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DEVELOPMENT OF A METHODOLOGY FOR ASSESSING INNOVATION ACTIVITIES FOR MANAGEMENT PURPOSES FOR OIL AND GAS COMPANIES

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The study focuses on the innovation activity of oil and gas companies, solving the problem of evaluating this activity and presenting the results:

– the author's methodology for assessing the innovation activity of oil and gas companies has been developed, the results of which allow to fix the development point in the range of [0–0.5) – "Inert"), [0.5–0.7) – "Developing" and more than 0.7 – "Active". For each range, management strategies for the future are recommended;

– the 5 oil and gas companies were evaluated according to three criteria. In the group of indicators "Investments" the best result is Total (0.95), in the group of indicators "Human resources" all companies showed a high result, on patent activity the European companies have a high result (0.81–0.83). Kazakhstan organizations, having more than sufficient human resources in the R&D sector, are not financed at a competitive level, which leads to a low level of patent activity of companies;

– according to the result of the innovation activity assessment, the companies were distributed as follows: "Inert" – TCO (0.43) and KPO (0.32), "Developing" – Shell and ENI (0.68), "Active" – Total (0.81).

The results suggest that the calculated method for determining indicators can be used to assess the innovation activity of oil and gas companies, considering the production factor.

The results highlight the development of a methodology for assessing the innovation activity of oil and gas companies based on three main criteria, aimed at improving management.

The methodology can be used by oil and gas companies and government agencies interested in industry development

Keywords: oil and gas companies, innovation activity, investments, human resources, patent activity, R&D

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1. Introduction

The oil and gas sector has been going through a challenging period in recent years. Due to prolonged volatility in oil prices, asset owners have been forced to be more careful in selecting projects, resulting in capital outflows in the industry. As sources of conventional oil are exhaustible, the development of hard-to-recover reserves, including those located in remote regions or difficult geographical conditions, is becoming necessary for these companies, but these projects are characterized by both high investment costs and complexity of implementation.

At the same time, the return on long-term investments is increasingly influenced by the geopolitical situation, which determines the decline in the accuracy of medium- and long-term forecasts. Difficulties in determining future oil prices are associated with the inelasticity of supply and demand in the industry, market hypersensitivity to various economic, and nowadays political and economic, shocks, for example: the oil production crisis in Venezuela, unpredictable behavior in the world market of Russia and Iran, OPEC decisions and others. Taking into account these and other variables, it can be noted that since 2020 there has been an acute crisis in the global energy market.

In conditions of tougher competition for energy resources, there is an increase in the diversification of innovation development strategies, both in European companies and in corporations in America and China. In this situation, the principle of strategic management [1] is applicable, which is that when the risks of uncertainty in the external environment increase, companies diversify their innovation portfolio. In order to diversify the goals and objectives of innovative development, it is necessary to form a favorable internal environment of the organization, to create innovative potential, on which the growth of patent activity and leadership in the field of creation and implementation of new technological solutions is based.

In the near future of "Industry 4.0" technological advantages will become the determining factors of competitiveness on the global stage [2]. Increased interest in innovation is shown by successful players, which will allow them to compensate for possible losses in the face of new shocks in the oil market and strengthen their own competitiveness in the industry.

The assessment of innovation activity as part of management helps to identify the strengths and weaknesses of innovation processes, determine the tasks for their improvement, and prevent possible risks. Large industrial corporations create a hierarchical system of innovation performance indicators. Performance evaluation is carried out by controlling units that are part of the innovation management system.

The growing requirements to the performance of innovation activity lead to the need to develop a methodological base for its assessment and management, and to make effective strategic decisions. Thanks to the improvement of methods of strategic management of innovation activity, the stability of the oil and gas industry development is ensured, which in many countries is the stronghold of the entire economy. The problems of oil and gas companies' development are complicated by the lack of theoretical elaboration on the issues of innovation activity management in this industry. All this determines the relevance of studying the topic of assessment of innovation activity for management purposes for oil and gas companies.

2. Literature review and problem statement

The paper [3] presents the results of the study of innovation activity of extractive industry organizations. It is shown that such activity can be qualitatively assessed by determining the efficiency of activity for a certain period. But there are still unresolved issues related to the fact that the effectiveness of innovation activity in this study is reduced to efficiency. The reason for this may be the lack of development of the categorical apparatus at the stage of preparation for the study. The way to overcome these difficulties may be to distinguish between the effect and the result of the enterprise's activity. This approach was used in the classic work [4], which notes that first it is necessary to choose a strategy, target orientation of activity, and then to direct efforts to achieve the set goals at the minimum amount of necessary costs. But it is important to note that there are fundamental differences that should be taken into account in the process of analysis: efficiency shows to what extent the planned activity is realized and the planned results are achieved, efficiency is determined by the ratio of the achieved result to the used resources. All this suggests that it is advisable to conduct a study on the integrated assessment of innovation activities for the purposes of company management, reflecting both results and efficiency.

