Industry 4.0. and an upgrade of the business models of large mining companies

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Abstract. With the depletion of easily accessible deposits and the transition of the industry to the Industry 4.0 principles the need for more than just increasing production volumes and applying new technologies including automation and modern digital technologies, but also for solutions to a number of organizational and socio-economic problems faced by this sector. All these problems are in one way or another related to the change in the business model of extractive companies. Under these conditions, studying the features of the business models of the major Russian companies in the extractive sector under the transition to the Industry 4.0 is a relevant research task. The purpose of this article is to characterize the features of business models of large Russian extractive companies operating in the fuel and energy complex and to describe the possible directions of their transformation under the influence of Industry 4.0. Our analysis of the business models of the major Russian mining companies and comparison to their foreign counterparts showed a certain conservatism in Russian companies and the lag in the implementation of digital platforms, despite the interest of companies' management in using digital technologies. This is largely due to the low willingness of most companies to complicate their business models and to implement digital transformation. Such trends can be explained by the fact that companies tend to choose a vertically integrated model. They are in the early stages of digital transformation and mainly focused on operational aspects. In most Russian mining companies, the level of automation of production and administrative processes is low, and the use of digital technologies is still limited mainly to pilot projects. To achieve a systemic effect from digitalization, it is necessary to combine the efforts of all interested parties – the government, companies, the innovation community, and academic circles.

1. Introduction

Under contemporary conditions, both researchers and professional community are increasingly addressing the issue of business models. Its topicality is largely due to the serious volatility of the global and national economies in the context of digitalization and transit towards a new industrial revolution (Industry 4.0): nations, regions and individual companies are extremely interested in new sources of growth and increased competitiveness. Currently, the successful development of companies is largely determined by the business models they use. At the same time, the number of really successful business models is not large, and companies are actively looking for new approaches that can create and maintain successful business models in the context of the transition to the Industry 4.0 principles. This can explain the fact that the number of studies in this area in recent years has
increased more than 10 times. Until now, the study of the peculiarities of business models has been limited to processing, logistics and service companies. Business models based on Internet technologies of such companies as Amazon (the largest online bookstore), Uber (taxi operator), Skype (the largest telecommunications service provider) have been studied in sufficient detail. Until recently, the specifics of the business models of extractive companies were outside the field of research. At the same time, the features of business models in the extractive sector have been studied insufficiently, despite the fact that the role of the extractive industries as the basis of modern society all over the world is growing yearly.

With the depletion of easily accessible deposits and the transition of the industry to the Industry 4.0 principles the need for more than just increasing production volumes and applying new technologies including automation and modern digital technologies (Pollon, 2018, Knapp et al., 2014; Nadolski et al., 2015, McKinsey, 2018, Calvo et al., 2016 [1-5]), but also for solutions to a number of organizational and socio-economic problems faced by this sector. All these problems are in one way or another related to the change in the business model of extractive companies. Under these conditions, studying the features of the business models of the major Russian companies in the extractive sector under the transition to the Industry 4.0 is a relevant research task.

The purpose of this article is to characterize the features of business models of large Russian extractive companies operating in the fuel and energy complex and to describe the possible directions of their transformation under the influence of Industry 4.0.

2. Materials and methods
The materials for the study were borrowed from the annual reports of the fuel and energy complex enterprises: PJSC Gazprom, OJSC NK Rosneft, PJSC RusHydro, PJSC OGK-2, PJSC Rosseti, Rosatom State Corporation, and PJSC Gazpromneft. The research used such methods as analysis and synthesis, graphical method, and functional analysis.

3. Business model: concept, types and structure
The term “business model” has recently appeared in modern literature. In world management, the emergence of this area of research is associated with the second half of the twentieth century; in Russian management practice, it appeared in the early 2000s. The most prominent foreign studies on business models were published by H. Chesbrough, A. Slywotzky, A. Osterwalder and Y. Pigneur [6-10]. Among the Russian researchers, the papers by Strekalova, Markova, L.V. Frolova, V. Yu. Kotelnikov, A. Gusakov [11-15] and others stand out. Currently, each large Russian company has its own business model, which underlies its activities and allows evaluating the effectiveness of its current activities and development prospects. In its most general terms, theorists and practitioners define a business model as the way a company does business and makes a profit by using its resources or assets. Giving a description of a company’s business model, they also distinguish a set of indicators of the company’s performance.

