



Management of a Sustainable Development of the Oil and Gas Sector in the Context of Digitalization

Alexey I. Shinkevich¹, Damir R. Baygildin², Ekaterina L. Vodolazhskaya³

¹ Department of Logistics and Management, Kazan National Research Technological University (KNRTU), Kazan, Russia

² Department of Public and Municipal Administration, The Institute of Management, Economics and Finance, Kazan (Volga region) Federal University Kazan, Russia

³ Department of Business Statistics and Economics, Kazan National Research Technological University (KNRTU), Kazan, Russia

Received: 10/01/2020

Accepted: 14/03/2020

Published: 20/05/2020

Abstract

The oil and gas sector is characterized by a high level of polluting emissions, which confirms the need for the development of a management mechanism in the field of automation and greening of technological processes. Thus, in the conditions of the fourth industrial revolution, digital transformation is an integral element of sustainable development. The purpose of the study is to develop a methodology for assessing the sustainable development of the oil and gas sector of the Russian economy, taking into account aspects of digitalization. The methodological base covers the method of systematization of the collected information, which made it possible to track the dynamics of changes in the environmental and economic indicators of the oil and gas sector and in the mining industry as a whole; modeling method (including the correlation-regression method and the method of principal components), which determined the mathematical relationships between indicators of sustainable development and digital transformation of the oil and gas sector; forecasting method, which presents scenarios of changes in the level of environmental friendliness of the oil and gas sector. As a result, a linear regression model is proposed that reflects the dependence of emissions of harmful substances by mining enterprises on the financial leverage ratio and determines the necessities to increase the ratio in order to reduce harmful emissions; alternatives options of forecasting the level of harmful emissions by the mining industry of the Russian economy are developed; to assess the sustainable development of the oil and gas sector of the Russian economy in the context of digitalization, an integrated sustainable development index is elaborated through the use of the factor analysis tool. The factors identified by the principal component analysis enable to evaluate the influence of digitalization on the sustainable development of the oil and gas sector of the Russian economy. In addition, correlation coefficients between each selected factor and each variable were pairwise estimated. Based on the simulation results, interdependencies of two key aspects of the study - the sustainable development of the oil and gas sector and its digital transformation are observed. The practical significance of the obtained model lies in the possibility of its application in order to predict the sustainable development of the oil and gas sector in Russia, taking into account the industry digitalization trend. The results of this study can be taken into account in strategic documents and programs for the development of the oil and gas sector and digital transformation of the industrial complex of the Russian Federation.

Keywords: Oil and gas sector, Sustainable development, Digital technologies, Factor analysis, Sustainable development index

1 Introduction

The basis of this study is the concept of “sustainable development”, which is inaccurate reflected in the Russian translation, since the definition of “sustainable development” at first glance does not take into account the environmental aspect. The primary source, which firstly mentioned «sustainable development» term was the World Conservation Strategy. Today, the concept of sustainable development, which firmly entrenched in the theory and practice of economic systems, involves the consolidation of three factors - economic, social and environmental.

The oil and gas industry is an intense environmental pollutant. Oil and gas production and energy consumption are steadily increasing. Oil and gas production in Russia has increased over the past 5 years by 5.5% and 13%

respectively [1]. Energy production is directly accompanied by emissions of harmful substances. Technological development, automation of production processes and modernization of monitoring systems make it possible to timely capture and neutralize atmospheric pollutants and help to reduce harmful effects on the environment. The goal of sustainable socio-economic development of Russia is enshrined in documents such as the Decree of the President of the Russian Federation “On the Concept of the Transition of the Russian Federation to Sustainable Development” [2], State Program of the Russian Federation “Development of Industry and Increasing Its Competitiveness” [3], State Program of the Russian Federation “Economic Development and innovative economy” [4], “Strategy for the socio-economic development of the Republic of Tatarstan until

Corresponding author: Alexey I. Shinkevich, Department of Logistics and Management, Kazan National Research Technological University (KNRTU), Kazan, Russia. E-mail: ashinkevich@mail.ru.

2030" [5] and others. Despite the fact that Russia's transition to sustainable development was planned back in 1996, the country lags far behind developed and a number of developing countries. According to the level of the Sustainable Society Index (SSI), in 2016 among 154 countries of the world, Russia ranked 64th in terms of human well-being, 144th in terms of environmental well-being and 37th in terms of economic well-being [6].

Nowadays digital technology is an important tool for economic development. The fourth industrial revolution covers the whole world and it is an unconditional catalyst for increasing the competitiveness of industrial complexes and enterprises. In the framework of the "digital" development vector, the National Program "Digital Economy of the Russian Federation" outlines the task: to put into operation the unified state cloud platform and a cyber-attack warning system by the end of 2021[7].