Another study [5] shows that both efficiency and effectiveness of innovation activity are assessed through a system of indicators of the final performance of the enterprise as a whole. Standards, regulations and procedures that reflect the actual state of the enterprise's performance are presented. The list consists of a set of indicators subject to quantitative measurement, in a certain period of time, the degree of achievement of operational and strategic objectives, comparison of the results of the organization with other industry organizations. However, here the main indicators of the final performance of the enterprise are incorrectly considered as a list of "key performance indicators", although it appears only as "key performance indicators" or "key performance indicators". The way to overcome this error may be the creation of an independent system of indicators directly related specifically to innovation activity.

The paper [6] expresses the opinion that it is necessary to introduce the parameters for assessing the functioning of the enterprise in the innovation sphere only at the project level from the stage of prototyping to the final product. It is proposed to use various criteria to evaluate the project, including innovativeness, level of technological complexity, expected profitability. Critical understanding of this statement leads to the position of the system approach, which assumes the interrelation of processes and results at all levels. And it is the system approach in management that is important for management. The implemented analysis and monitoring tools are an integral element of the strategies of enterprises, their branches, subdivisions and subsidiaries, so the level of a single project is clearly insufficient.

The work [7] proposes a program-targeted method of evaluating innovation projects, in which the latter are combined into groups or "programs". At this stage of management, the manager combines risky and low-risk projects, creating a balance between profitability and risk. But the issues of the overall economic effect for the company as a whole remain unresolved. This suggests the inexpediency of artificial groupings without linking them to the target development of the enterprise.

A similar approach was used in [8]. It is proposed to assess the innovation portfolio, which consists of innovative projects of the enterprise. At this stage, the assessment of timing, technological complexity, potential profitability and risks is carried out. However, it is not assessed whether the projects correspond to the strategy of the enterprise.

The paper [9] evaluates non-financial results that are achieved by R&D units. It analyzes the quality indicators of the innovation development process and the achievement of planned results of the innovation strategy, as well as the innovation culture of the enterprise. Such an assessment can be critically defined as one-sided, incomplete, when innovations are assessed for the sake of innovations themselves, their "embeddedness" in the system of the enterprise's activity is not taken into account.

Traditional methods of assessing the innovation activity of extractive industry enterprises are often based on the assessment of investment projects. Thus, in the study [10] the main indicators are the payback period of capital expenditures, net discounted income, profitability index and internal rate of return of the project, internal rate of return and accounting profitability, etc. Despite the importance of the financial aspect in innovation management, it is important to take into account that the system of innovation assessment, which is based on the profitability of projects, is not universal due to the following reasons:

– implementation of innovative activities under conditions of uncertainty and high risk;

– long-term nature and delayed profitability from the implementation of innovative developments, management innovations have a long lag of profit receipt.

The paper [11] developed an assessment of the innovation activity of oil and gas companies based on the profitability of investment in projects. But if the company limits itself to short-term research to obtain a quick profit, it can become a barrier to achieving a better result in the long term. The solution to this problem can be the development of indicators with a balance between standard financial and long-term characteristics of innovation activity.

The paper [12] proposes to calculate economic, scientific and technological, environmental, social and resource effects when assessing the innovation activity of large business enterprises. But there are still unresolved issues related to the integration of these effects into one system. In cases when the effects associated with innovation activities are not limited by economic frameworks, there is a difficulty in developing an adequate set of indicators to assess innovation activities. A way to overcome these difficulties may be to exclude derivative, but not direct effects of the sphere under study.

The study [13] suggests analyzing innovation projects by evaluating assets, discounted cash flows, real managerial options, etc. It is envisaged to add up economic, environmental, intellectual and social effects with their correct translation into cost indicators. However, the fact that financial and economic indicators are the main criteria of innovation activity for an oil and gas company is not taken into account. This suggests that it is advisable to rank different effects in order to obtain a balance that corresponds to the interests of a particular enterprise.

The effectiveness of scientific and technological developments has a predominant importance in assessing the performance in the field of innovation in those oil and gas projects, where the period of implementation of innovations, as stated in [14], is at least 10 years. Agreeing with this position, we emphasize that it is in the longitudinal assessment that we can observe a decrease in the cost of technology and equipment, a decrease in resource requirements, production costs and an increase in labor productivity.

