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INTELLIGENT MANAGEMENT OF AN INNOVATIVE OIL AND GAS PRODUCING COMPANY UNDER CONDITIONS OF THE MODERN SYSTEM CRISIS

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ABSTRACT

This publication presents the part of the research results and practical results obtained by the authors regarding the hybrid use of economic-mathematical modelling, knowledge-oriented decision support technology of an oil and gas production company using fuzzy logical inference.
The purpose of this research *is the development of theoretical provisions of modelling and knowledge-oriented decision support means at the macro level of oil and gas production companies.*
The purpose of the work *determined the solution of the following tasks:*
- development of science-based recommendations regarding the architecture of a knowledge-oriented DSS of an oil and gas company, the basic model of knowledge presentation, features of the logical conclusion mechanism, etc.;
- development of a complex system of economic and mathematical support for decision-making at the macro level of an oil and gas production company in modern economic conditions.
The object *of the study is the oil and gas production industry.*
The subject of the research *is information processes, economic-mathematical models and knowledge-oriented methods and means of supporting the adoption of management decisions at the strategic level on economic and production issues of the domestic oil and gas production project.*
Methods/Approach: *Economic and mathematical methods, methods of artificial intelligence, methods of logical generalization, expert evaluations and situational approach are used to solve the tasks set in the work.*
Results: *The main scientific result of the work consists in the creation of the concept that allows creating a hybrid DSS of an oil and gas company on the basis of the developed systems of economic and mathematical decision-making support at the macro level of an oil and gas production company, focused on knowledge of technology and intelligent technologies.*
Conclusions*: The scientific, theoretical and applied practical solutions proposed in this publication are universal for implementation by both state and private oil and gas resident and non-resident companies for emerging markets, however, in order for a specific oil and gas company to obtain special additional competitive advantages over others, additional industry-specific Big Data Analysis of collected and stored heuristics, expertise and project development are required.*

Keywords: economic and mathematical modelling, oil&gas exploration and production, investment project, DSS, production rules, fuzzy inference

JEL classification: C01, G11, D81, D83, L71

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INTRODUCTION

The oil and gas industry is a powerful branch of economy, the influence of which on functioning and development of the entire national economy is decisive, but today most of countries of Eastern Europe are energy-deficit countries. In particular, the oil and gas production industry of Ukraine with significant volumes of unexplored oil and gas resources, with the cost of oil and gas which is several times lower than average world costs, the presence of a significant number of oil and gas fields, drilling and geophysical enterprises, oil refineries, an extensive network of oil and gas pipelines, highly qualified production teams allows, with their effective use, to stabilize, and in the long run, increase oil and gas production (Hrashchenko et al., 2022) . An important reason for the decline in oil and gas production volumes is insufficient management efficiency of a cycle of parallel business processes of a domestic oil and gas company: exploration, drilling and development of deposits, production and sale of oil and gas. Therefore, one of necessary factors for increasing hydrocarbon production is improvement of the efficiency of management of business processes of an oil and gas company through the use of effective economic and mathematical modelling at the strategic level of management and the use of knowledge-oriented decision support tools as an integral component of the complex corporate information system of an oil and gas company (Kulynych et al., 2021).

The most important conclusion of the economic analysis of the oil and gas industry is that, taking into account the trend of growing reserves of explored deposits, in order to support production in countries with well-explored regions, it is necessary to significantly improve the technology of exploration and production of hydrocarbons and use all possible innovations in the field of exploration and production management. The introduction of advances in information systems and information technologies in the oil and gas industry is one of the main factors in ensuring the growth of oil and gas reserves in countries of Eastern Europe, which has significant fuzziness. In addition, the researched dependence of the intensification of oil and gas production on information support rapidly raises the role and importance of information modelling in the oil and gas industry.

The absence of a balanced automation strategy of an oil and gas company has the greatest negative impact at the strategic level of the company's management, where the cost of a manager's error is the greatest. Therefore, for the first time, the principles, characteristics, architecture, specific industry problems and the strategy of creating an information system of an oil and gas company are comprehensively defined in this research. In particular, the concept of the architecture of the information system of an oil and gas company which provides for the allocation of 3 macro levels (process management subsystem; tactical management subsystem; analytical subsystem of top management) and 4 macro-functional blocks (exploration and production management subsystem; transport management subsystem; management subsystem implementation; subsystem of the control apparatus) was developed (Tuhaienko et al., 2022).

On the basis of the developed strategy for configuring the information system of an oil and gas company, it can be concluded that: the construction of an effective information system of an oil and gas company is possible through the integration of purchased and self-developed components; specialized software that helps manage mission-critical business functions of an oil and gas company is a potential center of competitive advantage for an oil and gas company (most often HYBRID DSS) (Kustarovskiy et al., 2018).

The form of knowledge representation has a significant impact on the characteristics and properties of a knowledge-oriented system. Therefore, based on the specifics of exploration and development of oil and gas deposits and the main advantages of the rule-oriented model of the HYBRID DSS knowledge base, it is possible to conclude on the need to use a rule-oriented knowledge base for the HYBRID DSS of an oil and gas production company (Kulynych et al., 2022). The rule-oriented subsystem is the main one in the knowledge-oriented HYBRID DSS of an oil and gas production company, in fact, other subsystems provide it with analyses, assessments, and knowledge. Namely, the final product of the system: recommendations for making management decisions and is carried out by a rule-oriented subsystem (Krasnyuk et al., 2021). In general, science-based conclusions were obtained regarding the knowledge-oriented intelligent HYBRID DSS architecture of an oil and gas company, the basic model of knowledge representation (production), features of the inference mechanism (direct logical inference), conflict resolution procedure (product compilation method), etc.

In addition, the relevance of the problem of handling uncertainty in supporting decision-making of an oil and gas production company has been investigated. The use of the theory of fuzzy sets for dealing with the specific uncertainty inherent in the oil and gas industry is substantiated. On the basis of the conducted research, it was concluded that the following combination of components of the algorithm of fuzzy logical inference with production rules is recommended for use in the subject area under consideration: Gaussian membership functions, composition using the product operator, implication according to the Larsen algorithm and the centroid method.

METHODOLOGY

The paper uses a mathematical apparatus of the Data Mining, fuzzy logic inherence, knowledge-oriented decision support, theory of risky investment management and expertise in the field of investment management of oil&gas exploration and production of local and international projects.

