

Technological challenges in the economy of the oil and gas sector

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Abstract. Technological challenges related to the "green" economy, digitalization of business processes, and intelligent manufacturing affect all sectors of the global economy. The oil and gas complex has a complexly organized production process, while the oil industry depends on the volatility of coal prices and the general decline of the world economy. In this regard, it is important to analyze the current state and propose environmental, technological, financial and economic measures to minimize the impact of scientific, technological, and financial risks on the companies' technological integration. Oil and gas companies of the Russian Federation and the Republic of Kazakhstan were selected as the object of the study. In order to overcome the technological lag, increase the depth of processing of raw materials at enterprises, a search for new mechanisms was initiated through the development of the institute of stakeholder relations and the improvement of the scientific and technological risk management system. The study revealed that the combination of the advantages of internal and external growth contributes to the increase of the innovative potential of oil and gas companies. It is an important incentive when concluding transactions to combine the capital of related industries, support the education system, cultural traditions of the population in the regions of the presence of oil, gas, oil refining and petrochemical companies. An open system of "corporate integration spaces", the innovativeness of the integration strategy, the knowledge economy, and the intellectualization of production were used as the elements of the concept of technological challenges mitigation. There is emphasized high importance of artificial intelligence in the management system of the oil industry economy.

1 Introduction

Economy development relies on production as a technological system, which combines interrelated processes that meet the technological, environmental and intellectual challenges of modern society. Practice has repeatedly proved that the production potential of world leaders

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directly depends on the technological state of their structural units, which are part of industrial complexes, have constant injections into maintaining the resource base, and are focused on a closed economic cycle (Bag et al. 2020). This applies to human resources development, renewal of machinery and equipment as well as modernization of the technological portfolio. (Lola et al. 2020). The specialization of production facilities, methods of extraction and processing of raw materials, the demand for finished products in the market of high-tech goods and services affect the formation of oil and gas companies' strategy of technological growth. (Nekrasova et al. 2014). According to experts, the deepening of technological integration within the production cycle, and the formation of innovative regional and sectoral scientific and technological platforms with elements of digital data processing distinguish this strategy. (Platonov et al. 2017). This provides prospects for increasing the stability of the economy as a whole.

Technological integration contributes to deepening the processing of raw materials and exchange of technologies along certain production lines, development of research centers, and formation of industrial clusters. (Kuznetsov et al. 2019). For these reasons, a significant part of the risks in the field of technological integration in the oil industry can be classified as a combination of scientific, technological and financial risks that have been intensified during the CO₂ pandemic (Ershov 2021). The researchers note that social challenges related to the shortage of qualified specialists who can ensure a continuous process of production management in the conditions of remote work have been added to the problems of economic nature. (Faleev et al. 2021).

According to global trends, taking into account the energy transition, the oil industry expects a transformation of human capital. "Green" economic transformations are a prerequisite for the emergence of new professions with the use of the latest digital technologies in connection with the greening of the economy (International Monetary Fund 2021a). The formation of companies with new values requires an influx of capital. At the same time, the consequences of the pandemic have negatively affected the "green" recovery of the oil and gas industry worldwide. Investments in energy efficiency in the industrial sector amounted to less than \$40 billion in 2020, which is about 1% less than in 2019. Global industrial activity has declined, and capital expenditures on energy-efficient equipment have been limited (International Energy Agency 2021). Given the volatility of the oil market and the difficult epidemiological situation in the world, the loss of demand for the Russian oil and gas complex amounted to about 17 million tons of hydrocarbons, which in the long term may affect the level of 85% capacity utilization in the industry. By the end of 2020, the volume of national crude oil production decreased by 48.4 million tons or by 8.6% compared to 2019 (Ministry of Energy of Russian Federation 2021). Experts note that the optimal forecast values of oil production reflect the readiness of Russian oil companies and the state to respond to different scenarios in the future (Azieva 2021). Taking into account the relevance of the technological strategy for the integration of production structures, within the framework of which universal programs are being developed in response to technological challenges, it is necessary to focus on finding conceptual foundations for managing scientific, technological and financial risks of technological integration of Russian and Kazakh oil and gas sector enterprises. Such enterprises provide a high share in the GDP of these countries and can significantly affect the socio-economic situation and ecology of regions.

