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Research of the environmental sustainability of enterprises in the oil and gas sector of the Russian economy

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Abstract. In 2015, the UN Member States took 17 Sustainable Development Goals. Innovative development and environmental protection played a significant role in them. The solution to this problem directly depends on the environmental programs adopted at the state level, competent management, development of environmental innovations and their introduction. This article considers how sustainable development programs at the oil and gas enterprises are implemented to preserve the environment on the example of PJSC Gazprom. PJSC Gazprom, following the principles of sustainable development, combines economic growth and environment preservation. In 1995, PJSC Gazprom adopted an ecological program and gradually solves the environmental problems of the corporation, country and the world. Therefore, the study of some indicators of oil and gas enterprises affecting Russian environmental ecology, on the example of Gazprom Corporation, is relevant. The proceedings of Russian and foreign scientists were analyzed; UNDP's annual and environmental reports for 2018–2022 were studied; leading Russian oil and gas companies for 2009–2021 and their environmental activities were analyzed to conduct the study. The calculations were carried out using Rosstat (2009–2021), World Bank (2009–2021), PJSC Gazprom (2009–2021). The regression analysis and econometric modeling were carried out through MS Excel and Eviews 12. The linear and exponential models of the innovative component in the environmental protection system were built and studied. It was proved the linear model can be used to build short-term forecasts, while the exponential model turned out to be untenable. PJSC Gazprom invested 658,284 billion rubles in environmental protection and rational use of natural resources, 139,1 billion rubles in R&D from 2009 to 2021. In 2021, PJSC Gazprom fulfilled all of its innovative and environmental objectives and approved Environmental Program until 2024 with an outlook for 2030. The company's contribution to the implementation of the UN sustainable development goals and objectives amounted to 89,9 %.

Keywords: oil and gas sector, PJSC GAZPROM, innovative, environmental, sustainable development, econometric modeling

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Исследование экологической устойчивости предприятий нефтегазового сектора российской экономики

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Аннотация. В 2015 г. государствами — членами ООН были приняты 17 Целей устойчивого развития. Значительная роль в них отводилась инновационному развитию и защите окружающей среды. Решение данной проблемы напрямую зависит от экологических программ, принятых на государственном уровне, грамотного менеджмента, развития экологических инноваций и их внедрения. Рассмотрено, как реализуются программы устойчивого развития на предприятиях нефтегазового сектора в области сохранения окружающей среды на примере PJSC Gazprom. PJSC Gazprom, следуя принципам устойчивого развития, в своей деятельности стремится к экономическому росту наряду с сохранением окружающей среды. В 1995 г. PJSC Gazprom принял экологическую программу и постепенно решает экологические проблемы корпорации, страны и мира в целом. Поэтому исследование некоторых показателей предприятий нефтегазового сектора, влияющих на экологию России, на примере корпорации Газпром актуально. Для проведения исследования были проанализированы труды российских и иностранных ученых, изучены годовые и экологические отчеты UNDP за 2018–2022 гг., ведущих российских нефтегазовых компаний за 2009–2021 гг., проанализирована их экологическая деятельность. Расчеты проводились по данным Rosstat (2009–2021), WorldBank (2009–2021), PJSC Gazprom (2009–2021). Регрессионный анализ и эконометрическое моделирование проведено с помощью пакетов прикладных программ MS Excel и Eviews-12. Были построены и исследованы линейная и экспоненциальная модели инновационной составляющей в системе охраны окружающей среды. Доказано, что линейную модель можно использовать для построения краткосрочных прогнозов, экспоненциальная же модель оказалась несостоятельной. За период с 2009 по 2021 г. ПАО «Газпром» инвестировало в охрану окружающей среды и рациональное использование природных ресурсов 658 284 млрд р., в НИОКР — 139,1 млрд р. В 2021 г. ПАО «Газпром» выполнило все свои инновацион-

ные и экологические задачи и утвердило экологическую программу развития до 2024 г. с перспективой на 2030 г. Вклад компании в реализацию целей и задач устойчивого развития ООН составил 89,9 %.

Ключевые слова: нефтегазовый сектор, PJSC GAZPROM, инновационное, экологическое, устойчивое развитие, эконометрическое моделирование

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Introduction

Environmental pollution and climate change pose an urgent threat to humanity. This can lead to a shift in climatic zones and economic reconstruction of many countries. The environmental issue has recently attracted considerable attention of scientists and politicians. In 2015, the UN members formulated and adopted 17 Sustainable Development Goals to be achieved by 2030[1]. One of the main objectives of the Goals is increasing the level of environmental sustainability and resilience of society. However, today the pace of global progress does not always meet the goals of sustainable development. The solution to this problem directly depends on environmental programs adopted at the state level, competent management, the level of development of environmental innovations and their introduction. Ecological innovations should become a necessary component of the strategic development of a modern enterprise, its competitive advantage (Antonioli et al., 2018). However, today not all enterprises seek to introduce environmental innovations, some do not even know or do not want to know about their existence. Companies do not always see the benefits of their introduction. They consider them to be a loss-making business component and, if they introduce them, it is only under the threat of serious penalties or fines that exceed their income. Therefore, the study of the impact of innovations on environmental sustainability and the activities of enterprises is relevant (Choi et al., 2018).