As for the digitalization of the oil and gas sector of the Russian economy, it is necessary to note the relatively low "digital" activity of the industry, which negatively affects its competitiveness in the world market. In accordance with the Business Digitalization Index (Business Digitalization index reflects the percentage of organizations using digital technologies of the total number of organizations in the business sector), the extractive sector with an indicator of 29.1% lags behind the telecommunications sector (42.5%), the trade sector (35.7%), manufacturing industry (34.9%), information technology industry (34.7%), etc. [23]. Secondly, in the structure of shipped goods, works and services in the Russian economy, the prevailing share of shipped goods and services are accounted for the extraction of crude oil and natural gas (18.49% in 2018) and the production of coke and oil products (14.93% in 2018) [8]. Third, well drilling operations are very complex. They are carried out in an environment with high risks to health and safety, and often cover the interactions of a wide range of suppliers jointly drilling of one well. Fourth, the share of drilling costs in the total cost structure is 40–70% of the capital costs of an oil and gas company [9].

The above emphasizes the importance of integration of both aspects of the modernization of the oil and gas industry - sustainable development and digitalization, while development of a methodology for assessing the evolution of the oil and gas sector of the Russian economy.

2 Literature Review

The economic aspects of the development of the oil and gas industry are studied in a number of papers. L.V. Eder [10] published a series of works containing an economic assessment of the state of the oil and gas sector. T.V. Malysheva et al. [11] contributed to the coverage of the economic and environmental aspects of industrial development. Environmental safety issues in industrial development are disclosed in the works of A.N. Dyrdonova [12, 13]. In the papers of T.V. Alexandrova [14] provisions regarding the implementation of the environmental responsibility of oil and gas enterprises are disclosed. Also, she reflected the goals of sustainable business development. S.A. Patin [15] deeply reveals the technological features of the offshore oil and gas industry and presents a methodology for assessing environmental risk and the economic damage resulting from oil pollution. A methodology for assessing the sustainable development of an industrial region was proposed by O.S. Korobova [16] and represents an economic approach to monitoring based on an integrated indicator of the region's carbon intensity.

Along with the foregoing, studies in the field of digital transformation of macro-, meso- and microeconomic systems are also relevant. So, information support of

industrial enterprises is considered in the works of V.P. Meshalkin and E.R. Moshev [17], E.R. Moshev and M.A. Romashkin [18]. Digitalization of the industrial sector is reflected in the works of T.V. Kulagi, A.V. Babkina and S.A. Murtazaev [19], P. Gölzer and A. Fritzsche [20]. The issues of digitalization of the oil industry, contributing to the reduction of harmful emissions are the subject of A.E. Vorobiev, K.A. Vorobev and H. Tcharo [21]. The research topics mentioned above are quite extensive and are not limited to the specified list of researchers. However, there is a scarcity of studies which empirically investigates the area of sustainable development of the oil and gas sector, taking into account the digital vector of economic development. This fact determines the relevance of the topic covered in this paper and the theoretical significance of the results. Thus, the formation of a digital platform to control the environmental impact of industry is broad interest to scientists. However, the studies are primarily of a technical nature, which allows us to conclude that it is necessary to develop a methodology for assessing the impact of the industrial complex on the environment.

3 Description of Data

According to statistical and coming from stationary sources data, the volumes of air polluting emissions generated as a result of oil and natural gas production decreased by 20.83% over 2012-2018, which is shown in Fig. 1 [8]. Over the same period, an increase in the level of capture of pollutants in the corresponding industry sector was recorded by 68.64% (Fig. 1) [8]. Nevertheless, the volumes of neutralized substances emanating from stationary sources in the field of crude oil and natural gas production at the end of 2018 amounted to only 3.7% of the total emissions. One of the key ways to reduce the degree of negative impact on the environment is to ensure energy efficiency, which has high potential in the oil and gas sector and involves the rationalization of energy use, taking into account economic and technological parameters. A comparative analysis of the energy intensity of GDP in the world and in Russia allows us to state a high level of the indicator in the domestic economy, which is 2-3 times higher than the energy intensity in the OECD countries [22]. A related area for reducing atmospheric emissions is the digitalization of the oil and gas sector, which had the highest activity in 2015 (Fig. 2).

At the same time, statistics represent only the use of information technologies for the automation of processes and production, which, in fact, does not reflect digitalization as such and complicates the objective assessment of the digitalization of these processes. However, based on the statistical base, we emphasize that, in general, the digital activity of extractive enterprises is unstable and reflects the low interest of business entities in digitalization. As a result, trends in reducing the negative impact of the industrial complex on the environment, but low volumes of capture of air polluting substances and a decrease in the digitalization rate of industrial enterprises determine the urgency of developing a system for monitoring and managing the sustainable development of the oil and gas industry. Moreover, the need for a systematic approach to management is obvious. According to these trends, the development of a rational methodology for assessing the impact of an industrial complex on the environment, capable of providing alternative options for this effect in the future, as well as the development of an assessment of the sustainable development of an industrial complex taking into account digital parameters, is relevant. The solution of these problems is proposed to be carried out through economic and mathematical modeling.