RESULTS

In this part of research results, the concept of economic and mathematical modelling of an oil and gas company as a whole complex specific system was further developed and here partly presented (i.e., such factors as: significant inertia of the management object; multi-level management structure; irregularity of the management system of the oil and gas company; the need to decompose the system along the weakest lines of communication "vertical" and "horizontal" connection and construction of economic and mathematical models of smaller dimensions for each selected element). It should be noted, that economic models in oil and gas exploration are used to identify major trends, not precise predictions (Krasniuk et al., 2020a).

A set of economic and mathematical models and indicators necessary for making management decisions on economic and production issues of an oil and gas company were studied, in particular for: substantiating an economic feasibility of carrying out work on search and exploration of oil and gas deposits; assessment of recoverable hydrocarbon reserves; ranking of individual promising areas into groups according to economic criteria and the sequence of their development; forecasting of oil and gas prices, taking into account the level of forecast aggregate specific costs for the preparation and development of reserves and expected profit (Krasniuk et al., 2020b).

In the Figure 1, the diagram of the developed integral system of economic and mathematical decision-making support at the macro level of a domestic oil and gas production company is given. The diagram shows the degree of scientific novelty and the interconnection of the blocks.

In particular, the block 1 in the fig. 1. reflects the conducted studies of the economic and mathematical modeling of an oil and gas company as a complete complex specific system, i.e. the following factors are taken into account: significant inertia of the management object; multi-level management structure; irregularity of the management system of the oil and gas company; the need to decompose the system along the weakest lines of communication "vertically" and "horizontally" and construction of economic and mathematical models of smaller dimensions for each selected element.

The block 2 in the fig. 1. reflects the scheme of effective decision-making support processes of the strategic management of an oil and gas company (search and development of oil and gas fields). In addition, in cooperation with highly experienced experts of domestic oil and gas companies, the core of the knowledge base (with elements of ambiguity) of an oil and gas company was formed to support strategic decision-making at various stages of the production cycle.

The block 3 in the fig. 1. reflects the proposed set of economic and mathematical models and indicators of the tactical level of management, which are the information base for making strategic management decisions on economic and production issues of an oil and gas production company. Such economic indicators should include: the price of the deposit, the amount of capital investments, operating costs, production cost, profit, profitability, payback period, etc.

The block 4 in the fig. 1. reflects the proposed system of macro-prognostic economic and mathematical models of investment decision-making support for the strategic planning of an oil and gas production company based on expert knowledge, in particular: both forecasting the impact of investments in geological exploration and drilling on the future growth of reserves and production, and the inverse problem.

The block 5 in the fig. 1. reflects the economic and mathematical model of the optimal distribution of capital investments by regions and stages of work.

The block 6 in the fig. 1. reflects the proposed algorithm based on economic and mathematical modeling (with elements of fuzzy knowledge) for the selection of a contractor - a service company based on the evaluation of proposed business plans, which will guarantee the maximization of production, compliance with environmental requirements, the use of modern technologies and the development of an infrastructure of a

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region. Experience shows that making such a complex decision in the oil and gas industry requires the use of qualitative elements - fuzzy goals and limitations. That is, the problem is a multi-criteria two-level optimization system in fuzzy circumstances.

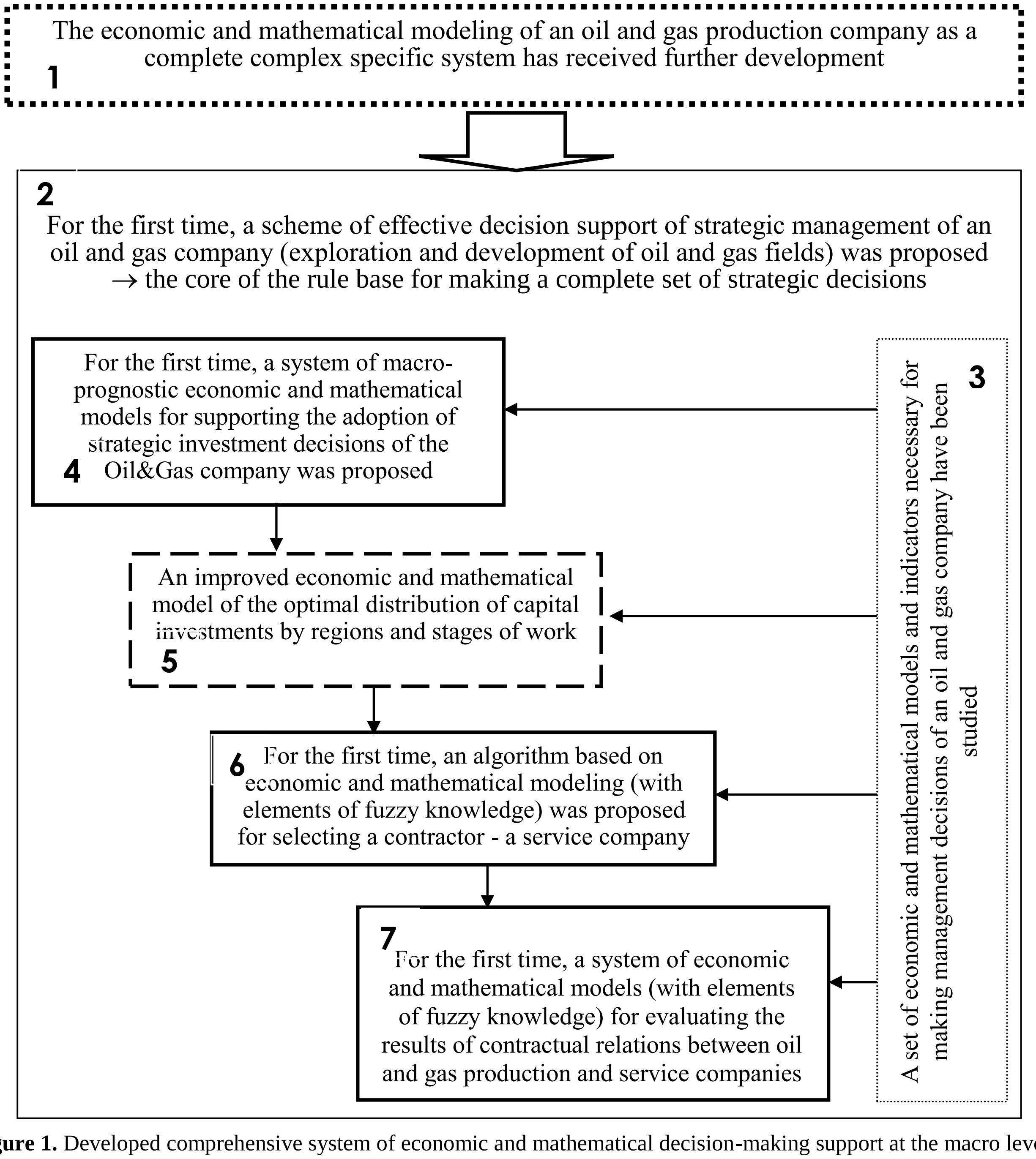

Figure 1. Developed comprehensive system of economic and mathematical decision-making support at the macro level of management of oil&gas production company