Problem Statement. According to the UN report, investments in environmental programs in the amount of only 2 % of the country's GDP can ensure long-term economic growth and significantly improve the environmental situation[2].

[1] UNDP (2020). Sustainable Development Goals. Retrieved June 25, 2022, from https://www.un.org/sustainabledevelopment/

[2] UNDP (2019). New UN Global Climate report 'another strong wake-up call' over global warming: Guterres. Retrieved June 25, 2022, from https://news.un.org/en/news/topic/sdgs/date/2019/date/2019-03

Evidently, the economic competitiveness depends on the correct choice of its development model. The technological and environmental components should be among the most important factors of this model (Antonioli et al., 2018; Baranova, Sorokin, 2017; Baranova, Loginova, 2021). Environmental development management should be carried out using environmental innovation and the EU Eco-Management and Audit Scheme (EMAS) (Yu et al., 2017).

The introduction of the ISO 14001 environmental management system and the reduction of the use of toxic substances are the most common environmental innovation practices[3]. Porter said (Rexhäuser, Rammer, 2014) environmental innovation has a positive effect on the competitiveness of enterprises and could be aimed at the efficient and rational use of resources, minimizing the environmental fines (Skordoulis et al., 2020). Many times, companies introduce environmental innovations if it is necessary to emphasize their social responsibility, unveil their positive attitude towards the environment, attract new customers, etc. (Yu, Ramanathan, Nath, 2017; Rexhäuser, Rammer, 2014). The studies of the financials of various firms have shown that pollution prevention measures are more effective than cleanup activities in increasing their productivity (Cainelli, De Marchi, Grandinetti, 2015).

The development and introduction of technological innovations are associated with high risks and costs for enterprises, and the economic effect may not be forthcoming. Therefore, companies are in no hurry to introduce environmental innovations. And, if they do, they use them only as long as it benefits. Competitors can become a factor encouraging the development of environmental programs (Dai, Cantor, Montabon, 2015; Souto, Rodriguez, 2015).

The statistical studies on the introduction of environmental innovations in Russia have been conducted since 2009. The studies have shown that enterprises with hazardous industries, such as the production of tobacco (67 %), coke and petroleum products (39 %), metallurgy (35 %), chemical industry (34 %), are leaders in the implementation of environmental innovations[4] (Orazalin et al., 2018).

The role of environmental modernization in the economic development of oil and gas enterprises in Russia. Despite the economic crises and sanctions, the environmental care remains one of the main tasks in Russia. This is evidenced by the Decrees[5] adopted by the government, and Federal acts[6], regulations and standards (ISO 14001, GOST R 17.0.0.06-2000, GOST R ISO 14001–2007, GOST R 52108–2003, GOST R 54199–2010, etc.). The state is ready to support green

[3] National standard of the Russian Federation. Environmental management systems ISO 14001. Retrieved from https://docs.cntd.ru/document/1200134681.

[4] Rosstat (2021). Key environmental indicators. Statistic Bulletin. Retrieved June 25, 2022, https://rosstat.gov.ru/storage/mediabank/oxr_bul_2021.pdf

[5] Decree of the Government of the Russian Federation of April 20, 2022 No. 707. Retrieved March 14, 2022, from https://www.garant.ru/news/1544128/; Decree of the Government of the Russian Federation of March 14, 2022 No. 355;

[6] Art. 7 of the Federal Law of July 2, 2021. No. 296-FZ

projects[7] of enterprises. Concessionary financing through special bonds or loans[8], tax breaks, the opportunity to get grants, green projects, government tenders, receive municipal orders and loans, etc. These are some of the preferences that the state is ready to provide subject to the implementation of environmental projects.

In modern conditions, large Russian companies, including companies in the oil and gas sector, are strategic industries in Russia. Oil and gas companies entered the top twenty in the 2020 RAEX-600[9] rating of the leading Russian companies. Thus, PJSC Gazprom ranked 1st in terms of sales, it is followed by PJSC LUKOIL (2nd), PJSC Rosneft (3rd), PJSC Surgutneftegaz (12th), PJSC Tatneft (17th), PJSC NOVATEK (18th). This economic sector can have a great impact on the ecological state of the regions. Rosstat estimated that the emissions of air pollutants in Russia amounted to 32,3 million tons in 2018, 22,7 million tons in 2019, 22,2 million tons in 2020. These amounted to 220 kg (2018), 155 kg (2019), 152 kg (2020) on a per capita basis. It is clear that the situation is gradually improving[10] (Mityakov et al., 2018).

