oriented management at oil and gas production enterprises.

Achieving the goal involves: the study and approbation of the STELLA software for information support of value-oriented management of oil and gas enterprises using predictive modeling tools; the formation of factual data processing, the analysis of sales as a performance indicator and the research of economic behavior of influencing factors for regression analysis; the development of a prediction equation based on the regression analysis and its use in the STELLA program; the formulation of recommendations for optimizing value-oriented management of oil and gas enterprises based on the research results.

Predictive modeling is an important tool for optimizing the information support of management processes and making decisions with awareness in the system of value-oriented management of oil and gas enterprises. This approach allows

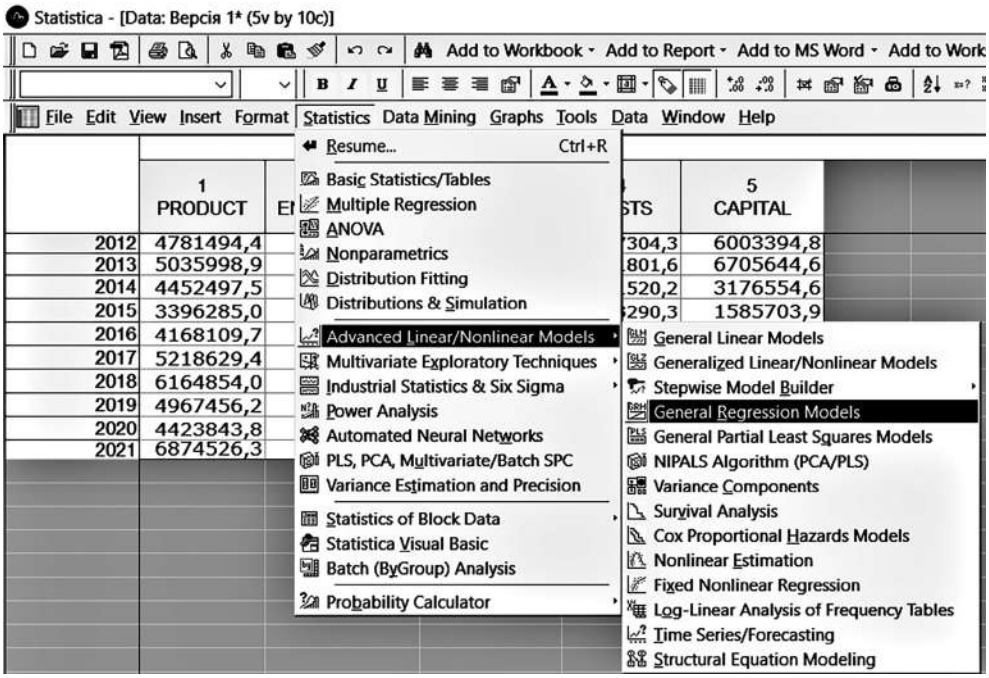

Fig. 2. Bookmarks in *Statistics* for selecting *"Advanced Models"* and *"General Regression"*

forecasting and predicting possible scenarios of the development of events based on the available data, which makes it a valuable tool for managers of oil and gas enterprises. A critically important task for the strategic management of processes in the oil and gas industry is forecasting the sales by business entities, given the key factors influencing this performance indicator (Table 1).

Table 1. **Aggregate Statistical Indicators that Characterize the Activities of Crude Oil and Natural Gas Enterprises for 2012–2021**

Year	Turnover of business entities, USD thousand	Influence factors			
		Number of active business entities	Number of employees of business entities	Personnel costs of enterprises, USD thousand	Equity at the end of the year, USD thousand
A	PRODUCT	ENTERPRISES	EMPLOYEES	COSTS	CAPITAL
2012	4781494.4	101	55698	567304.3	6003394.8
2013	5035998.9	119	55617	571801.6	6705644.6
2014	4452497.5	110	50191	401520.2	3176554.6
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2018	6164854.0	114	45082	378146.3	5456161.6
2019	4967456.2	131	43946	338645.2	5664668.2
2020	4423843.8	143	41384	399073.1	5740006.2
2021	6874526.3	152	40503	458276.7	8517867.3

Source: data of government statistical surveys [15].