The paper [15] argues that innovation investments include investments in infrastructure, human resources (the number of personnel of the innovation unit and their level of education) and research tools, which should be evaluated separately. Not agreeing with this position completely, we note the following. Despite the fact that it is not always possible to accurately determine the level of innovation activity of an organization when studying the R&D cost indicator, it is important for monitoring innovation activity by managers of large corporations (small and medium-sized enterprises due to their scale almost do not perform it).

Thus, in economic science the problem of assessment of innovation activity for management purposes for oil and gas companies is insufficiently researched. Difficulties with the selection and systematization of indicators, the mechanism of evaluation and, most importantly, the application of its results in making managerial decisions have not been solved. In addition, the assessment is often reduced to the general financial results of the enterprise, or, on the contrary, is diluted by the inclusion of derivative, indirect effects. All this suggests the expediency of conducting research on the development and application of a methodology for assessing the innovation activity of oil and gas companies, applicable in management.

3. The aim and objectives of the study

The aim of the study is: to develop and apply a methodology of innovation activity assessment for companies in the oil and gas industry. This will make it possible to apply the assessment results for strategic management purposes.

To achieve this aim, the following objectives are accomplished:

– to disclose the main groups of indicators of the methodology for assessing the innovative activity of oil and gas companies;

– to carry out calculations to assess the innovation activities of specific oil and gas companies;

– to summarize the assessment of innovation activities of oil and gas companies.

4. Materials and methods of research

The object of the study is the innovative activity of oil and gas companies.

Hypothesis of the research: innovation activity of oil and gas companies can be evaluated on the basis of the calculation method of determining indicators taking into account the factor of production.

The study is simplified by using average indicators both horizontally (for the period under study) and vertically (by indicators within groups).

Analytical, induction, deduction, comparative, statistical, dynamic methods and regression analysis method were used in this study.

The source information was obtained from available data sources: accounting and financial and economic reports of oil and gas companies and other information available on official websites. The selection of companies is based on the relevance of the industry under study and availability of source data for analysis. The period of the last 10 years (2014–2023) selected for the analysis allows the use of averaged data to minimize the probability of a random decline or peak.

In accordance with the selected method, the estimated indicators based on world practice (averaged) presented in [16] were used. Thanks to the regression method it became possible to determine the estimated result (the regression equation is presented in the structure of indicator formulas). The calculations are carried out through the ratio of the obtained result of the enterprise to the model indicator among organizations of the same profile, excluding the indicators of statistical outliers.

An integral indicator is calculated from its constituent private indicators that are commensurate with each other and are in the same format.

Data processing was performed using Statistica 12 software (France).

5. Results of the study on assessment of innovation activity of oil and gas companies

5. 1. Main groups of indicators of the innovation performance assessment methodology

The groups of indicators are categorized according to three criteria:

1. Investments.

R&D expenses (VC):

$$VC=\frac{VC_f}{VC_m}, \tag{1}$$

where VC_f – R&D expenses,

VC_m – model R&D costs.

R&D costs to company revenue ratio (VCR):

$$VCR=\frac{VC_f}{0.005*R-0.09}, \tag{2}$$

where R – revenue, bln USD.

R&D costs per person (VCP):

$$VCP=\frac{VCP_1}{VCP_m}, \tag{3}$$

where VCP_1 – R&D expenditures per person, thousand USD;

VCP_m – model costs per person, thousand USD.

Consistency of the R&D cost per person indicator with the estimated figures (VCP_c):

$$VCP_c=\frac{\frac{VC_f}{n}}{\frac{1,000(0.005*R-0.09)}{n}}, \tag{4}$$

where n – number of R&D employees.

2. Human resources.

Number of R&D personnel (P):

$$P=\frac{P_h}{P_m}, \tag{5}$$

where P_h – number of R&D employees, persons;

P_m – model number of R&D employees, persons.

The ratio of the number of R&D employees to the scale of operating activities (P_c):

$$P_c=\frac{P_h}{0.0465(0.022*P-7.489)}, \tag{6}$$

where P – production (thousand barrels per day).

3. Patent activity.

Patents Obtained (PA):

$$PA=\frac{PH}{PH_m}, \tag{7}$$

where PH – patents received, units;

PH_m – model number of patents obtained, units.

A measure of the number of available patents to estimated patents (PA_c):

$$PA_c=\frac{1.4*VC_f+41.23}{PH}, \tag{8}$$

Cost-effectiveness (E):

$$E=\frac{EP}{EP_m}, \tag{9}$$

where EP – R&D cost-effectiveness of patents;

EP_m – model indicator of R&D cost efficiency on patents.

