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Modeling the Impact of New Technologies on the Financial Performance of Russian Vertically Integrated Oil Companies

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Abstract

The article explores the impact of the oil recovery factor on the financial performance of Russian vertically integrated oil companies. Special attention is given to hydraulic fracturing technologies (HFT) and rotary steerable systems (RSS), which are critical for enhancing oil extraction rates and oil recovery factor, particularly for hard-to-recover reserves (HTR). Sanctions have complicated access to these technologies, leading to a deterioration in the financial results of Russian oil companies in 2022-23. The study identified a decrease in revenue due to the restricted activities of foreign oilfield service companies and an increase in the discount on Urals crude oil. Using the financial model of Russia's largest vertically integrated company, Rosneft, it was demonstrated that improving extraction efficiency through the adoption of technologies can increase the company's value by 8%. The analysis highlights that delayed technology replacement directly threatens production sustainability, especially for HTR reserves, which require advanced extraction methods. The study's findings align with the resource-based view: effective management of technological resources is one of the key factors in the competitiveness of oil companies. Under the conditions of sanctions pressure, it remains necessary for Russian oil companies to reduce technological dependence.

Keywords: oil industry, development, companies, new technologies, modeling, company value

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Introduction

The present paper aligns with the resource-based view (RBV) of business [1]. According to the RBV, a company gains an advantage over its competitors by making optimal use of its technical, human and other resources [2]. At the same time, technologies are one of the key resources that enhance oil companies' profitability [3]. The present research models the technologies' impact on the financial performance of vertically integrated oil companies in order to assess the effects of their adoption.

With each passing year, easily accessible oil reserves in Russia are decreasing. As conventional deposits are depleted, companies start developing less accessible resources. The majority of analysts assert that by 2050 hard-to-recover (HTR) oil reserves in the Russian Federation will amount to approximately 70% of the cumulative oil production. The energy strategy of the Russian Federation up to 2035 is based on the target of increasing the oil recovery factor (ORF) from the current level of 0.3 to 0.45 by 2035. Special-purpose technologies are used to enhance recovery efficiency of HTR oil reserves and maintain the ORF at a certain level: rotary steerable systems, hydraulic fracturing and other methods that maximize the volume of hydrocarbon extraction from complex geological structures. One of the projects that facilitates the implementation of this strategy is the road map signed by PJSC Gazprom Neft, the Ministry of Energy of the Russian Federation and the Ministry of Industry of the Russian Federation.

Formerly, advanced oil extraction technologies have been provided to Russian vertically integrated oil companies by the global leaders in oilfield services known as the "Big Four": Halliburton, Schlumberger, Baker Hughes and Weatherford. However, in 2022, operations of these companies were restricted in the Russian market, thus generating a need for import phase-out in order to mitigate operational risks and maintain oil production efficiency. So, currently Russia develops its own technologies, purchases services from domestic service companies and buys components abroad, for example, in China.

The following vertically integrated oil companies have been considered in the present research: PJSC Rosneft, PJSC Lukoil, PJSC Gazprom Neft, PJSC Tatneft, and PJSC Bashneft. Besides, in the paper we compare Russian vertically integrated oil companies to foreign ones: ExxonMobil, Chevron, Shell, BP, and TotalEnergies. It is done to weigh the dynamics of the key financial indicators against each other. The primary objective of the research is to study the effects related to technological development, such as improvement of operating efficiency, cost saving, margin expansion and market capitalization growth. This type of the influence of technology development is confirmed in the papers that reveal the significance of innovation processes for the strengthening of company's competitive position in the global market [4; 5].

Effects of Development of Hydraulic Fracturing and Rotary Steerable Systems

As of today, the major part of oil is recovered in the oil fields that have already reached the peak of oil production. To operate these fields further, it is necessary to implement new enhanced oil recovery methods. At the moment, the most common technologies are physical ones, such as hydraulic fracturing, lateral drilling, electromagnetic methods, etc. They are also known as workover methods applied in the low profitability wells [6].

