EXPERIENCE OF MINING PROJECT IMPLEMENTATION

Review paper

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The assessment of the level of digitalization and digital transformation of oil and gas industry of the Russian Federation

V.V. Yurak[1, 2], **I.G. Polyanskaya**[1], **A.N. Malyshev**[1, 2]
[1] *Institute of Economics of Ural Branch of RAS, Yekaterinburg, Russian Federation*
[2] *Ural State Mining University, Yekaterinburg, Russian Federation*
✉ *vera_yurak@mail.ru*

Abstract
Digitalization and digital transformation of companies have turned from global trends to an urgent need. Thanks to digitalization and digital transformation, organizations can overcome the times of crisis, the times of lockdowns with less losses and respond more effectively to any adverse changes in the external environment. The assessment of the level of digitalization and digital transformation allows to determine how fast the processes of introducing digital technologies and optimizing processes with digital solutions proceed, both in companies and across the industry as a whole. The article provides an analysis with the systematization of foreign and domestic methods, methodological approaches, methods for assessing the digitalization level and digital transformation, as well as reveals their positive and negative aspects. Based on a comparative analysis, an improved author-developed methodological toolkit is proposed for assessing the level of digitalization and digital transformation, alleviating the disadvantages of the existing methodological experience. The approbation of the author-developed methodological toolkit was performed using the oil and gas industry as an example; the following companies, being the industry leaders, were analysed: PJSC "Lukoil", PJSC "NK "Rosneft", PJSC "Gazprom", and PJSC "Tatneft". According to the results, the digitalization and digital transformation processes of the domestic oil and gas industry are insufficiently dynamic. It was found that in the period from 2016 to 2020, the Russian Federation industry leaders were in the following order from the most advanced to the least advanced in terms of the digitalization level and digital transformation: PJSC "Gazprom" topped the list; PJSC "NK "Rosneft" was second; PJSC "Lukoil" was the third largest company, and PJSC "Tatneft" held the fourth position.

Keywords
oil and gas industry, digitalization, digital transformation, assessment, methodological approaches, methodological toolkit, comparative approach, ranking, strategic development, comparative analysis, Russian Federation

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ОПЫТ РЕАЛИЗАЦИИ ПРОЕКТОВ В ГОРНОПРОМЫШЛЕННОМ СЕКТОРЕ ЭКОНОМИКИ

Обзорная статья

Оценка уровня цифровизации и цифровой трансформации нефтегазовой отрасли РФ

В.В. Юрак[1, 2], **И.Г. Полянская**[1], **А.Н. Малышев**[1, 2]
[1] *Институт экономики УрО РАН, г. Екатеринбург, Российская Федерация*
[2] *Уральский государственный горный университет, г. Екатеринбург, Российская Федерация*
✉ *vera_yurak@mail.ru*

Аннотация
Цифровизация и цифровая трансформация компаний из мировых тенденций превратились в насущную необходимость. Организации благодаря цифровизации и цифровой трансформации могут с меньшими потерями преодолевать кризисные времена, времена локдаунов и наиболее эффективно отвечать на любые негативные изменения внешней среды. Оценка уровня цифровизации и цифровой трансформации позволяет определить: насколько быстро протекают процессы внедрения циф-

ровых технологий и оптимизации процессов цифровыми решениями как в компаниях, так и в отрасли в целом. В статье проведен анализ с систематизацией зарубежных и отечественных методов, методологических подходов, методик по оценке уровня цифровизации и цифровой трансформации; выявлены их положительные и отрицательные стороны. На базе сравнительного анализа предложен усовершенствованный авторский методический инструментарий по оценке уровня цифровизации и цифровой трансформации, нивелирующий недостатки существующего методического опыта. Апробация авторского методического инструментария была выполнена на примере нефтегазовой отрасли; анализу подлежали следующие компании – лидеры отрасли: ПАО «ЛУКойл», ПАО НК «Роснефть», ПАО «Газпром», а также ПАО «Татнефть». Результаты продемонстрировали недостаточную динамику процессов цифровизации и цифровой трансформации отечественной нефтегазовой отрасли. Было выявлено, что лидеры отрасли в период с 2016 по 2020 г. в РФ по уровню цифровизации и цифровой трансформации располагаются в следующем порядке от наиболее продвинутых к наименее продвинутым: ПАО «Газпром» на первом месте; на втором ПАО «НК «Роснефть»; на третьем ПАО «Лукойл»; на четвертом ПАО «Татнефть».

Ключевые слова
нефтегазовая отрасль, цифровизация, цифровая трансформация, оценка, методологические подходы, методический инструментарий, сравнительный подход, ранжирование, стратегическое развитие, сравнительный анализ, Российская Федерация

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Introduction

The relevance of digitalization and digital transformation of the oil and gas industry is indi-cated by both the global situation associated with changing oil prices and the sanctions policy against Russia, and the need to develop hard-to-recover oil reserves in the conditions of depleting exploited fields, as well as the Arctic projects, using digital models [1–3]. The significance of the development of hard-to-recover reserves in Russia is associated "… with an increase in their share in the structure of hydrocarbon reserves (now it exceeds 65 % of the total volume), as well as with the forecasts of a decline in oil production by 44 % by 2035, approximately 310 million tons. In 2017, oil production from hard-to-recover reserves in Russia amounted to 39 million tons, and according to the forecast of the Ministry of Energy of the Russian Federation, by 2035 this index is expected to be 80 million tons per year" [4]. Under the current conditions, it is digital solutions[1] [5] that become priority lines in improving the performance efficiency of the companies[2] [6]. Currently, almost all leading oil and gas companies of the world[3] [7–9]] establish their development strategy on the use of digital transformation as a major line [7–9]. Technological processes are being implemented in the industry since digital transformation is a significant competitive advantage, it contributes to the profitability of oil and gas companies and increases their market sustainability. The comprehensive digitalization of the companies' activities and the complete digital transformation

[1] INTERENERGO. On the digital transformation of Gazprom Neft and technological trends in the oil industry. URL: https://ieport.ru/stat/325802-o-cifrovoj-transformacii-gazprom-nefti-i-texnologicheskix-trendax-neftyanoj-otrasli.html (Accessed: 12.06.2022)

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[2] Oil and Gas Information Agency. LUKOIL introduces digital field models. URL: https://www.angi.ru/news/2878022-LUKOIL-introduces-digital-field-models/ (Accessed: 12.06.2022)

Neftegaz.RU. Strategy "Rosneft-2022". URL: https://neftegaz.ru/tech-library/menedzhment/142430-strategiya-rosneft-2022/ (Accessed: 12.06.2022)

[3] Siemens. Making the digital leap with Topsiders 4.0. URL: https://assets.siemens-energy.com/siemens/assets/api/uuid:a0f97b62-5070-46a3-984f-1ed4144e398d/topsides-whitepaper.pdf (Accessed: 12.06.2022)

BP. BP Sustainability report 2018. Responding to the dual challenge. URL: https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/sustainability/group-reports/bp-sustainability-report-2018.pdf (Accessed: 12.06.2022)

Equinor. Equinor Sustainability report 2018. URL: https://www.equinor.com/en/news/2019-03-15-annual-sustainability-reports-2018.html (Accessed: 12.06.2022)

Chevron. Chevron Sustainability report 2018. Climate change resilience framework. URL: https://www.chevron.com/-/media/shared-media/documents/climate-change-resilience.pdf (Accessed: 12.06.2022)

Eni. Eni Sustainability report 2018. URL: https://www.eni.com/assets/documents/EniFor-2018-eng.pdf (Accessed: 12.08.2022)

ExxonMobil. ExxonMobil Sustainability report 2018. Highlights. URL: https://corporate.exxonmobil.com/Community-engagement/Sustainability-Report (Accessed: 12.06.2022)

Shell. Shell Energy transition report 2018. URL: https://www.shell.com/energy-and-innovation/the-energy-future/shell-energy-transition-report/_jcr_content/par/toptasks.stream/1524757699226/3f2ad7f01e2181c302cdc453c5642c77acb48ca3/web-shell-energy-transition-report.pdf (Accessed: 12.06.2022)

Sinopec. Sinopec Sustainability report 2018. URL: http://www.sinopec.com/listco/en/investor_centre/reports/2018/ (Accessed: 12.06.2022)

can allow them to become at least 20 % more efficient than they are these days [7].

Along with positive trends towards digitalization in the leading companies of the oil and gas industry in Russia, there are still unresolved problems hindering its transformation and the formation of digital platforms. The major problem is observed in the dependence of the industry on foreign technologies, equipment, software and investments, which is aggravated by sanctions and other restrictions. The level of import substitution remains insufficient. With regard to the Arctic shelf projects, they are scarcely being developed after the U.S. company ExxonMobil and the British company BP, possessing the necessary technology, withdrew from the joint projects. Shell Company also ceased its activities. Total Company transferred its share in the Bazhenov formation fields to Lukoil, and the latter transferred its share in Shtokman to Gazprom [10]. "Many Western oilfield services companies have also reduced the scale of their business in Russia" [1]. The situation is aggravated by the COVID-19 pandemic, which hinders the growth of financial performance of companies, which affects the amount of investment in R&D and various innovations.

Another significant challenge for the industry is the training of qualified personnel [11, 12]. This problem is typical for the entire mineral resource complex [13, 14]. Specialists "with digital competencies, such as analytics and big data, robotics, operation of unmanned aerial vehicles, programming, 3D modeling" [2], as well as with the competencies of new emerging professions in the industry related to digitalization are required [15].

The issues related to economic security and trade secrets upon the exchange of technical data remain to be the areas of concern. According to the experts' opinion, the funding provided in the Digital Economy program for information security leaves much to be desired. In this connection, the Russian companies, unlike the foreign ones, are often afraid to share information. In turn, this can slow down the process of neural network prediction [16].

The success of the digitalization transformation in industry is largely hindered by the lack of an optimal level of management of the entire set of processes from a single control center in the companies.

There is also a problem of institutional support or legal regulation of the activities of digital platforms, covering a complex of various organizations, along with the parent one. The problem arises "due to the lack of a well-defined legal definition of a digital platform in the jurisdiction of most countries, including Russia" [17]. In the Russian legislation, "The Legal Regulation of Digital Environment", Federal Project developed as the follow-up of Decree of the President of the Russian Federation No. 204 "On the National Goals and Strategic Objectives of the Development of the Russian Federation for the Period up to 2024" of May 7, 2018, involves the elaboration of a list of regulations for the removal of obstacles hindering the development of the digital economy. The settlement addresses the relevant administrative, production and economic issues of enterprises in related industries that comprise the digital platform, including issues related to legal status, protection of rights, obligations and security.

Along with the identified problems, the issue of the development of methodological support for assessing the level of digitalization and digital transformation, as well as the economic assessment of the implementation of the achieved levels within the industry, which would be applicable for each industry enterprise (company), as well as digital transformation, requires further development. The availability of such methodological support will allow to perform a timely diagnosis of "constrictions" and effective management of digitalization and digital transformation.