Patents received per person (PQ):

$$PQ=\frac{P_q}{P_m}, \tag{10}$$

where P_q – number of patents received per person, units;

P_m – model indicator of the number of patents obtained per person, units.

Correspondence between the number of patents granted per person and the calculated indicator (PQ_c):

$$PQ_c=\frac{0.001*VC_p+0.073}{P_q}, \tag{11}$$

where VC_p – costs per R&D employee, thousand USD.

The final score for the three criteria (investments, human resources, patent activity) is determined by calculating the average score for their respective indicators.

Thus, the proposed assessment methodology combines publicly available economic indicators of oil and gas companies' activities directly related to the innovation sphere. Their correlation with the calculated indicators makes it possible to take into account the company's place in the competitive market, and the inclusion of the production factor – to reflect the effectiveness of innovation activity.

5. 2. Calculations on assessment of innovation activity of oil and gas companies

The results of oil and gas companies sampling for analysis showed that the most open and transparent in official statistics are European companies, namely: Dutch Royal Dutch Shell PLC (hereinafter – Shell), French Total Energies SEE (hereinafter – Total) and Italian Eni S.p.A (hereinafter – ENI). The largest Kazakhstani oil and gas companies Tengizchevroil LLP (hereinafter – TCO) and Karachaganak Petroleum Operating B.V. CJSC (hereinafter – KPO) were selected for comparison with them (hereinafter – KPO).

According to the presented model, the innovation activity of these companies was assessed, which starts with calculation of scores for the group of indicators "Investments" (Table 1).

Table 1

Evaluation of the group of indicators "Investments" 2014–2023

Indicator	TCO	KPO	Shell	Total	ENI
R&D expenses (VC)	0.40	0.16	0.79	0.80	0.81
Matching R&D costs to company revenue (VCR)	0.48	0.32	0.55	1	0.54
R&D costs per person (VCP)	0.09	0.04	0.75	1	0.45
Compliance of the R&D cost per person with the estimated figures (VCP_c)	0.47	0.32	0.55	1	0.54
Average score	0.36	0.21	0.66	0.95	0.585

As can be seen from Table 1, despite the similar R&D expenditures of European companies, the final average score of Shell and ENI is significantly different from Total, which is due to their low positions in the competitive innovation market. For Kazakh companies, the low score for investment sphere indicators reflects the result of low indicators for all structural components (<0.5).

At the second stage of the assessment, the indicators of the "Human Resources" group are calculated (Table 2).

Table 2

Evaluation of the group of indicators "Human Resources" 2014–2023

Indicator	TCO	KPO	Shell	Total	ENI
R&D personnel (P)	0.83	0.73	0.83	0.80	0.83
Matching the number of R&D personnel to the scale of operations (P_c)	1	1	1	1	0.88
Average score	0.92	0.86	0.92	0.9	0.85

According to the data in Table 2, all companies under study demonstrate good performance in terms of the "Human Resources" criterion. The final score of Kazakhstan TCO corresponds to the level of Dutch and French companies, while KPO corresponds to the level of the Italian company.

Patent activity data are then computed, including cost-effectiveness in this area (Table 3).

Table 3

Evaluation of indicators of the "Patent Activity" group 2014–2023

Indicator	TCO	KPO	Shell	Total	ENI
Number of patents (PA)	0.38	0.14	0.47	0.8	0.8
Number of patents to estimates (PA_c)	0.32	0.29	0.62	1	0.92
Cost-effectiveness (E)	0.63	0.56	0.93	0.8	0.86
Number of patents per person (PQ)	0.16	0.08	0.8	0.75	0.7
Number of patents per person to the estimated figures (PQ_c)	0.44	0.20	0.81	0.82	0.84
Average score	0.39	0.25	0.73	0.83	0.82

As can be seen from Table 3, the high scores for all items of patent activity of Total and ENI give a good result (0.83 and 0.82 points, respectively), while Dutch Shell comes close to it solely due to cost efficiency and the number of patents per person to the calculated indicators. Despite the fact that Kazakhstani companies have cost efficiency greater than 0.5, the other indicators that make up the patent activity block are considerably low, which levels out the total for this criterion.

Thus, all indicators are converted into scores, which allows us to calculate their average final value. This will provide an opportunity to assess the innovative activity of companies, but the structural cross-section also allows us to see the causes and build management strategies.

5. 3. Outcome of the assessment of innovation activity of oil and gas companies

Let us compare the overall assessment of innovation activity of companies (Table 4).