2 Review of the literature

Active scientific research of technological transformations and their impact on the socio-economic development of complex systems can be traced in the work (Schwab and Vanham 2021). Due to the factor assessment of the place and role of large companies in the regions of their presence, when their effective policy forms the institution of stakeholders, joint

programs are implemented within the education and healthcare systems, and the population's motivation to digital literacy increases (Bisht et al. 2021). It can be agreed that economic entities, especially when enterprises are city forming, are optimistic on the part of residents and the state (Krasnyuk et al. 2020). The well-coordinated system includes banks, institutional investors, fund managers who participate in the implementation of a growth strategy in various variants of volatility or economic activity of the industry market by diversifying the portfolio and environmental/climatic conditions (Leitao et al. 2021). In particular, in the countries of East Asia and Africa, there is a tendency to form a new asset class – "climate" infrastructure. According to scientists, such projects are capable of forming a pricing system for carbon emissions into the atmosphere (Dafermos et al. 2021). The trend towards a "green" economy has manifested itself in the development of a system of financial instruments to solve the problems of "climatically" sustainable economic growth in Russia with the preservation of natural landscapes and increasing the potential of "ecosystem" services. The role of cluster structural formations in Russia has increased (Tarkhanova et al. 2020). The integration of production technologies generates multiplicative synergy within the framework of international projects, such as "One Belt, One Road" (He 2020).

The works of scientists cite the experience of transforming the system of building human capital in the face of technological challenges. The postulates in the field of human resource management strategy are put forward through the stimulation of leadership positions, the emotional commitment of employees to their organization, the empowerment of personnel, and the implementation of a system of personal trust management of personnel. (Tahereh et al. 2020; Rohman et al. 2020).

Global digitalization is a factor affecting technological development, while it is also a technological challenge for oil and gas companies. (Chkalova et al. 2020).

3 Methodology

Currently, the management of scientific, technological and financial risks of technological integration, more than ever, needs a logical rethinking and adaptation to the crisis in all spheres of public life. The proposed conceptual framework for managing these types of risk includes generalized methods of scientific research, tested by the practice of functioning of Russian and Kazakh integrated industrial complexes; principles of reliability, objectivity, causality of economic phenomena.

The methods of economic and statistical analysis (dynamic series, structural analysis), graphic illustration of data, selective observation are used to study the trends in the development of the oil industry. The quantification method and the parametric method make it possible to formalize the procedure for evaluating the effectiveness of technological integration in a set of measures agreed on terms, resources and performers. The systematization of scientific approaches and risk management measures contributes to the development of the concept of scientific, technological and financial risk management of technological integration of oil refining and petrochemical industry enterprises.

The theoretical and methodological prerequisites of this study are based on the identification of the essence and content of the "technological integration" concept, scientific and institutional prerequisites for risk management of technological integration, as well as the assessment of factors determining its specific features in the context of global challenges. When assessing current economic trends, emphasis is placed on the energy sector, for which industry-specific statistical indicators are used. The sources of statistical and operational information were the data of the Federal State Statistics Service of Russia, corporate websites of PJSC "Gazprom", National company "KazMunayGas", The Institute of Energy of the National Research University of the Higher School of Economics of Russia, the International Energy Agency and the International Monetary Fund.

4 Results

The process of technological integration and deep processing of raw materials is fully represented by Russian economic entities of oil refining and petrochemistry focused on the extraction, processing, marketing of hydrocarbons and their products. As of 01.01.2021, 285 organizations licensed for the use of subsoil extract oil and gas condensate (crude oil) on the territory of Russia. They include 98 organizations that are part of the structure of 11 vertically integrated companies, which account for a total of 84.1% of all national oil production; 184 independent mining companies; 3 companies operating under production sharing agreements (Ministry of Energy of Russian Federation 2021). The dynamism of the industry market has completely become dependent on the volatility of hydrocarbon prices and the general decline of the global economy (Figure 1).