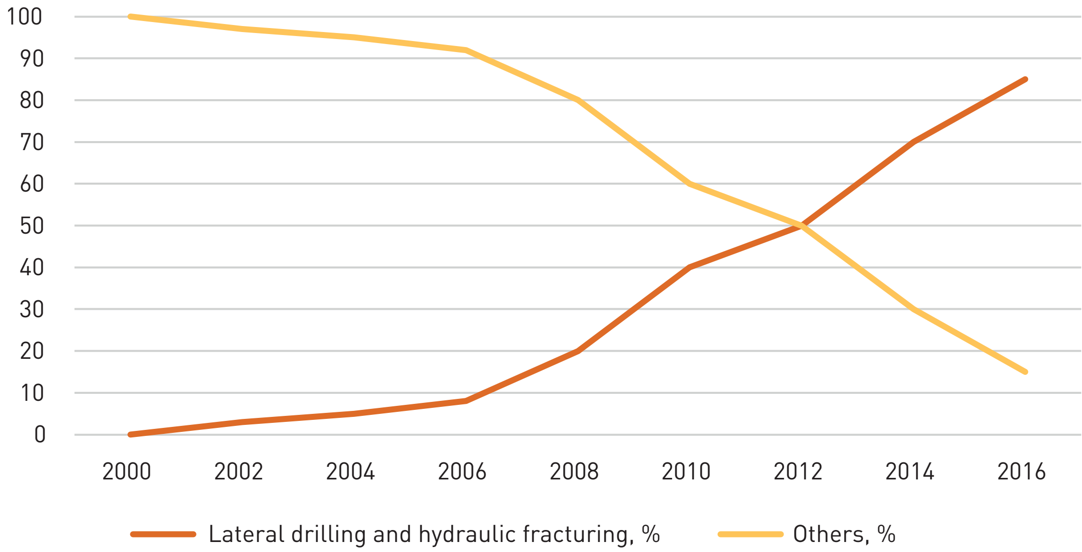
Hydraulic fracturing is one of the methods for the development of productive strata, especially low-permeability ones. It impacts the hole-bottom region, as well as contributes to enhanced oil recovery. Hydraulic fracturing creates a system of deeply extending fractures, thus greatly expanding the drainage area and improving the productive capacity of a well. Several stages of hydraulic fracturing are possible in a horizontal well. This approach is called multistage hydraulic fracturing. In lateral drilling, the rotary steerable systems (RSS) technology is applied.

The foundation of modern improved hydrocarbon extraction methods was laid at the time of technological development of the US oil industry throughout the XX century. The first steps in hydraulic fracturing were taken in 1930s, when non-explosive fluids – well stimulation acids – were brought into use [7]. The effectiveness of the applied technology was proven in 1940-1950s. That is when it became one of the key recovery stimulation techniques, and was used extensively up to the beginning of the XXI century [8]. In the 2000s, a significant breakthrough in this sphere was achieved, so the efficiency of oil recovery was enhanced as compared to conventional methods due to the development of multistage hydraulic fracturing [9]. By 2014–2015, the pilot testing of multistage hydraulic fracturing technology was completed and it was beginning to be widely implemented in the US market, accompanied by a considerable progress in increasing hydrocarbon recovery [10].

It should be noted that hydraulic fracturing technology is the key area of technological progress in oil production that undeniably influences the efficiency of oil field development. Statistical data confirms a wide use of hydraulic fracturing. Thus, in 1949–2010, the number of wells developed in the USA using hydraulic fracturing exceeded 60%. Already by 2016, horizontal wells, where hydraulic fracturing was applied, accounted for 69% of the total number of drilled oil wells and for 83% of the total number of drilled line meters in the USA [11].

According to the US Department of Energy, approximately 95% of wells are currently drilled by hydraulic fracturing. As a result, this technology accounts for two thirds of the total natural gas extraction and approximately half of crude oil production [12].

Figure 1. Dynamics of the share of lateral drilling (and hydraulic fracturing) in the total number of wells, 2000–2016



Source: [13].

The indicators stated in Figure 1 show the annual growth of integration of lateral drilling technologies (RSS and hydraulic fracturing) into hydrocarbon extraction processes and emphasize a significant impact of these technologies on enhancement of efficiency and economic benefit from the development of deposits. The growing share of the wells drilled using directional and lateral drilling is also indicative of an increase in the share of hard-to-recover reserves in total reserves. Application of hydraulic fracturing was the fundamental factor that determined the opportunities for an increase in the extraction volume and development of new, previously inaccessible hydrocarbon deposits.