Table 4

Assessment of innovation activity of oil and gas companies 2014–2023

Indicator	TCO	KPO	Shell	Total	ENI
R&D costs (VC)	0.40	0.16	0.79	0.8	0.81
Correspondence of R&D costs to the company's revenue (VCR)	0.48	0.32	0.55	1	0.54
R&D costs per person (VCP)	0.09	0.04	0.75	1	0.45
R&D costs per person to estimated costs (VCP_c)	0.47	0.32	0.55	1	0.54
Number of personnel R&D (P)	0.83	0.73	0.83	0.8	0.83
Number of personnel to the scale of operations (P_c)	1	1	1	1	0.88
Patents obtained (PA)	0.38	0.14	0.47	0.8	0.8
Number of patents to estimated (PA_c)	0.32	0.29	0.62	1	0.92
Cost-effectiveness (E)	0.63	0.56	0.93	0.8	0.86
Number of patents per person (PQ)	0.16	0.08	0.8	0.75	0.7
Number of patents per capita to estimated (PQ_c)	0.44	0.2	0.81	0.82	0.84
Final score	0.43	0.32	0.68	0.81	0.68

As can be seen from Table 4, the R&D expenditure indicators for three positions for Italian ENI and two positions for Dutch Shell did not allow them to reach the high level of innovation of French Total. Shell's lagging behind is also due to its low score on patents obtained (0.47). High indicators of the group "Human Resources" did not help Kazakh oil and gas companies to become in line with European companies, as for other components of innovation activity there is a significant lag.

To visualize the final results, a graphical method with conversion of scores into percentages (where 1 point=100 %) was applied (Fig. 1).

According to Fig. 1, Kazakh oil companies TCO and KPO occupy positions below the median (less than 50 %), the next level is occupied by Italian and Dutch companies (ENI and Shell with the same result of 68 %), and the leading, but not the maximum position, is occupied by French Total (81 %).

The outcomes of the assessment identify the strategies that are recommended for each outcome to promote innovation (Table 5).

Thus, the outcome of the assessment of the innovation activity of oil and gas companies allowed us to position them on a comparative scale. The distribution of evaluated companies into groups will allow not only to fix the current level of innovation activity development, but also to determine the necessary directions for the strategic perspective.

Table 5

Characterization of the results of the assessment of innovation activity of companies and proposed strategies

Result name	Points	Characterization	Management
"Inert"	[0–0.5)	Maintain competitive market positions due to periodic purchase of new technologies. Funds are saved by reducing R&D costs	It is necessary to set a strategic goal of development and implementation of own innovative technologies, otherwise there is a high probability of consolidation of technological dependence, which, firstly, increases the total cost of technology procurement, secondly, puts at risk all the work of enterprises in case of a supply crisis, and thirdly, prevents them from becoming leaders in terms of investment attractiveness
"Developing"	[0.5–0.7)	Competitive position in the market is maintained due to the use of technologies to improve operational efficiency. Low costs of high-risk projects, small potential to enter emerging markets	It is necessary to develop a strategic plan for gradual substitution of partially purchased new technologies for a long-term period with monitoring and evaluation of innovation activities and overall financial and economic performance of the company
"Active"	>0.7	Characterized by significant R&D costs, high patent activity in a competitive environment. This strategy allows capturing new markets due to technological leadership, increased costs for innovation projects with high risks and long payback period	There is a need to develop strategic risk management of innovation activities