Despite a growing body of research on business models, a large number of unresolved questions remain in the literature. The question of a conceptual approach to the study of business models remains controversial. There is no unity among researchers in the definition of the concept, boundaries and main components of the business model; the issues of the relationship between the business model and supply chains (value chains), business model and company strategy have not been resolved. The published studies actively investigate such issues as factors determining the choice of a business model by companies, the impact of a business model on the results of operations and a company’s competitive advantages (Strekalova, 2009 [11]; Teece, 2010 [16]; Markova, 2010 [12]; Zott, Amit, 2011 [17]; DaSilva, Trkman, 2013 [18]; Baden-Fuller, Mangematin, 2015 [19]).

Most of the research is focused on the analysis of the current state of business models of specific companies (Hamel, 2000; Johnson, Christensen, Kagermann, 2008 [20-21]; Teece, 2010 [16]; Isaev, 2010 [22]) and the search for opportunities for its improvement under the conditions of high uncertainty (Osterwalder, Pigneur, 2010, 2005, 2004 [8-10]), digitalization and transition to the
Industry 4.0 principles. Industry 4.0 allows traditional manufacturing processes to be flexible and self-learning.

Combining similar approaches to the study of business models allows us to distinguish three basic concepts of business models, see Table 1 (Gassmann, Frankenberger, Sauer, 2016 [23]): Process School focused on business processes and technologies; Value School focused on describing the company’s marketing efforts; and Dual School that combines a description of key technologies and business processes with a description of the nature of the company’s interaction with all stakeholders. The latter approach is especially productive in the context of the transition of industries to the Industry 4.0 principles, since within this approach the business model does not only go beyond the boundaries of a single company and includes a whole complex of interaction participants – suppliers, distribution channels, consumers, but, which is important, expands the boundaries of the business process by widening the boundaries of the market, switching to network forms of interaction with key partners, the government and society, which can significantly increase the added value and ensure greater stability not only of an individual company, but of the entire national economy.

The authors share the last approach as it allows analyzing the changes taking place in large companies under the influence of Industry 4.0.

Table 1. Basic concepts of business models.

| Concept       | Key researchers                                                                 | Approach to defining business model                                                                 | Key performance indicators                                                                 |
|---------------|---------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------|
| Process School| R. P. Ward, T. Shuan [24], C. K. Prahalad, M. S. Krishnan [25], A.V. Shingarev  | The business model of an organization is the logic of combining its resources and potential with the aim of step-by-step solution of its strategic tasks and efficient execution of operational activities. A business model is a set of interdependent model parts that determine the endogenous and exogenous environment in organizations in the format of a common system. | A description of technologies and business processes that ensure the company's competitiveness. An analysis of failures and mismatches between participants in the value chain that regularly occur in business. Manufacturing approach. |
| Value School  | R. Mills [27], A. Osterwalder, Y. Pigneur, C. L. Tucci [9], M. Johnson, C. M. Christensen, H. Kagermann [21], V.A. Gusakov [15] | The business model demonstrates the value that the enterprise offers to diversified consumers, reflects the capabilities of the company, the list of counterparties required to manufacture, develop and supply this value to consumers, the capital ratios required to obtain stable cash flows. | A description of the company's most important values as viewed by external consumers. Marketing approach. |
| Dual School   | W. Scott Dunbar, A. Moss A, J Davies, J. McKinnell [28], Zott, Amit, Massa [17] | Business model as a set of technologies, organization and interaction with the external environment based on common values. | Combining the first two approaches. An important element of a business model is its going beyond the boundaries of a single company. Network and social license approach. |

Depending on how value is created (independently or with the involvement of other companies), there are three basic types of business models:

- closed vertically integrated, assuming that the company carries out all the main, auxiliary and supporting activities independently;
• open network business model, consisting of a group of independent companies that purchase
raw materials, products and services for each other on the basis of long-term external contracts
and share certain types of both the main and, especially, auxiliary activities;
• digital business model – an open network model, which, in addition to a deeper division of
labour in relation to types of activities and digitalization, is characterized by joint ownership
of unique assets, joint project activities, joint production and consumption of resources, etc.