In 1952, in the USSR there was a time lag in adaptation and development of hydraulic fracturing [13]. In spite of the fact that the USSR started using hydraulic fracturing approximately at the same time as the USA, its further development slowed down dramatically when large high-output deposits in West Siberia were discovered. Hydraulic fracturing was almost abandoned because "easy" oil did not require additional stimulation methods. At the same time, globally this technology was developed rapidly. Since there was no demand for this technology, Russian equipment and experience in application of hydraulic fracturing fell significantly behind other markets.

An important instrument that ensures improvement of the efficiency of lateral drilling, RSS, was proposed in 1940–1950s [14]. However, its extensive implementation and commercial operation started as late as mid-2000s with Schlumberger's developments [15]. RSS makes an enormous contribution to the improvement of drilling operating procedures, and the analysis of dynamics of their development and adaptation to the oil industry confirms this fact. They comprise innovative equipment, which ensures accurate directional drilling that makes field development more productive and cost-effective.

A significant growth of RSS use is observed North America (from 20% in 2016 to 28% in 2019) due to an increase in the share of wells drilled using this technology. This factor emphasizes the growing interest of operators in the integration of technology solutions to improve the drilling performance. RSS will even more heavily dominate the directional drilling market. Thus, in 2021, their market share already exceeded 50%, and according to forecasts, by 2029 it should be over 70%. Such statistical changes are indicative of the key role of this technology in the drilling process optimization and minimization of its costs [16].

From the point of view of the Russian fuel and energy sector, the scope of drilling where RSS are applied has grown significantly since 2014. At that point, there were less than 210 horizontal wells. In 2024, the scope of horizontal wells drilling in Russia is expected to reach approximately 30,000 km, which equals 7,000–12,000 wells. The reason is that it is necessary to develop new deposits, especially HTR reserves, which account for a significant part of oil extraction [17].

The above trends confirm that RSS play a critical role in enhancing efficiency and reducing drilling time, at the same time ensuring a high accuracy in achieving the set goals. Implementation of RSS drives the optimization of hydrocarbon production, increasing economic returns on deposit development and contributing to the sustainable development of the energy industry.

Investing in drilling technologies produced a pronounced influence on the oil industry, improving its efficiency and profitability in the USA and across the globe [15]. Implementation of hydraulic fracturing technology, in particular multistage hydraulic fracturing, curtailed the drilling time by 25% and increased the cumulative oil production (the total amount of oil recovered from a certain deposit or region throughout its producing life) [18]. Additional studies point out an opportunity to increase cumulative oil production up to 36% in the immediate future and a significant improvement of well producing characteristics [19; 20].

Due to the development of RSS, the average drilling rate increased by 26% [21]. This factor was emphasized repeatedly in various studies dedicated to the oil market [22; 23]. Such an approach to the development of RSS provided access to hard-to-reach reserves, increased production, mitigated the impact on the environment and improved the wellbore stability.

Dissemination of new technologies significantly improved the overall effectiveness of the oil industry [24]. This partially solved a number of problems, including cost growth, infrastructure obsolescence, toughening of regulatory requirements, as well as lack of skilled personnel. These new ways helped to improve decision-making, optimization of performed operations and environmental impact mitigation. Thus, RSS and hydraulic fracturing allowed to recover oil and gas from the reserves previously considered inaccessible or economically unsound [25].

Since the 2010s, hydraulic fracturing in Russia has been used on a much more extensive scale. Thus, up to 2014 this technology had ensured additional extraction of 30 million tons of oil. This is indicative of the dynamics of its wide implementation in the oil sector. In 2018, incremental oil production due to the enhanced oil recovery methods, including hydraulic fracturing, amounted to approximately 25 million tons [26]. So, the technology allows to increase the ORF and well flow rate in complex and mature fields. However, there are certain fluctuations in the amount of incremental oil production that depend on economic feasibility and state of the fields [27].

The main prospects of expansion of the technological oil service market are associated with the dynamics of development of the segments in oil-field service which implies sustained growth in the key spheres: horizontal well development (including horizontal sidetracks); hydraulic fracturing and multistage hydraulic fracturing; use of bottom hole drilling systems and geophysical research (including continental shelf projects).

Comparing EBITDA Margins of Russian and Foreign Vertically Integrated Oil Companies

In modeling we used data from corporate financial statements for 2019–2023. The following indicators were applied in the analysis: revenue, EBITDA, free cash flow (FCF), capital expenditures (CAPEX) etc. Moreover, we used such technical characteristics as extraction volume, production costs, ORF etc. Also, in order to determine the discount, we took into account data on the price of Brent, WTI and Urals.