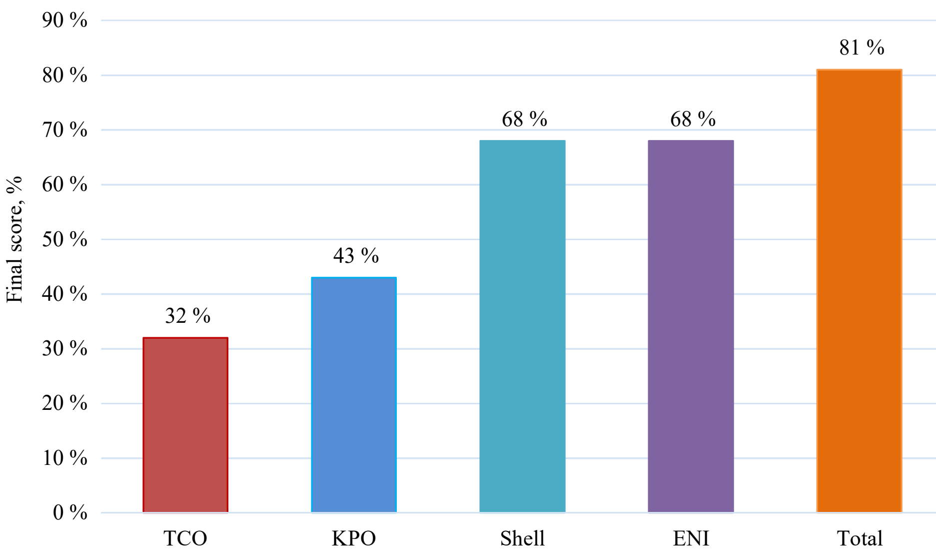

Fig. 1. Assessment of innovation activity of oil and gas companies 2014–2023 in %

6. Discussion of the results of the assessment of oil and gas companies' innovation activities

The methodology for assessing the innovation activity of companies in the oil and gas industry presents indicators, the calculation of which complies with the principles of accessibility and clarity. If the ratio according to (1)–(11) is greater than one, the result is taken as 1 in order to normalize the indicators. The average score is calculated for three groups of indicators: investments (1)–(4), human resources (5), (6) and patent activity (7)–(11). The overall score shows the level of technological independence and readiness to successfully develop breakthrough innovations in a strategic perspective.

Kazakhstani companies lag behind their competitors in terms of absolute R&D costs, as can be seen in Table 1. Rosneft's results are the closest to the indicators of the competitive environment.

Similar results are obtained when analyzing the VCR indicator (compliance of R&D costs with the company's revenue) of two Kazakh oil and gas corporations Gazprom PJSC and Lukoil PJSC: their score was no more than 0.5 and does not correspond to the calculated indicator, so we can conclude that these organizations attach less importance to financing in innovations when their revenues are comparable with their competitors.

Kazakhstani companies have an oversupply of personnel, at the same time innovation activities are insufficiently financed, which leads to lagging R&D expenditure indicators compared to those of foreign competitors. It can be concluded that the volume of investments does not correspond to the number of personnel and is insufficient to achieve ambitious goals. If the R&D costs are increased to the estimated values, it will lead to an improvement in the financing indicators per employee.

According to the data obtained, it can be noted that the largest gap of indicators for the "Investments" group is observed in PJSC Gazprom. Total's data are the closest to the calculated values.

Analyzing the indicator of the number of R&D personnel in relation to the total number of employees of the enterprises, we can notice insufficient staffing of the R&D centers of the Kazakh companies PJSC "Gazprom" and PJSC "Lukoil" with scientific personnel, so the speed and quality of execution of goals and objectives for the implementation of innovation strategies are reduced (Table 2).

Although the estimated personnel indicator is indicative, domestic companies may be overstaffed (Table 2). The total number of R&D employees of Kazakhstani companies is above the expected figures, which are obtained according to the existing level of oil and gas production. Due to the fact that there is a general oversupply of staff in the key segment, popular conclusions about the shortage of R&D staff may be erroneous.

In general, the correspondence of the number of R&D personnel to the scale of operations is quite high for all the companies represented.

Oil and gas companies Total and ENI are the leaders according to the indicators of the "Patent Activity" group (Table 3).

Comparing the data of Tables 1, 3, we can conclude that innovation activity in Kazakhstani companies is insufficiently financed, due to which patent activity indicators are at a low level. It can be assumed that Kazakhstani companies lag behind foreign industry leaders in the development of innovative ideas, but the problem may lie deeper: in post-Soviet countries the institution of property rights protection is not developed, many innovations are simply not registered, but are provided by the principle of non-disclosure of trade secrets. There is a need for standardization of innovation management processes in Kazakhstani companies.

Indicative analysis of the efficiency of R&D expenditures by Kazakhstani companies confirms the results obtained: the number of patents corresponds to the volume of expenditures and is within the European experience (>0.5). Increase in R&D expenditures will help to increase absolute indicators of the patent activity of Kazakhstani enterprises.

The analysis shows that the number of patents obtained per one laboratory employee in European companies is several times higher than in Kazakhstani companies. According to the current R&D funding, the indicator of the model number of patents per person has not yet been reached. This could arise due to the dilution of the R&D budget directed to R&D centers with increased staffing.

The obtained results (Fig. 1) indicate the need to improve the mechanism of innovation management in Kazakhstani companies.