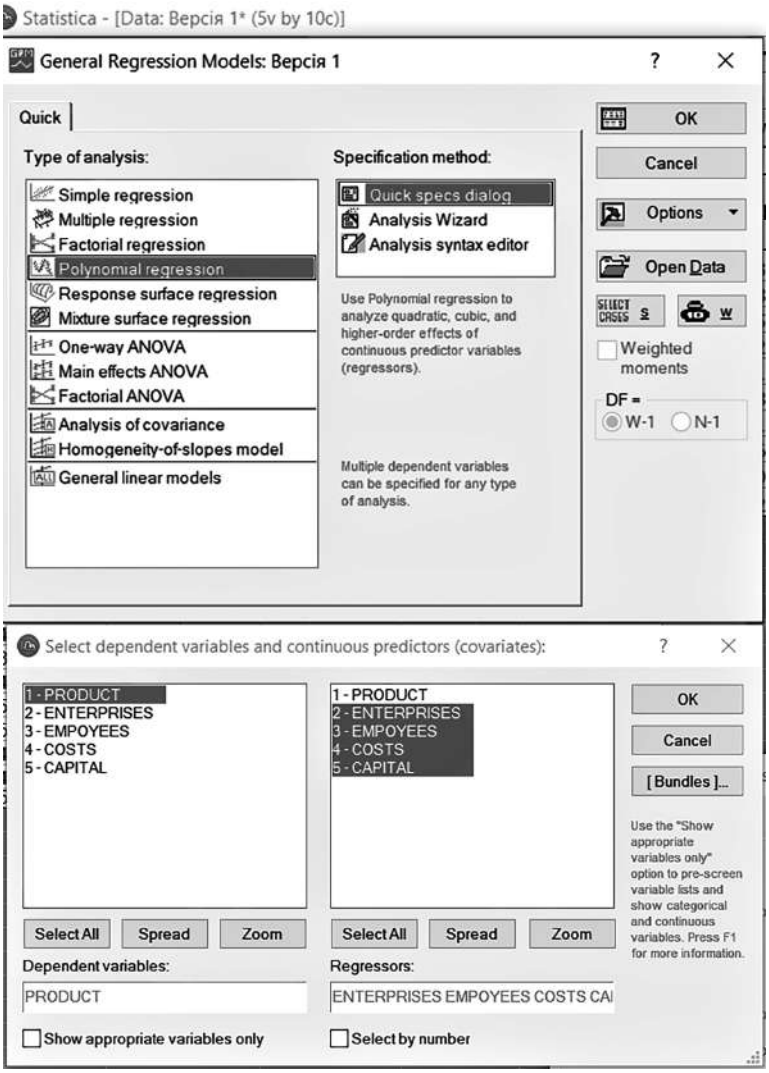

Fig. 3. Evaluating the dependence of the sales on the influence factors studied

When forecasting the sales by crude oil and natural gas enterprises, we have used the *Statistics* 12 program that enables analyzing the selected factors and their influence on the performance indicator.

The first step is the upload of data into the *Statistics* program (Fig. 1).

To analyze the imported data, it is necessary to select "*Advanced Models*" from the list of statistical models, indicating the type of analysis *"General Regression"* (Fig. 2). The use of *"General Regression"* is a convenient approach to data analysis. This method makes it possible to establish dependencies between dependent variable and independent ones, that is, between those factors that affect the object studied [16].

The choice of a specific model depends on the nature of the data and the tasks. In general, the use of *"Advanced Models"* allows for a more in-depth and comprehensive analysis of imported data, which helps to make more effective decisions with awareness. After selecting a model and performing an analysis using *"Advanced Models"*, a data state space, i.e. a description of the object's behavior based on the collected data is

established. This allows getting an idea of the structure and relationships between the variables studied. State diagrams can be used to visualize these dependencies and to help define discrete behaviors of objects of any complexity (Fig. 2).