In modern conditions in the manufacturing industries, the second model is most common, with
information, innovative ideas, production capacity, human resources, individual stages of the
production process, auxiliary and supporting works or services increasingly becoming its subject.
However, under the influence of Industry 4.0, digital models are sprouting in all sectors of the
economy, including the extractive sector.

4. Business models in the modern extractive sector
In the extractive sector, vertical integration is the prevailing (typical) pattern. In addition to the typical
business model of vertical integration, internationally, there exists its advanced version – a vertically
integrated business model with service departments. Besides, under the influence of Industry 4.0,
within the framework of the major global mining companies, an open network business model with
elements of a digital model has started to develop see table 2.

Table 2. Types of business models in the extractive sector.

| Vertically integrated model | Vertically integrated model with service departments | Networked business model with elements of a digital model |
|----------------------------|----------------------------------------------------|-------------------------------------------------------|
| Closed model               | Open model                                         |                                                       |
| The main task is to ensure control over the market. Poor consideration of environmental issues and costs of the local community. Focus on extensive development of natural resources. | The main task is to maximize the sustainability of the company’s production. Consideration of certain problems of the local community. Focus on economic goals. | The main task is to maximize the flexibility of the company. Considering the interests of local community. Focus on social and economic goals. |
| ExxonMobil, Shell, Chevron, BP, Total, PJSC Gazprom, OJSC NK Rosneft, OJSC SUEK, OJSC SDS | BG, BP, Eni, Repsol, Royal Dutch Statoil and Total, BHP Billiton, Rio Tinto, Fortescue, Vale | Certain projects of Total, PJSC Gazprom, RioTinto, Vale |

The vertical integration model allows major extracting companies to reduce the risks arising from
the volatility of energy prices in the world markets, increase price control and expand the sales market
through a stable connection between various production processes. An important thing is the ability to
accumulate funds and reallocate investments in favor of the most promising business segments.
However, the consolidation of diversified business processes within one company leads to serious
risks, especially during crisis periods accompanied by a decrease in demand for energy resources and falling prices. Therefore, in the last 10 years, two main trends can be observed in changes in the
business models of extractive companies. A number of large coal and oil and gas companies have chosen the path of total cost reduction, sought to eliminate all non-core assets from their structure, transferred a significant amount of risks to specialized service organizations, and outsourced transportation, primary processing and beneficiation operations. This allowed for the formation of the so-called lean business model “without non-core assets”. This trend was especially pronounced in coal mining companies, including Russian ones.

![Figure 1. Typical business model structure.](image)

On the other hand, a number of extracting companies have tried to secure their competitive advantages by means of increasing competitive advantages of the highest order (technologies, patents), transition to digital and thus reducing specific capital and operating costs. This led to the growth of non-core investments (related sectors, new technologies) and caused the formation of the second model and individual elements of the third one. An example of the latter is the decision of the seven major European oil and gas companies (BG, BP, Eni, Repsol, Royal DutchShell, Statoil and Total) in June 2015 to support the transition to a low-carbon development paradigm. These changes were directly reflected in the business models of these companies. Thus, in the business model of British Petroleum (BP), along with the main business segments: Upstream and Downstream, the division of "Alternative Energy BP" appeared, which carries out strategic management in the field of renewable energy sources (RES) and is engaged in the production and sales of low carbon energy.

![Figure 2. Business model structure of British Petroleum (BP) [29].](image)

As can be seen from figure 2, the company structure includes divisions not related to the main production processes: BP WindEnergy, which operates in the field of wind energy and BP Biofuels, which develops biofuels. In addition, the AlternativeEnergy segment includes research centres that work on technologies for capturing and storing CO2. BP also owns a network of petrol stations that run on hydrogen and oil companies and receiving terminals in the Gulf of Mexico that specialize in liquefied gas. All this suggests that the BP business model is a network one.