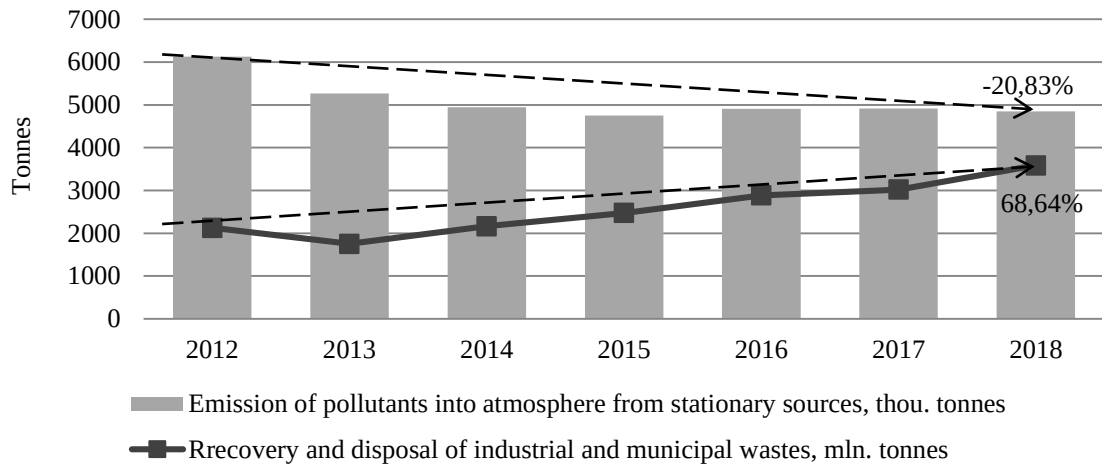


Figure 1: Pollution and neutralization of harmful substances in the field of crude oil and natural gas production (compiled according to the Federal State Statistics Service, from: <http://www.gks.ru>)

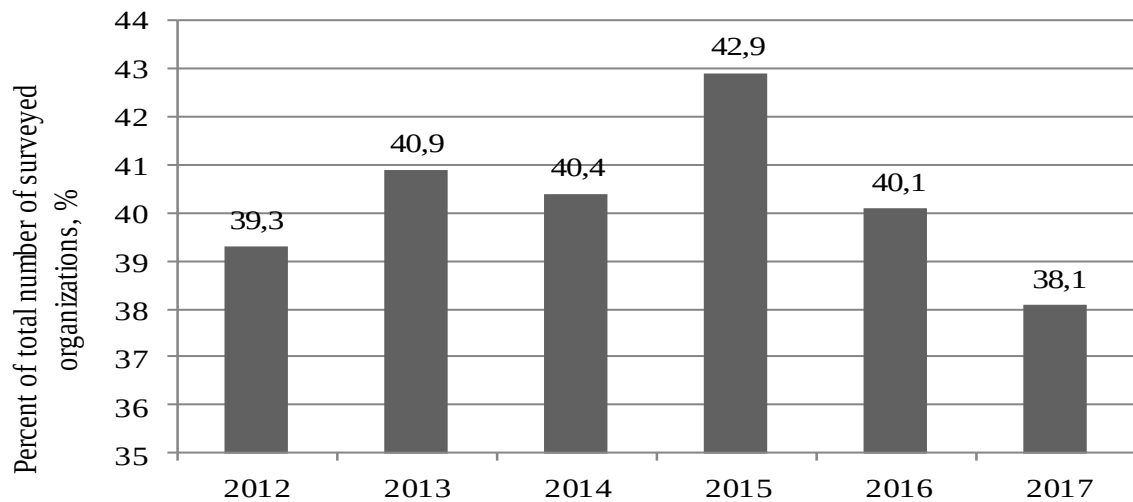


Figure 2: The share of mining organizations using information technology as part of the automation of production and technological processes, % (compiled from the HSE) [23].