The block 7 in the fig. 1. reflects the proposed system of economic and mathematical models (with elements of fuzzy knowledge) for evaluating the results of contractual relations of subcontracting (for the execution of R&D, drilling and seismic exploration works) between oil and gas production and service companies. Taking into account the current state of oil and gas production companies in the current conditions, the issue of using reserves to improve quality and reduce cost in relations between oil and gas production companies and service companies regarding prospecting and exploration for oil and gas is gaining a particular importance. This can be achieved thanks to an accurate assessment of the actual cost of main types of these works: research, drilling, seismic exploration; with the use of fuzzy " penalty-incentive coefficient" of completed works and knowledge base with production rules.

The scheme of decision-making support processes and knowledge base as architecture of effective strategic management of an oil and gas production company (Hrashchenko et al. 2019).

On the basis of the conducted research, the decision tree diagram of a complex of effective processes of strategic management of a domestic oil and gas company (from the selection of the target region to industrial development) in modern economic conditions is proposed (Goncharenko et al. 2022).

The scheme under consideration is the basis for building effective computer support for making strategic decisions of an oil and gas company and was obtained thanks to the analysis of historical data, expert experience and with the application of business process reengineering principles. In this scheme, the main problem situations that require support are marked by consecutive blocks. The information from the previous block is used to make a decision on the block under consideration. Arrows indicate possible solutions to the problem situation and the direction of further actions. In addition, dotted footnotes indicate the main consequences of earlier decisions.

In cooperation with highly experienced experts of domestic oil and gas companies, taking into account the developed scheme of strategic management processes (investing in oil and gas exploration and production), the core of the knowledge base of an oil and gas company was formed (which should be detailed on several levels in further research) (Table 1).

This database consists of 29 products with elements of ambiguity. So, the developed economic and mathematical models from blocks 4, 5, 6, 7 from the Figure 1 are connected to this base.

Table 1. The fragment of the developed database of fuzzy rules for DSS of oil and gas production company

Rule #	Content of the rule
1	IF open deposits OR existing oil and gas generating systems THEN rule 2 ELSE loss of interest
2	IF the degree of study of the pool is high THEN loss of interest or search and analysis of additional information ELSE rule 3
3	IF oil is predicted THEN rule 7
4	IF gas is predicted AND gas pipelines are available THEN rule 7
5	IF gas is predicted AND there are no gas pipelines THEN additional economic analysis rule 6
6	IF additional economic analysis is positive THEN rule 7
7	IF oil and gas basin on the mainland THEN oil and gas basin prospective rule 9 ELSE rule 8
8	IF water area depths are available THEN oil and gas bearing pool is promising rule 9 ELSE loss of interest
9	IF the oil and gas basin is promising AND there is political stability THEN rule 10 ELSE waiting and monitoring the situation

10	IF stable and favorable legislative framework for regulating the country's economy THEN rule 11 ELSE waiting and monitoring the situation
11	IF a stable monetary and credit system THEN political and economic conditions in the region are favorable ELSE additional analysis of investment opportunities in conditions of an unstable monetary and credit system (work on the terms of product distribution, concession, etc.) rule 12
12	IF the analysis of investment opportunities in the conditions of an unstable monetary and credit system is positive THEN political and economic conditions in the region are favorable ELSE expectations and monitoring of the situation
13	IF political and economic conditions in the region are favorable AND available collectors and traps for oil&gas THEN rule 14 ELSE loss of interest
14	IF there are detected pitfalls or a positive prediction of them THEN rule 10 ELSE additional study or loss of interest
15	IF there is an opportunity to obtain rights to a specific plot (license) THEN drawing up a business plan rule 16 ELSE studying additional opportunities or loss of interest
16	IF the result of the business plan is positive THEN the area is promising and available ELSE loss of interest (economically impractical)
17	IF the area is promising and available AND the water area THEN PR regarding investments in 3D seismic ELSE rule 18
18	IF simple geological conditions OR complex surface conditions THEN PR for investment in 2D seismic ELSE investment in 3D seismic
19	IF, based on the results of seismic exploration, a structure was discovered THEN rule 20 ELSE loss of interest
20	IF the estimated resources are small and the depths of the forecast deposits are unavailable THEN loss of interest (economically impractical)
21	IF estimated resources are large or medium AND depths are available THEN exploratory drilling ELSE loss of interest
22	IF the result of exploratory drilling is negative THEN loss of interest or additional study ELSE rule 23
23	IF received an influx of oil THEN PR regarding the start of exploratory and industrial exploitation and investments in exploratory drilling
24	IF received gas inflow AND existing infrastructure THEN PR regarding the start of exploratory exploitation and investment in exploratory drilling
25	IF received gas flow AND no infrastructure THEN Feasibility study on investment in infrastructure construction and exploratory drilling
26	IF Feasibility Study on investment in infrastructure construction and exploratory drilling is positive THEN PR on investment in exploratory drilling and infrastructure construction ELSE waiting and looking for new opportunities
27	IF the results of exploratory drilling are available AND there is infrastructure AND exploratory and industrial exploitation took place THEN calculation and assessment of the deposit reserves
28	IF the calculation and assessment of the deposit reserves is made THEN conducting the |Feasibility Study of the deposit development
29	IF the Feasibility Study of the field development is positive THEN making decision regarding the investment of funds in the development of the field, operational drilling and the start of industrial exploitation ELSE waiting or selling a share

The economic and mathematical model of the optimal distribution of capital investments by regions and stages of work.