Hence, *the purpose* of this research is to improve the management of digitalization and digital transformation of the oil and gas industry through the development of the author guidelines, mitigating the shortcomings of existing methods.

The purpose determines the importance of performing the following tasks:

1. The analysis of the theoretical foundations of digitalization and digital transformation.
2. The assessment of the current state of the digital transformation of the oil and gas industry.
3. The study, analysis and systematization of foreign and domestic general, industry and production methods (for individual enterprises and companies), methodological approaches, recommendations and methods for assessing digitalization and digital transformation.
4. The development of an improved author methodology for assessing the level of digitalization and digital transformation of the oil and gas industry, alleviating the disadvantages of existing methods.

Research Methods

The methodological basis of the research was composed of standard general scientific methods, as well as the method of content analysis upon the study and systematization of foreign and domestic general, industry and production methods (for individual enterprises and companies), methodological

approaches, recommendations and methods for assessing the level of digitalization and digital transformation. The methods of mathematical statistics and the foresight method were also used in the formation of the author methodology for assessing the level of digitalization and digital transformation of the oil and gas industry, alleviating the disadvantages of the existing methods.

Results and Discussion

The Analysis of the Theoretical Foundations of Digitalization and Digital Transformation

The digital transformation is characterized by the penetration of advanced technologies introduced in the process of digitalization into the entire complex of ongoing business processes of companies. Along with this, "digital transformation is increasingly understood as a controllable adaptation of companies in the context of advancing digitalization for the provision of sustainable value creation" [18]. In Russia, these processes are supposed to be implemented in a digital economy, which is defined by Decree of the President of the Russian Federation No. 204 of May 07, 2018 to be one of the national development goals of the Russian Federation until 2024 and highlighted among the priority national projects. One of the tasks, being set to achieve the goal, is formulated as the transformation of priority sectors of the economy, including industry, transport and energy infrastructure "through the introduction of digital technologies and platform solutions"[4]. Obviously, it is of direct relevance to subsurface resources management. The major lines of the development of the digital economy were previously approved in the relevant program by the Order of the Government of the Russian Federation No. 1632 of 28.07.2017[5].

The relation of the main terms is shown in Fig. 1. The term "digital economy" was introduced in 1995 by Canadian scientist Don Tapscott, who described the digital form of representation of objects, the impact of information technology on business, public administration system, etc. [19]. Subsequently, the term "digital economy" was interpreted differently by other authors, meanwhile the interpretations were close in meaning [20–23].

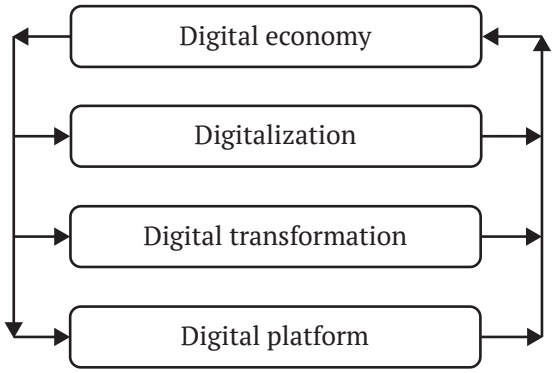

Fig. 1. The chronology of the development of the conceptual construct and the relationship between the concepts of the digital economy and digital transformation

According to Decree of the President of the Russian Federation No. 203 of May 9, 2017, the "digital economy" is defined as "economic activity in which digital data constitute a key factor of production, the processing of large volumes and the use of the results of the analysis of these data allow to significantly increase the efficiency of various types of production, technologies, equipment, storage, sale, delivery of goods and services compared to the traditional forms of management"[6].

A key concept for understanding the terms "digital economy" and "digital transformation" is "digitalization", which is commonly interpreted as "the process of introducing digital technologies for generating, processing, transmitting, storing and visualizing data in various fields of human activity" [24], as well as "integrating digital technologies into everyday life by digitizing everything that can be digitized"[7].

The oil and gas industry is also one of the industries with a particular emphasis put on digitalization and digital transformation. The digitalization of the oil and gas complex as an integral part of the fuel and energy complex (FEC), its essence and development prospects are directly addressed within the framework of "Digital Energy" departmental program developed as a follow-up to the main federal regulations concerning digitalization.

"The digitalization of the oil and gas complex should be understood as the application of new advanced technologies within existing business

[4] Decree of the President of the Russian Federation of 07.05.2018 No. 204 "On the national goals and strategic objectives of the development of the Russian Federation for the period up to 2024". URL: http://kremlin.ru/acts/bank/43027/page/1 (Accessed: 12.06.2022)

[5] Decree of the Government of the Russian Federation of July 28, 2017 No. 1632-r "On Approval of the Digital Economy Program of the Russian Federation". URL: https://www.garant.ru/products/ipo/prime/doc/71634878/ (Accessed: 12.06.2022)

[6] Decree of the President of the Russian Federation of May 9, 2017 No. 203 "On the Strategy for the Development of the Information Society in the Russian Federation for 2017–2030". URL: http://kremlin.ru/acts/bank/41919 (Accessed: 12.06.2022)

[7] Growth people. Global digitalization. URL: https://ludirosta.ru/post/globalnaya-tsifrovizatsiya_2225 (Accessed: 12.06.2022)

processes without changing their principles and structure" [25]. Digital transformation involves the improvement and change of business processes by managing a complex of elements of digital technologies.

Overall, the scheme of the digital transformation of the oil and gas industry, including its impact on the final performance of companies, can be presented as follows (Fig. 2). According to Fig. 2, digital technologies based on the principles of artificial intelligence, being reinforced in the national strategy for its development up to 2030[8], and implemented in the Russian oil industry, include big data, neural networks, digital twins, cognitive technologies, machine learning.

The assessment of the current state of the digital transformation of the oil and gas industry: the major lines of digital transformation of the largest Russian oil and gas companies

Digital transformation is now taking place in all large oil and gas companies [16]. This applies to both foreign and Russian companies. Foreign oil and gas companies such as Equinor[9], BP[10], Shell[11], have a high level of digitalization and digital transformation for the achievement of which, along with digital technologies, they improve partnerships in the area of creating platforms for digital transformation[12] [7–9].

[8] Decree of the President of the Russian Federation of October 10, 2019 No. 490 "On the development of artificial intelligence in the Russian Federation". URL: https:///garant.ru/products/ipo/prime/doc/72738946/ (Accessed: 12.06.2022)

[9] Equinor. Equinor Sustainability report 2018. URL: https://www.equinor.com/en/news/2019-03-15-annual-sustainability-reports-2018.html (Accessed: 12.06.2022)

[10] BP. BP Sustainability report 2018. Responding to the dual challenge. URL: https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/sustainability/group-reports/bp-sustainability-report-2018.pdf (Accessed: 12.06.2022)

[11] Shell. Shell Energy transition report 2018. URL: https://www.shell.com/energy-and-innovation/the-energy-future/shell-energy-transition-report/_jcr_content/par/toptasks.stream/1524757699226/3f2ad7f01e2181c302cdc453c5642c77acb48ca3/web-shell-energy-transition-report.pdf (Accessed: 12.06.2022)

[12] Siemens. Making the digital leap with Topsiders 4.0. URL: https://assets.siemens-energy.com/siemens/assets/api/uuid:a0f97b62-5070-46a3-984f-1ed4144e398d/topsides-whitepaper.pdf (Accessed: 12.06.2022)

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ExxonMobil. ExxonMobil Sustainability report 2018. Highlights. URL: https://corporate.exxonmobil.com/Community-engagement/Sustainability-Report (Accessed: 12.06.2022)

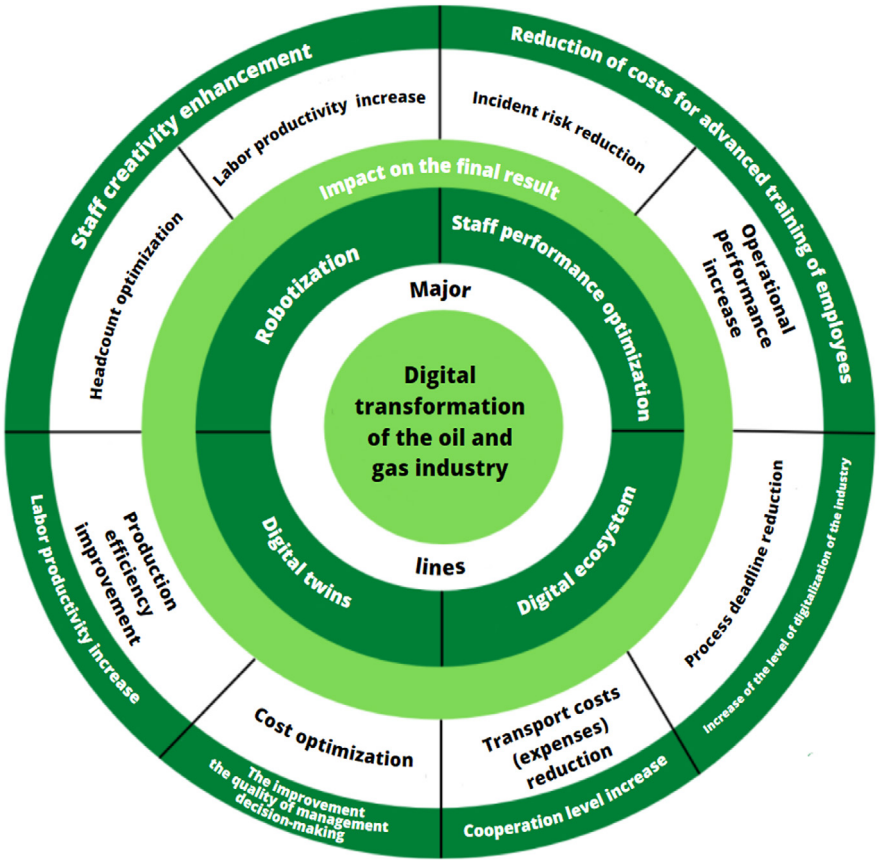

Fig. 2. The major lines of digital transformation of the oil and gas industry and their impact on the final result

In Russia, "the technological portfolio of oil companies consists of hundreds of projects aimed at maximizing oil recovery in conventional fields, as well as providing access and the possibility of efficient development of hard-to-recover reserves" [5]. At the same time, the complexity of digitalization in this very industry is higher than in other industries. "The business consists of managing complex physical and chemical processes, as well as a large number of complex manufacturing and oil extracting assets. The work is performed within the framework of a complex cyber-physical system, where real production is combined with its digital twin[13]. Among the oil organizations, we can highlight such large holdings as PJSC "Lukoil", PJSC "NK "Rosneft", PJSC "Gazprom", which are the industry leaders in terms of digitalization and digital transformation[14]. PJSC "Tatneft" also demonstrates good performance. Let us discuss each company in detail.