From the historical point of view, the oil sector was exposed to geopolitical risks, and 2022 was no exception. The sanctions pressure on the Russian oil industry, domestic companies faced not only the denial of access to the cutting-edge technologies which maintain and increase the ORF, but also restrictions such as the price cap on Urals. This aspect exerted a significant influence on the ultimate price of sold products. An increase in the discount for the Russian Urals as compared to Brent and WTI in 2022 amounted to 19%. First of all, this brought pressure on corporate revenues and, consequently, on marginal operating profit (EBITDA margin) of Russian vertically integrated oil companies.

Further we compare the changes in the financial indicators of Russian vertically integrated oil companies and foreign ones in 2022–2023.

Table 1. Comparison of revenue of Russian and foreign vertically integrated oil companies, 2019–2023

	Revenue (billion roubles)				
	Rosneft	Lukoil	Gazprom Neft	Tatneft	Bashneft
2019	8.676	7.841	2.485	932	855
2020	5.757	5.639	2.000	796	533
2021	8.761	9.431	3.068	1.205	852
2022	9.072	11.869	3.430	1.427	1.100
2023	9.163	7.928	3.520	1.589	1.032

	Revenue ($ billion)				
	Rosneft	Lukoil	Gazprom Neft	Tatneft	Bashneft
2019	134	121	38	14	13
2020	80	78	28	11	7
2021	119	128	42	16	12
2022	134	176	51	21	16
2023	108	94	42	19	12

	Revenue ($ billion)				
	ExxonMobil	Chevron	Shell	BP	TotalEnergies
2019	265	140	352	184	176
2020	182	94	183	109	120
2021	286	156	273	164	185
2022	414	236	386	249	263
2023	345	201	323	213	219

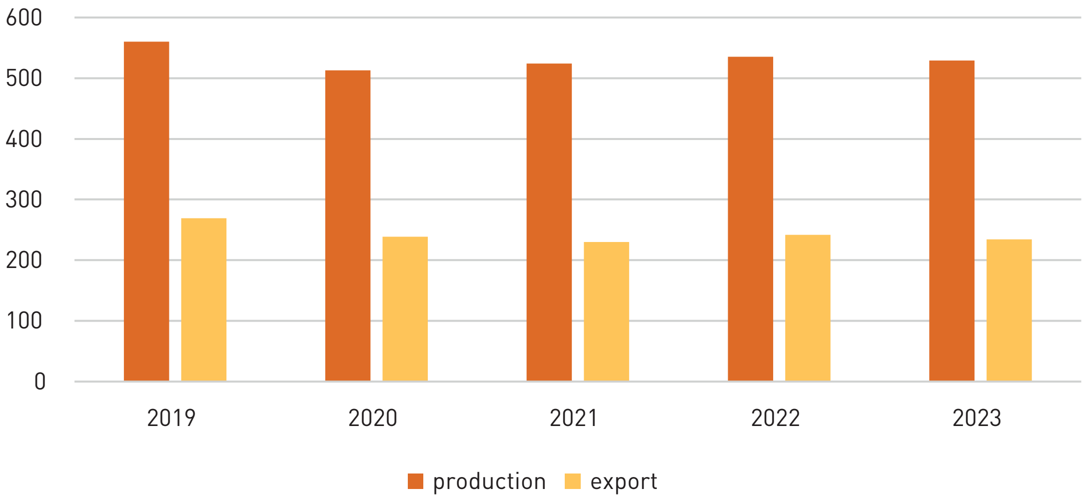
Table 2. Comparison of average weighted revenue dynamics in Russian and foreign vertically integrated oil companies, %

	Russian vertically integrated oil companies		Foreign vertically integrated oil companies	
	Relative change			
	Average value	Median	Average value	Median
2019–2020	–7	–4	–8	–6
2020–2021	11	7	11	9
2021–2022	5	3	9	8
2022–2023	–6	–3	–3	–3

Analysis of Tables 1 and 2 points out a revenue increase in dollar terms in 2022 for Russian vertically integrated oil companies as compared to foreign ones (5 versus 9%). The average weighted growth of Russian oil companies' revenue is lower because, among other things, the Urals discount increased by 19% and the rouble strengthened by 8% against the US dollar within the same period. In 2023, similar revenue dynamics are observed in Russian vertically integrated oil companies, besides, the average weighted values still demonstrate less favorable dynamics as compared to foreign oil companies. This trend may persist in the medium term due to the restrictions on access to technologies.