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In order to make decisions about investing in hydrocarbon exploration, there is a need to evaluate different investment allocation strategies between different regions and by stages, for which the following stochastic model can be used:

$$\max \sum_{j=1}^{n} \mathrm{M}\left[fe_j \varphi_{fej}\left(Z_j, \varphi_{zj}\right)\right], \tag{1}$$

$$\sum_{j=1}^{n} z_j^i \le \overline{Z^i} \ ,$$

$$z_j^i \ge 0 \ ,$$

where,

i = [1,m] – simulated investment period in years;

j = [1,m] – simulated geographical investment region;

zji – investments in the j-th region per year i;

Zj – vector of investments in the j-th region;

M[·] – mathematical expectation;

φzj , φfej – vectors simulating the inaccuracy of knowledge;

fej – criterion for the efficiency of work in region j, for example, discounted hydrocarbon reserves;

$\overline{Z^i}$ - limitations on the size of investments per year i;

And the following model can be used to make decisions about investments in the search for hydrocarbons in a certain region j by stages:

$$\begin{cases} \max \mathrm{M}\left[fe_j \varphi_{fej}\left(ZS_j, ZB_j, ZN_j, \varphi_{zj}\right)\right] \\ ZS_j^i + ZB_j^i + ZN_j^i \le \overline{Z_j^i}, i = 1,2,\ldots,m \\ ZS_j^i, ZB_j^i, ZN_j^i \ge 0 \end{cases} , \tag{2}$$

where,

Zji – investments in the j-th region per year i;

Zj – vector of investments in the j-th region;

M[·] – mathematical expectation;

φzj , φfej – vectors simulating the inaccuracy of knowledge;

fej – criterion for the efficiency of work in region j, for example, discounted reserves;

$\overline{Z^i}$ - limitations on the size of investments per year i to region j;

ZS_j, ZB_j, ZN_j - vectors of investments, respectively, in seismic exploration works, in drilling, in other prospecting and exploration research.

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One of the ways to speed up the solution of this system of models is the use of expert estimates (in particular, the vector *Zj*) and the replacement of randomness modelling vectors φzj , φfej – with fuzzy sets.

The system of economic and mathematical models (with elements of fuzzy knowledge) for evaluating the results of contractual relations between oil and gas production and service companies.

Crisis phenomena in the economy over the last decade led to a sharp drop in the volume of exploration work for oil and gas, the loss of a significant number of specialists, the decrease in an interest of top management in effective work, moral obsolescence and wear and tear of an equipment and, as a result, the drop in a competitiveness of this area of domestic oil and gas companies (loss of cost and quality control). As is stated above, the basic sphere of activity of companies of the oil and gas production complex is to ensure the production of hydrocarbon reserves and their growing renewal, therefore, the issue of using reserves for quality improvement and cost reduction in relations between an oil and gas production company and service companies regarding oil and gas exploration and exploration is of particular importance.

This can be achieved due to an accurate assessment of the actual cost of the main types of these works: research, drilling, seismic exploration; with the use of fuzzy "penalty-incentive coefficients" of completed works. It should be noted that the following economic-mathematical models are used only if the customer has accepted the relevant works for actuation.

The cost of construction (drilling) of deep wells is proposed to be determined by the following formula:

$$V_{BUR} = \left(H_{dog} \times Vodb_r^h \times (1 - K_{vuk}^{bur}) + \sum_{i=1}^{n} Vod^i \times O_{dog}^i \times \left(1 - K_{vuk}^i\right) \right) \times D_{qual}^{bur}, \quad (3)$$

$$K_{vuk}^{bur} = {H_{dog} - H_f} / {H_{dog}},$$

$$K_{vuk}^{i} = {O_{dog}^i - O_f^i} / {O_{dog}^i},$$

where:

V_{BUR} - cost of construction (drilling) of the well;

H_{dog} - contractual depth of the well;

H_f - actual depth of the well;

K_{vuk}^{bur} - rate of execution of drilling volumes according to the contract;

$Vodb_r^h$ - cost of 1 m of drilling for cut type r and depth interval h;

O_f^i - cost of a unit of research volume of the method i and in the well;

Vod^i - actual volume of works of method i;

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O^{i}_{dog} - contractual scope of works of method i;

K^{i}_{vuk} - coefficient of execution of works of method i;

D^{bur}_{qual} – coefficient of "penalization-stimulation" of quality of the performed drilling works.

Such stimulation or penalization of the of price of well construction works is used exclusively on the condition of obtaining an inflow of hydrocarbons. When calculating this output coefficient, fuzzy rules are used together with above mentioned model, which operate with the following input fuzzy dimensions: well construction period (Figure 2.), quality of geological task performance (Figure 3.).

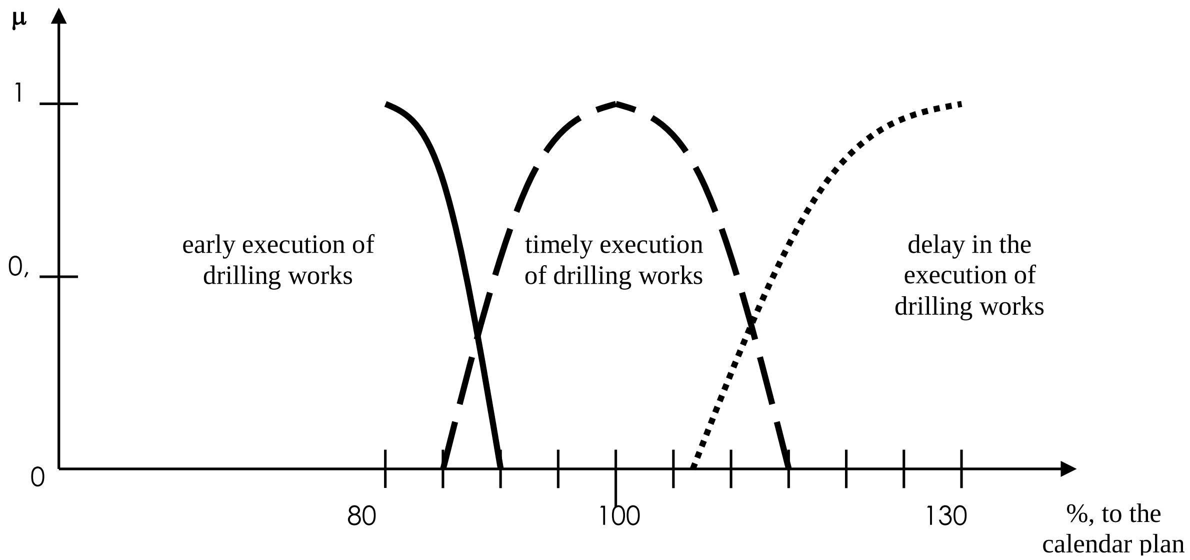

Figure. 2. Membership functions of the linguistic variable "meeting the oil and gas drilling deadline"