PJSC "NK "Rosneft". The company's enterprises provide more than 35 % of liquid hydrocarbons production in Russia. Half of the produced raw materials are extracted from large fields: Priobskoye, Samotlorskoye, Prirazlomnoye and Malobalykskoye (the Khanty-Mansiysk Autonomous Area – Yugra), Vankorskoye (the Krasnoyarsk Territory), Verkhnechonskoye (the Irkutsk Region)[15]

The company's comprehensive digitalization plan is an integral part of "Rosneft-2022" strategy approved in 2017. The plan includes such programs as "digital field", "digital plant", "digital supply chain", "digital filling station", the implementation of which will contribute to the transition to a higher level of business information service, reliability and efficiency of production, as well as to the reduction of losses. Upon that, the controllability and decision-making time along the entire production chain of the company will be improved. The strategy provides for the introduction of 78 proven technologies and obtaining effect of the implementation in the amount of more than 11 billion rubles[16]

At the Ilishevsky field (Bashkiria), there is an operating *Digital Field*, "an analogue of real production, where all processes, from oil production and transportation to the movement of personnel and vehicles, are reflected on a digital platform. The process is performed on the basis of "*digital twins*" using a 3D visualization platform. A pipeline monitoring system using drones, which is based on machine learning and computer vision technologies, is allocated within a separate project"[17].

The Digital Transformation Center and the Digital Cluster are the key mechanisms for the implementation of the digital programs. Based on the artificial intelligence algorithm, a computer vision technology has been introduced at the facility of PJSC "Varyoganneftegaz". "Detailed 3D models have been created for six producing assets ("RN-Uvatneftegaz", "Slavneft-Krasnoyarskneftegaz", "RN-Vankor", "NK "Kondaneft", "Verkhnechonskneftegaz" and "Vostsibneftegaz"). The 3D models will be used upon the creation of a unified information and technology environment for the monitoring the operation of oil fields using advanced visualization and a three-dimensional twin of the asset"[18].

The company implements all its projects based on the introduction of innovative technologies, including the use of unique domestic drilling rigs in the northern version, as well as its own software[19]. The company is building a 770-kilometer pipeline to connect the Vankor and Payakh clusters with the oil loading terminal being under construction at the Bukhta Sever port[20].

PJSC "Gazprom Neft" develops fields in the largest oil and gas regions of the country, namely in the Khanty-Mansiysk and Yamalo-Nenets Autonomous Areas, as well as in the Irkutsk, Omsk, Orenburg, Tomsk Regions and on the shelf of the Barents Sea. The key asset of the company is the southern part of the Priobskoye field (LLC "Gazpromneft-Khantos"), where oil production amounted to 10 million tons in 2020. The company is actively working on the development of new major projects for the development of the Novoportovskoye, Prirazlomnoye and Vostochno-Messoyakhskoye fields[21].

[13] INTERENERGO. On the digital transformation of Gazprom Neft and technological trends in the oil industry. URL: https://ieport.ru/stat/325802-o-cifrovoj-transformacii-gazprom-nefti-i-texnologicheskix-trendax-neftyanoj-otrasli.html (Accessed: 12.06.2022)

[14] Neftegaz-EXPO. Oil organizations. URL: https://www.neftegaz-expo.ru/ru/ui/17160/ (Accessed: 12.06.2022)

[15] State report "On the state and use of the mineral resource base of the Russian Federation in 2020". Moscow: Ministry of Natural Resources and Ecology of Russia. Federal Agency for Subsoil Use (Rosnedra); 2021. Pp. 22–23.

[16] Tadviser. State. Business. Technologies. Information technologies in Rosneft.

[17] Tadviser. State. Business. Technologies. Information technologies in Rosneft.

[18] Tadviser. State. Business. Technologies. Information technologies in Rosneft.

[19] Ekb. Tsargrad. Checkmate in Taimyr: Vostok Oil will turn the oil industry around the world. URL: https://tsargrad.tv/articles/shah-i-mat-na-tajmyre-vostok-ojl-perevernjot-mirovuju-jenergetiku_592772 (Accessed: 01.08.2022)

[20] BFM. Rosneft has started development drilling at the Payakhskoye field of the Vostok Oil project.

[21] State report "On the state and use of the mineral resource base of the Russian Federation in 2020". Moscow: Ministry of Natural Resources and Ecology of Russia. Federal Agency for Subsoil Use (Rosnedra). 572 p.

The policy of digital transformation is performed at all stages of activities, starting from geological exploration and up to product sales. In 2013, the introduction of innovative was started in "Gazpromneft-Khantos" Company, and a production control center (PCC) has been operating here since 2017[22]. Later, digital transformation is approved in the list of priority lines of the company's activities, coordinated by the relevant directorate[23].

In 2019, PJSC "Gazprom Neft" "launched over 150 new digital initiatives and 10 digital transformation programs"[24].

The company "focuses on the implementation of digital technologies, including the early stages of working with assets, when the maximum value is created, because the uncertainties relating to the geological objects are still too great and making high-quality decisions is crucial"[25].

The following projects are being implemented: "*Cognitive Geologist*" project, which allows using the initial geological information "in order to provide a clear mathematical assessment of the probability of success in a particular case"[26]; "*Digital Drilling*" project, which facilitates remote control from the Geo-Navigator Drilling Control Center (DCC); "Smart Field" project, which "allows online viewing of any information on the field development, i.e. well operation parameters, repair history and plans, the levels of fluid withdrawal compensation, conducted and planned studies"[27]; "*Cognitive Engineering*" project that optimizes many field development schemes using machine intelligence.

The development of the Novoportovskoye oil and gas field is performed using an integrated model, "including five hydrodynamic models of major development objects; the models of production and injection wells; the models of a land network for product gathering, including the models of pipelines from wellheads" [26]. In conjunction with subsidiary company "Gazpromneft-Angara", a digital model of oil reservoirs, which will become the basis for the formation of a strategy for the development of hard-to-recover reserves by its "digital twin"[28]. was developed. "The company has established competence centers for ML and AI, VR/AR, IoT, robotics, blockchain, video analytics and product service design"[29].

"The launch of a digital logistics management system in the Arctic, which allowed to optimize the cost of exporting ARCO and Novy Port oil by 10 %", should not go unmentioned[30]. "Prirazlomnaya" offshore ice-resistant fixed platform (OIRFP) was created, allowing performing all technological operations, such as drilling, oil production and storage, preparation and shipment of finished products[31].

Virtually, PJSC "Gazprom Neft" is a "digital oil company" managed on the basis of big data and digital twins. The company produced the world's first oil found using artificial intelligence, and it operates 40,000 "digitized" wells[32]. To implement the digital transformation strategy, it is planned to allocate up to 5 % of the total investment of Gazprom Neft. According to expert opinion, "the digital platform will allow to increase the base effect of digital transformation programs by 23 % due to faster project

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[23] Gazprom Neft. Digitization is a fundamental trend. URL: https://www.gazprom-neft.ru/press-center/sibneft-online/archive/2018-may/1589542/ (Accessed: 23.07.2022)

[24] Comnews. The digital transformation of Gazprom Neft has produced an economic effect. URL: https://www.comnews.ru/content/208475/2020-08-06/2020-w32/cifrovaya-transformaciya-gazprom-nefti-dala-ekonomicheskiy-effekt (Accessed: 23.08.2021)

[25] Gazprom Neft. On the digital transformation of Gazprom Neft and technological trends in the oil industry. URL: https://www.gazprom-neft.ru/press-center/lib/4029430/ (Accessed: 19.09.2021)

[26] Gazprom Neft. Production in a digital format Gazprom Neft combines the entire cycle of field development with digital technologies. URL: https://www.gazprom-neft.ru/press-center/sibneft-online/archive/2018-may/1589543/ (Accessed: 21.09.2021)

[27] Neftegaz.RU. The correspondent of Neftegaz.RU learned how digitalization helped Salym Petroleum Development to optimize the work of the production fund at Salym. URL: https://neftegaz.ru/news/dobycha/512708-korrespondent-neftegaz-ru-uznal-kak-tsifrovizatsiya-pomogla-salym-petroleum-development-optimizirova/ (Accessed: 09.09.2021)

[28] Neftegaz.ru. Gazprom Neft has created the industry's first digital model of the Achimov formation. URL: https://neftegaz.ru/news/Geological-exploration/197900-gazprom-neft-sozdala-pervuyu-v-otrasli-tsifrovuyu-model-achimovskoy-tolshchi/https://neftegaz.ru/news/partnership/538597-achimovka-i-tsifrovizatsiya-gazprom-neft-i-halliburton-razrabotayut-programmu-tekhnologicheskogo-sot/ (Accessed: 19.09.2021)

[29] Neftegaz.ru. Gazprom Neft has created the industry's first digital model of the Achimov formation. URL: https://neftegaz.ru/news/dobycha/512708-korrespondent-neftegaz-ru-uznal-kak-tsifrovizatsiya-pomogla-salym-petroleum-development-optimizirova/ (Accessed: 09.09.2021)

[30] Neftegaz.ru. Gazprom Neft has created the industry's first digital model of the Achimov formation. URL: https://neftegaz.ru/news/dobycha/512708-korrespondent-neftegaz-ru-uznal-kak-tsifrovizatsiya-pomogla-salym-petroleum-development-optimizirova/ (Accessed: 09.09.2021)

[31] Pro-arctic. The record well of the Prirazlomnoye field has been put into operation. URL: https://pro-arctic.ru/08/09/2021/news/44438#read (Accessed: 25.07.2022)

[32] Microsoft. How is a digital oil company built? URL: https://news.microsoft.com/ru-ru/features/belevtsev/ (Accessed: 25.07.2022)

implementation"[33]. The company also uses a digital approach in its procurement activities. The optimization of the procurement, supply and logistics system is performed through the introduction of "i-sourcing" system[34].

In relation to the personnel policy issues, PJSC "Gazprom Neft" acts as one of the founders of Scientific and Educational Center "Artificial Intelligence in Industry", it is implementing "Business Thinking in Digital Reality" Program[35]. Along with Equinor, BP, Shell, PJSC "Gazprom Neft", is a member of International Consortium "Open Subsurface Data Universe" (OSDU) the subject of which is work with a large amount of geological data[36].