The most important indicators that show the state of the sector under consideration and the Russian vertically integrated oil companies selected for analysis are export volumes and crude oil production. In 2022–2023, there was a reduction in crude oil exports (Figure 3), and this is to rebound on Russian oil companies' revenue in the nearest reporting periods. For this reason, in the settings of the current rate of reduction in revenue and in order to maintain their financial standing, Russian oil companies have to work on an increase in EBITDA margin.

Figure 2. Dynamics of volumes of Urals production and export, million tons



As seen in Table 3, the historic EBITDA margin values of Russian vertically integrated oil companies are higher than those of foreign oil companies. Among other things, this occcurs due to weakening of the rouble. However, in spite of this consistent pattern, EBITDA margin may decrease significantly in the future as a result of the growing oil discount, a reduction in oil exports and restricted access to technologies. This will eventually adversely affect the companies' market value.

Table 3. Comparing EBITDA margin of Russian and foreign vertically integrated oil companies, %

	Rosneft	Lukoil	Gazprom Neft	Tatneft	Bashneft
2019	24	16	32	31	20
2020	21	12	21	23	6
2021	27	15	29	24	18
2022	28	16	36	34	21
2023	33	25	38	25	24
	ExxonMobil	**Chevron**	**Shell**	**BP**	**TotalEnergies**
2019	15	25	17	18	20
2020	11	13	16	–6	15
2021	18	26	22	19	23
2022	24	28	22	13	22
2023	21	24	21	20	23

Summing up the results, it should be noted that the actual financial statements of Russian vertically integrated oil companies for 2022-2023 and their comparison to those of foreign oil companies reveal substantial risks for the subsequent stable development of the sector. In the immediate future the effect of the weakened rouble will be limited, thus, resulting in reduced support of revenues of Russian vertically integrated oil companies (and EBITDA margin) ,while the risk of the Urals discount growth may increase. In this scenario, abandonment of development and implementation of the considered technologies by Russian vertically integrated oil companies will jeopardize the possibility of the sector's subsequent growth at the pre-sanction rate.

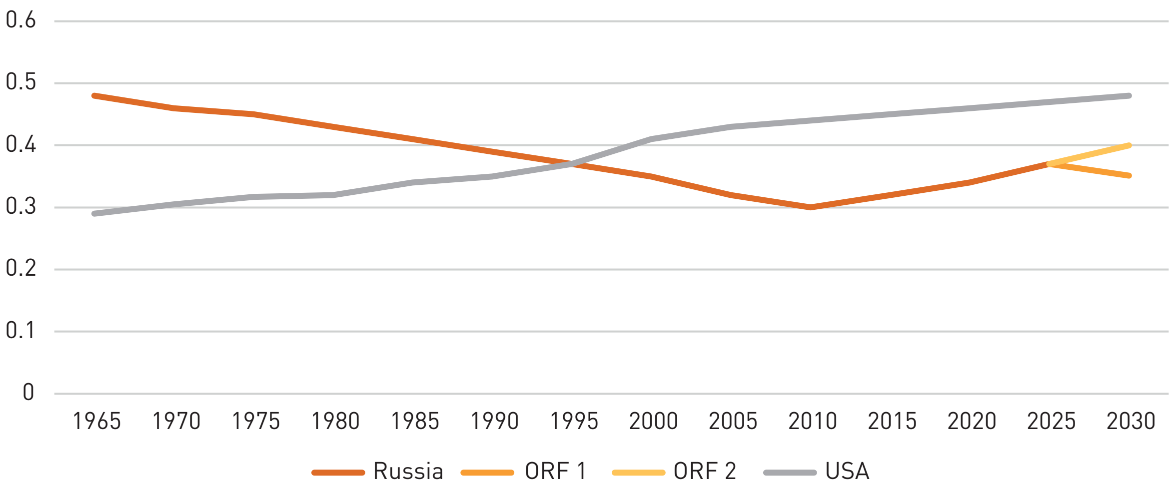
Cash Flow Modeling

The results of comparison of EBITDA margins of Russian and foreign vertically integrated oil companies provide an opportunity to evaluate how the value of Russian oil companies will change if they abandon replacement or development of the existing technologies over the next five years. Based on the literature review, it should be noted that the oil recovery factor depends directly on such enhanced oil recovery methods as hydraulic fracturing, RSS, and access to their latest modifications, which Russian vertically integrated oil companies lost in 2022. Thereby, we have to evaluate the influence of the ORF on the value of Russian oil companies.