Further, we choose the type of regression analysis *"Polynomial regression"* and determine the dependent and independent variables: the dependent variable PRODUCT (the sales of products by companies producing crude oil and natural gas) and the independent variables ENTERPRISES (the number of active economic entities), EMPLOYEES (the number employees at business entities), COSTS (the enterprise personnel costs), and CAPITAL (the equity of enterprises) (Fig. 3).

After confirming the selection of the influence variables, a result window appears in the *Statistics* program, where we select *"All effects"* (Fig. 4).

The generalized results of the regression analysis for the dependent variable PRODUCT (the product sales by enterprises producing crude oil and natural gas) are shown in Fig. 5. We see that the Fisher coefficient meets the inequality $P \leqslant 0.05$ and allows us to continue the analysis. The evaluation of the Beta-indicator has proven that EMPLOYEES (the number of employees in economic entities) has the greatest influence on PRODUCT (the sales) growth. This variable is followed by ENTERPRISES (the number of active economic entities), COSTS (the costs for personnel of enterprises), and CAPITAL (the equity of enterprises).

The analysis of standardized deviations has shown a lack of values higher than ±3 sigma for dependent variable PRODUCT, which is explained by the lack of significant data deviations (Fig. 6).

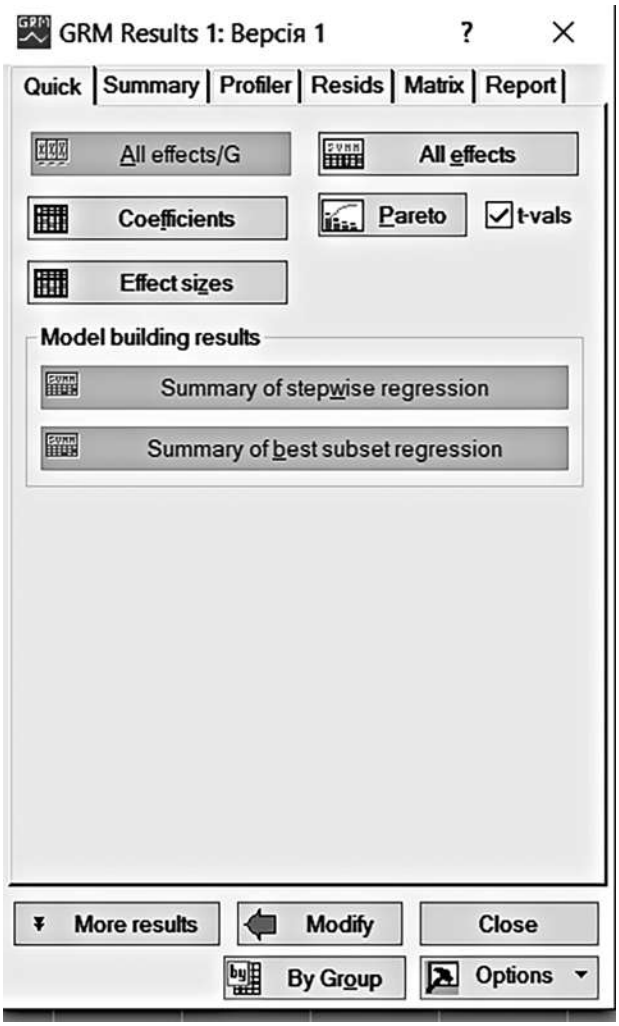

Fig. 4. The result window for selecting *"All effects"*

The next step is to create a prediction equation in the *Statistics* program, which later is placed in the STELLA application. For this, we need to use the "Print prediction equation to report window"

Statistica - [Workbook2* - Test of SS Whole Model vs. SS Residual (Версія 1)]

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Test of SS Whole Model vs. SS Residual (Версія 1)

Dependent Variable	Multiple R	Multiple R2	Adjusted R2	SS Model	df Model	MS Model	SS Residual	df Residual	MS Residual	F	p
PRODUCT	0,999740	0,999481	0,995326	8,833043E+12	8	1,104130E+12	4,590011E+09	1	4,590011E+09	240,5507	0,049827