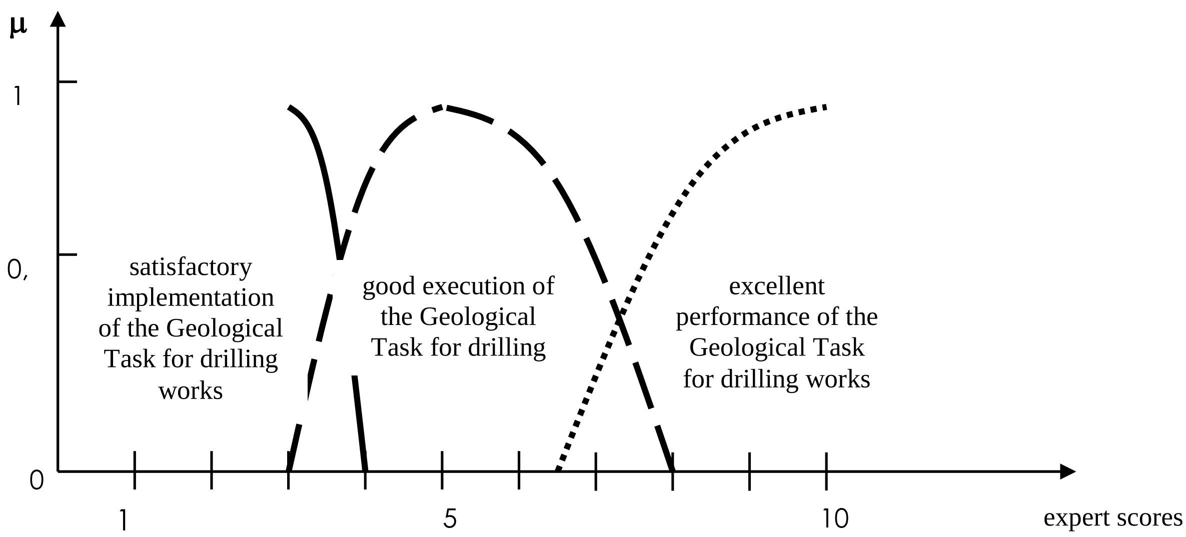

Figure. 3. Membership functions of the linguistic variable "execution of Geological Task for oil and gas drilling"

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Based on the study of the practice of domestic companies, this coefficient stimulation or penalization is proposed to be set within the range of [0.95; 1.05] to the contractual value of these works (Figure 4.).

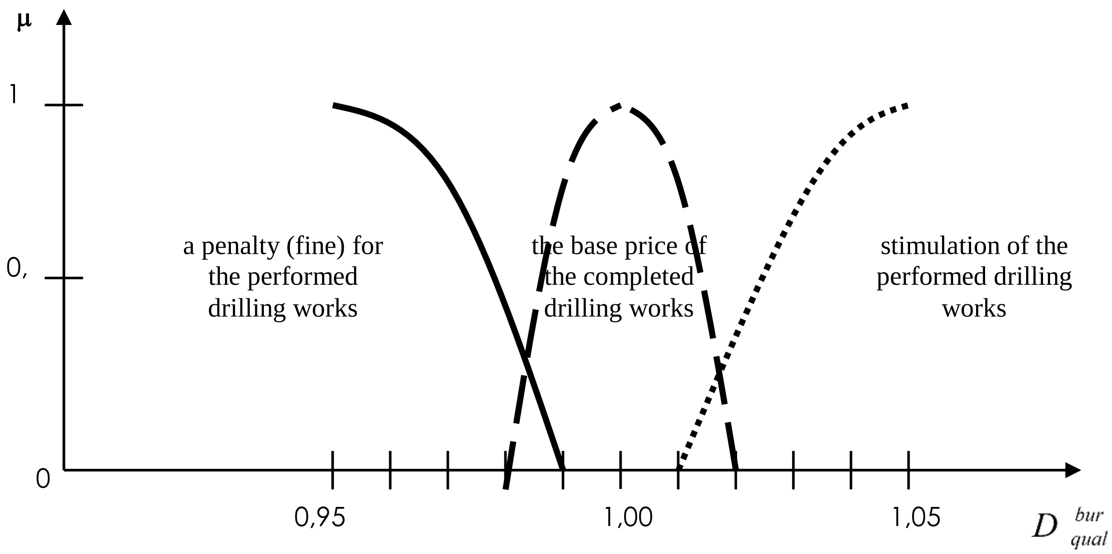

Figure 4. Membership functions of the target output linguistic variable "stimulation or penalization coefficient of the oil and gas drilling performed"

Implementation of a knowledge-oriented HYBRID DSS of an oil and gas production company

On the basis of the above studies, the knowledge-oriented DSS architecture of an oil and gas company was designed (Figure 5). It should be noted that the architecture and work algorithms of each module are developed in more detail above. The block for processing rules is the main one in this knowledge-oriented HYBRID DSS, in fact, other subsystems provide it with analyses, evaluations, and knowledge. Namely, the final product of this system: recommendations for making managerial decisions are carried out by a rule-oriented subsystem. According to the figure 5. the built architecture of HYBRID DSS is relatively "open", which once again emphasizes the importance of the issue of information security of an oil and gas company. The data warehouse structure of an oil and gas production company is designed (figure 6.)

The architecture of the network support for the operation of the DSS of an oil and gas production company has been developed. The choice of a tool for the development of a designed DSS of an oil and gas company is not unambiguous task (the hybrid DSS architecture is proposed, therefore each module has a distinct specificity, and therefore an effective tool will differ for different modules; the complex of management solutions of an oil and gas company is very diverse, and therefore each group of solutions has its own effective DS methods (to which the modules of the designed DSS correspond); the subject area is characterized by a large non-factorizable solution space and, at some times, ambiguous and unreliable data and knowledge).