The Krasnoyarsk Krai is the leader in terms of the amount of harmful emissions — air pollutant emissions amounted to 2,5 million tons there. Multi-ton emissions are also present in the Kemerovo Oblast, the Khanty-Mansiysk and Yamalo-Nenets Autonomous Districts, the Sverdlovsk, Irkutsk and Chelyabinsk Oblasts, the Republic of Bashkortostan, Krasnodar Krai and the Orenburg Oblast. Most harmful emissions were recorded in the energy sector in 2020 (17,1 % of the total volume), in the metal ore mining (2,4 million tons or 14,1 %), in the oil and gas production[11] (2,3 million tons or 13,8 %) (Mityakov et al., 2018).

The oil and gas industry can severely damage the environment. However, green innovations were not introduced into production for a long time. Since 2009, Russian oil and gas companies have begun to implement most actively environmental programs, under the influence of international cooperation and through the development of domestic scientific developments (Chang et al., 2020; Jain et al., 2020). Therefore, their environmental activities became one of the priorities in the sustainable development strategy as early as 2010 (Heidenreich, Spieth, Petschnig, 2017; Baranova, Loginova, 2021; Liao, 2018).

Industry Rating of Eco Transparency of Oil and Gas Companies presents some works to interested people to receive complete information about the ecological state of Russian companies[12]. This rating can become an engine

[7] Decree of the Government of the Russian Federation of July 14, 2021 No. 1912

[8] Decree of the Government of the Russian Federation of September 21, 2021 No. 1587

[9] Rating of the largest companies in Russia RAEX-600 FY2020. Retrieved April 10, 2022, from https://raex-a.ru/ratings/raex-600/2021

[10] Rosstat (2021). Key environmental indicators. Statistic Bulletin. Retrieved June 25, 2022, from https://rosstat.gov.ru/storage/mediabank/oxr_bul_2021.pdf

[11] Ibid.

[12] Industry rating of eco transparency. Oil and gas companies (2014–2021). Retrieved April 07, 2022, from https://wwf.ru/what-we-do/green-economy/eco-transparency-rating/ngk-russia-2021/

of development and a competitive advantage, help companies compare and change their development strategies. The rating results[13] for 2021 showed that there are large differences in environmental responsibility among Russian oil and gas companies. It is worth pointing out that major companies got top ranking: JSC Zarubezhneft and PJSC Tatneft shared 1–2 places, Sakhalin Energy Investment Company Ltd. and PJSC Surgutneftegaz took 3–4 places, Salym Petroleum Development N.V." was on 5th place, PJSC Gazprom was on 6th place (Shvarts, Pakhalov, Knizhnikov, 2016).

Since the 2020 diesel spill by PJSC MMC Norilsk Nickel in the Arctic, Russian companies in this sector launched a long-term program to reduce environmental risks and update their ESG strategy until 2030[14] (Jain, Panda, Choudhary, 2020; Baranova, Loginova, 2020; Baranova, Loginova, 2021).

Let us consider how sustainable development programs are implemented at oil and gas enterprises to fulfill environmental conservation programs on the example of PJSS Gazprom, the leading enterprise in the oil and gas sector[15].

PJSC GAZPROM is the largest global and domestic gas supplier. Fortune Global 500 estimates that PJSC GAZPROM ranked 42nd in the world in terms of net profit ($23 billion) in 2019, 55th place ($19 billion) in 2020[16], and $29 billion in 2021.[17] The state of the environment of both Russia and the world depends on its "ecological" functioning[18]. (Orazalin, Mahmood, 2018)

PJSC GAZPROM, in contrast to many of the largest enterprises in Russia, adopted its Environmental Program back in 1995 and gradually began to solve the environmental issues of the corporation, the country and the world[19].

Innovative projects of PJSC GAZPROM in the sustainable and environmental development of the corporation contribute to the spread of environmentally friendly form of energy carriers, strengthen energy security, and lead to the socio-economic

[13] Decree of the Government of the Russian Federation of September 21, 2021 No. 1587

[14] PJSC Gazprom environmental report (2021). Retrieved April 15, 2022, from https://www.gazprom.ru/f/posts/57/982072/gazprom-environmental-report-2021-ru.pdf

[15] PJSC Gazprom (2011). PJSC Gazprom in Figures 2007–2011. Factbook. Retrieved April 05, 2022, from https://www.gazpro m.com/f/posts/81/070547/gazprom-reference-figures-2007-2011-eng.pdf; PJSC Gazprom (2016). PJSC Gazprom in Figures 2012–2016. Factbook. Retrieved April 05, 2022, from https://www.gazprom.com/f/posts/44/307258/gazprom-in-figures-2012-2016-en.pdf; PJSC Gazprom. (2021). PJSC Gazprom in Figures 2017–2021. Retrieved April 05, 2022, from https://www.gazprom.com/f/posts/13/041777/gazprom-in-figures-2017-2021-en.pdf; PJSC Gazprom sustainability-report (2021). Retrieved April 05, 2022, from https://www.gazprom.ru/f/posts/57/982072/sustainability-report-ru-2021.pdf