Fig. 5. The results of regression analysis for PRODUCT dependent variable

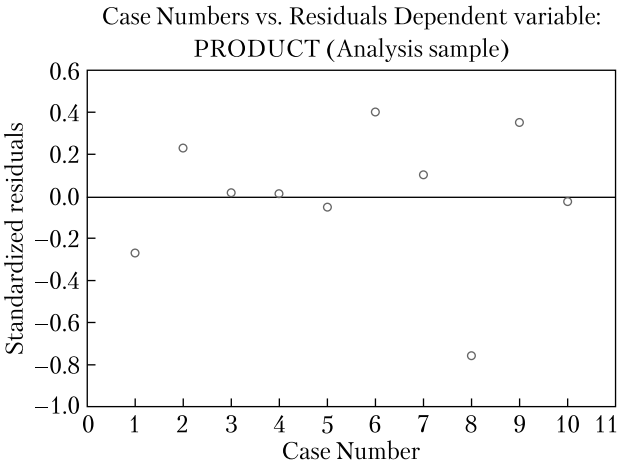

***Fig.* 6.** Display of standardized deviations for dependent variable PRODUCT in *Statistics* program

attachment. The generated prediction equation in the *Statistics* program has the following form (Fig. 7).

For the convenience and further use of the created equation, it is necessary to replace all commas and dots and to remove the quotation marks from the names of all variables. After that, the equation is written the following form:

Prediction equation for: PRODUCT = = –97755513.21+127926.8456* ENTERPRISES-714.8631645*ENTERPRISES^2+4469.673764* EMPLOYEES-0.04985905385*EMPLOYEES^2-19.6306438*COSTS+4.23442639e-05*COSTS^2-0.6285300842*CAPITAL+1.09135331e-07 *CAPITAL^2

The next step is building a model in the STELLA program. Figure 8 shows the flowchart of the model. We see a rectangle (the stock) for dependent variable PRODUCT (the sales by enterprises producing crude oil and natural gas, USD thousands), which is replenished at the expense of 4 converters: ENTERPRISES (the number of active economic entities), EMPLOYEES (the number of employees at business entities), COSTS (the enterprise personnel costs), CAPITAL (the equity of enterprises). The connections between the dependent variable and the independent ones are shown by the arrows (the connectors). To the right of the model, there are the graphic element of forecasting (Graph 1) and the tabular element of forecasting (Table 1).

We insert the prediction equation that is previously developed in the *Statistics* application to the valve that indicates the flows in both directions of FLOW (Fig. 9).

The verification of the model includes comparing the data of 2021 with the data predicted in the model for 2021. We can see that the model matches the real data of 2021 by 95—99%.

The actual data of 2021 for the variables are as follows: USD 6874526.3 thousand for PRODUCT; 152 units, for ENTERPRISES; 40503 persons, for EMPLOYEES; USD 458276.7 thousand, for COSTS; and USD 8517867.3 thousand, for CAPITAL. Accordingly, the model has shown (Fig. 10) that, in 2021, the indicators for the variables are: USD 6647134.73 thousand, for PRO-