The system of economic and mathematical models (with elements of fuzzy knowledge) for evaluating the results of contractual relations between oil and gas production and service companies, namely seismic exploration works, was chosen for the approbation of economic efficiency in view of the specifics of the subject area. The results of the simulation on real data are shown in the table 2.

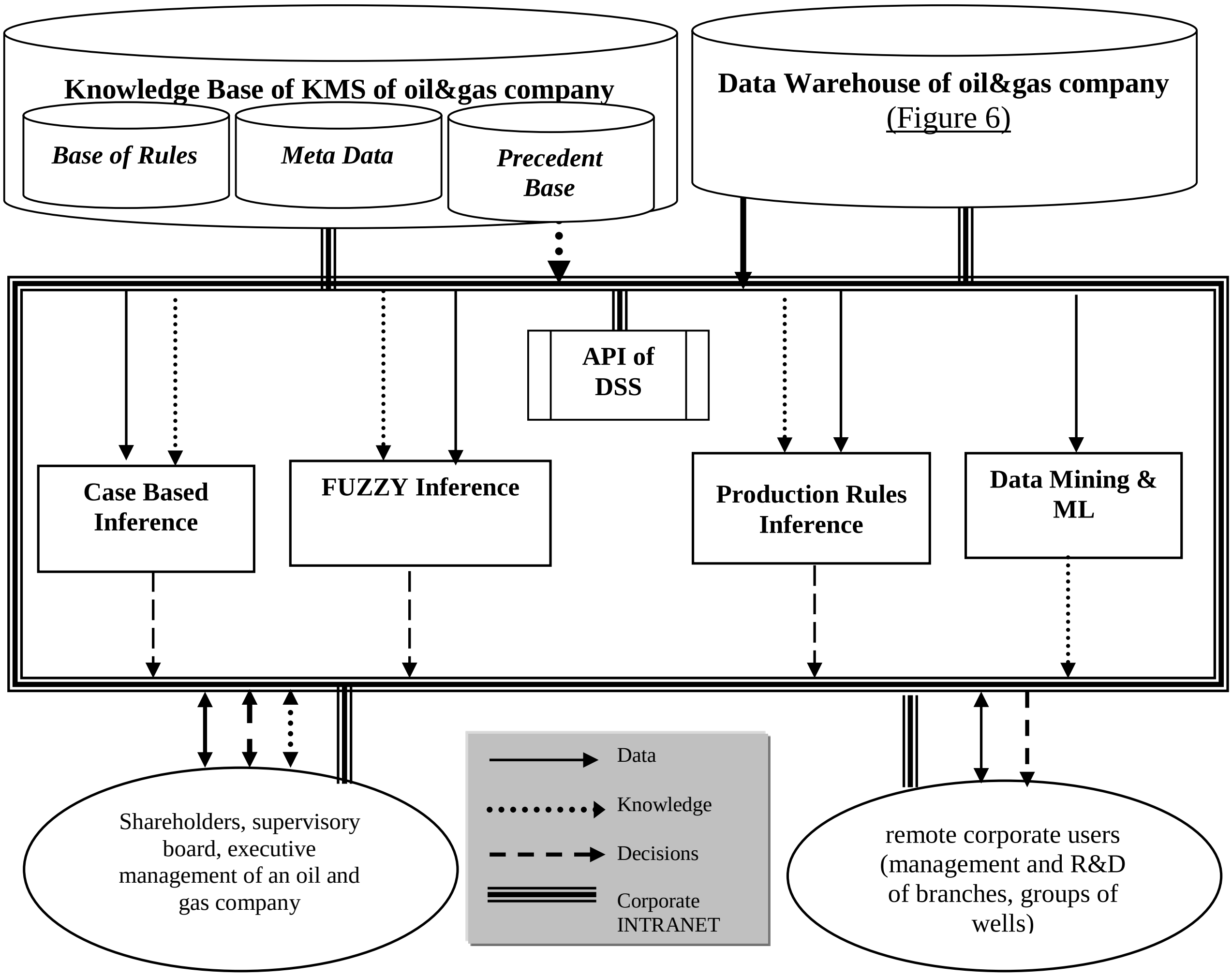

Figure 5. Developed architecture of a knowledge-oriented HYBRID DSS of oil&gas company

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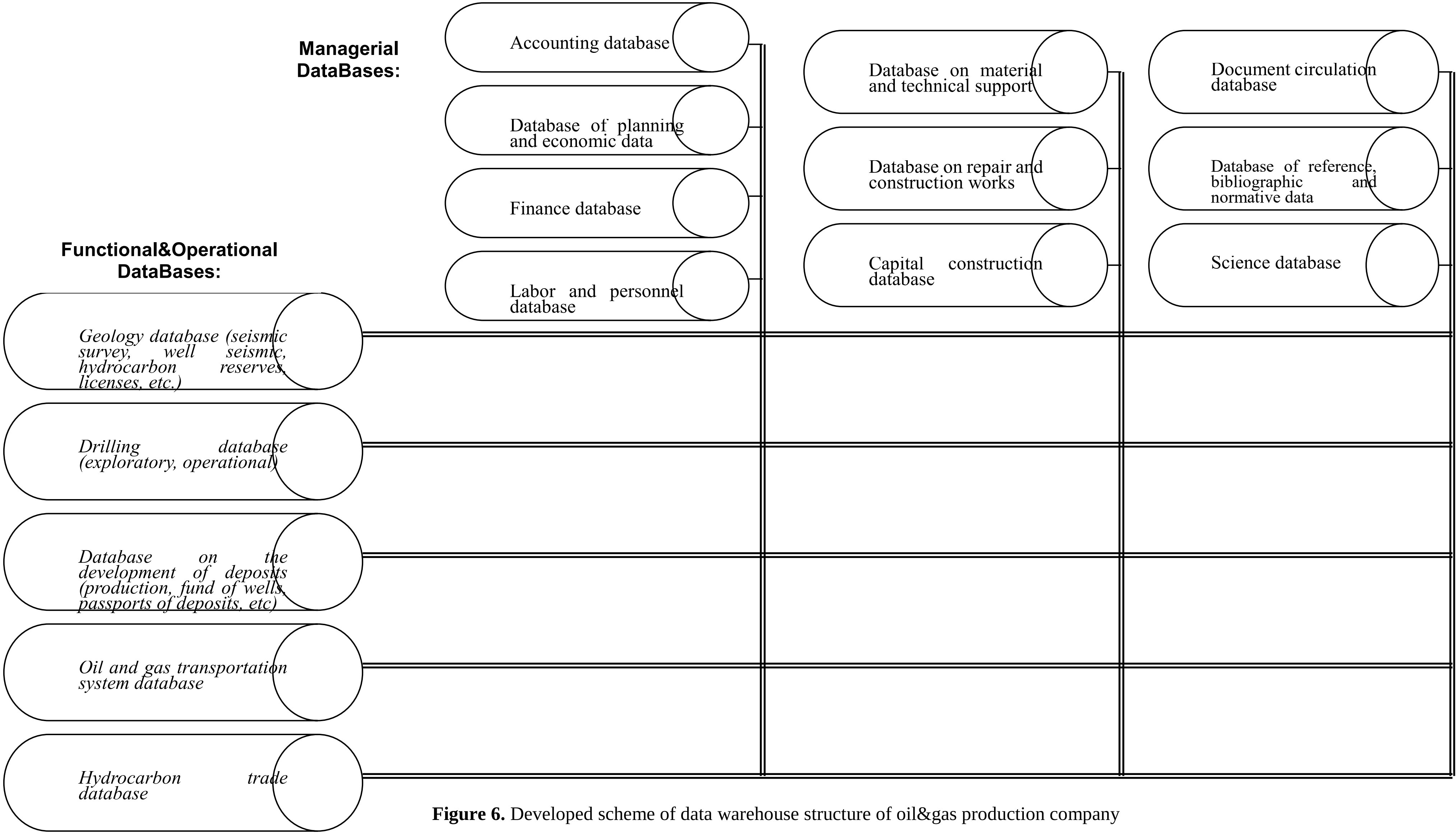