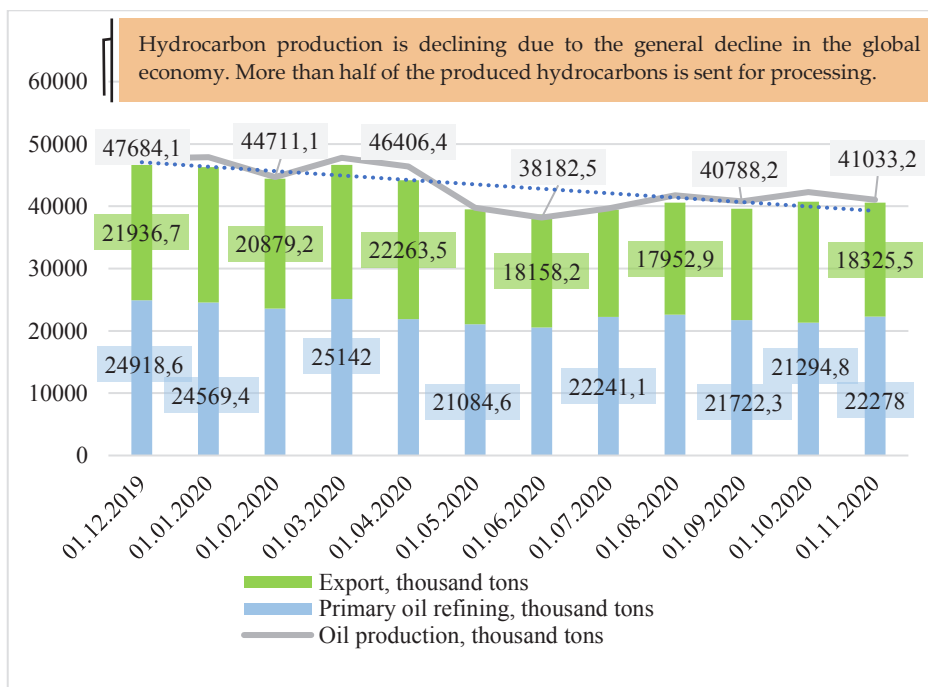


Fig. 1. Dynamics of hydrocarbon production and processing in Russia in 2020. Source: (Ministry of Energy of Russian Federation 2021).

The observations of Russian experts show that, taking into account, the possible decrease in the amount of oil coming for processing, as well as further deterioration of its quality, in order to meet the growing demand in the segment of light fuels, special emphasis should be placed on technological integration in the field of improving existing and developing new processes for deep processing of vacuum gasoil and other oil residues. Catalytic cracking and hydrocracking are the main processes developed specifically for this purpose. At the same time, it is taken into account, that the production of the most popular types of oil refining catalysts is concentrated mainly in 10 leading companies. Thus, the German corporation BASF Societas Europaea (18.1%), American concern W. R. Grace and Company (7.0%), British company Johnson Matthey (5.9%), American group Albemarle Corp. (9.3%), Danish company Haldor Topsoe (3.0%) and American corporation Honeywell (9.8%) provide 53% of the global catalyst market (Pinaeva et al. 2020). In this regard, mutually beneficial research

cooperation can be designated as an important direction for the development of the global oil industry.

Representing large and medium-sized businesses in the Russian industry, oil and gas companies rely on global experience and consider overcoming technological challenges by combining economic mechanisms of internal and external development. In 2019, out of the 10 largest transactions in the Mergers and Acquisitions (M&A) market, 6 agreements were concluded between economic entities of the oil industry. Namely, there took place repurchase of the PJSC Oil Company “LUKOIL” shares, sale of 6.5% of the PJSC “Gazprom” shares, sale of the PJSC “NOVATEK” stake to Chinese and Japanese partners in the «Arctic LNG 2» project / 10% – French corporation Total S.A., 10% – China National Petroleum Corporation, 10% – China National Offshore Oil Corporation, 10% – Japanese consortium Mitsui и Jomec/ (NOVATEK 2022).