PJSC "NK "LUKOIL" produces oil in the Western Siberia (the Khanty-Mansiysk Autonomous Area – Yugra), the Perm Territory, the Nenets Autonomous Area, the Komi Republic, and on the continental shelf. About half of the oil production is performed by subsidiary company LLC "Lukoil-Western Siberia" at the Vatyegansky, Tevlinsko-Russkinsky, Povkhovsky and Yuzhno-Yakunsky fields. Approximately 37 % is produced by two enterprises of the holding, namely LLC "Lukoil-Perm" and LLC "Lukoil-Komi". In 2020, the company's production of liquid hydrocarbons (excluding its share in joint ventures) amounted to 73.4 mln t, having decreased by 10.6 % compared to the previous year[37]. In 2021, the oil production increased by 2.7 % compared to 2020[38]

The digital development of the company is conducted under "The Information Strategy of LUKOIL Group up to 2030"[39], including the following programs: digital twins, ecosystem, digital staff and robotics. The applied technologies include the following ones: "the industrial internet of things, interaction technologies, robots and drones, artificial intelligence, mobile devices, cloud technologies, Big Data"[40]. Within the elaboration of the strategy, a "smart field" project is being implemented at the Vatyoganskoye field. "There are 12 facilities, 29 oil reservoirs and 156 deposits under development." Within the framework of the project, "the following tasks are solved: updating the understanding of the geological structure, elaborating effective solutions for optimizing field development, detailing and implementing the prospects for increasing oil production"[41]. In the Bolshekhetskaya depression of the Yamal-Nenets Autonomous Area, the company is implementing a digital pilot project[42]. The intellectual field elements are present in the following subsidiaries of the company: "LUKOIL-Perm", "LUKOIL-Western Siberia", "LUKOIL-Nizhnevolzhskneft", "LUKOIL-Komi", RITEK. These ones include Integrated Operation Centers (ICOs).

At the Kokuyskoye field of "LUKOIL-Perm", the introduction of digital technologies allowed to "manage production more efficiently"[43] by monitoring well operation parameters, pumping equipment, as well as controlling the emergence of dangerous situations.

The digital oil and gas production model was created on the basis of the Yuzhno-Yagunskoye and Vostochno-Ikilorskoye fields being developed by "LUKOIL-Western Siberia". Here, there is an operating Integrated Operation Center, in which "new management approaches are embodied, including integrated planning, close cooperation with scientific institutions and a collective analysis of the technological process"[44]. The automated systems of the

[33] Manufacturing control. How GAZPROM NEFT has already received 7.2 billion rubles. from digitalization. URL: https://up-pro.ru/library/information_systems/automation_management/mlrd-rub-ot-tsifrovizatsii/ (Accessed: 25.07.2022)

[34] Isource. How digital technologies are changing the procurement process of societies. URL: https://isource.neftegaz.ru/chapter2 (Accessed: 26.07.2022)

[35] Neftegaz.ru. Gazprom Neft has created the industry's first digital model of the Achimov formation. URL: https://neftegaz.ru/news/Geological-exploration/197900-gazprom-neft-sozdala-pervuyu-v-otrasli-tsifrovuyu-model-achimovskoy-tolshchi/ https://neftegaz.ru/news/partnership/538597-achimovka-i-tsifrovizatsiya-gazprom-neft-i-halliburton-razrabotayut-programmu-tekhnologicheskogo-sot/ (Accessed: 19.09.2021)

[36] Gazprom Neft. Gazprom Neft will make the development of digital solutions cheaper through an open industrial data platform. URL: https://digital.gazprom-neft.ru/about-news?id=94 (Accessed: 21.09.2021)

[37] State report "On the state and use of the mineral resource base of the Russian Federation in 2020". Moscow: Ministry of Natural Resources and Ecology of Russia. Federal Agency for Subsoil Use (Rosnedra); 2021. 572 p.

[38] Neftegaz.ru. LUKOIL's hydrocarbon production in 2021 increased by 4.7 %, refining volume – by 7.4 %.

[39] Lukoil. Digitalization program. URL: https://csr2018.lukoil.ru/strategy/digitalization-program (Accessed: 04.08.2022)

[40] Expert. Analytical Center. Digital fountain. URL: http://www.acexpert.ru/archive/nomer-20-796/cifrovoy-fontan.html (Accessed: 27.09.2021)

[41] Oil and Gas Information Agency. Lukoil introduces digital field models. URL: https://www.angi.ru/news/2878022-ЛУКОЙЛ-внедряет-цифровые-модели-месторождений/ (Accessed: 28.10.2021)

[42] Expert. Analytical Center. Measure oil with your mind. URL: http://www.acexpert.ru/archive/nomer-12-13-792/izmerit-neft-umom.html (Accessed: 28.10.2021)

[43] Association of independent oil and gas producing organizations. Oil with intelligence. URL: http://www.assoneft.ru/activities/press-centre/tek/5164/ (Accessed: 27.07.2022)

[44] RBC. Companies that can quickly implement digital solutions become leaders. URL: https://plus.rbc.ru/news/5ad2f7ba7a8aa94d53490a4f (Accessed: 27.10.2020)

Advanced Process Control[45] are being implemented at all enterprises of the company for oil refining and petrochemistry.

PJSC "TATNEFT". "The major region of activity of PJSC "Tatneft", which extracts 4–5 % of the Russian oil, is conventionally the Republic of Tatarstan. The company's largest fields are Romashkinskoye, Bavlinskoye, Novo-Elkhovskoye in the Republic of Tatarstan, the production at which amounted to 22.9 mln t in 2020"[46].

The beginning of the process of digital transformation in PJSC "Tatneft" dates back to 2014. Currently, digital technologies cover all processes, i.e. collection and processing of geological and technological information; creation and updating of geological and hydrodynamic models, decision-making on the choice of optimal geological and technical measures (GTM) as well as their implementation. Wells are designed on the basis of three-dimensional (3D) field models. Active work is being conducted to create artificial intelligence and digital "twins". Digital twins have also been implemented "in the form of hydrodynamic models for oil assets that provide 80 % of oil production" at the Almetievskaya and Abrakhmanovskaya fields, as well as at the Romashkinskoye and Novoelkhovskoye fields.

There is an operating GTM Center (geological and technical measures), where the measures for oil recovery increase are modeled. "Mobile OGPW" Project (oil and gas production workshop) has been implemented as well, it allows to continuously monitor and coordinate the process of oil and gas production remotely from the workplace throughout the day. On the basis of the company, its own software is being developed, including the following: the software package of CIS ARMITS, CIS "Tatneft-Neftedobycha", Roxar, T-navigator. A software package based on neural network interpretation of the logging material has also been developed. NGT Smart software is being actively implemented to monitor and manage the development of oil fields.

In PJSC "Tatneft", a significant role is assigned to the digital transformation of investment activities. In 2019, "the Automated Investment Management System (AIMS) was created". The system constitutes a single bank of investment projects, being an analytical tool for managing the company's investment activities. The system was developed as part of the software import substitution program based on 1C: Enterprise platform. Thus, the company was able to ensure information transparency, strengthen control over the implementation of its projects, apply neural network data analysis and obtain a significant economic effect of 1 billion rubles. Specialists of the company consider it promising to use the results of the Modeling Center to calculate the volume of production when choosing the optimal business projects.

The company's relatively high level of digital transformation allows its specialists to work on the formation of a digital platform to coordinate a complex of activities in this line.

The analysis and systematization of foreign and domestic general, industry and production methods (for individual enterprises and companies), methodological approaches, recommendations and methods for assessing digitalization and digital transformation

The level of development of the methodological system for assessing the level of digitalization and digital transformation is evidenced by a significant number of the developed foreign and domestic methods related to global and country (regional) levels. Most of them have been analyzed, systematized and presented in a series of scientific researches[47] [23, 27–31]. The international methods for assessing the level of digitalization and digital transformation include: Digital Evolution Index (DEI) Rating, Information and Communication Technologies Development Index (ICT Development Index, IDI), Global Cybersecurity Index, PwC's The Future is Coming Rating, Global Connectivity Index (GCI); International Digital Economy and Society Index (I-DESI); Boston Consulting Group's Economy Digitalization Index (e-Intensity); World Digital Competitiveness Index (WDCI); e-Government Development Index (The UN Global E-Government Development Index – EGDI); Networked Readiness Index; E-Participation Index (EPART). In Russia, the following methods have been developed to determine the level of digitalization of the country: the rating of regions of the Russian Federation by the level of development of the information society (the Ministry of Digital Development, Telecommunications and Mass Media of the Russian Federation; "Digital Russia" Index (Skolkovo Information Center); Business Digitalization Index (Institute for Statistical Research and Economics of the National Research University Higher School of Economics); Ivanov Digital Index (PJSC "Sberbank").

[45] RBC. Companies that can quickly implement digital solutions become leaders. URL: https://plus.rbc.ru/news/5ad2f7ba7a8aa94d53490a4f (Accessed: 27.10.2020)

[46] State report "On the state and use of the mineral resource base of the Russian Federation in 2020". Moscow: Ministry of Natural Resources and Ecology of Russia. Federal Agency for Subsoil Use (Rosnedra); 2021. 572 p.

[47] Moscow School of Management "Skolkovo". Center for Financial Innovation and Cashless Economy. Methodology for calculating the "Digital Russia" index of the constituent entities of the Russian Federation. URL: https://finance.skolkovo.ru/downloads/documents/FinChair/Research_Reports/SKOLKOVO_Digital_Russia_Methodology_2019-04_ru.pdf (Accessed: 12.06.2022)

A comparative analysis of the major methods and methodological approaches for assessing the level of digitalization and digital transformation at the level of sectors of the economy (industries) and individual enterprises is provided in Table 1.

The analyzed methodological approaches and techniques assess the level of digitalization and digital transformation of the industry (sectors of the economy) and individual enterprises from various perspectives using appropriate methods and indices upon that. The major methods include: questioning, analytical and comparative methods, the integral assessment method, economic and mathematical methods and financial and economic analysis methods, as well as the method of expert assessments, fuzzy (uncertain) sets, moving curves, etc. The indices of digital maturity, including innovative capacity, are assessed as well. Some of the proposed assessment methods have a significant error, which does not allow accurate assessment due to the use of extremely limited conditions and parameters.

With respect to the oil and gas industry, a comprehensive methodology for determining the level of digitalization is of interest, the application of the one can be attributed both to the level of a country, an industry, and an individual company. It was developed and successfully applied by EY (Ernst & Young, UK). EY has already conducted digital transformation readiness assessments for more than 3,800 companies in 44 countries. Pursuant to Order of the Ministry of Energy of the Russian Federation, such an assessment was also carried out for the domestic oil and gas industry[48]. In accordance with the methodology, the readiness of the country's institutional environment, the degree of the penetration of digital solutions in the industry are determined; in particular, Digital DNA map is built for companies based on analytical data on the current level of implementation and the use of digital systems, as well as on the level of readiness of the company for digital transformation. The following areas are considered for calculations: strategy, innovation and development; interaction with clients; supply chain and operation management; information technologies; risks and cybersecurity; finance; legal support; taxation; leadership and organizational culture. The methodology allows to compare the results of assessing the levels of digitalization of the industry and individual companies, to identify their strengths and weaknesses. Deloitte Company offers a digital transformation model for oil and gas exploration and production, which can be used to calculate the level of digitalization and digital transformation in these segments. However, the analysis revealed that there is no approved industry methodology, as well as a methodology for assessing digitalization and its transformation at the level of enterprises of the industry.