"Inert" result of innovation activity (Table 4) is shown by Kazakhstani oil and gas companies TCO and KPO. If it is maintained for a long time, it leads to the development of technological dependence, acceptance of a catching-up role in the world market. False saving of funds for innovation activities gives only short-term result, while in the medium and long term the company will lose in comparison with competitors, including in investment attractiveness and financial and economic results. It is important to emphasize the emerging negative macroeconomic effect of choosing such inert functioning by systemically important enterprises: if market leaders reduce R&D costs, there may be a risk of the industry lagging behind at the national and global levels. To solve the problem, it is recommended to set a strategic goal at the top management level to develop and implement their own innovative technologies (Table 5).

The European oil and gas companies Shell and ENI demonstrate a "developing" result of innovation activity. Expenditures on high-risk innovation projects are foreseen here, but they are limited to medium-term results. In this regard, some technologies are still purchased. As a result, in the absence of a progressive strategy, it is possible to "hang in the balance", which prevents the company from claiming leadership in the global market and taking a stable position in new markets. Therefore, it is necessary to develop a strategic plan for gradual replacement of partially purchased new technologies for a long-term period. To mitigate risks, it is recommended to promptly monitor and evaluate innovation activities at each stage, as well as control the dynamics of the company's overall financial and economic performance.

Only the French oil and gas company Total has an "active" result of innovation activity. Such companies are pioneers in innovation development and constantly monitor competitors in the global market to adjust the level of their innovation activity. Since high innovation activity is associated with increased risks, it is recommended to put innovation risk management at the center of the strategic management of the company.

The proposed methodology provides an opportunity to expand the innovation funnel, to create and implement progressive ideas of sustainable development, to become the owner of leadership positions in the competitive environment, to acquire technological independence from exporters of innovative solutions.

A similar study was found [17], which analyzes the process-space management of innovation activity of an oil and gas enterprise on the basis of evaluation. Compared to the present study, the evaluation indicators here are much larger, represented by 8 criteria (material and technical, personnel, infrastructure, research and development, etc.). This is due to the fact that in [17] management proposals are formed based on the assessment of innovation potential. Nevertheless, access to such a significant list of indicators is significantly limited, therefore, the methodology proposed in this study is more realistic and convenient.

Unlike [17], where the assessment of innovation potential is proposed for management purposes, this result (methodology for assessing innovation activity) allows building management decisions based on the actual work of the company that develops and implements innovations. This became possible due to a specified set of indicators in the direction of "investment – result" taking into account the factor of oil and gas production.

The study has certain limitations, as the dynamics of changes in the studied parameters is calculated for the last 10 years. Expansion of the period can give more accurate results.

A disadvantage of the study is that the list of indicators is limited by official reporting, while the increased availability and openness of data on the innovation activities of the selected oil and gas companies could provide a more accurate result.

The difficulties of the study are related to access to the source data for the assessment of innovation activity, as the reporting of oil and gas companies in different countries is not standardized. The obtained results reflect the peculiarities of Kazakh and European oil and gas companies. Comparative analysis of different countries is necessary to obtain more universal results.

Thus, the research has allowed us to develop a methodology for assessing innovation activity applicable to oil and gas companies. The possibility of using this methodology in management determines its practical value, while the existing limitations and shortcomings can be overcome.

7. Conclusions

1. The author's methodology for assessing the innovation activity of oil and gas companies has been developed on the basis of three groups of indicators: investments (R&D expenditures, their ratio to the company's revenue, R&D expenditures per person and their compliance with the calculated indicators); human resources (the number of R&D personnel and compliance with the scale of operating activities); patent activity (the number of patents, the efficiency of expenditures on them, the number of patents per person and their compliance with the calculated indicators). The results allow fixing the development point in the range of [0–0.5) – "Inert"), [0.5–0.7) – "Developing" and more than 0.7 – "Active".

2. Five oil and gas companies were assessed according to three criteria. In the group of indicators "Investments" the high result was shown by Total (0.95), in the group of indicators "Human Resources" all companies showed a high result, with TCO and Shell leading with an indicator of 0.92. In the group of indicators "Patent activity" only European companies have a high result: Shell (0.81), ENI (0.82) and Total (0.83). Kazakhstan organizations, having more than sufficient human resources in the R&D sector, are not financed at a competitive level, which leads to a low level of patent activity of companies.

3. "Inert" final result of innovation activity is shown by Kazakh oil and gas companies TCO (0.43) and KPO (0.32). At the top management level it is recommended to set a strategic goal of development and realization of own innovative technologies. "Developing" result of innovation activity (0.68) is demonstrated by European oil and gas companies Shell and ENI. It is recommended to develop a strategic plan for gradual replacement of partially purchased new technologies for a long-term period with operational monitoring and evaluation of innovation activity at each stage. "Active" result of innovation activity was obtained only by the French oil and gas company Total (0.81). It is recommended to put innovation risk management at the center of the company's strategic management.