5. Industry 4.0 and the formation of elements of digital business models in the extractive sector

The energy sector is undergoing industrial revolution under pressure from three main groups of factors: the exhaustion of energy sources traditional for the previous stage of development, rapid changes in the energy market and the emergence of new technological development opportunities including digital and production technologies (see Fig. 3), which are intertwined in the closest way.

In modern foreign and Russian studies, the fourth industrial revolution is mainly viewed through the prism of the use of information and digital technologies in industrial processes. The most important among them are cyberphysical systems (CPS); industrial Internet of Things (IoT –the use of digital twins, scanners, and sensors); BigData and business intelligence; AR technologies (augmented reality); cloud storage technologies; autonomous operation; information security (protected data, access authentication system, full control of management networks); additive manufacturing; digital modeling; horizontal and vertical integration of systems (internal and external organizational interaction of the enterprise) [30].

However, it would be wrong to reduce the fourth industrial revolution to digital technologies only. Changes are occurring rapidly and along with digital technologies are associated, firstly, with
breakthrough industrial production technologies that, no less than digital, change production processes, structure and organization of company management, secondly, with the advent of platform solutions, which are based on new products, the way of their promotion and consumption, which means a radical restructuring of markets and the mechanisms of interaction between their main participants, thirdly, with a change in the relationship of companies with the external environment implying a blurring of boundaries between businesses, industries and sectors. There is also a transformation of part of the external environment of companies into the internal one, which opens up new opportunities for interaction between business, government and society and necessitates the transition to an open platform model.

At present, in the energy sector, global vertically integrated companies (VICs), whose competitiveness is largely determined by the ability to build upward, high supply chains, are being replaced by national and regional companies included in horizontal networks (clusters), whose competitiveness is largely determined by flexibility and ability cooperate and adapt to flexible market conditions. Large energy companies are increasingly cooperating with companies in knowledge-intensive industries. For example, only in 2017, BP acquired BeyondLimits, a start-up based on artificial intelligence and cognitive computing, which is adapting NASA’s upstream technologies for deep space exploration. Chevron is actively developing GPUs for seismic data visualization and 3D reservoir modeling. The main goal is to determine the most suitable locations for drilling. Shell develops machine learning algorithms for seismic exploration to automatically detect and classify geological structures in onshore and offshore oil and gas fields. This shows that not only a deep transformation in the energy sector, but also barriers between industries and the boundaries between suppliers, producers and consumers are being destroyed. These global changes allow researchers to state a complete change in the development paradigm of the energy sector and related industries [31]. They have almost put an end to the old approach to the extraction and use of energy resources, the essence of which was “the consistent development of new” mineral reserves, “while the main emphasis was placed on the discovery and development of primarily large and giant deposits”. Now they require to include a new conceptual approach in the process of developing more actively. In recent decades, there has been a transition of direct control over the world’s oil and gas resources from “super majors” (the largest transnational non-state-controlled oil and gas and mining companies) to national and regional companies [32-33]. All of this has had an impact on business models in the energy sector, which are gradually becoming digital.

Finally, the business model itself of companies is changing. The traditional model of energy sector organization is being replaced by various types of digital business models: a platform model and a Smart Field model, which can eventually turn into an integral cyberphysical system (see table 3).

| Table 3. Modern concepts of digital business models [34]. |
|----------------------------------------------------------|
| **Key function** | Platform model | Smart Field | Cyberphysical system |
| Upgrade (modification) of existing value chains | Based on market and price management by coordinating the activities of various market participants | Based on full product lifecycle management | Based on the design and management of the entire value chain and the external environment of the company |
| Key digital business processes | Automatic monitoring of prices, markets and consumer requests. Replacing intermediaries - optimizing the process of making transactions and settlements. | Flexible batch automated production - transformer. Lean automated supply chain driven by the Internet of Things. Integration with research, service, logistics and sales. | A single complex of computing resources and physical processes, covering both individual enterprises and complexes of enterprises that implement successive redistributions in value chains. The formation of a digital ecosystem that includes business and other stakeholders. |
Key digital technologies
Big data, cloud storage, distributed ledgers
Industrial Internet of Things, Robots, including drones, digital twins, smart materials, 3D printing

Restrictions removed
Expanding the boundaries of demand restrictions
Expanding the boundaries of resource constraints
The formation of a new development paradigm based on the Industry 4.0 principles.