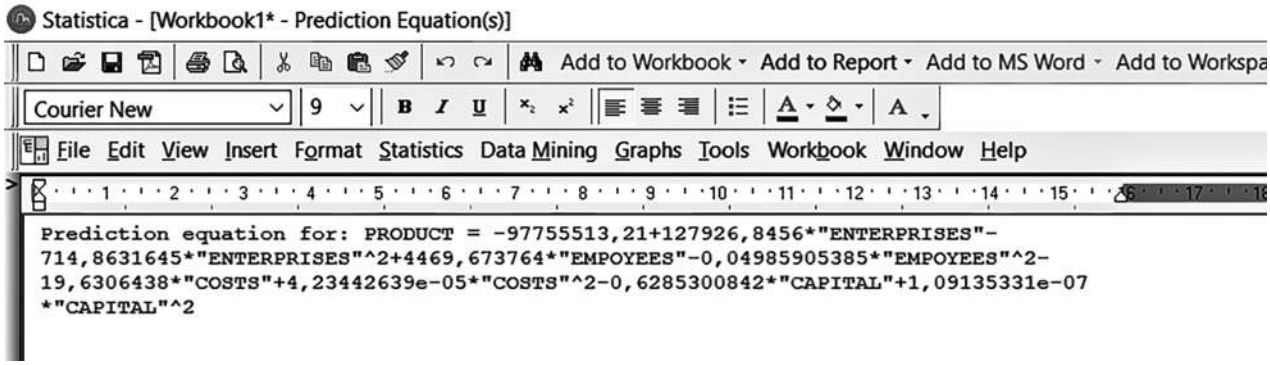

***Fig.* 7.** Prediction equation in the *Statistics* program

DUCT; 152 units, for ENTERPRISES; 45082 persons, for EMPLOYEES, USD 451236 thousand, for COSTS, and USD 8532491.5 thousand, for CAPITAL.

On the left, there are the scales within which each analyzed variable can vary, namely: PRODUCT can range from USD 4,500,000 to 1,050,000 thousand; CAPITAL can vary from USD 2,000,000 to USD 9,000,000; COSTS can vary from 0 to 600,000 USD; EMPLOYEES can range from 30,000 to 60,000 persons; ENTERPRISES can vary from 100 to 160 units.

The generalized forecast results are shown in Fig. 11 that features a possible increase in the sales by companies producing crude oil and natural gas with a slight decrease in the equity capital, the personnel costs, the number of employees at economic entities, and in the number of active economic entities, especially at the end of the forecast.

Figure 12 shows that the model provides a forecast until 2030. Provided the equity get stabilized at a level of USD 7,412,545 thousand, the personnel costs at USD 36,254 thousand dollars, the number of employees at business entities at 34,295.3 people, and the number of active economic entities at 103, it is possible to observe positive changes in the sales by crude oil and natural gas producers up to USD 9602265.79 thousand.

The study of information support for value-oriented management of oil and gas production enterprises using predictive modeling tools has shown that forecasting the sales is important for strategic planning of the development of the oil and gas industry.

The use of the STELLA software application in combination with the *Statistics* 12 program has made it possible to analyze the sales by crude oil and natural gas producers in relation to the influencing factors. As a result of the regression analysis, it has been determined that the number of employees at business entities, the number of active business entities, and the personnel costs of enterprises have the greatest influence on the