We used the largest Russian oil producer PJSC Rosneft for evaluation. Two main scenarios were considered: according to the first one, Russian oil producers decide against replacement of the technologies withdrawn from Russia (ORF 1), according to the second one, they invest in the development of technologies (ORF 2) (Figure 2). Additionally, the ORF 1 scenario implies a decline in efficiency of oil recovery to a level comparable with the historical one (within the period of 1965 to 2010). At the same time, the ORF 2 scenario implies the attainment of target indicators set by the Energy Strategy of the Russian Federation for the period up to 2035.

According to the model premises, it is assumed that a change in the ORF results in changes in production costs (pretax), recovery volumes and capital investments in development of the oil field.

Figure 3. Historical and forecast dynamics of the ORF, %



Notably, an increase in the ORF of foreign vertically integrated oil companies is caused by some specific aspects, for example, management of the project portfolio and predominance of shale oil production, where this indicator is not typically used.

Modeling of Discounted Cash Flow

For several reasons, the discounted cash flow method (DCF) is a substantiated choice for the study of the influence of new technologies on financial indicators of Russian vertically integrated oil companies [28]. Implementation of new technologies may cause significant changes in corporate cash flows, i.e., both enhanced efficiency and cost saving, and an increase in proceeds from new products and services [29]. Apart from that, the DCF method is widely acknowledged in academic literature as one of the most reliable and flexible tools for evaluation of investment projects and corporate value of companies [30; 31]. Against the background of oil markets' high volatility and specific nature of the Russian economy, DCF offers analysts an opportunity to take into consideration various event scenarios and businesses' susceptibility to the key risks related to the implementation of new technologies [32].

The created model calculates the net effect of the impact produced by the ORF 1 and ORF 2 scenarios on cash flows and the value of PJSC Rosneft. We start calculating the effects of oil recovery with defining the underlying operating profit from the Upstream segment:

$$OP = PV \cdot (SP - PC), \quad (1)$$

where OP – operating profit; PV – production volume; SP – sales price (Urals); PC – production costs.

Then we apply the ORF's effects to determine operating profit after these effects have exerted their impact (OP'):

$$OP' = PV \cdot (1 + ORF) \cdot (SP - PC \cdot (1 - ORF)). \quad (2)$$

$$\text{ORF effect} = \frac{OP'}{OP} - 1. \quad (3)$$

The obtained values of operating profit for each scenario are compared to the actual value and are carried over to FCF. Moreover, in order to obtain the estimated value of the company, the influence of the ORF's effects on capital expenditures (CAPEX) is taken into account:

$$\text{ORF effect}(CAPEX) = \frac{CAPEX \cdot (1 - ORF)}{CAPEX} - 1 \quad (4)$$

$$FCF' = FCF + OP \cdot \text{ORF effect} - \\ - CAPEX \cdot \text{ORF effect}(CAPEX), \quad (5)$$

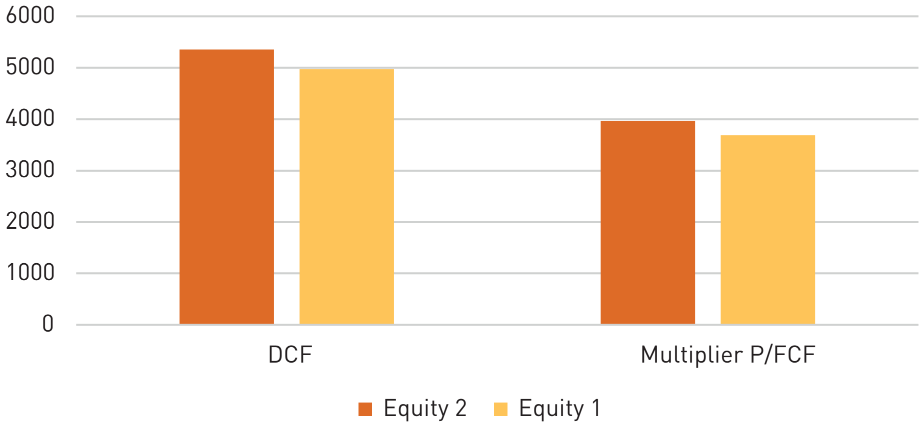
where FCF – factual value of cash flow; ORF effect (CAPEX) – effect of the factor on increase/decrease in capital expenditures; CAPEX – factual value of capital expenditures; *FCF'* – value of cash flow taking into consideration the scenario.