[16] GlobalStocks.ru. Retrieved April 05, 2022, from https://globalstocks.ru/

[17] PJSC Gazprom sustainability-report (2021). Retrieved April 05, 2022, from https://www.gazprom.ru/f/posts/57/982072/sustainability-report-ru-2021.pdf

[18] PJSC Gazprom annual report (2021). Retrieved April 05, 2022, from https://www.gazprom.ru/f/posts/57/982072/gazprom-annual-report-2021-ru.pdf; PJSC Gazprom environmental report (2021). Retrieved April 05, 2022, from https://www.gazprom.ru/f/posts/57/982072/gazprom-environmental-report-2021-ru.pdf

[19] PJSC Gazprom environmental report (2021). Retrieved April 05, 2022, from https://www.gazprom.ru/f/posts/57/982072/gazprom-environmental-report-2021-ru.pdf

development of Russian regions. The corporation improves its energy efficiency and reduces the negative impact on the climate by introducing innovative projects and environmental protection patents. The corporation solves business problems with the maximum benefit for society and care for nature, understanding the responsibility to millions of people in different countries.[20]

Materials and Methods

The development of economic science generates a great interest in sustainable environmental development, which attracts the attention of company executives and relevant government authorities to regulate environmental development issues.

The introduction of green innovations in the enterprise performance, their impact on the environment and the economy are of considerable interest to Russian and foreign scientists. D. Antonioli, M. Gilli, M. Mazzanti, F. Nicolli (Antonioli et al., 2018), W. Yu, R. Ramanathan, P. Nath (Yu et al., 2017), Z. Liao (2018), J. Dai, D. Cantor, F. Montabon (2015), J.E. Souto, A. Rodriguez (2015), M. Skordoulis, S. Ntanos, G.L. Kyriakopoulos, G. Arabatzis, S. Galatsidas, M. Chalikias (Skordoulis et al., 2020), K.H. Chang, D.F. Gotcher (2020), S.N. Mityakov, O.I. Mityakova, E.S. Mityakov, I.V. Alenkova (Mityakov et al., 2018), S. Rexhäuser, C. Rammer (2014), G. Cainelli, V. De Marchi, R. Grandinetti (2015), H. Choi, D. Yi (2018), S. Heidenreich, P. Spieth, M. Petschnig (2017), etc. are among them.

N.M. Baranova (Baranova, Sorokin, 2017; Baranova, Loginova, 2020; Baranova, Loginova, 2021), D.S. Loginova (Baranova, Loginova, 2020; Baranova, Loginova, 2021), L.V. Sorokin (Baranova, Sorokin, 2017), V.V. Vlasova, L.M. Gokhberg, G.A. Gracheva and others (Vlasova et al., 2022), J.A. Bamgbade, A.M. Kamaruddeen, M.N.M. Nawi, A.Q. Adeleke, M.G. Salimon, W.A. Ajibike (Bamgbade et al., 2019), N.K. Jain, A. Panda, P. Choudhary (Jain et al., 2020), N. Orazalin, M. Mahmood (2018), E.A. Shvarts, A.M. Pakhalov, A.Y. Knizhnikov (2016), T. Thurner, L.N. Proskuryakova (2014), M. Bambi, C., Di Girolami, S. Federico et al. (Bambi et al., 2017), etc. were engaged in the research of the innovative component of the sustainable development of the companies, including in the oil and gas sector.

The article carried out econometric modeling and established the relationship between the innovative and environmental components of the sustainable development of the oil and gas sector in Russia, by the example of PJSC GAZPROM. The UN reports[21],

[20] PJSC Gazprom sustainability-report (2021). Retrieved April 05, 2022, from https://www.gazprom.ru/f/posts/57/982072/sustainability-report-ru-2021.pdf; PJSC Gazprom annual report (2021). Retrieved April 05, 2022, from https://www.gazprom.ru/f/posts/57/982072/gazprom-annual-report-2021-ru.pdf

[21] UNDP. (2018–2022). UNDP Climate Reports. *Climate Action*. Retrieved June 25, 2022, from https://www.un.org/en/climatechange/reports; UNDP. (2021). The Sustainable Development Goals Report. Retrieved June 25, 2022, from https://unstats.un.org/sdgs/report/2021/The-Sustainable-Development-Goals-Report-2021.pdf;

statistical data from Rosstat[22], the World Bank[23], PJSC GAZPROM for 2009–2021[24] were used for the purpose.