Conflict of interest

The authors declare that they have no conflict of interest in relation to this research, whether financial, personal, authorship or otherwise, that could affect the research and its results presented in this paper.

Financing

The study was performed without financial support.

Data availability

Data will be made available on reasonable request.

Use of artificial intelligence

The authors have used artificial intelligence technologies within acceptable limits to provide their own verified data, which is described in the research methodology section.

References

1. Ansoff, H. I. (1979). Strategic Management. Palgrave Macmillan UK. https://doi.org/10.1007/978-1-349-02971-6_6
2. UNIDO strengthens global collaboration at ISO Annual Meeting 2024. Available at: https://www.unido.org/news/unido-strengthens-global-collaboration-iso-annual-meeting-2024
3. Gruenhagen, J. H., Parker, R. (2020). Factors driving or impeding the diffusion and adoption of innovation in mining: A systematic review of the literature. Resources Policy, 65, 101540. https://doi.org/10.1016/j.resourpol.2019.101540
4. Drucker, P. F. (1964). Managing for Results: Economic Tasks and Risk-Taking Decisions. London: Heinemann. Available at: https://archive.org/details/managingforresul0000druc_f0p5
5. Yang, H. (2023). Resource Integration and Synergistic Innovation Effect of Innovative Enterprises. SSRN Electronic Journal. https://doi.org/10.2139/ssrn.4454176
6. Taques, F. H., L pez, M. G., Basso, L. F., Areal, N. (2021). Indicators used to measure service innovation and manufacturing innovation. Journal of Innovation & Knowledge, 6 (1), 11–26. https://doi.org/10.1016/j.jik.2019.12.001
7. Islam, M. M., Hossain, M. M. (Eds.) (2020). Science and Technology Innovation for a Sustainable Economy. Springer International Publishing. https://doi.org/10.1007/978-3-030-47166-8
8. Yaghmaei, E., van de Poel, I. (2020). Assessment of Responsible Innovation. Routledge. https://doi.org/10.4324/9780429298998
9. Scaliza, J. A. A., Jugend, D., Chiappetta Jabbour, C. J., Latan, H., Armellini, F., Twigg, D., Andrade, D. F. (2022). Relationships among organizational culture, open innovation, innovative ecosystems, and performance of firms: Evidence from an emerging economy context. Journal of Business Research, 140, 264–279. https://doi.org/10.1016/j.jbusres.2021.10.065
10. Grabowska, S., Saniuk, S. (2022). Assessment of the Competitiveness and Effectiveness of an Open Business Model in the Industry 4.0 Environment. Journal of Open Innovation: Technology, Market, and Complexity, 8 (1), 57. https://doi.org/10.3390/joitmc8010057
11. Bai, C., Dallasega, P., Orzes, G., Sarkis, J. (2020). Industry 4.0 technologies assessment: A sustainability perspective. International Journal of Production Economics, 229, 107776. https://doi.org/10.1016/j.ijpe.2020.107776
12. Schot, J. W. (1992). Constructive Technology Assessment and Technology Dynamics: The Case of Clean Technologies. Science, Technology, & Human Values, 17 (1), 36–56. https://doi.org/10.1177/016224399201700103
13. Zhdaneev, O. V., Ovsyannikov, I. R. (2024). Influence of External Factors on Innovation Activity of Fuel and Energy Companies. Studies on Russian Economic Development, 35 (2), 208–214. https://doi.org/10.1134/s1075700724020175
14. Urazbayev, N., Nurmaganbetova, B., Nauryzbaev, A., Aidosova, B., Alibekova, A. (2023). Financial evaluation and prediction of the efficiency of investments in "green" technologies for oil and gas companies in Kazakhstan. The Bulletin, 4 (404), 573–591. https://doi.org/10.32014/2023.2518-1467.570
15. Sánchez, F., Hartlieb, P. (2020). Innovation in the Mining Industry: Technological Trends and a Case Study of the Challenges of Disruptive Innovation. Mining, Metallurgy & Exploration, 37 (5), 1385–1399. https://doi.org/10.1007/s42461-020-00262-1
16. Badiru, A. B., Tourangeau, M. L., Badiru, A. B. (2023). Leadership Matters. CRC Press. https://doi.org/10.1201/9781003311348
17. Horal, L., Konkolnyak, M. (2021). Process-spatial management of enterprises innovative activities. Adaptive Management: Theory and Practice. Series Economics, 12 (24). https://doi.org/10.33296/2707-0654-12(24)-13