As a result of the study of production management systems at the enterprises of the oil and gas sector of Kazakhstan, it was found that an important aspect of safe technological development is seen in the program of interaction between the subjects of investment activity and the oil sector, who are faced with the choice of the most effective production technologies that it is advisable to implement in the shortest possible time and at the same time not cause global damage to the ecosystem of the country. (Figure 2).

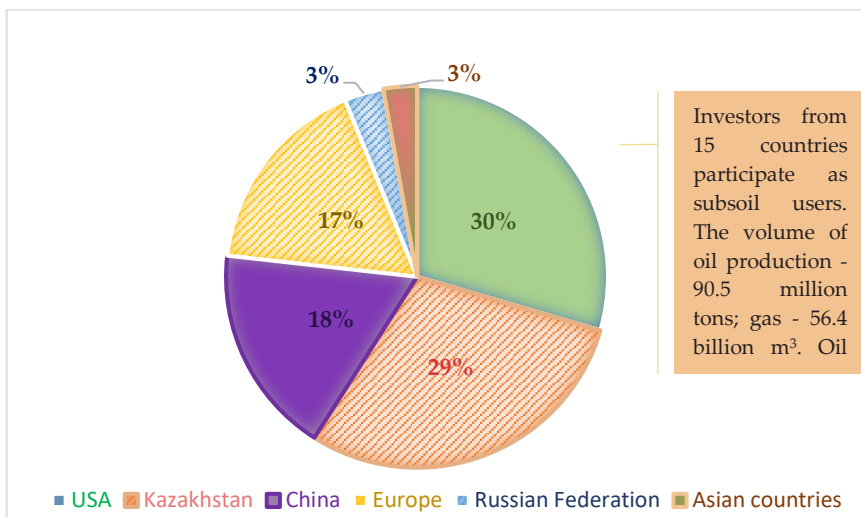


Fig. 2. Countries represented by shareholders in the authorized capital of 86 Oil Producing companies of Kazakhstan in 2019 / based on the results of a study by the Union of Oilfield Service Companies of Kazakhstan. Source: (Oil and Gas sector of Kazakhstan 2020).

In order to overcome the technological lag behind the leading companies in the field of technological development and ecosystem improvement, there have been proposed modernization projects of the Kazakh oil and gas complex for implementation (Table 1).

Table 1. Breakthrough Kazakh projects to deepen technological processes in the oil industry.

Project	Implementation period	Investments, in US dollars
The first integrated gas chemical complex for the production of polypropylene with a capacity of 500 thousand tons in the Atyrau region	period 2018-2021	US\$2.6 billion
Construction of a plant for the production of polypropylene in Shymkent (the administrative center of the Turkestan region, South Kazakhstan) with a capacity of 80 thousand tons per year and octane-boosting additives with a capacity of 60 thousand tons per year for PetroKazakhstan Inc. Prospects for creating the production of synthetic materials for integration with the cotton cluster that is being formed in the region	period 2019-2023	US\$2.8 billion (the volume of capital investments will be adjusted)
The project for the construction of a chemical complex for the production of carbamide with an annual capacity of 887 thousand tons (FEZ “Chemical Park Taraz”, Zhambyl region, South Kazakhstan)	period under adjustment	US\$492 million
Project for the construction of a plant for the production of technical carbon black, with a capacity of 40 thousand tons per year (Zhanazhol village, Aktobe region, Western Kazakhstan)	period under adjustment	US\$37 million

The study of the management mechanisms operating at enterprises leads to conclusions about the urgent need to improve the corporate governance system in the face of aggravated external challenges. In turn, the response provides for the organization of well-coordinated work of structural units, taking into account the stakeholders' interests. In particular, contractors and representatives of the microenvironment can have a beneficial effect on business development in the regions where the structural divisions of oil and gas complexes are located.

As effective measures to accelerate technological development, there is proposed a structural and logical scheme for updating the provisions of the stakeholder approach in the development of corporate governance models for oil and gas complexes. (Figure 3).