4 Methods and Models

The formation of a methodology for assessing the sustainable development of the oil and gas sector in the context of digitalization covers a number of stages and economic-mathematical models, including: 1) *correlation and regression analysis*, allowing to identify the dependence of the environmental component of the mining industry on economic indicators of the performance of the oil and gas sector; 2) *scenario modeling*, contributing to the construction of forecasting models that reflect the level of environmental friendliness of the oil and gas sector; and 3) *factor analysis*, allowing to identify the aggregated components of sustainable development, taking into account the influence of digital technologies, which as a result is integrated into a single methodology for assessing the sustainable development of the oil and gas sector. In order to assess the environmental impact of the industrial complex, a model of correlation and regression analysis was applied. In the framework of the correlation analysis, the closeness of the relationship between the dependent and independent variables is estimated. Significant correlation coefficients exceeding 0.6 are recognized. The linear regression equation has the form:

$$Y = a_0 + b_1 \cdot x_1 + \dots + b_i \cdot x_i, \quad (1)$$

where Y is a dependent variable, a_0 is the free term of the estimation line, the value of Y at zero x ; b_i - gradient of the estimated line, reflects the change in Y with increasing x by one; x_i is an independent variable. The obtained regression equation is considered to be qualitative if the determination coefficient R^2 exceeds 0.7 (according to the Cheddock scale), if the calculated value of the Fisher F-criterion exceeds the tabular one, and the regression coefficients are significant if the calculated values of the t-criterion exceed the tabulated ones [24]. Correlation-regression analysis was carried out according to the following variables [1]: (a) atmospheric emissions of pollutants emanating from stationary sources in the field of mining, thousand tons (B , dependent variable); (b) coefficient of profitability of sales by net profit for the oil and gas industry in Russia, % (K_R); (c) production efficiency coefficient for the revenue of the oil and gas industry in Russia, rub. / t. t. (K_{EP}); (d) asset turnover ratio of the oil and gas industry in Russia, % (K_{AT}); (e) financial leverage ratio of the Russian oil and gas industry, % (R_{FL}). At the next stage, pessimistic and optimistic scenarios of the impact of the oil and gas industry on the environment are constructed. The best prognostic

model is selected taking into account the highest value of the reliability of the approximation R^2 , exceeding a level of 0.7.

Also, due to the lack of a single integrated methodological approach to assessing sustainable development, including taking into account the specifics of the industrial complex, an index of sustainable development of the oil and gas complex, taking into account the digitalization factor, has been proposed. As a method of forming the index, a factor analysis tool is used, which is implemented in the Statistica package for statistical data processing. The method allows to aggregate a number of variables into aggregated factors, combined on the basis of latent relationships. Thus, indicators are classified into categories. The analysis is based on the principal component method, which assumes that the variances of the variables are 1. Factors include only variables that have high correlation coefficients (greater than 0.7). The determination of the optimal number of factors is carried out according to the Kaiser criterion, according to which factors with eigenvalues exceeding 1 are included in the model. Each factor is described by a dependence on factor loads taking into account the correlation coefficients between each variable and the aggregated factor:

$$F_i = \sum_{j=1}^n r_{ij} \cdot x_j, \quad (2)$$

where n is the number of identified factors; r_{ij} is the correlation coefficient between the i th factor and the j th variable (j is the number of variables), i.e. factor load; x_j is the value of the j th variable. The author's model of integrated assessment of the sustainable development of the oil and gas complex is based on a formula, the general mathematical form of which is presented below:

$$I = \sum_{i=1}^n \lambda_i \cdot F_i, \quad (3)$$

where λ_i is the eigenvalue of the i th factor. In order to switch to dimensionless quantities, the data was standardized using formula (4) [25]:

$$y_{ij} = \frac{x_{ij} - \bar{X}_j}{S_j} \quad (4)$$

where y_{ij} is the normalized value; S_j is the sample variance of the j th variable; x_{ij} is values of different dimensions; $\bar{X}_j$ is the sample mean of the j th variable. The information base for building economic and mathematical models was data published in the publication of the Institute of Petroleum Geology and Geophysics named after A.A. Trofimuka SB RAS [1] and database of Federal State Statistics Service [8] and the Higher School of Economics [23]. So, the indicators characterizing the 3 components of sustainable development for 2011-2018 were selected. Environmental parameters:

- x_1 - emissions into the atmosphere of pollutants emanating from stationary sources, thousand tons (for mining);
- x_2 - utilization and neutralization of production and consumption wastes, mln tons (for mining).
- *Economic parameters:*
- x_3 - profit margin of sales by net profit for the oil and gas industry in Russia, %;
- x_4 - coefficient of economic efficiency of capital investments in the oil and gas industry of Russia, %;
- x_5 - net profit of the oil and gas sector, billion rubles

– *Social options:*

- x_6 - average monthly nominal accrued wages of employees, rubles. (for mining);
- x_7 - the average annual number of employees, thousand people. (for mining).