6. Business models in major Russian mining companies and alternative pathways of their transformation

Currently, a vertically integrated business model and a vertically integrated business model with service divisions are typical for the major Russian business companies. An example is the business model of NK Rosneft.

The business model of NK Rosneft OJSC has a typical closed vertically integrated nature. It ensures the growth of shareholder value through the use of the company’s competitive advantages: availability of a promising resource base; an integrated business model; diversifying sales channels and increasing the share of long-term contracts; strategic development of oilfield services and infrastructure areas; and cost monitoring. Therefore, it can be classified as a vertically integrated business model with service departments [35].

The model includes structures in the field of hydrocarbon production (upstream) – 25 subsidiaries and affiliates. The company produces hydrocarbons at basic production fields in Western and Eastern Siberia, Timan-Pechora, Central Russia, the southern part of the European Russia and the Far East. Refining and downstream activities employs 16 divisions. The Refining and Sales segment includes nine basic refineries: Komsomolsk, Tuapse, Kuibyshev, Novokuibyshev, Syzran, Achinsk, Saratov refineries, Ryazan Oil Refining and Angarsk Petrochemical Companies. Integrated service divisions (oilfield services are represented by RN-Service LLC; RN-Burenie LLC; RN-Inform LLC; RN-Uchet LLC; Private Security Company RN-Okhrana LLC; RN-Fire safety LLC; RN-GRP LLC; Samara ITC LLC; Targin Logistics LLC – a total of 9 dependent companies. They perform auxiliary operations in relation to the main business and are engaged in the construction of facilities, maintenance, renovation, technical monitoring, control of a single information space providing technological switching, power generation, and R&D [36].

SUEK JSC employs a similar vertically integrated business model. The company’s website states that its business model “is based on vertical integration, which ensures control of operational processes and costs throughout the entire business cycle. Due to its vertical integration SUEK obtains competitive advantages, such as economies of scale of production, its own railway and port infrastructure, its own sales and distribution network”. The company includes 27 mines and open-pit mines, 24 thermal power plants, 9 preparation plants and facilities, 42,900 railcars under its management, and 3 ports. The company owns an international sales network, a research institute, and auxiliary enterprises. Service departments are absent from the company’s business model. The increasing complexity of the company is mainly due to the complication of the main production units, as well as transport and logistics units [37].

In general, evaluating the state of the fuel and energy complex it is possible to conclude that oil and gas companies are closer to a vertically integrated business model with service divisions, while coal companies – to a simple vertically integrated model.

Digitalization and the need to switch to the Industry 4.0 principles have not spared the Russian fuel and energy complex. The digital development of the sectors of the fuel and energy complex is one of the priority tasks in Russia. Within the framework of the federal program “Digital Economy” [38], the Ministry of Energy of Russia with the participation of fuel and energy companies has developed a departmental project “Digital Energy” [39]. The digitalization of the Russian fuel and energy complex occurs through the introduction of digital technologies and platform solutions in order to increase efficiency and safety. Today, such messages are formulated in the Energy Strategy of Russia until
2035, recently adopted by the Government of the Russian Federation. The main tasks determined by the Energy Strategy in the field of digitalization of the fuel and energy complex are to systematize the experience in implementing digital solutions, to create conditions for the development of digital services, as well as to develop and amend legislation [37].

Major Russian extracting companies in the fuel and energy complex have begun to actively introduce smart digital technologies. For instance, SUEK JSC plans to invest about 2 billion rubles in digitalization of production by 2023. Its areas of digitalization includework safety systems for employees, in particular, systems for positioning people in mines, a system for monitoring rock production, and digitalization of activities related to nature conservation. The company's divisions are already implementing such advanced technologies as unmanned mining, unmanned dump trucks, predictive repair technologies with big data based analysis of future trends. Digital platforms increase the transparency of communication with customers and suppliers. In 2019, the company launched a system for remote control of industrial safety in Kuzbass on the basis of the Unified Dispatch and Analytical Centre, which has no equals anywhere in the world. Owing to this, the entire technological process of coal mining is under control, from the face to loading into railcars, which makes it possible to predict and prevent possible threats and failures.