While implementing the proposed approaches in practice, it is important to understand that accelerated digitalization of business processes and technological modernization can also lead to job cuts in production, and in the information and communication environment, there is a threat to data security. Therefore, clustering and stratification of technologies with the formation of market centers represented by industrial corporations will allow maintaining the pace of sustainable development with a high degree of "fragmentation" of the oil and gas market.

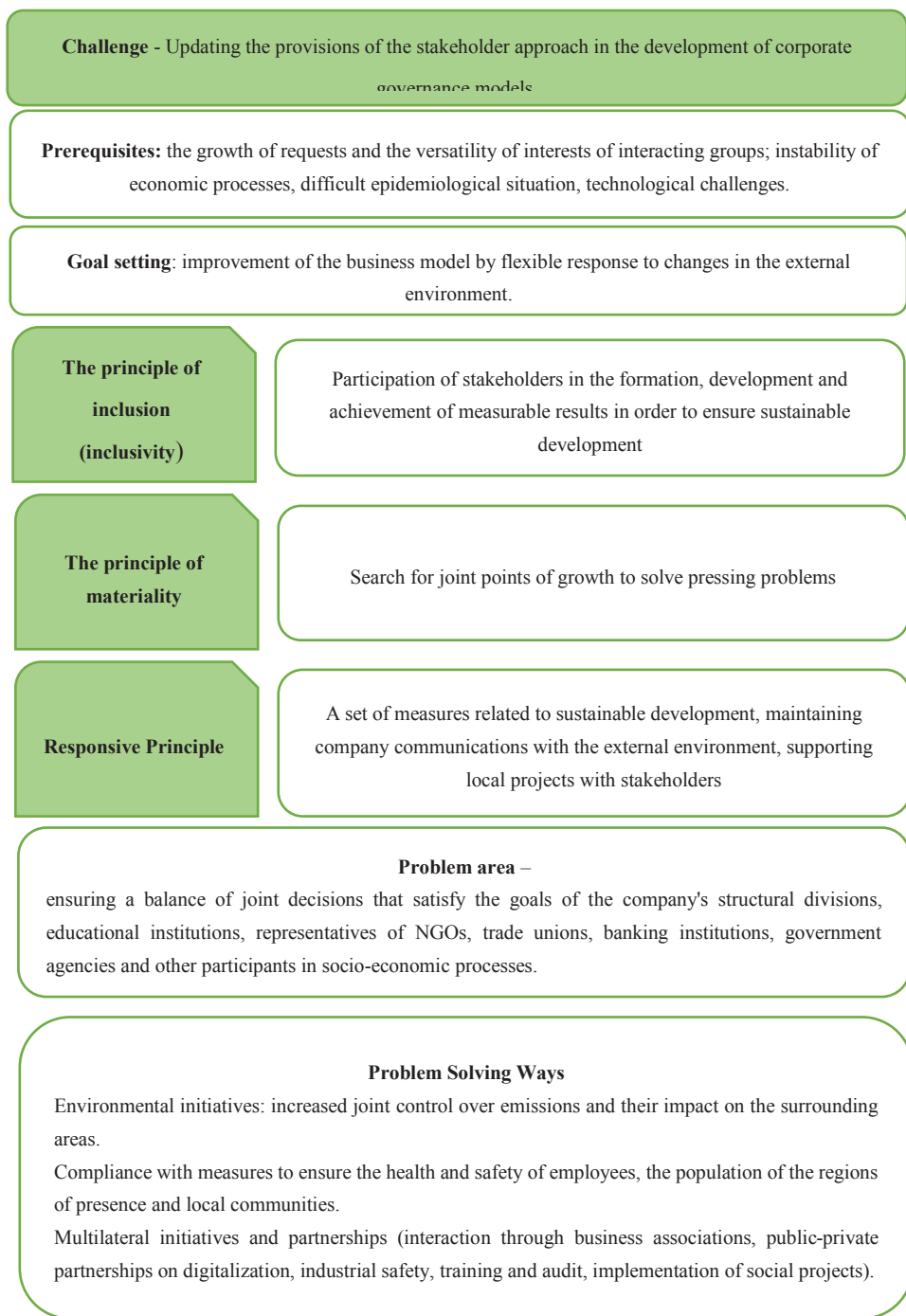


Fig. 3. Structural and logical scheme for updating the provisions of the stakeholder approach in the development of models for managing technological development. Authors using the source: (Schwab and Vanham 2021).