Finally, we calculate the company's value based on the obtained estimated value of cash flow (FCF') taking into consideration the scenarios using the discounted cash flow method (DCF) and the multiples method (P/FCF).

Results of Calculations

The results of calculation of the two scenarios are indicated in Figure 5, which shows the value of companies Equity 1 and Equity 2 for each scenario of ORF 1 and ORF 2 dynamics, respectively.

Figure 4. Estimated value of PJSC Oil Company Rosneft (Equity) depending on the ORF scenario, billion roubles.



In Figure 4, Equity 1 indicates the scenario when the company abandons the development of its own technology (ORF 1); Equity 2 is for the scenario when the company starts to develop its own technology (ORF 2).

The obtained results indicate that a decision on strengthening the technological sovereignty will provide additional 8% of company value for Russian vertically integrated oil companies as compared to the scenario of abandoning the development of technologies (only taking into account the effect on the Upstream).

It should be noted that certain limitations were taken into consideration in the modeling process. There is an important assumption that there is no multiplicative effect of the impact of new technologies from the Upstream segment on the lower business segments – Midstream and Downstream. In case of the multiplicative effect on the company's margin, the technology replacement scenario (ORF 2) is the most preferable from the standpoint of company capitalization. A deeper study of this limitation in further research is intended.

Conclusion

Our research provides an opportunity to make several conclusions concerning the technological development of the oil sector. We revealed the significance of hydraulic fracturing and RSS for the development of this sector, in particular, the impact of these technologies on the drilling rate and an increase in the ORF. The examined technologies ensure a significant enhancement in the efficiency of drilling and oil recovery. For this reason, they are widely used across the globe. Lately, the growing share of HTR reserves in the extraction volume has made these technologies even more important.

The 2022 changes in the oil sector exerted a significant negative impact on Russian vertically integrated oil companies. Their revenue dynamics was inferior to that of foreign oil companies due to an increased Urals discount. We also found out that withdrawal of technologies had no immediate effect on the financial indicators of Russian vertically integrated oil companies, and it will most probably manifest itself over a medium-term or long-term horizon.

Furthermore, a limited access to technologies and a decision against their replacement will have an adverse effect on all financial indicators of oil companies in the medium term, reducing their value by over 8%. As a result of the geopolitical crisis of 2022, sanctions were imposed on the Russian oil industry. This caused a series of restrictions, including the price cap for Russian oil and withdrawal from the Russian market of the leading technology solution providers that worked with Russian oil companies. Thus, taking into consideration the growing share of HTR reserves Russian vertically integrated oil companies are forced to invest in replacement of hydraulic fracturing and RSS in order to maintain the current levels of recovery and growth rates of the financial indicators.

The research results are indicative of a high dependence of the Russian oil industry on the technologies provided by the companies that pulled out of Russia in 2022. Besides, it was established by means of comparing revenues of Russian and foreign vertically integrated oil companies that an increase in the oil discount related to the limited access to the technologies produced more significant influence on financial indicators of Russian oil companies in 2022. On the basis of this conclusion, we offered the calculation method that allows to determine how the value of the largest Russian vertically integrated oil companies will change depending on the chosen strategy for implementation of the technologies which lead to ORF growth.

We proposed a financial model using PJSC Rosneft as an example to model a medium-term impact of lack of the technologies under consideration. Based on the model, various scenarios of change in the ORF were considered. The obtained results demonstrate that it is necessary to look for the ways of subsequent technological development of the oil industry in order to improve its financial indicators. The decision against replacement of the technologies may result in the risk of a decrease in the oil production volumes and marginal profit. This will eventually entail a significant reduction in the companies' value.

From a theoretical point of view, this research contributes to RBV. According to this approach, the company may outperform its competitors in terms of efficiency due to the way it uses its technical, human and other resources. Technologies in particular are one of the most important resources of oil companies. Also, according to RBV, development of competitive advantages is possible through efficient management of internal and external resources.

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