– *Digitalization Options:*

- x_8 - the cost of information and communication technologies (ICT) per 1 RUB. Shipment, rub / rub. (for mining);
- x_9 - the intensity of the use of software in organizations extracting minerals for the management of automated production and individual technical means and technological processes, the share of organizations in the total number of organizations in the business sector;
- x_{10} - the intensity of the use of electronic data exchange technologies between their and external information systems in organizations extracting minerals, the share of organizations in the total number of organizations in the business sector;
- x_{11} - the intensity of broadband Internet use in organizations extracting minerals, the share of organizations in the total number of organizations in the business sector;
- x_{12} - the intensity of use of ERP-systems in organizations extracting minerals, the share of organizations in the total number of organizations in the business sector;
- x_{13} - the intensity of use of CRM systems in organizations extracting minerals, the share of organizations in the total number of organizations in the business sector;
- x_{14} - the intensity of the use of SCM systems in organizations extracting minerals, the share of organizations in the total number of organizations in the business sector.

5 Results and Discussions

5.1 A model of the Dependence of Environmental Factors in the Oil and Gas Sector on Economic Indicators

The study assessed the environmental impact of the oil and gas industry. Initial parameters were key indicators of the performance of the oil and gas sector (economic indicators, including profitability ratios of sales, production efficiency, asset turnover, financial leverage of the oil and gas sector, etc.). The close relationship between the level of atmospheric emissions of pollutants emanating from stationary sources (in the field of mining) and the following economic indicators are identified: (a) the coefficient of profitability of sales by net profit for the oil and gas industry in Russia (%) - is 0.66; (b) the coefficient of production efficiency for the revenue of the oil and gas industry in Russia (rubles / ton UT) – is -0.67; (c) asset turnover ratio of the oil and gas sector in Russia (%) – is 0.71; (d) financial leverage ratio of the Russian oil and gas sector (%) - is -0.96. The significant regression equation was obtained in only one of the following cases:

$$B = 7729,36 - 4064,42 \cdot R_{FL}, \quad (5)$$

The resulting regression equation has a high degree of process description, in other words it is qualitative, since the coefficient of determination $R^2 = 0.914$. Evaluation of the Fisher and Student criteria allows us to conclude that the obtained equation is adequate, the coefficients are significant and the equation can be considered acceptable for predicting emissions in future reporting periods. Independent variable - R_{FL} is of interest. It reflects the ratio of liabilities to equity. In the oil and gas sector of the Russian economy, this indicator for the years 2012-2018 ranges from 0.43% to 0.75% [1], which indicates the use by enterprises own equity mainly. Given the inverse dependence of polluting emissions by mining enterprises on the financial leverage ratio, it must

be concluded that active attracting and using borrowed capital, will increase the environmental friendliness of industrial production. In addition, the optimal level of R_{FL} in the Russian economy is 1 (or 100%), i.e. equal ratio of own and borrowed funds. Thus, increasing R_{FL} is important both from an economic and environmental point of view.

5.2 Forecasting Models Reflecting Alternative Scenarios of Changes in the Level of Environmental Friendliness of the Oil and Gas Sector in Russia

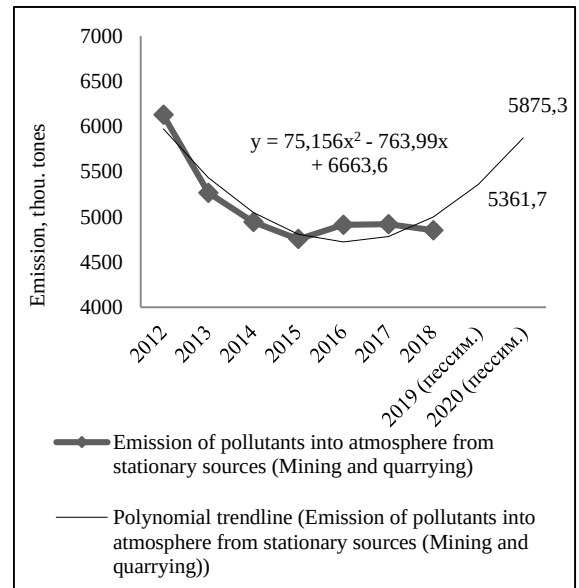
The obtained regression model allows us to build pessimistic (Fig. 3a) and optimistic (Fig. 3b) scenarios of the impact of the oil and gas industry on the environment. In the table 1, the results are systematized and the obtained regression equation is verified.

The forecast was calculated by two methods: based on the construction of a trend line described by the equation of dependence (polynomial and power-law trend line), and calculation of emissions based on the constructed regression equation, taking into account the trend value of the financial leverage ratio of the Russian oil and gas sector. In the first case, the predicted values of emissions polluting the atmosphere in 2020 under the optimistic scenario is 4,554.6 thousand tons, with the pessimistic scenario they will increase to 5,875.3 thousand tons. The constructed regression equation also made it possible to calculate the predicted values: 4,552.8 thousand tons (optimistic forecast) and 5555.3 thousand tons of emissions (pessimistic forecast). We observe slight deviations of the results of two calculation methods - within 6%. The aforesaid allows us to assert that the constructed economic and mathematical model has passed verification.