The statistical data from the annual reports of PJSC GAZPROM (2009–2021) were used for the calculations.[25] The regression analysis and econometric studies were carried out using the MS Excel and Eviews 12 software package. The linear and exponential models were built and studied in order to build a short-term forecast of the innovative component in the environmental protection system (Matyushok et al., 2020; Wooldridge, 2015; Ackerberg et al., 2015). The comparison was made and the assessment of the actual indicators of the corporation Y_i with the fitted $Y_i^{\wedge}$ (i = 1, …, 13) was given.

Results

We built the econometric models to study some indicators that affect the level of environmental pollution (by the example of PJSC Gazprom) (Matyushok, Balashova, Lazanyuk, 2020; Wooldridge et al., 2015; Ackerberg, 2015). The amount of total emissions (million tons), including air pollutant emissions, greenhouse gas emissions and waste generation, was taken as the explained variable *Y*. The regressors were X_1(PATENT) as the number of patents, X_2(NATURE) as the environmental costs (million rubles), X_3(EFFECT) as economic benefit from the use of patents (million rubles), X_4(EDUC) as the environmental training (number of people). The statistical data was taken from the official websites of PJSC GAZPROM; Sustainable, Innovative Development, Environmental Programs of the company for 2009–2021 were used.[26] MS Excel and Eviews 12 were used

[22] Rosstat (2021). Key environmental indicators. Statistic Bulletin. Retrieved May 05, 2022, from https://rosstat.gov.ru/storage/mediabank/oxr_bul_2021.pdf

[23] World Bank (2020). World Development Indicators. Retrieved from https://data.worldbank.org/indicator/

[24] PJSC Gazprom. (2011). PJSC Gazprom in Figures 2007–2011. Factbook. Retrieved May 05, 2022, from https://www.gazprom.com/f/posts/81/070547/gazprom-reference-figures-2007-2011-eng.pdf; PJSC Gazprom. (2016). PJSC Gazprom in Figures 2012–2016. Factbook. Retrieved May 05, 2022, from https://www.gazprom.com/f/posts/44/307258/gazprom-in-figures-2012-2016-en.pdf; PJSC Gazprom. (2019). Working towards our common future, Gazprom Group's Sustainability Report. Retrieved May 05, 2022, from https://www.gazprom.com/f/posts/72/802627/sustainability-report-en-2019.pdf; PJSC Gazprom. (2019). PJSC Gazprom Environmental Report. Retrieved May 05, 2022, from https://www.gazprom.com/f/posts/72/802627/gazprom-environmental-report-2019-en.pdf; PJSC Gazprom. (2021). PJSC Gazprom in Figures 2017–2021. Retrieved May 05, 2022, from https://www.gazprom.com/f/posts/13/041777/gazprom-in-figures-2017-2021-en.pdf; PJSC Gazprom annual report (2021). Retrieved May 05, 2022, from https://www.gazprom.ru/f/posts/57/982072/gazprom-annual-report-2021-ru.pdf

[25] PJSC Gazprom. (2011). PJSC Gazprom in Figures 2007–2011. Factbook. Retrieved May 05, 2022, from https://www.gazprom.com/f/posts/81/070547/gazprom-reference-figures-2007-2011-eng.pdf; PJSC Gazprom. (2016). PJSC Gazprom in Figures 2012–2016. Factbook. Retrieved May 05, 2022, from https://www.gazprom.com/f/posts/44/307258/gazprom-in-figures-2012-2016-en.pdf; PJSC Gazprom. (2021). PJSC Gazprom in Figures 2017–2021. Retrieved May 05, 2022, from https://www.gazprom.com/f/posts/13/041777/gazprom-in-figures-2017-2021-en.pdf; PJSC Gazprom annual report (2021). Retrieved May 05, 2022, from https://www.gazprom.ru/f/posts/57/982072/gazprom-annual-report-2021-ru.pdf

[26] Ibid.

for the regression analysis, calculations, and estimation of the required parameters of the desired models. (Matyushok, Balashova, Lazanyuk, 2020).

The correlation matrix established strong association between Y and X_1, X_2, X_3, X_4: $R_{YX1} = 0{,}8$, $R_{YX2} = 0{,}84$, $R_{YX3} = 0{,}85$, $R_{YX4} = 0{,}88$. Therefore, we built the models and studied the parameters of the model using the Eviews 12 application package (Figure 1).

Dependent Variable: TCO2
Method: Least Squares
Date: 07/09/22 Time: 12:22
Sample: 2009 2021
Included observations: 13

Variable	Coefficient	Std. Error	t-Statistic	Prob.
PATENT	-0.036123	0.008024	-4.502015	0.0020
NATURE	-0.000706	0.000170	-4.150688	0.0032
EFFECT	-0.001502	0.000617	-2.433206	0.0010
EDUC	-0.003668	0.001031	-3.557205	0.0074
C	303.7127	11.46302	26.49501	0.0000

R-squared	0.882854	Mean dependent var	240.8400
Adjusted R-squared	0.844281	S.D. dependent var	11.40799
S.E. of regression	6.203670	Akaike info criterion	6.771882
Sum squared resid	307.8842	Schwarz criterion	6.989170
Log likelihood	-39.01723	Hannan-Quinn criter.	6.727220
F-statistic	144.0761	Durbin-Watson stat	1.991204
Prob(F-statistic)	0.000000		

Figure 1. Coefficients and estimation of the linear model

Source: compiled by the authors (Eviews12).