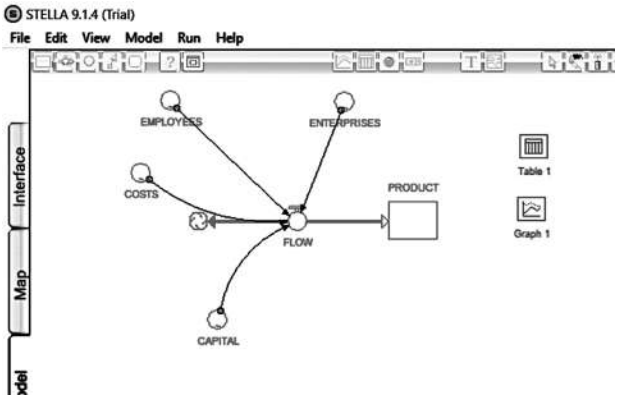

***Fig.* 8.** The model interface in the STELLA program

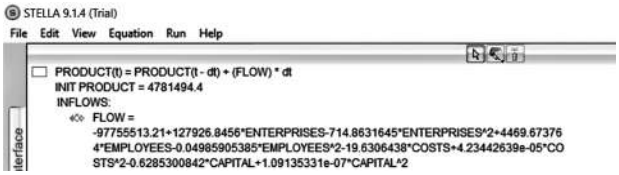

***Fig.* 9.** A fragment of the prediction equation inserted into the STELLA program

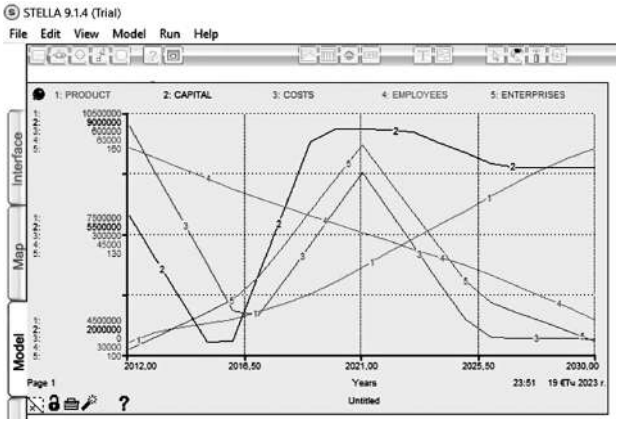

Fig. 10. Graphical results of forecast in the STELLA program

sales growth. The equity capital of enterprises also has an effect, although it is smaller as compared with the other factors.

The prognostic model in the STELLA program has made it possible to forecast the sales until 2030. According to the forecast, provided certain

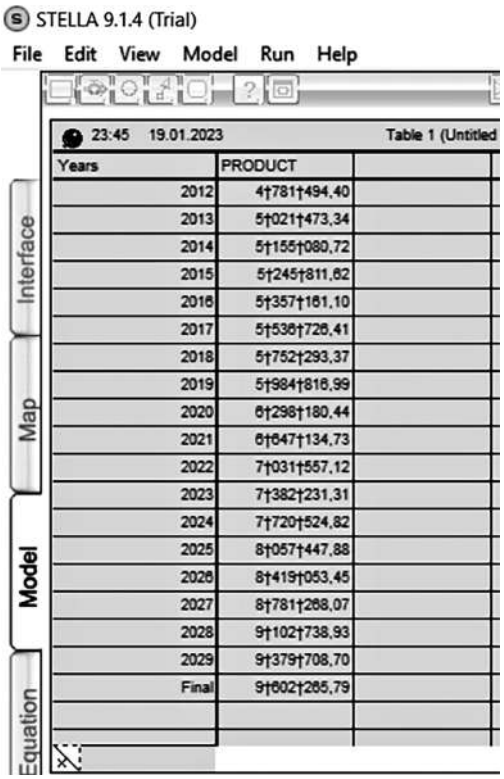

Fig. 11. The tabular presentation of sales by oil and gas companies in the STELLA program

factors get stabilized, a positive increase in the sales by oil and gas enterprises is expected.

The novelty of this study is the formation of a conceptual approach to the information support of value-oriented management, based on the use of predictive modeling tools for the analysis and forecast of the sales of oil and gas enterprises. The application of prognostic methods in the information support of value-oriented management creates new opportunities for optimizing management processes and making decisions with awareness in the oil and gas industry.

Therefore, the results of the study have confirmed that the use of predictive modeling tools is an important factor for optimizing management processes and making decisions with awareness in the system of value-oriented management of oil and gas enterprises. Forecasting the sales helps to develop possible scenarios of the events based on the available data, given useful tools for managers of oil and gas enterprises.

The prospects for further research are the progressive development and improvement of