The improved author methodological toolkit for assessing the level of digitalization and digital transformation of the oil and gas industry

The author methodology implies a comprehensive assessment of the strategic level of digitalization and digital transformation of both an enterprise and the industry as a whole. Thanks to this assessment it is possible not only to calculate the aforesaid level, but also to determine the role of such phenomena as digitalization and digital transformation in the development strategy of the organization. The methodology of the author was developed based on the results of the study of foreign and domestic scientific publications, as well as the study of assessment methods used by consulting companies. The methodology of the author takes into account most of the advantages and disadvantages of existing methods, which were determined on the basis of a comparative analysis of 24 existing methodological recommendations and reflected in Table 1. Thus, taking into account the results of the comparative analysis, the list of indices being used has been reduced to three for the express assessment; it is recommended to obtain all indices used for the calculation from open sources of information.

The conditions/principles for the implementation of the author methodological toolkit for an express assessment of the level of digital transformation of companies in the industry, taking into account the shortcomings of existing methodological approaches to assessing the level of digitalization and digital transformation, will be as follows:

1. The assessment of the level of digital transformation is based on a comparative approach;
2. The selected leading companies of the analyzed and assessed industry are subject to the assessment of the level of digital transformation;
3. The selected indices of the assessment should concern digital transformation, they should characterize it and be publicly available;
4. The sources of information for the selected indices are exclusively official sources of information;
5. Based on the selected indices, the multipliers characterizing the level of digitalization and digital transformation are formed;
6. The multipliers are assigned certain weights, which are set on the basis of an expert survey.

[48] State contract dated 21.08.2019. No. 0173100008319000044/K/02. Analysis of the level of implementation and use of digital information systems. URL: https://in.minenergo.gov.ru/upload/iblock/971/971c417247ad76e15c6d3b910dc9dcca.pdf (Accessed: 12.06.2022)

Table 1

Comparative analysis of methodological approaches to the assessment of the level of digitalization and digital transformation of the industry and individual enterprises

Source	Method name, key assessment method	Indices in the methodology	Positive aspects	Negative aspects
Comprehensive methods and methodological approaches to assessing the level of digitalization and digital transformation (for industries and individual enterprises)				
Potetenko S. V. The assessment of the level of digitalization of enterprises (organizations) and industries. Belarus. OJSC "Giprosvyaz" [32]	The assessment of the level of digital development of enterprises, industries and functional areas	Automation, computerization, informatization, digitalization	Allows to obtain a generalized view of the assessment for the enterprise and industry, control measurement in the sphere of digitalization, identify and develop the prospects of growth points and determine the immediate prospects for the digital transformation of enterprises and the industry.	The document contains a very brief description of the assessment methodology
EY (Ernst & Young, Great Britain). The analysis of the level of implementation and use of digital information systems*	Methodology for the level of implementation and application of digital information systems	The readiness of the country's institutional environment, the degree of penetration of digital solutions in the industry, particularly for the companies, are determined, "Digital DNA" map based on the analytical data about the current level of implementation and application of digital systems, as well as the level of readiness for digital transformation is drawn. For calculations, the following areas are considered: strategy, innovation and development; interaction with customers; supply chain and operation management; information technologies; risks and cybersecurity; finance; legal support; taxation; leadership and organizational culture	The methodology allows to compare the assessment results of the levels of digitalization of the industry and individual companies, identifying their strengths and weaknesses	Difficulties in collecting data, in particular for the oil and gas industry
Deloitte: Digital transformation in oil and gas exploration and production – from bytes to barrels**	Digital transformation model	The digital transformation model represents a roadmap that includes 10 stages (mechanization, sensor installation, transfer, integration, analysis, visualization, addition, robotization, creation, virtualization) with detailed explanation of technologies for each stage. The current level of digital maturity, the desired level of transformation and lines for increasing the level of transformation are determined	The current and desired level of digital maturity and transformation is determined in the segments of exploration, development and production of hydrocarbon raw materials using the relevant technologies. The possibilities of digital transformation are assessed for each segment. It can be applied both to the industry as a whole and to enterprises in individual segments	A large number of assessment indices, cumbersome calculations
IBM Digital transformation of the oil and gas industry***	Digital transformation model	The areas that will benefit from digital transformation in the sectors of the oil and gas industry (exploration and assessment works, development and production) are specified	A wide range of assessment indices	Difficulty in obtaining statistical data when analyzing enterprises of the industries

* State contract dated 21.08.2019. No. 0173100008319000044/K/02. Analysis of the level of implementation and use of digital information systems. URL: https://in.minenergo.gov.ru/upload/iblock/971/971c417247ad76e15c6d3b910dc9dcca.pdf (Accessed: 12.06.2022)

** Deloitte. Digital transformation in oil and gas exploration and production – from bytes to barrels. URL: https://nangs.org/analytics/deloitte-tsifrovaya-transformatsiya-v-sfere-razvedki-i-dobychi-nefti-i-gaza-ot-bajtov-k-barrelyam-fevral-2018-pdf (Accessed: 26.08.2021)

*** IBM. Digital transformation of the oil and gas industry. URL: https://www.ibm.com/downloads/cas/JLE286ZX (Accessed: 27.08.2021)

Table 1 continued

Source	Method name, key assessment method	Indices in the methodology	Positive aspects	Negative aspects
Kuklina E.A., Mitselovskaya O.S. Methodological approach to assessing the level of innovative development of enterprises (exemplified by the sphere of housing and utility services) [33]	A methodological approach to assessing the level of innovative development of an industry and an enterprise using the methods of expert assessments, Innovation Scorecard (ISC), assessment of financial stability, ratios, etc.	The assessment of prospects for innovative development of the industry: the ratio of organizations implementing technological innovations in the total number of organizations, %; the volume and intensity of expenses for technological innovations; the volume and ratio of innovative goods, works, services in the total volume of shipped goods, works, services. The assessment of the innovation potential of an enterprise: innovation process, innovation strategy, innovation structure, innovation culture, provision of resources. The assessment of the level of innovative activity: intellectual property security ratio; R&D personnel ratio; coefficient of property intended for R&D; the rate of development of new technologies; the rate of introduction of new products; innovative growth rate	A comprehensive assessment using several recognized methods for each stage. The possibility of application in various areas	Difficulty in obtaining statistical data when analyzing enterprises of certain industries
Institute for Statistical Studies and Economics of Knowledge, National Research University Higher School of Economics [34]	The index of digitalization of economic sectors, social sphere and authorities, developed for an aggregate assessment of the distribution level of digital technologies	The index characterizes the rate of adaptation to digital transformation, the level of application of broadband Internet, cloud services, RFID technologies, ERP systems, and the involvement of business sector organizations in e-commerce. The index is calculated for Russia and the European countries, the Republic of Korea and Turkey	Calculated on the basis of small number of indicators	Cannot be considered optimal because of a small number of indicators being taken into account
Istomina E.A. The assessment of digitalization trends in industry [35]	Methodology for assessing digitalization in industry	Methods for assessing digitalization at the macro level and for a certain business entity are considered. Economic effect of investments in digitalization, percentage of labor productivity, profitability	The author indicates only 3 indices that are extremely important for an entrepreneur, in her opinion. The rest of indices is described as insignificant, therefore the assessment can be neglected.	The fragmentation of the methodological presentation. There is no link between the assessment of digitalization trends of individual enterprises and the industry as a whole
Methods for assessing the level of digitalization and digital transformation of individual enterprises and their innovative component				
Yashin S.N., Shchekoturova S.D. The application of the methodology for assessing the efficiency of the innovative development of an enterprise examplified by PJSC “RUSPOLYMET” [36]	Moving curve method	• The ratio of employees engaged in R&D • The level of mastering of new technology • The degree of mastering of new products • The ratio of material resources for R&D • The degree of provision of the enterprise with intellectual property • The ratio of investment in innovative projects	• The completeness of the assessment. The logical structure is ensured throughout the methodology • The assessment is focused on the analysis of a relatively small number of related indices. This simplifies the calculation and generalization • Developed on the basis of complementary methodologies • The assessment of innovative development is performed in conjunction with the economic status of the enterprise	The company's strategic and tactical guidelines are not considered. There is no comparison with other companies in the industry

Table 1 continued

Source	Method name, key assessment method	Indices in the methodology	Positive aspects	Negative aspects
Kokhanova V.S. Fuzzy logic apparatus as a tool for assessing the effectiveness of a company's digitalization [37]	Fuzzy logic	The parameters vary depending on the need. One can enter both the simplest binary scale "good - bad", and a more complex one, in which the number of terms will reach 5, 7, or even 10	It is on par with other assessment systems; the assessment is performed in a more free form than upon formal logic. The comprehensive and applicable nature of fuzzy logic tools	There is still a portion of people who do not accept this method of assessment
Brusakova I.A. Methods and models for assessing the maturity of the innovation structure [38]	The production model of corporate knowledge about the enterprise readiness for digital transformations	Innovativeness of the infrastructure of an enterprise, innovative activity, innovative complexity of an enterprise	After assessing three macro parameters, one can talk about the readiness of the enterprise for digital transformations	Not the entire level of digitalization is determined, but only the innovative component, while taking into account the information component
Zakharova E.V., Mityakova O.I. The assessment of the innovative potential of an enterprise, taking into account the digitalization of the economy [39]	Methods for calculating the innovative potential of information potential indices (analytical method for calculating the system of indices, method for calculating an integral index based on the logistic regression model, method for financial and economic analysis, method for expert assessments, method for calculating the integral index based on the logistic regression model)	It covers 19 indices in 4 groups: production and technology, management and finance, the factors of innovative activity and the indices of information component	Relatively easy calculations due to the small number of indices. Due to the assessment of the information component, it is possible to determine the strengths and weaknesses of the enterprise's potential. The base is formed on methods for assessing innovative potential	Not the entire level of digitalization is determined, but only the innovative component, while taking into account the information component
Mityakova O.I. The assessment of the innovative potential of an industrial enterprise [40]	Analytical method for calculating the system of indices	The determination of the state of each component of the innovation potential by calculating a number of indices characterizing the innovation potential: 1. Staff 2. Production and technology 3. Scientific and technical 4. Financial and economic 5. Organizational and managerial potential	The calculations are based on the data reflected in the statements of financial and economic activity of the company, a high level of objectivity of the calculations, a comprehensive assessment of the potential	Not the entire level of digitalization is determined, but only the innovative component of the one
Delloite: Digital Maturity Model Achieving digital maturity to drive growth*	Digital Maturity Model	5 key indices are highlighted, based on which the assessment is performed: consumers, strategy, technology, production, structure and culture of the organization (Customer, Strategy, Technology, Operations, Organization & Culture). In their turn, they have 28 sub-indicators, which are divided into 179 digital characteristics. The emphasis is put on the strategy (Business Strategy), which determines the focus of the transformation. The successive steps of strategy concretizing are the definition of a business model (Business Model) and an operating model (Operating Model), which determine the required level of digital maturity according to the selected measures	The assessment is performed based on a large number of indicators, which increases its accuracy and depth in the internal aspects	An example of the application of this assessment has not been found due to the closed nature of the data. One cannot perform a prompt assessment