Table 4. Implementation of digital technologies by Russian fuel and energy companies [36-37, 40-43].

| Company / Industry | Digital business model          | Pilot projects |
|--------------------|--------------------------------|---------------|
| PJSC Rosneft / oil | Technology platform            | Cloud computing model |
|                    |                                | SmartField    |
|                    |                                | Smart Well    |
| PJSC Lukoil / oil  | Technology platform            | BigData based modeling |
|                    |                                | Centre for spatial visualization |
|                    |                                | SmartField    |
|                    |                                | Smart Well    |
| PJSC Tatneft / oil | Technology platform            | Engineering Centre |
|                    |                                | Smart Well    |
| PJSC Gazprom / gas | Technology platform            | Engineering Centres (Russian Natural Gas Research Institute VNIIGaz, Tyumen Gas Equipment Research and Design Institute NIIgiprogaz, etc.) |
|                    |                                | SmartField    |
| PJSC GazpromNeft  | Comprehensive multifunctional platform | Geomat Geological Information Analysis |
|                    |                                | Refinery digital twin |
|                    |                                | Smart Well    |
|                    |                                | Automated control centre |
|                    |                                | Industrial Internet implementation |
| JSC SUEK           | Comprehensive multifunctional platform | Sales management |
|                    |                                | SmartOpen-Pit |
|                    |                                | A complex of intelligent systems to ensure work safety |

Even today, the use of digital technologies makes it possible to increase the accuracy of geological prospecting and drilling of wells, reduce the number of errors in the design and operation of industrial facilities, and warn about possible equipment failures in advance.

Yet, the Russian fuel and energy complex is still far behind foreign mining companies both in terms of introducing new digital technologies and in transforming their business models. In 2019, the consulting company Strategy Partners Group conducted a survey of executives of mining companies in order to investigate their readiness to implement digital technologies and transform business models based on Industry 4.0 principles. The survey showed that about 80% of companies used digital design technologies in one form or another; about 60% of the surveyed companies used new materials, big data and cloud technologies. Every second company experimented with robotization, additive
manufacturing, the Internet of Things and social networks, but only every tenth used “advanced” artificial intelligence or blockchain. Most companies did not have a roadmap for digital transformation initiatives and changing management mechanisms. The volume of investments in digitalization was also small. 62% of businesses had less than 5% of the total personnel engaged in digital transformation activities. Moreover, for 71% of companies the total volume of investments for these purposes did not exceed 5%. 67% of companies had no specialized digital transformation competency centre. Among the largest mining companies, things were not much better, see Table 4

Nevertheless, experts from StrategyPartners Group note that companies expect the government, primarily, to develop specialized fields of training and to support corporate R&D, or else, to take initiative in introducing technological solutions: 35% of the surveyed executives think so. 22% of the respondents expect incentives for hi-technology entrepreneurship (grants and acceleration programs). All this allows the authors to conclude that in order to fully unleash the potential of digital transformation of the extractive industries and obtain a systemic effect from the introduction of digital technologies, it is necessary to radically change the business model of companies.

7. Conclusions

Our analysis of the business models of the major Russian mining companies and comparison to their foreign counterparts showed a certain conservatism in Russian companies and the lag in the implementation of digital platforms, despite the interest of companies’ management in using digital technologies. This is largely due to the low willingness of most companies to complicate their business models and to implement digital transformation. Such trends can be explained by the fact that companies tend to choose a vertically integrated model. They are in the early stages of digital transformation and mainly focused on operational aspects. In most Russian mining companies, the level of automation of production and administrative processes is low, and the use of digital technologies is still limited mainly to pilot projects. To achieve a systemic effect from digitalization, it is necessary to combine the efforts of all interested parties – the government, companies, the innovation community, and academic circles.

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