5.3 Development of a Methodology for Assessing the Sustainable Development of the Oil and Gas Sector of the Russian Economy Based on an Integrated Approach to the Aggregation of Sustainable Development Components and Digital Factors

For building model, we selected indicators characterizing the 3 components of sustainable development: environmental parameters, economic parameters, social parameters, as well as digitalization parameters. All variables were normalized by the formula (4). The results of determining the optimal number of factors are shown in table. 2. Thus, based on the Kaiser criterion, the optimal number of factors (two) was revealed with a total dispersion fraction of 87.68%. In this regard, as a result of factor analysis, 14 variables characterizing the economic, social, environmental and "digital" aspects are aggregated by two factors (Table 3). Factors are distinguished by the method of principal components, the Varimax raw rotation method is applied. Identified factors can be interpreted as follows. The first factor F_1 - accounts for the largest share of the total variance - 56.3%.

a) Pessimistic forecast



(b) Optimistic forecast

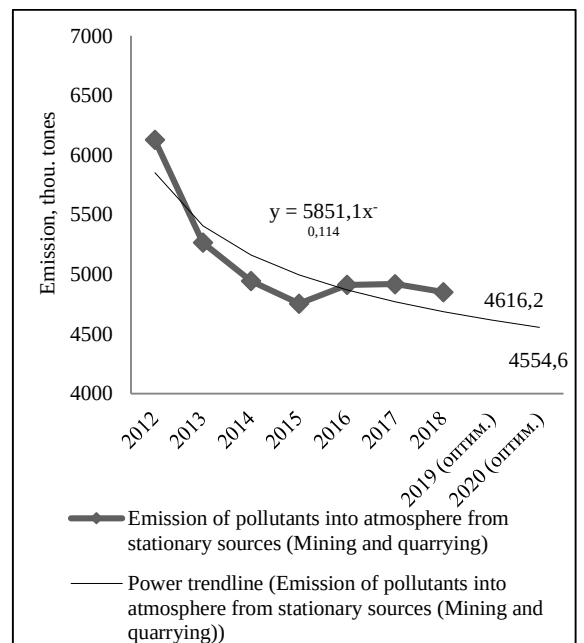


Figure 3: Scenarios for changing the environmental level of the oil and gas sector (built on the basis of data) [1]

Table 1: Forecast indicators of emissions of harmful substances in general for mining (compiled by the authors)

Period	B , thousands tons	R_{FL} , %
2018	4851,4	0,66
Pessimistic scenario for 2019 (polynomial trend line, $R^2 = 0.896$)	5361,7	0,38
Pessimistic scenario for 2020 (polynomial trend line, $R^2 = 0.896$)	5875,3	0,53
Optimistic scenario for 2019 (power trend line, $R^2 = 0.796$)	4616,2	0,80
Optimistic scenario for 2020 (power trend line, $R^2 = 0.796$)	4554,6	0,78
Pessimistic scenario: $B_{2020} = 7729,36 - 4064,42 * R_{FL}$	5555,3	0,53
Optimistic scenario: $B_{2020} = 7729,36 - 4064,42 * R_{FL}$	4552,8	0,78

This factor is characterized by capacity and covers the environmental aspect (variables x_1 and x_2), social (variables x_6 , x_7) and digital (x_8 , x_{10} , x_{12} , x_{13} , x_{14}). The second factor F_2 is mainly microeconomic in nature, combining directly the economic indicators of the oil and gas sector (x_3 , x_4 , x_5) and also the “digital” control factor (x_9 and x_{11}). It has been revealed that digitalization firmly permeates sustainable development, which is determined by the high correlation coefficients of “digital” variables with two distinguished factors.

An assessment of the nature of the revealed dependencies allows us to state the negative impact of the volume of polluting emissions x_1 and the cost of information and communication technologies per 1 rub shipment x_8 on the socio-environmental factor F_1 , which indicates an insufficiently efficient expenditure of investments of industrial enterprises in ICT. The economic factor F_2 is inversely related to the intensity of automation of production x_9 and the intensity of use of broadband Internet x_{11} . A negative coefficient for two “digital” variables also indicates a low contribution of digitalization to revenue generation. According to the formula (1), the dependence of factors on the selected variables is formalized. Where F_1 is a socio-environmental factor that takes into account the influence of digital technologies; F_2 is an economic factor that takes into account the impact of digital technology. According to formula (2), a methodology for determining the integral index of sustainable development is presented:

$$I_{yp} = 7,94 \cdot F_1 + 4,34 \cdot F_2$$

Thus, the proposed model of the dependence of environmental factors of the oil and gas sector on economic ones suggested two alternative development scenarios: with an optimistic forecast, the level of emissions in 2020 is about 4,552.8 thousand tons, while a pessimistic one is 5555.3 thousand tons. Note that by the end of 2020, in the first case, the financial leverage ratio rises to 0.78, in the second case it decreases to 0.53. Since the coefficient level equal to 1 is recognized as optimal, it is recommended that enterprises in the oil and gas sector in Russia review the capital structure and more actively attract and use borrowed capital. The resulting model of the integral index of sustainable development allows one to take into account the indicators of the three main components of sustainable development -

$$F_1 = -0,81 \cdot x_1 + 0,93 \cdot x_2 + 0,97 \cdot x_6 + 0,88 \cdot x_7 - 0,72 \cdot x_8 + 0,87 \cdot x_{10} + 0,99 \cdot x_{12} + 0,98 \cdot x_{13} + 0,79 \cdot x_{14},$$

$$F_2 = 0,72 \cdot x_3 + 0,93 \cdot x_4 + 0,87 \cdot x_5 - 0,75 \cdot x_9 - 0,92 \cdot x_{11}$$

Table 2: Eigenvalues of factors. Principal component analysis. (Compiled according to the Federal State Statistics Service, from: <http://www.gks.ru>)

Factors	Eigenvalues of factors	The proportion of factor in the total variance	Accumulated eigenvalues	Accumulated share in total variance
1	7,936833	56,69167	7,93683	56,6917
2	4,338182	30,98702	12,27502	87,6787
3	0,732858	5,23470	13,00787	92,9134
4	0,495654	3,54038	13,50353	96,4538
5	0,300075	2,14339	13,80360	98,5972
6	0,126886	0,90633	13,93049	99,5035
7	0,069512	0,49652	14,00000	100,0000

economic, social and environmental, and the characteristics of the integral component of the fourth industrial revolution - the digital one. The unity of approach distinguishes the author's model from the capacious system of indicators developed by the UN Commission on Sustainable Development [26].

6 Conclusion

The study, which focuses on two main aspects - sustainable development and digitalization, reflects the characteristics of the Russian economy. It is revealed that monitoring the impact of the industrial complex on the environment is important in the framework of sustainable development. Digital technologies relevant for the modern economy are called upon to act as a catalyst for this process. Based on the processing of statistical data and the construction of a regression model, it is found that the environmental factor (level of air polluting substances) is highly dependent on the economic (asset turnover and financial leverage ratio of the Russian oil and gas sector). It is determined that increasing the financial leverage ratio due to more active attraction and use of borrowed capital contribute to the reduction of harmful emissions by industrial facilities. The model allows us to build optimistic and pessimistic forecasts of the impact of the oil and gas sector on the environment, which makes it possible to assume the need to strengthen monitoring and its digitalization in order to develop along an optimistic vector. In general, environmental indicators of the mining industry are characterized by positive trends: a decrease in pollutant emissions both in mining and in the sphere of extraction of crude oil and natural gas and an increase in neutralized pollutants and production and consumption wastes [8].

The second aspect is digital transformation. As a result of factor analysis, 2 factors were selected that take into account “digital” variables. Both identified factors reflect the low-efficiency use of digital technologies in the activities of extractive organizations, including the oil and gas sector. At this stage of development in the industry, digital technologies do not yet provide a synergistic effect in consolidation with the implementation of the concept of sustainable development. This is also due to the fact that, in general, in the Russian economy, the field of information and communication technologies is in its infancy compared with developed countries [27].

Table 3: Factor loads of variables for identified factors, taking into account the rotation of factors (compiled by the authors)

Variables	Factor 1	Factor 2
X ₁	-0,811349	0,347441
X ₂	0,932936	0,293899
X ₃	-0,645732	0,721626
X ₄	-0,185894	0,933407
X ₅	0,330573	0,871915
X ₆	0,968547	0,154488
X ₇	0,880131	0,282310
X ₈	-0,720691	-0,157737
X ₉	-0,498242	-0,751370
X ₁₀	0,872459	-0,399520
X ₁₁	0,029981	-0,919811
X ₁₂	0,985159	-0,111965
X ₁₃	0,982286	-0,051886
X ₁₄	0,785352	0,563645
Expl. Var	7,884100	4,390916
Prp. Totl	0,563150	0,313637

Acknowledgments

The research was carried out within the framework of the grant of the President of the Russian Federation for state support of leading scientific schools of the Russian Federation, project number NSH-2600.2020.6.