Figure 6. Developed scheme of data warehouse structure of oil&gas production company

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Table 2. Application of proposed economic-mathematical models (with elements of fuzzy knowledge) for evaluating the results of contractual relations between oil and gas production and service companies for conducting seismic exploration works

The oil and gas production company - the customer	The service crompany - executor	Deposit	The amount under the contract for conducting seismic exploration works, in thousand USD	The calculated value of the "penalty-incentive" coefficient of the quality of performed seismic exploration works for oil and gas	Calculated economic effect, in thousand USD
OJSC "Ukrgazvydobuvannya	CJSC "UNGG"	Lychkivsko-Novoselivske	3 235,7	1,03	80,9
OJSC "Ukrgazvydobuvannya	CJSC "UNGG"	Bilske	13 850,0	1,01	138,5
OJSC "Ukrgazvydobuvannya	CJSC "UNGG"	Bohatoiske	14 000,0	0,97	-420,0
OJSC "Ukrgazvydobuvannya	CJSC "UNGG"	Sentianivske	12 340,0	0,96	-493,6
OJSC "Ukrgazvydobuvannya	CJSC "UNGG"	Orilske	18 000,0	0,98	-360,0
JSC "Ukrnafta"	CJSC "UNGG"	Vilshansko-Reshetniakivske	5 736,0	0,97	-172,1
JSC "Ukrnafta"	CJSC "UNGG"	Buhruvativske	8 400,0	0,97	-252,0
Economic efficiency:					
		1). for an oil and gas production company:			*1 697,7*
		2). for a service company:			*219,4*
TOTAL general economic efficiency:					**1 917,1**

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DISCUSSION

Taking into account the cybernetic concept presented in this publication of the information system of an oil and gas company for emerging markets, the system of economic and mathematical support for decision-making at the macro level of an oil and gas production company, the use of knowledge-oriented DSS as a component of the means of implementing the developed knowledge management policy of an oil and gas production company require significant changes in the organizational structure of an oil and gas production company, changes in the business processes of the management decision-making, significant investments in the infrastructure of Data Centers of corporate IS (Ostapenko T. et al. 2022), which must undergo total reengineering.

However, according to the testimony of both Western and domestic experts and top managers, if even according to the most pessimistic forecast the result of implementation will be an increase in the effectiveness of management decisions by 5-10%, taking into account the huge economic and natural basis, the application of knowledge-oriented technology is always economically justified.

The practical implementation of certain theoretical provisions developed in this research project in the processes of supporting managerial decisions, managing the information system and existing knowledge met with full understanding and support of senior management and showed positive results (new innovative clients, shortening of the production life cycle, increase in total revenues, etc.) (Ramazanov et al. 2020a; Kovalenko-Marchenkova et al., 2022; Lazarova et al., 2023; Mikhno et al., 2022; Shopova et al., 2023; Iliev et al., 2023; Sribna et al., 2023).

In particular, modeling was carried out using real data to determine the economic efficiency of the economic and mathematical models developed in this publication (with elements of fuzzy knowledge) to evaluate the results of contractual relations of subcontracting for seismic exploration works on 7 areas between oil and gas production companies ("Ukrgazvydobuvannya" and "Ukrnafta") and the service company ("Ukrnaftogazgeofizyka") resulted in a total calculated economic efficiency.

It is necessary to take into account the fact that knowledge-oriented DSS cannot replace an experienced manager and a team of expert professionals in solving the tasks of an oil and gas company, but is only a tool that provides managers support to solve problems faster and more efficiently (Ramazanov et al. 2020b).

The theoretical provisions put forward in the paper and the developed DSS project are universal for implementation by both state and private oil and gas companies of various sizes, resident and non-resident companies, however, in order for a specific company to obtain its own special additional competitive advantages over others, additional R&D in this direction is required.

In addition, it should be noted that the full-scale practical implementation of similar content, scope and complexity of projects in the oil and gas industry, according to Western experts, takes up to 5 years for a highly experienced research team of experts.

Therefore, it can be concluded that, subject to further additional research and improvements, the practical use of the theoretical and practical provisions proposed in the scientific project is a necessary factor for ensuring the successful future existence of any oil and gas production company in the modern high-risk world of emerging markets.

CONCLUSION

This publication presents the part of the research results and practical results obtained by the authors regarding the hybrid use of economic-mathematical modeling, knowledge-oriented decision support technology of an oil and gas production company using fuzzy logical inference.