* Delloite. Digital Maturity Model Achieving digital maturity to drive growth. URL: https://www2.deloitte.com/content/dam/Deloitte/global/Documents/Technology-Media-Telecommunications/deloitte-digital-maturity-model.pdf (Accessed: 28.08.2021)

Table 1 continued

Source	Method name, key assessment method	Indices in the methodology	Positive aspects	Negative aspects
Merzlov I. Yu., Shilova E. V., Sannikova E. A., Sedinin M. A. A comprehensive methodology for assessing the level of digitalization of organizations [27]	A comprehensive methodology for assessing the level of digitalization of organizations	A step-by-step methodology for determining the digitalization of business processes has been developed. Six enlarged business processes are highlighted, each of which is itemized by a number of sub-processes: staff management, production, performance of work, provision of services, marketing, logistics, finance and accounting, general economic activity. A pyramid of the digitalization process has been developed, including five levels (primary, local, partial, complex digitalization; "smart" organization; digital ecosystem. Based on the final data, the sectoral and country level of digitalization can be determined, as well as the corresponding rating for the formation of various types	It is based on the methods of expert assessments and questionnaires. It is easy to understand and count the results	Public access to filling out the questionnaire due to the creation of the site, which can lead to errors in the calculation, as well as the possibility of the questionnaire being filled out by non-specialists from the organization
Babkin A. V., Pestova A. Yu. The assessment of the level of digitalization of an industrial enterprise (Peter the Great St. Petersburg Polytechnic University) [41, 42]	The assessment of the level of digitalization of an industrial enterprise	Labor resources, material and technical support, digital infrastructure of an enterprise, software, financial resources, organizational and managerial indicators / 19 indicators	Complex assessment using the statistical data of an enterprise and average market values for each of the assessed parameters	The complexity of the assessment. There is no comparison with other companies in the industry
Kozlov A. V. Teslia A. B. Digital potential of industrial enterprises: essence, definition and calculation methods [43]	The methodology for determining the digital potential of an industrial enterprise as a tool for managing digital transformation processes at an enterprise (expert assessments + to obtain a numerical assessment of the integral index – digital potential – other models, being more complex, can be used, for example, the parametric entropy method, Saaty method, the method of principal components)	The external environment index, the internal environment index, including 2 subgroups: reflecting the resources at the moment and reflecting the future capabilities of the enterprise for the implementation of digital technologies. 17 indicators	The proposed approach to assessing digital potential allows to analyze not only the current level of digitalization of business processes in an enterprise, but also the possibility of increasing digital potential	Not quite accurate assessment because of practical focus mainly on subjective assessments
MIT Center for Digital Business and Capgemini Consulting*	Digital transformation assessment	Customer experience, operational processes and business models / 9 indices	Relatively small number of indices and available calculations	Difficulty in collecting statistical data for assessment

* MIT Center for Digital Business and Capgemini Consulting. Assessment of digital transformation. URL: https://www.capgemini.com/wp-content/uploads/2017/07/The_Digital_Advantage__How_Digital_Leaders_Outperform_their_Peers_in_Every_Industry.pdf (Accessed: 27.08.2021)

Table 1 continued

Source	Method name, key assessment method	Indices in the methodology	Positive aspects	Negative aspects
Analytical Agency Arthur D. Little. Digital Transformation – How to Become Digital Leader*	Digital transformation index	When calculating the index, 23 indicators are used that characterize the development strategy and leadership; products and services; customer management; transactions and supply chains; corporate services and control; information technologies; workplace and culture	The result of the assessment of the indices allows to determine the level of the company, the efficiency of the transformation, and to predict the result of the company's development. Relatively straightforward calculations due to a small number of indices	Difficulty in collecting statistical data for assessment
KPMG Company. Are you ready for digital transformation? Measuring your digital business aptitude**	Model of digital aptitude assessment	Vision and strategy, digital talents, key digital processes, flexible sources and technologies, leadership – 5 major indices, 23 indices in total	Calibrated Risk Management, Digital Management, Architectural Discipline, Engagement, Agile Architecture, Infrastructure, Social Media, Mobile Interaction, Mobility, Strategic Partnerships, Measurement & Analytics, Optimized Platforms, Agile Development, Interface Design, Talent Development, Skill Optimization, Talent Development, Obtaining Talents, Strategy Implementation, Thought Leadership, Strategy is defined, goals are defined	An example of the application of this assessment has not been found due to the closed nature of the data. One cannot perform a prompt assessment
Global Center for Digital Business Transformation [27]	Digital piano	Business model, organizational structure, employees, processes, IT opportunities, offerings, interaction model	Based on the questions asked in the course of this assessment, the gap between the current state of affairs and the required level in each line can be determined, thus indicating the volume of changes required	Answering questions will be the key aspect. An inaccurate answer to them is equivalent to a fuzzy assessment
Ionology Company. Step by Step Guide to Digital Transformation***	Digital transformations	Strategy and culture, people and customers, processes and innovation, technology, data and analytics	The methodology is focused on the younger generation's interests	There is no total number of assessment indices, only the key lines are singled out. Therefore, there is no way to assess the positive points
National Academy of Sciences and Engineering of Germany. Industry Maturity Index 4.0. Management of the Digital Transformation of Companies. Acatech research***	Acatech Industrie 4.0 Maturity Index	Resources, information systems, culture and organizational structure	The processing of advantages, disadvantages and existing opportunities, the analysis of deficiencies, allowing subsequently to assess the degree of flexibility and continuous development of the established company	Complex methodology for assessment

* Analytical agency Arthur D. Little. Digital Transformation – How to Become Digital Leader. URL: https://www.adlittle.com/sites/default/files/viewpoints/ADL_HowtoBecomeDigitalLeader_02.pdf (Accessed: 05.09.2020)

** KPMG. Are you ready for digital transformation? Measuring your digital business aptitude. URL: https://assets.kpmg/content/dam/kpmg/pdf/2016/04/measuring-digital-business-aptitude.pdf (Accessed: 04.09.2021)

*** Ionology. Step by Step Guide to Digital Transformation. URL: https://www.ionology.com/step-by-step-guide-to-digital-transformation (Accessed: 05.10.2021)

*** National Academy of Sciences and Technology of Germany. Industry Maturity Index 4.0. Managing the digital transformation of Companies. Acatech research. URL: https:// www.acatech.de/wp-content/uploads /2018/03/acatech_STUDIE_rus_Maturity_Index_WEB.pdf (Accessed: 04.09.2020)

Table 1 continued

Source	Method name, key assessment method	Indices in the methodology	Positive aspects	Negative aspects
Komanda-A Company (KMDA). The assessment of strategic transformations in the process of digital transformation*	The assessment of strategic transformations in the process of digital transformation	Customer centricity, collaboration, data, innovation, value, people	Link to strategy. Customer-oriented approach	Offered by the developer for assessment. Lack of any document where one could go through the methodology in detail
DMA Pulse. A digital solution for assessing the potential and dynamics of changes in your company during digital transformation**	Digital maturity assessments	Digital infrastructure, HR and human capital development, product creation and value management, digitalization of business processes, data use, customer experience management	More than 40 blocks of questions of different levels of depth, allowing to identify the areas of underdevelopment and development potential	Lack of any document where one could go through the methodology in detail

* Team-A Company (KMDA). Assessment of strategic transformations in the process of digital transformation. URL: https://komanda-a.pro/transformation (Accessed: 02.09.2020)

** DMA Pulse. A digital solution for assessing the potential and dynamics of changes in your company in the process of digital transformation. URL: https://komanda-a.pro/audit (Accessed: 09.08.2021)

The stages of implementation of the author methodological toolkit for assessing the level of digital transformation of enterprises (companies) and the industry as a whole are shown in Fig. 3.

Stage I. The approbation of the author methodological toolkit was performed in the context of the oil and gas industry. Annual reports of the selected enterprises (PJSC "Gazprom", PJSC "NK "Rosneft", PJSC "Tatneft" and PJSC "Lukoil") constituted the information base of the research.

The key indices characterizing the level of digitalization and digital transformation were as follows: profit, intangible assets, R&D costs, company market value. To calculate the market value of the company, financial Internet resources[49] were used as the sources of information concerning the stock quotes and their number.

[49] Finanz.ru. Share quotes. URL: https://www.finanz.ru/aktsii (Accessed: 12.06.2022)

InvestFunds. Independent data source for private investment in Russia. Share quotes. URL: https://investfunds.ru/stocks/ (Accessed: 12.06.2022)

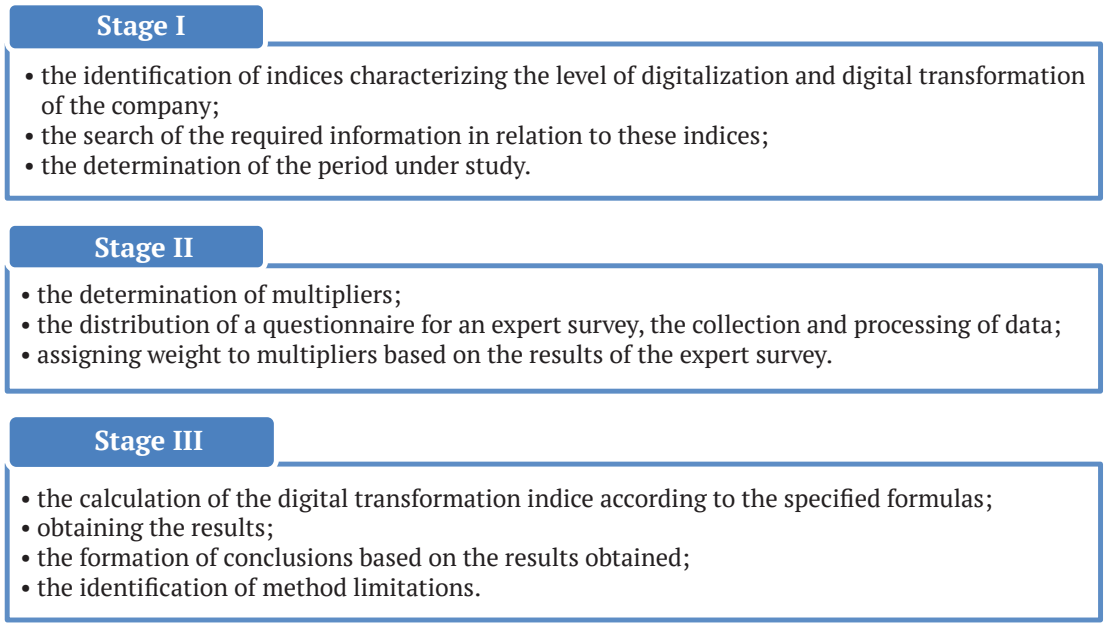

Fig. 3. The stages of implementation and approbation of the author methodology toolkit under the conditions of the oil and gas industry of the Russian Federation

Excluding economically unrepresentative time periods, three periods were selected for the research:

– 2008. The Year of the global economic crisis;

– 2010–2011. The period of recovery, economic rehabilitation;

– 2016–2020. The period of design, development, formation and implementation of digital technologies and platform solutions in the Russian Federation. The period under consideration has been increased from 2 to 4 years due to the extremely rapid development of the line under investigation.