References

- [1] Filimonova IV, Nemov VYu, Provornaya IV. Oil and gas complex of Russia. Novosibirsk: INGG SB RAS. 2019.
- [2] On the concept of the transition of the Russian Federation to sustainable development. Decree of the President of the Russian Federation of April 1, 1996 No. 440. URL: <http://www.pravo.gov.ru/>. 1996.
- [3] On the approval of the State program of the Russian Federation. Development of industry and increasing its competitiveness. Decree of the Government of the Russian Federation of April 15, 2014 No. 328. URL: <http://www.pravo.gov.ru/>. 2014b.
- [4] On approval of the State Program of the Russian Federation. Economic Development and Innovative Economy. Decree of the Government of the Russian Federation of April 15, 2014 No. 316. URL: <http://www.pravo.gov.ru/>. 2014a.
- [5] On approval of the Strategy of socio-economic development of the Republic of Tatarstan until 2030. Law of the Republic of Tatarstan dated 06/17/2015 No. 40-3PT. URL: <http://mert.tatarstan.ru/eng/>. 2015.
- [6] Sustainable Society Foundation. URL: <http://www.ssfindex.com/>. 2020.
- [7] Passport of the national program. Passport of the national program "Digital Economy of the Russian Federation". Presidium of the Council under the President of the Russian Federation for Strategic Development and National Projects, Minutes No. 16 of December 24, 2018. URL: <http://government.ru>. 2018.
- [8] Rosstat. URL: <http://www.gks.ru>. 2020
- [9] McKinsey & Company. URL: <https://www.mckinsey.com>. 2020.
- [10] Eder LV, Filimonova IV, Komarova AV, Shumilova SI, Nemov VYu, Agile IV, Mishenin MV, Zemnukhova EA. Oil and gas complex of Russia. Economics of the oil and gas industry: long-term trends and current status. Novosibirsk: INGG SB RAS. 2018.
- [11] Malysheva TV, Shinkevich AI, Kharisova GM, Nuretdinova, YV, Khasyanov OR, Nuretdinov IG, Zaitseva NA, Kudryavtseva SS. The Sustainable Development of Competitive Enterprises through the Implementation of Innovative Development Strategy. International Journal of Economics and Financial Issues. 2016;6(1):185–191.
- [12] Dyrdonova AN, Lin'kova TS. Principles of petrochemical cluster' sustainability assessment based on its members' energy efficiency performance. International Scientific and Technical Conference Smart Energy Systems. (SES-2019), 124;04013. 2019.
- [13] Dyrdonova AN, Shinkevich AI, Galimulina FF, Malysheva TV, Zaraychenko IA, Petrov VI, Shinkevich MV. Issues of industrial production environmental safety in modern economy. Ekoloji. 2018;27(106):193–201.
- [14] Alexandrova TV. Development of corporate environmental responsibility of the oil and gas business in the context of the transition to a green economy. Management Consulting. 2019;9(129): 55–70.
- [15] Patin SA. Oil and the ecology of the continental shelf: in 2 vols. 2nd ed. revised and supplemented. Environmental impacts, monitoring and regulation during the development of shelf hydrocarbon resources. Moscow: VNIRO Publishing House. 2017.
- [16] Korobova OS. On the monitoring system for greenhouse gas emissions in the region. Labor Protection and Economics. 2015;4(21):94–100.
- [17] Meshalkin VP, Moshev ER. Modes of functioning of the automated system «pipeline» with integrated logistical support of pipelines and vessels of industrial enterprises. Journal of Machinery Manufacture and Reliability. 2015; 44(7):580–592.
- [18] Moshev ER, Romashkin MA. Development of a conceptual model of a piston compressor for automating the information support of dynamic equipment. Chemical and Petroleum Engineering. 2014;49(9-10):679–685.
- [19] Kulagi TV, Babkina AV, Murtazaev SA. Matrix tool for efficiency assessment of production of building materials and constructions in the digital economy. Advances in Intelligent Systems and Computing. 2016;692:1333–1346.
- [20] Gölzer P, Fritzsche, A. Data-driven operations management: organisational implications of the digital transformation in industrial practice. Production Planning and Control. 2017;28(16):1332–1343.
- [21] Vorobiev AE, Vorobev KA, Tcharo H. Digitalization of the oil industry. Moscow: Sputnik + Publishing House LLC. 2018.
- [22] Analytical Center under the Government of the Russian Federation. Energy Efficiency to Prevent Climate Change. Energy Bulletin. 2018;57:14-18.
- [23] HSE. URL: <https://www.hse.ru>. 2020
- [24] Orlova IV, Polovnikov VA. Economic and mathematical methods and models: computer modeling. Moscow: University textbook. 2007.
- [25] Khalafyan AA. STATISTICA 6. Statistical data analysis. Moscow: Binom-Press LLC. 2007.
- [26] United Nations. Indicators of Sustainable Development: Framework and Methodologies. New York: Department of Economic and Social Affairs. 1996
- [27] Galimulin, FF. Digital transformation of the national innovation system. Science and Business: Ways of Development. 2018;12(90):83–86.