Russian oil and gas companies are striving to reduce technological risks by increasing investments in relevant projects, including research and development work. Specialists single out “clean” technologies as a promising area of innovation activity. In particular, PJSC “Gazprom” conducts research to increase the share of multicomponent gas, as the "effective monetization" of such gas reserves and an increase in the production of liquid products will contribute to the long-term growth of profitability and balance of the corporation's gas business. (Gazprom PJSC 2021). In March 2021, Gazprom PJSC delivered the first batch of carbon-neutral liquefied natural gas (LNG) to the European concern Shell Global LNG Limited. The entry into the world market of Russian gas corresponds to the general trend "Net Zero by 2050". In this regard, the financing of environmental projects is included in the strategic programs of scientific and technological development of Russian enterprises. The investment trends of large oil and gas companies can be called positive (Figure 4, 5).

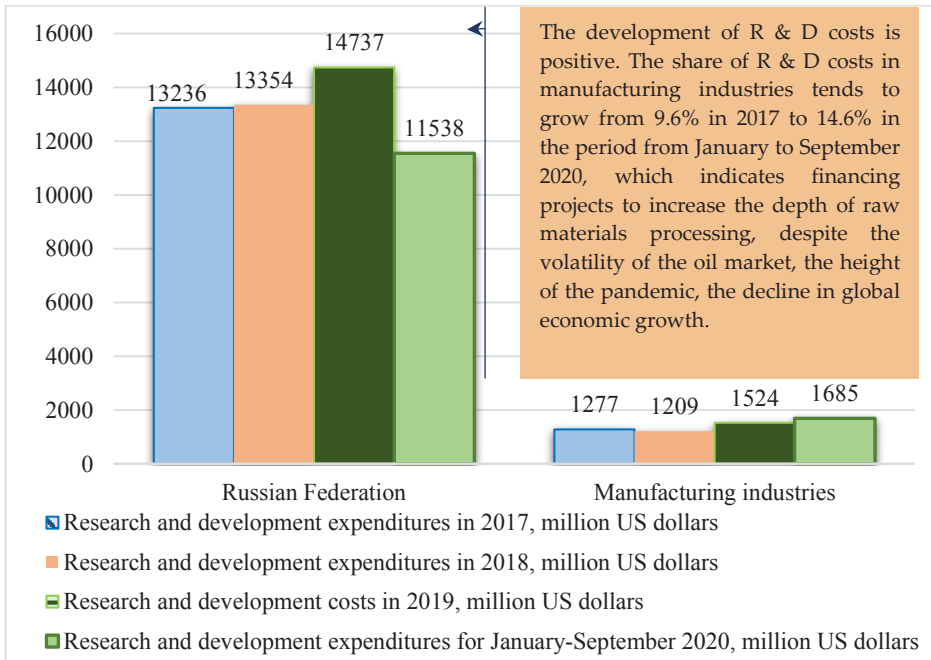


Fig. 4. Trends in research and development costs in Russia for the period 2017 - September 2020. Source: (Federal State Statistics Service of the Russian Federation 2022).