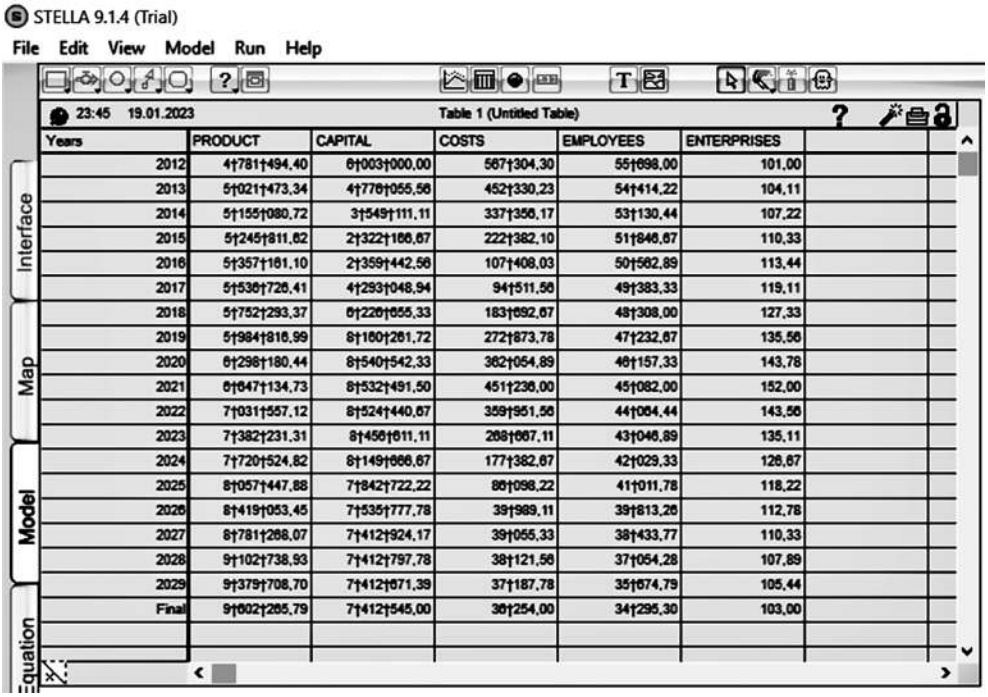

Fig. 12. Results of forecast for the period from 2012 to 2030 in the STELLA program

predictive modeling tools to raise the effectiveness of value-oriented management of oil and gas enterprises. Special attention will be paid to the analysis of the influencing factors related to institutional support and legal regulation of oil and gas production enterprises, based on the progressive international experience of value-oriented management.

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ІНФОРМАЦІЙНЕ ЗАБЕЗПЕЧЕННЯ ЦІННІСНО-ЗОРІЄНТОВАНОГО УПРАВЛІННЯ НАФТОГАЗОВИДОБУВНИМИ ПІДПРИЄМСТВАМИ

Вступ. У контексті сучасних викликів енергетичного переходу система управління нафтогазовидобувними підприємствами потребує ефективного інформаційного забезпечення. Прогностичне моделювання слугує ключовим інструментом для розроблення ціннісно-зорієнтованих стратегій, спрямованих на ефективний розвиток нафтогазовидобувних підприємств у нових енергетичних реаліях.

Проблематика. Недостатнє інформаційне забезпечення обмежує потенціал ефективного ціннісно-зорієнтованого управління нафтогазовидобувних підприємств. Використання прогностичного моделювання допоможе передбачати зміни в обсягах продукції для покращення стратегічного планування та прийняття обґрунтованих рішень.

Мета. З'ясувати можливості використання прогностичного моделювання як інструменту для забезпечення інформаційної бази ціннісно-зорієнтованого управління нафтогазовидобувними підприємствами.

Матеріали й методи. Дослідження проведено за матеріалами державної служби статистики України. Використано методи аналізу, синтезу, аналогії, моделювання, абстрагування, конкретизації. Для обробки даних застосовано програмні продукти *Statistics* 12, *STELLA*.

Результати. Встановлено, що застосування інструментарію прогностичного моделювання дає можливість удосконалити інформаційне забезпечення ціннісно-зорієнтованого управління на нафтогазовидобувних підприємствах. Регресійний аналіз показав, що кількість найманих працівників, кількість діючих суб'єктів господарювання та витрати на персонал мають найбільший вплив на зростання обсягів реалізованої продукції нафтогазовидобувних підприємств.

Висновки. Отже, проведене дослідження аргументує важливість прогностичного моделювання для підвищення ефективності ціннісно-зорієнтованого управління нафтогазовими підприємствами, формування ефективних стратегій їх розвитку в контексті енергетичного переходу, забезпечення інформаційної підтримки, підвищення їхньої здатності до адаптації та інновацій в динамічному середовищі зовнішньому середовищі.

Ключові слова: інформаційне забезпечення, ціннісно-зорієнтоване управління, нафтогазовидобувні підприємства, прогнозування, моделювання.