All indices are presented in a comparable form. Some of the indices were missing in the 2008 reports, while another part was reported in dollars, not in rubles. Dollars were converted into rubles at the average rate for each year[50]. HBelow are the tables for each company with the selected indices. Dashes indicate no publicly available data.

Stage II. The application of the cost approach allowed to distinguish the following multipliers characterizing the level of digitalization and digital transformation:

1. The multiplier of the ratio of intangible assets and the market value of the company

$$A = \frac{HA}{P}, \quad (1)$$

where *HA* stands for intangible assets of the company; *P* stands for the market value of a company, obtained by multiplying the value of a share by the number of shares.

2. The multiplier of the ratio of R&D activities and the market value of the company

$$B = \frac{RDC}{P}, \quad (2)$$

where RDC stands for the company's R&D expenses.

3. The multiplier of the ratio of the net profit of the company and the market value of the company

$$C = \frac{Pt}{P}, \quad (3)$$

where *Pt* stands for net profit of the company.

Thus,

$$DL = (x_1 A + x_2 B + x_3 C)100\ \%, \quad (4)$$

where *DL* stands for the indicator of the level of digitalization and digital transformation; x_1 stands for the weight of multiplier *A*; x_2 stands for the weight of multiplier *B*; x_3 stands for the weight of multiplier *C*.

[50] Ministry of Finance. Currency Converter. URL: https://minfin.com.ua/currency/converter/ (Accessed: 12.06.2022)

Table 2

Selected indices for PJSC "Gazprom"

Indices	Year							
	2008	2010	2011	2016	2017	2018	2019	2020
Intangible assets, RUB	$3.2 \cdot 10^8$	$3.7 \cdot 10^8$	$3.7 \cdot 10^8$	$1.49 \cdot 10^{10}$	$2.009 \cdot 10^{10}$	$1.93 \cdot 10^{10}$	$1.71 \cdot 10^{10}$	$1.474 \cdot 10^{10}$
R&D expenses, RUB	$2.67 \cdot 10^9$	$2.62 \cdot 10^9$	$3.2 \cdot 10^9$	$2.89 \cdot 10^{10}$	$1.61 \cdot 10^{10}$	$1.359 \cdot 10^{10}$	$1.92 \cdot 10^{10}$	$1.807 \cdot 10^{10}$
Net profit, RUB	$1.73 \cdot 10^{11}$	$7.8 \cdot 10^{11}$	$1.307 \cdot 10^{12}$	$9.516 \cdot 10^{11}$	$7.143 \cdot 10^{11}$	$1.456 \cdot 10^{12}$	$1.203 \cdot 10^{12}$	$1.35 \cdot 10^{11}$
Share price, RUB	108.6	193.5	171.3	154.55	130.5	153.5	256.4	212.98
Number of shares outstanding, pcs.	$2.367 \cdot 10^{10}$	$2.367 \cdot 10^{10}$	$2.367 \cdot 10^{10}$	$2.367 \cdot 10^{10}$	$2.367 \cdot 10^{10}$	$2.367 \cdot 10^{10}$	$2.367 \cdot 10^{10}$	$2.367 \cdot 10^{10}$

Table 3

Selected indices for PJSC "NK "Rosneft"

Indices	Year							
	2008	2010	2011	2016	2017	2018	2019	2020
Intangible assets, RUB	$1.83 \cdot 10^{10}$	$2.3 \cdot 10^{10}$	$2.2 \cdot 10^{10}$	$5.9 \cdot 10^{10}$	$7.5 \cdot 10^{10}$	$7.5 \cdot 10^{10}$	$6.9 \cdot 10^{10}$	$8 \cdot 10^{10}$
R&D expenses, RUB	$2.05 \cdot 10^9$	$2.9 \cdot 10^9$	$8.55 \cdot 10^9$	$2.02 \cdot 10^{10}$	$2.99 \cdot 10^{10}$	$3.21 \cdot 10^{10}$	$3 \cdot 10^{10}$	$2.68 \cdot 10^{10}$
Net profit, RUB	$1.43 \cdot 10^{11}$	$3.47 \cdot 10^{11}$	$3.84 \cdot 10^{11}$	$1.74 \cdot 10^{11}$	$3.83 \cdot 10^{11}$	$8.28 \cdot 10^{11}$	$9.17 \cdot 10^{11}$	$3.24 \cdot 10^{11}$
Share price, RUB	112.34	218.85	214.55	402.8	291.5	432.5	454	435.1
Number of shares outstanding, pcs.	$1.0598 \cdot 10^{10}$	$1.0598 \cdot 10^{10}$	$1.0598 \cdot 10^{10}$	$1.0598 \cdot 10^{10}$	$1.0598 \cdot 10^{10}$	$1.0598 \cdot 10^{10}$	$1.0598 \cdot 10^{10}$	$1.0598 \cdot 10^{10}$

Table 4

Selected indices for PJSC "Lukoil"

Indices	Year							
	2008	2010	2011	2016	2017	2018	2019	2020
Intangible assets, RUB	$2.42 \cdot 10^{10}$	$4.407 \cdot 10^{10}$	$4.34 \cdot 10^{10}$	$4.313 \cdot 10^{10}$	$4.13 \cdot 10^{10}$	$4.18 \cdot 10^{10}$	$4.31 \cdot 10^{10}$	$5 \cdot 10^{10}$
R&D expenses, RUB	$2.3 \cdot 10^{9}$	$3.65 \cdot 10^{9}$	$4.11 \cdot 10^{9}$	$5.8 \cdot 10^{9}$	$5.8 \cdot 10^{9}$	$6.2 \cdot 10^{9}$	$5.7 \cdot 10^{9}$	$5.2 \cdot 10^{9}$
Net profit, RUB	$2.674 \cdot 10^{11}$	$2.743 \cdot 10^{11}$	$3.345 \cdot 10^{11}$	$3.038 \cdot 10^{11}$	$3.994 \cdot 10^{11}$	$6.192 \cdot 10^{11}$	$6.402 \cdot 10^{11}$	$1.52 \cdot 10^{10}$
Share price, RUB	948	1742	1702.5	3449	3345.5	4997	6169	5169.5
Number of shares outstanding, pcs.	$6.93 \cdot 10^{8}$	$6.93 \cdot 10^{8}$	$6.93 \cdot 10^{8}$	$6.93 \cdot 10^{8}$	$6.93 \cdot 10^{8}$	$6.93 \cdot 10^{8}$	$6.93 \cdot 10^{8}$	$6.93 \cdot 10^{8}$

Table 5

Selected indices for PJSC "Tatneft"

Indices	Year							
	2008	2010	2011	2016	2017	2018	2019	2020
Intangible assets, RUB	$2.2 \cdot 10^{8}$	$2 \cdot 10^{8}$	$1.9 \cdot 10^{8}$	$4.6 \cdot 10^{8}$	$8.8 \cdot 10^{8}$	$1.5 \cdot 10^{9}$	$1.85 \cdot 10^{9}$	$2.05 \cdot 10^{9}$
R&D expenses, RUB	–	$9 \cdot 10^{7}$	$6 \cdot 10^{7}$	$6.3 \cdot 10^{8}$	$6 \cdot 10^{8}$	$1 \cdot 10^{9}$	$2.5 \cdot 10^{9}$	$2.4 \cdot 10^{9}$
Net profit, RUB	$3.43 \cdot 10^{10}$	$3.89 \cdot 10^{10}$	$5.488 \cdot 10^{10}$	$1.05 \cdot 10^{11}$	$1 \cdot 10^{11}$	$1.98 \cdot 10^{11}$	$1.56 \cdot 10^{11}$	$8.16 \cdot 10^{10}$
Share price, RUB	56	148.7	160.69	427	478.8	737.9	759.7	513.7
Number of shares outstanding, pcs.	$2.18 \cdot 10^{9}$	$2.18 \cdot 10^{9}$	$2.18 \cdot 10^{9}$	$2.18 \cdot 10^{9}$	$2.18 \cdot 10^{9}$	$2.18 \cdot 10^{9}$	$2.18 \cdot 10^{9}$	$2.18 \cdot 10^{9}$

It is recommended that the weight of each of the multipliers be determined by an expert survey of specialists in a given field of activity. Within the implementation of the author methodological toolkit, the experts were offered a questionnaire. According to the results of a survey of 35 experts from the Institute of Economics of the Ural Branch of the RAS, the Mining Institute of the Ural Branch of the RAS, Tomsk Polytechnic University, and Tyumen Industrial University, it was established that the weights of multipliers A and B are the same and equal to 0.4 c.u. accordingly, the weight of multiplier C is assigned at the level of 0.2 c.u. The weight was calculated by determining the arithmetic mean. Hence, the formula (4) is as follows:

$$DL = (A \times 0,4 + B \times 0,4 + C \times 0,2)100\ \%. \quad (5)$$

According to the data obtained at the stage I of the implementation of the author methodological toolkit, Tables 6–9 provide for the calculations and the assessment of the final level of digitalization and digital transformation of the companies in annual terms. There are no values in some cells of the table, and that is associated with the above mentioned factor, namely the closed data, the impossibility of performing the calculation.

In the Russian context, a satisfactory level of digitalization and digital transformation is recommended to consider more than 5 %; if the indicator is below this value, the level is considered unsatisfactory, therefore, the company is not focused on digital development in the long run.