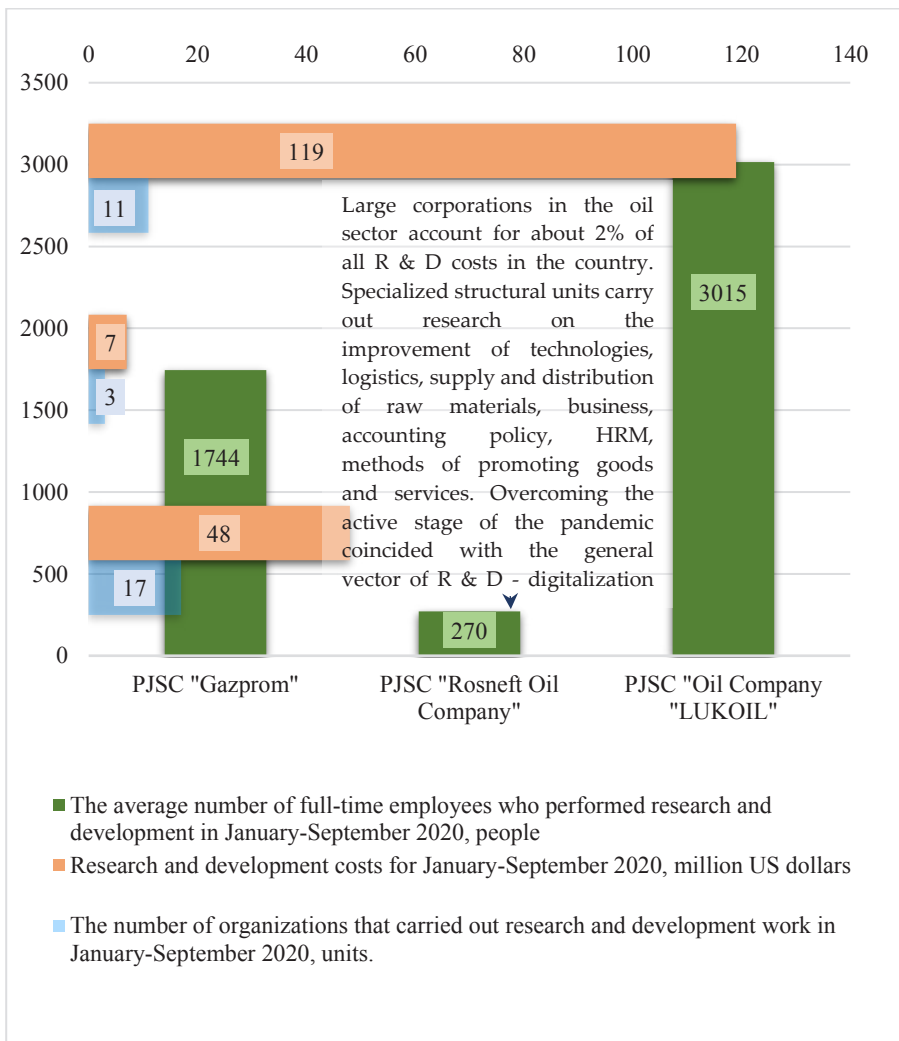


Fig. 5. Indicators of research activities of PJSC “Gazprom”, JSC “Russian Railways”, PJSC “Rosneft Oil Company”, PJSC “Oil Company “LUKOIL” for the period during the first wave of the pandemic January to September 2020. Source: (Federal State Statistics Service of the Russian Federation 2022).

5 Discussion

In order to mitigate technological challenges, it is advisable to identify the following scientific approaches.

Approach – an open system of "corporate integration spaces". From our point of view, in the management of oil and gas companies, the negative consequences of global risks should be leveled under the principles of openness of the economic system concerning the problem system, the ability and interest in an independent assessment. At the same time, the variety of elements of the control system should not be inferior to the diversity of the controlled object.

Approach – an innovative integration strategy, focused on technological growth and the use of R&D results. The implementation of this approach will require improving strategic

management and strengthening the spatial development of the innovation economy and the environment.

Approach – knowledge economy with human capital increment. When implementing this approach, behavioral factors affecting the “talent management” policy should be taken into account. In this direction, it is possible to change public relations in the conditions of a global recession, structural shifts in the economy, accelerated development of production automation.

Approach – digitalization of production systems and intellectualization of production. It implies the introduction of technologies that change the production cycle, starting with automation and ending with the large-scale implementation of technological solutions to increase productivity, optimize costs, and increase the quality and reliability of the system of inter-economic relations.

The implementation of these approaches in oil and gas companies will allow achieving optimal proportions between the costs of technological growth, ensuring environmental parameters and digitalization.