The estimates of the parameters of the desired linear model showed that this model is significant ($F_{stat} = 144{,}08$, p-value = 0,000000) and can be used to build short-term forecasts (Figure 1). The coefficient of determination R^2 is 0,8829, therefore, 88,29 % of the total variation of the Y variable is explained by the variation of the independent variables X_1, X_2, X_3, X_4. Therefore, the linear model is adequate according to the formal criterion. The linear model is as follows:

$$Y\hat{}(1) = 303{,}7 - 0{,}036X_1 - 0{,}00071X_2 - 0{,}0015X_3 - 0{,}0037X_4. \quad (1)$$

As a comparison an exponential model should be built and investigated (Figure 2):

Dependent Variable: LOG(TCO2)
Method: Least Squares
Date: 07/09/22 Time: 20:06
Sample: 2009 2021
Included observations: 13

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOG(PATENT)	-0.367102	0.103929	-3.532251	0.0077
LOG(NATURE)	-0.185912	0.053560	-3.471077	0.0084
LOG(EFFECT)	-0.026303	0.017716	-1.484667	0.1059
LOG(EDUC)	-0.157440	0.046206	-3.407367	0.0093
C	7.483359	0.498257	15.01907	0.0000

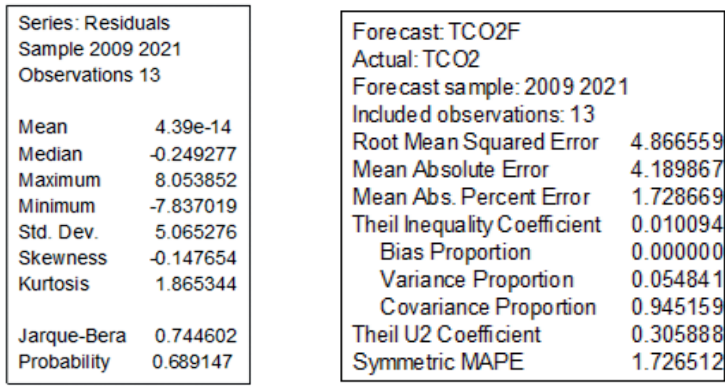
R-squared	0.809070	Mean dependent var	5.483083
Adjusted R-squared	0.798605	S.D. dependent var	0.047888
S.E. of regression	0.029959	Akaike info criterion	-3.894237
Sum squared resid	0.007180	Schwarz criterion	-3.676949
Log likelihood	30.31254	Hannan-Quinn criter.	-3.938900
F-statistic	5.664900	Durbin-Watson stat	2.000603
Prob(F-statistic)	0.000039		

Figure 2. Parameters and estimates of the nonlinear model

Source: compiled by the authors (Eviews12).

The exponential model is being studied (Figure 2): $R^2 = 0{,}81$, Prob = 0,000039, i.e. $R^2(1) > R^2(2)$. However, the coefficient of X_3(EFFECT) is not significant (Prob(X_3) = 0,106). Therefore, the model (2) is insignificant and cannot be used for forecasting.

According to Figure 3, the resulting model (1) is investigated.



a ***b***

Figure 3. Jarque-Bera Test (***a***) and estimates of the linear model (***b***)

Source: compiled by the authors (Eviews12).

The fitted Y^(1) approximates well the dependence of the actual Y(Xi), i = 1, …, 13. The deviation of the average fitted Y^(1) from the average actual Y tends to zero (Figure 3, *a*). The standard deviation (Variance_Proportion) of the fitted Y^(1) from the standard deviation of the actual Y is approximately 0,055. The intermittent error (Covariance_Proportion) of the predictive linear model is 0,945 (Figure 3, *b*). These three values of the model (1) are equal to 1 in total (the closer the first two values are to 0, and the third to 1, the better the forecast). Theil coefficient is 0,31 (0<0.31<1).

For this model, White test cannot be used to test the model for the heteroscedasticity due to insufficient sample size. Therefore, we use the Goldfeld-Quandt test, while it is necessary to order the observations by X_2(NATURE). H_0: The variance of residuals does not depend on the expenditures on technological innovation. H_1: The variance of residuals depends on the expenditures on technological innovation.

$$F_{stat} = RSS_3/RSS_1 = 35{,}49/112{,}8 = 0{,}31;\ F_{cr} = 161{,}4 \rightarrow F_{stat} < F_{cr};\ P - \text{value} = 0{,}67 > 0{,}05.$$

On the basis of Goldfeld-Quandt test, we can say that there is no heteroscedasticity.