1. In particular, for the first time, the comprehensive system of economic and mathematical support for decision-making at the macro level of a domestic oil and gas production company in modern economic conditions was developed, and the following scientific results were obtained:

- the decision tree of effective decision-making support processes of the oil and gas company's strategic management (exploration and development of oil and gas fields) was developed and the rule base was formed for making this complete set of strategic decisions;

- the system of macro-prognostic (forecasting the growth of hydrocarbon reserves and their production) economic-mathematical models to support the adoption of strategic investment decisions of oil&gas production company was proposed;

- the economic and mathematical model of the optimal distribution of capital investments by regions and stages of work was improved;

- the algorithm based on economic and mathematical modeling (with elements of fuzzy knowledge) for selecting a contractor - a service company was proposed;

- the system of economic-mathematical models (with elements of fuzzy knowledge) for evaluating the results of contractual relations between oil and gas production and service companies was proposed.

2. Taking into account the obtained results of the economic analysis of the oil and gas production complex, the specifics of the oil and gas industry, the main factor in increasing production is the improvement of the efficiency of knowledge management in general thanks to the application of economic and mathematical modeling in the implementation of a knowledge-oriented decision support system of an oil and gas production company. This HYBRID DSS will be based on the following technologies: economic and mathematical modeling of the main investment and production business processes in the conditions of crisis phenomena, Data Science technology for filling and updating the corporate knowledge base, rule-oriented fuzzy Inference.

3. In order to carry out further studies of the effectiveness of the proposed provisions, a detailed approbation (based on the obtained historical data and expert knowledge) of the algorithm for using fuzzy knowledge-oriented technology in the developed system of economic and mathematical models was carried out.

An evaluation of the effectiveness of the developed economic and mathematical support of HYBRID DSS of an oil and gas company was carried out, in particular, the system of economic and mathematical models (with elements of fuzzy knowledge) for evaluating the results of contractual relations of subcontracting for seismic exploration, drilling and other R&D service between oil and gas production and service companies. The obtained results of the conducted simulation on real data are positive and have a tangible economic effect (table 2).

4. Based on the conducted research, the knowledge-oriented HYBRID DSS architecture of an oil and gas company was designed. The block for processing rules is the main one in this knowledge-oriented HYBRID DSS, in fact, other subsystems provide it with analyses, evaluations, and knowledge. The data storage structure of the oil and gas production company is designed, which correlates with the developed functional structure and is structured.

5. The scientific, theoretical and applied practical solutions proposed in this publication are universal for implementation by both state and private oil and gas resident and non-resident companies for emerging markets, however, in order for a specific oil and gas company to obtain special additional competitive advantages over others, additional industry-specific Big Data Analysis of collected and stored heuristics, expertise and project development are required

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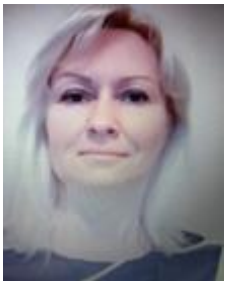

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APPENDIX A

The formalized content of the base of rules for determining the coefficient of "penalization-incentive" of the quality of executed R&D for oil and gas is presented in the table. 3, and in linguistic expression it is presented similarly to the above-mentioned base of rules for drilling works.

Table 3. Formalized content of the fuzzy base of rules for determining the coefficient of "penalization-incentive" of the quality of executed R&Ds for oil and gas

	name of the linguistic variables of the rule conditions	compliance with the deadline for the implementation of the R&D for oil and gas			validity of the results of the performed research works on oil and gas			scientific novelty of the performed NDR for oil and gas		
	range of definition of linguistic variables of conditions	delay in the implementation of the R&D	timely implementation of the R&D	early implementation of the R&D	satisfactory validity of the results	good validity of the results	excellent validity of the results	satisfactory scientific novelty	good scientific novelty	excellent scientific novelty
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
name of the target linguistic variable	*area of definition of the target linguistic variable*									
coefficient of "penalization-incentive" of the quality of executed R&Ds for oil and gas	fine for the insufficient quality of completed R&D	X			X			X		
			X		X			X		
		X				X		X		
		X			X				X	
		X			X					X

	base price of completed R&Ds	X				X			X	
coefficient of "penalization-incentive" of the quality of executed R&Ds for oil and gas	base price of completed R&Ds	X					X	X		
		X					X		X	
		X					X			X
			X		X				X	
			X		X					X
			X			X		X		
			X			X			X	
			X			X				X
			X				X	X		
			X				X		X	
				X	X			X		
				X	X				X	
				X	X					X
				X		X		X		
				X		X			X	
				X			X	X		
	stimulation of the quality of completed R&Ds			X			X			X
			X				X			X
				X			X		X	
				X		X				X

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The formalized content of the base of rules for determining the coefficient of "penalization-incentive" of the quality of performed seismic exploration works for oil and gas is given in table 4, and in linguistic expression it is presented similarly to the above-mentioned base of rules for drilling works.

Table 4. Formalized content of the fuzzy base of rules for determining the coefficient of "penalization-incentive" of the quality of performed seismic exploration works for oil and gas

	name of the linguistic variables of the rule conditions	compliance with the deadline for performing seismic exploration works for oil and gas			implementation of GTT for seismic exploration works for oil and gas			Probability of the existence of a hydrocarbon geological trap		
	range of definition of linguistic variables of conditions	delay in the execution of seismic exploration works	timely implementation of seismic exploration works	early implementation of seismic exploration works	satisfactory execution of GTT on the seismic exploration works	good execution of GTT on the seismic exploration works	excellent execution of GTT on the seismic exploration works	low probability of the existence of a trap	middle probability of the existence of a trap	high probability of the existence of a trap
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
name of the target linguistic variable	*area of definition of the target linguistic variable*									
coefficient of "penalization-incentive" of the quality of executed seismic exploration works on oil	fine for the insufficient quality of completed seismic exploration works	X			X			X		
			X		X			X		
		X				X		X		
		X			X				X	

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	base price of completed seismic exploration works	X			X					X
		X				X			X	
		X				X				X
coefficient of "penalization-incentive" of the quality of executed seismic exploration works on oil and gas	base price of completed seismic exploration works	X					X	X		
		X					X		X	
		X					X			X
			X		X				X	
			X		X					X
			X			X		X		
			X			X			X	
			X			X				X
			X				X	X		
			X				X		X	
				X	X			X		
				X	X				X	
				X	X					X
				X		X		X		
				X		X			X	
				X			X	X		
	stimulation of the quality of completed seismic exploration works			X			X			X
			X				X			X
				X			X		X	
				X		X				X