Stage III

Table 6

The values of the calculated multipliers and the level of digitalization and digital transformation for PJSC "Gazprom"

Multipliers	Year							
	2008	2010	2011	2016	2017	2018	2019	2020
HA / *P*, c.u.	0.00012	0.00009	0.00009	0.00407	0.00650	0.00531	0.00282	0.00292
RDC, c.u.	0.00104	0.00057	0.00079	0.00790	0.00521	0.00374	0.00316	0.00358
Pt / *P*, c.u.	0.06729	0.17019	0.32230	0.26009	0.23121	0.40067	0.19819	0.02678
DL, %	1.39	3.43	6.48	5.68	5.09	8.38	4.20	0.80

Table 7

The values of the calculated multipliers and the level of digitalization and digital transformation for PJSC "NK "Rosneft"

Multipliers	Year							
	2008	2010	2011	2016	2017	2018	2019	2020
HA / P, c.u.	0.01537	0.00992	0.00968	0.01382	0.02428	0.01636	0.01434	0.01735
RDC, c.u.	0.00172	0.00125	0.00376	0.00473	0.00968	0.00700	0.00623	0.00581
Pt / P, c.u.	0.12011	0.14961	0.16888	0.04076	0.12397	0.18064	0.19058	0.07026
DL, %	3.09	3.44	3.91	1.56	3.84	4.55	4.63	2.33

Table 8

The values of the calculated multipliers and the level of digitalization and digital transformation for PJSC "Lukoil"

Multipliers	Year							
	2008	2010	2011	2016	2017	2018	2019	2020
HA / P, c.u.	0.03684	0.03651	0.03679	0.01805	0.01782	0.01207	0.01008	0.01396
RDC, c.u.	0.00350	0.00302	0.00348	0.00243	0.00250	0.00179	0.00133	0.00145
Pt / P, c.u.	0.40704	0.22725	0.28360	0.12713	0.17231	0.17884	0.14978	0.00424
DL, %	9.75	6.13	7.28	5.00	3.36	4.26	4.13	3.45

Table 9

The values of the calculated multipliers and the level of digitalization and digital transformation for PJSC "Tatneft"

Multipliers	Year							
	2008	2010	2011	2016	2017	2018	2019	2020
HA / P, c.u.	0.00180	0.00062	0.00054	0.00049	0.00084	0.00093	0.00112	0.00183
RDC, c.u.	–	0.00028	0.00017	0.00068	0.00058	0.00062	0.00151	0.00214
Pt / P, c.u..	0.28113	0.12016	0.15676	0.11265	0.09586	0.12285	0.09425	0.07291
DL, %	–	2.44	3.16	2.30	1.97	2.52	1.99	1.62

According to Tables 6–9, a final table of the levels of digitalization and digital transformation was compiled for each selected company and the industry as a whole (Table 10).

Conclusions: based on the obtained screening of the companies and the results of the approbation of the author methodological toolkit for assessing the level of digitalization and digital transformation (Table 10, Fig. 4), we can conclude that, in general, the situation with digital transformation of the oil and gas industry of the Russian Federation is unsatisfactory. The rates of change in the level of digitalization and digital transformation of the selected companies for the considered time periods are shown in Fig. 4. PJSC "Gazprom" exhibits the most stable and satisfactory development dynamics. PJSC "Lukoil" has a similar trend, but only in 2008, 2010 and 2011, after 2016 the index decreases to an unsatisfactory level. Besides, during the period of development and implementation of digital technologies and platform solutions in the Russian Federation, a trend towards increasing digitalization and digital transformation can be observed at PJSC "NK "Rosneft".

The lowest values of the level of digitalization and digital transformation in the considered time periods were recorded at PJSC "Tatneft". Upon that, each of the selected companies declares an ever-increasing rates of digitalization of all processes in its reports. Based on the data obtained, the observed situation can be characterized either by a slowdown in the rate

of implementation of digitalization and digital transformation processes due to the already achieved high level, or by the deterioration of the situation and the presence of not entirely reliable information in the reports of the companies. The year 2020 is characterized by a slowdown in growth in all companies due to the COVID-19 pandemic. Although it was noted in work [8] that companies with a high level of implementation of digital processes suffered the least from this pandemic.

Based on Fig. 4, we can present the following ranking of industry companies for the implementation of digital processes in their activities: PJSC "Gazprom" and PJSC "Lukoil" are among the leaders in terms of digitalization and digital transformation, PJSC "NK "Rosneft" is in second place and PJSC "Tatneft" closes the rating.

Conclusions

The developed author methodological toolkit for assessing the level of digitalization and digital transformation allows to perform an express analysis of both the enterprise (company) and the industry as a whole with regard to introducing digital processes and identifying their role in the strategic development. However, like any other toolkit, the methods have a number of minor limitations. Firstly, the methodological toolkit provides for the application of major key indices of digital transformation (intangible assets, R&D costs and net profit), but the narrower ones, for example, such as the number of patents in the field of digitalization, the introduction and use of digital twins of fields, etc. are not taken into account. The reasoning behind this is that the purpose was not to assess the digital platform, nor to consider

Table 10

A final table of the digitalization levels and digital transformation was compiled for each selected company and the industry as a whole, %

Company name	Year								The average DT for the analyzed periods
	2008	2010	2011	2016	2017	2018	2019	2020	
PJSC "Gazprom"	3.01	6.77	11.56	4.87	5.09	6.64	5.30	0.87	5.51
PJSC "NK "Rosneft"	3.09	3.44	3.91	1.56	3.84	4.55	4.63	2.33	3.41
PJSC "Tatneft"	–	2.44	3.16	2.30	1.97	2.52	1.99	1.62	2.28
PJSC "Lukoil"	9.75	6.13	7.28	3.36	4.26	4.13	3.45	0.70	4.88
Industry level	3.9625	4.695	6.4775	3.0225	3.79	4.46	3.8425	1.38	4.02

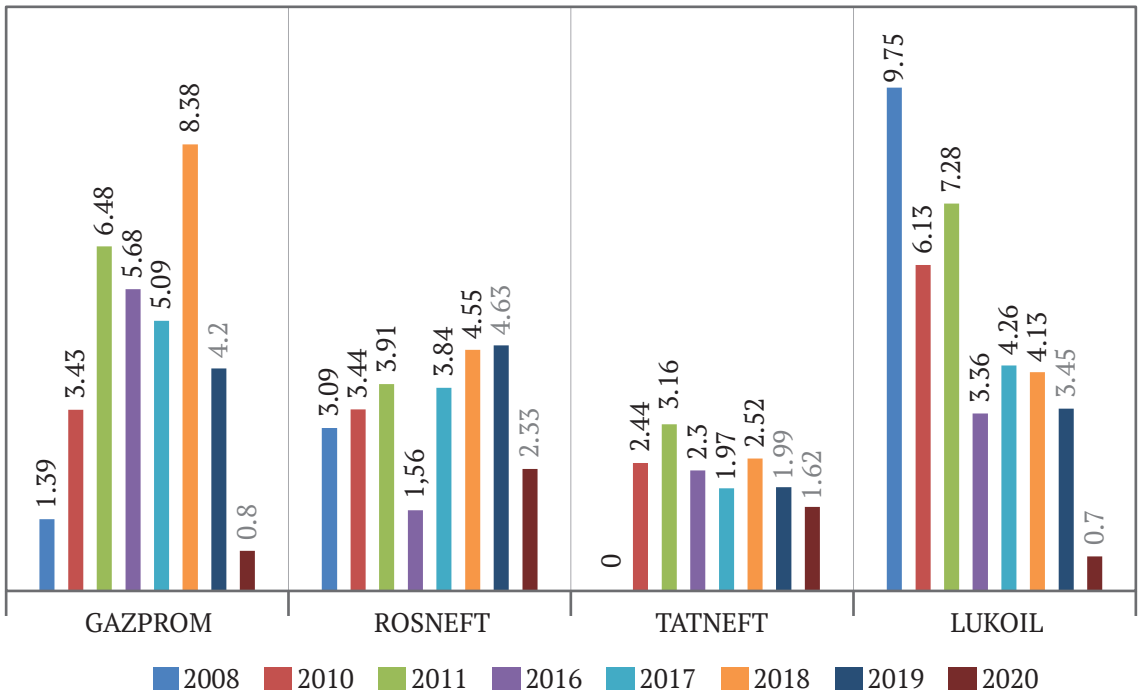

Fig. 4. The dynamics of changes in the level of digitalization and digital transformation of each company, %

the level of digitalization and digital transformation of the companies' suppliers and consumers. Secondly, the methodological toolkit is very dependent on the openness and completeness of the collected data, despite a small number of indices. Thirdly, there is no possibility of assessing the companies that are not listed on the stock exchange. Fourthly, the weight of the multipliers was determined on the basis of an expert survey, the results of which largely depend on the experts.

It has been established that the industry leaders of the Russian Federation in the period from 2016 to 2020 in terms of the level of digitalization and digital transformation range in the following order from the most advanced to the least advanced: PJSC "Gazprom" is in the first place (DL_{av} – 4.82 %); PJSC "NK "Rosneft" is in the second place (DL_{av} – 3.38 %); PJSC "Lukoil" is in the third place (DL_{av} – 3.18 %); PJSC "Tatneft" is in the fourth place (DL_{av} – 2.08 %). According to Table 10, the values were obtained by determining the arithmetic average of the levels of digitalization (DL_{av}) and digital transformation for each company for the periods under review.

The average index of the digitalization level and digital transformation by industry over the past 5 years is 3.36 %, which is extremely unsatisfactory in terms of a comprehensive digital transformation. A further line of the research is observed in assessing and comparing the levels of digitalization and digital transformation of foreign oil and gas industries of the leading oil and gas producing countries with the domestic ones applying the author methodological toolkit.

Thus, *the goal* of this research has been achieved, since the system for managing digitalization and digital transformation of the oil and gas industry has been improved through the development of author methodological toolkit for assessing the level of digitalization and digital transformation of both an individual enterprise and the oil and gas industry as a whole, based on a comparative analysis of existing methods.

The research provides for the analysis of the theoretical foundations of digitalization and digital transformation; foreign and domestic general, industry and production methodological toolkits (for individual enterprises and companies), methodological approaches, recommendations and methods for assessing digitalization, digital transformation have been studied and systematized; the current state of the digital transformation of the oil and gas industry has been identified by approbation of the author methodological toolkit for assessing the level of digitalization and digital transformation.

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Information about the authors

Vera V. Yurak – Cand. Sci. (Econ.), Associate Professor, Senior Researcher, Institute of Economics of the Urals Branch of the Russian Academy of Sciences; Associate Professor of the Department of Economics and Management, Ural State Mining University, Yekaterinburg, Russian Federation; ORCID 0000-0003-1529-3865, Scopus ID 57190411535, ResearcherID J-7228-2017; e-mail vera_yurak@mail.ru

Irina G. Polyanskaya – Cand. Sci. (Econ.), Associate Professor, Head of the Sector, Scientific Secretary, Institute of Economics of the Urals Branch of the Russian Academy of Sciences; Associate Professor of the Department of Economics and Management, Ural State Mining University, Yekaterinburg, Russian Federation; ORCID 0000-0002-0073-2821, Scopus ID 55764050500; e-mail irina-pol2004@mail.ru

Alexander N. Malyshev – Economist, Institute of Economics of the Urals Branch of the Russian Academy of Sciences; Laboratory Researcher of the Research Laboratory for the Reclamation of Disturbed Lands and Man-Made Objects, Ural State Mining University, Yekaterinburg, Russian Federation; ORCID 0000-0002-3104-1687, Scopus ID 57223099993; e-mail malyshev.k1b@gmail.com

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