Due to insufficient sample size, we can drop the test for the presence or non-presence of autocorrelation of the residuals. However, it can be assumed that it is absent in all respects, since DW = 1,99 ≈ 2, which falls into the zone of no autocorrelation at both 1 % and 5 % significance levels. Therefore, the model (1) can be used to build a short-term forecast.

The values of the regression coefficients can be interpreted as follows: 1) 1 unit increase in the number of patents decreases an amount of total emissions by 0,36 million

tons per year; 2) 1 million rubles increase in environmental costs decreases *Y*^(1) by 0,00071 million tons per year; 3) 1 million rubles benefit from the use of patents decreases *Y*^(1) by 0,0015 million tons per year; 4) 1 person increase in the number of employees who have undergone environmental training decreases *Y*^(1) by 0,0037 million tons per year; other things being equal. *C* is the free coefficient of the equation and has no interpretation, but if $X_1 = X_2 = X_3 = X_4 = 0$, then C = 303,7.

Evidently, *Y* will change linearly with a change in exogenous variables in one direction or another. According to the data of the correlation matrix, the influence of the variables X_1, X_2, X_3, X_4 on *Y* will be more sensitive with the growth of their correlation dependence.

Discussion

The article builds and investigates the linear and exponential models of some factors affecting environmental pollution. It is proved that the linear model can be used to build short-term forecasts, the exponential model turned out to be untenable.

It is found that the actual *Yi* and fitted *Yi*^(1) (i = 1, … ,13) of the linear model (1) for 2009–2021 differ slightly from each other. According to Gazprom's annual reports, *Y* equaled 19,045 billion rubles, *Y*^(1) equaled 19,007 billion rubles for 2009; *Y* = 16,617 billion rubles, *Y*^(1) = 16,734 billion rubles for 2013; *Y* = 12,831 billion rubles, *Y*^(1) = 13,021 billion rubles for 2019; *Y* = 11,030 billion rubles, *Y*^(1) = 11,024 billion rubles for 2021.[27]

In April 2019, PJSC GAZPROM presented a Sustainable Development Program up to 2030.[28] The company plans to develop and introduce innovative projects to protect the environment, improve water quality, water use efficiency, ensure the protection and restoration of water-related ecosystems (Goal 6). There were expended 97,54 billion rubles on the protection and rational use of water resources, 7,08 billion rubles on waste management, 6,65 billion rubles on protection and rehabilitation of land, surface and groundwater, 5,71 billion rubles on protection of atmospheric air and prevention of climate change, etc., as of 2021[29].

It is planned to provide universal access to affordable, reliable and modern energy supply, to double the global rate of energy efficiency improvement by 2030

[27] PJSC Gazprom (2011). PJSC Gazprom in Figures 2007–2011. Factbook. Retrieved May 05, 2022, from https://www.gazprom.com/f/posts/81/070547/gazprom-reference-figures-2007-2011-eng.pdf; PJSC Gazprom (2016). PJSC Gazprom in Figures 2012–2016. Factbook. Retrieved May 05, 2022, from https://www.gazprom.com/f/posts/44/307258/gazprom-in-figures-2012-2016-en.pdf; PJSC Gazprom. (2021). PJSC Gazprom in Figures 2017–2021. Retrieved May 05, 2022, from https://www.gazprom.com/f/posts/13/041777/gazprom-in-figures-2017-2021-en.pdf

[28] PJSC Gazprom. (2019). Working towards our common future, Gazprom Group's Sustainability Report. Retrieved May 05, 2022, from https://www.gazprom.com/f/posts/72/802627/sustainability-report-en-2019.pdf

[29] PJSC Gazprom environmental report (2021). Retrieved May 05, 2022, from https://www.gazprom.ru/f/posts/57/982072/gazprom-environmental-report-2021-ru.pdf; PJSC Gazprom sustainability-report (2021). Retrieved May 05, 2022, from https://www.gazprom.ru/f/posts/57/982072/sustainability-report-ru-2021.pdf

(Goal 7) (PJSC Gazprom, 2019), and to gasify 68 subjects of Russia in 2021–2025.[30] The company is at the ready of continuing the development and introduction of innovations (Goal 9). The R&D investment cost amounted to 24,6 billion rubles, the economic effect from the use of R&D was 34 billion rubles, the economic effect from the introduction of import substitution technologies amounted to 21,9 billion rubles in 2021.[31]

It is planned to provide universal access to affordable, reliable and modern energy supply, to double the global rate of energy efficiency improvement by 2030 (Goal 7) (PJSC Gazprom, 2019), and to gasify 68 subjects of Russia in 2021–2025.[32] The company is at the ready of continuing the development and introduction of innovations (Goal 9). The R&D investment cost amounted to 24,6 billion rubles, the economic effect from the use of R&D was 34 billion rubles, the economic effect from the introduction of import substitution technologies amounted to 21,9 billion rubles in 2021.[33]