Developing the proposed approaches, it is possible to confirm their validity, since overcoming technological barriers acts as an incentive to the development of economic relations at the same time. In particular, it promotes the development of institutional ties (Chung et al. 2020). At the same time, financing and documentary support of the process of technological integration, in particular, communication of procurement departments, research and development, production departments of integrated economic structures react faster to deviations from sustainability and management makes every effort to return the system to normal. In the context of cluster initiatives, the implementation of technological content programs can be based on the flexibility of the decision-making process, the implementation of a change management strategy taking into account possible risks. This is confirmed by the practical experience of medium-sized companies in Eastern and Western Europe (Tohanian et al. 2020). Such small firms in the information and communication technologies and consulting sector are successfully operating in Russia and Kazakhstan. In addition, they will be able to contribute to the development and implementation of artificial intelligence in the production systems of oil and gas companies.

By implementing measures to increase technological potential in difficult post-crisis conditions, it is important to strengthen the area of responsibility of company owners, since in addition to financial and economic tasks; they have a special responsibility for the physical health of employees and stable ties with the population. There is experience in this direction and it can be used in modern conditions. (Zhao et al. 2021).

The intensification of research and development work can be called a factor of accelerated technological restructuring. The most relevant of them for Kazakh and Russian companies are aimed at creating artificial intelligence and energy economics. Financing of such works is a major problem for industrial enterprises. Therefore, investment management mechanisms in the field of information and communication technologies and energy that work effectively in individual countries can be used to implement technological development programs (Hao et al. 2020). In matters of financial support for energy transfer and transformation of the management system of oil and gas companies, it is important to combine the areas of interest of the technological integration participants and institutional interactions with the financial system. Such actions have the purpose of clear regulation of actions and financing, which has been repeatedly confirmed in international practice and can be used in these circumstances (Gong 2020).

6 Conclusions

Technological challenges call for the management system of oil and gas complexes to adapt based on technological integration, which will facilitate the integration of production, technological, financial, and economic content into a single data set. According to domestic and foreign experts, the transition to the level of intelligent industrial production is determined by the readiness of enterprises to dialogue programs for the implementation of innovative projects at joint production sites by forming a joint bank of breakthrough technologies. After that, the management system of integrated mining and processing complexes will be able to move to a new level of production organization that meets the requirements of high returns on all types of invested capital.

The positions of states in the list of technological leaders depend on how smoothly and accurately the tasks of scientific and technological development of oil and gas companies in Russia and Kazakhstan are solved, and on the growth of competitiveness of environmentally friendly and high-tech products. Studying the management practices of leading companies allows choosing your own path of development, which will take into account the advantages and disadvantages of the process of technological integration in the world. Concerns about the preservation of jobs are systematically offset by the implementation of special programs for increasing labor productivity by training specialists of a wide profile with basic knowledge of the digital economy, technologies for deep processing of hydrocarbons and other minerals that represent a significant share in the structure of the national wealth of the country.

It can be concluded about the special role of scientific and methodological tools for the organization of industrial production through technological integration for the sustainable development of the system of economic relations regulating the flow of production resources in the form of applied technologies. The global crisis of 2020 affected not only and not so much the financial sector, the technology market, the raw materials market, but mainly, human capital. Managers of leading companies are forced to state the fact of time compression and the growing shortage of human resources for the effective technologization of economic processes.

Summarizing the conceptual approaches and minimizing the negative consequences of the deformation of the world economy, it is possible to emphasize the irreplaceable role of artificial intelligence. It is with its help that in the near future it will be possible to standardize risk management processes, thereby increasing the efficiency of the industrial enterprises functioning. Indeed, the management of scientific, technological and financial risks within the framework of technological integration can and should be adapted to the current crisis. It is recommended to consider technological resources with the use of artificial intelligence as a lever of point impact. From our point of view, in the conditions of a pandemic, unique startups of industrial design and engineering should receive a special incentive to develop, which will help remotely control technological processes without damaging control subsystems and the environment.

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