The company plans to continue developing and implementing sustainable consumption and production patterns by 2030 (Goal 12). Waste minimization technologies were introduced in 2021. 703,82 million rubles were allocated for the implementation of these projects.[34]

Measures of combating climate change and its consequences have been developed until 2030 (Goal 13). Methane emissions were reduced by 6 %; there were allocated 36,5 billion rubles to protect the atmospheric air and reduce greenhouse gas emissions, 5,7 billion rubles to protect the atmospheric air and prevent the climate change; 7429 people received environmental training, etc., in 2021. Strategies for the conservation and sustainable use of the oceans, seas and marine resources are also included in the Program (Goal 14). There were allocated 702,7 million rubles for the conservation of biodiversity and the protection of natural areas, the protection and reproduction of fish resourses in 2021.[35]

It is planned to continue maintaining the ecological balance, reducing the impact of production activities on the environment, investing in environmental protection, and increasing resilience to environmental hazards until 2030 (Goal 15). There were invested 13,634 billion rubles in the protection and rational use of land and recultivation, more than 7039 hectares of land were cleaned, etc., in 2021.[36]

PJSC GAZPROM invested 658,284 billion rubles in environmental protection and rational use of natural resources, 139,1 billion rubles in R&D for 2009–2021.[37]

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[30] PJSC Gazprom sustainability-report (2021). Retrieved May 05, 2022, from https://www.gazprom.ru/f/posts/57/982072/sustainability-report-ru-2021.pdf

[31] Ibid.

[32] PJSC Gazprom environmental report (2021). Retrieved May 05, 2022, from https://www.gazprom.ru/f/posts/57/982072/gazprom-environmental-report-2021-ru.pdf

[33] Ibid.

[34] Ibid.

[35] Ibid.

[36] PJSC Gazprom environmental report (2021). Retrieved May 05, 2022, from https://www.gazprom.ru/f/posts/57/982072/gazprom-environmental-report-2021-ru.pdf; PJSC Gazprom sustainability-report. (2021). Retrieved May 05, 2022, from https://www.gazprom.ru/f/posts/57/982072/sustainability-report-ru-2021.pdf.

[37] Ibid.

PJSC GAZPROM achieved all target, innovation and environmental indicators in 2021. PJSC GAZPROM has approved Comprehensive Environmental Program for 2020–2024 with an outlook for 2030 in order to further reduce the negative impact on the environment and fulfill Sustainable Development Goals. The Program is aimed at ensuring environmental safety, rational use of natural resources and energy saving in accordance with the state commitment to innovative environmental development. The Environmental and Sustainability Development Reports for 2021[38] note that PJSC GAZPROM has achieved the environmental goals set for 2020–2022 and contributed 89,9 % to the implementation of the UN Sustainable Development Goals.[39]

Conclusion

The Sustainable Society Foundation analyzes the level of sustainability of 154 countries in the three basic dimensions of the Sustainable Society Index (Human Wellbeing, Environmental Wellbeing, Economic Wellbeing). The data for 2018[40] shows that Russia ranked 53rd in the Human Wellbeing Index (7,6 out of 10), 145th in the Environmental Wellbeing Index (2,7 out of 10), 39th in the Economic Wellbeing Index (5,4 out of 10). The same indicators is observed in the USA: 7,4 points (58th), 2,4 points (150th), 4 points (81st); China: 7,3 points (59th), 3,4 points (131st), 5,2 points (46th); India: 6,6 points (78th), 3,3 points (133rd), 5,4 points (43rd). Finland occupied the first place in the Human Wellbeing Index with 9 points, however, it took 96th place (4,3 points) in the Environmental Wellbeing Index, and 50th place (5 points) in the Economic Wellbeing Index. Qatar (9,7 points) and Zimbabwe (8,3 points) ranked first in the Economic Wellbeing Index and in the Environmental Wellbeing Index, respectively. The studies have shown that there is no country in which all indicators would be at the highest level. This means that today, countries do not fully implement sustainable, innovative, environmental development programs (Helliwell, Layard, Sachs, 2018). Experts say the modern world is generally unable to achieve all the goals of sustainable development either by 2030 or 2050.[41]

[38] PJSC Gazprom environmental report (2021). Retrieved May 05, 2022, from https://www.gazprom.ru/f/posts/57/982072/gazprom-environmental-report-2021-ru.pdf; PJSC Gazprom sustainability-report (2021). Retrieved May 05, 2022, from https://www.gazprom.ru/f/posts/57/982072/sustainability-report-ru-2021.pdf

[39] UNDP (2019). New UN Global Climate report 'another strong wake-up call' over global warming: Guterres. Retrieved June 25, 2022, from https://news.un.org/en/news/topic/sdgs/date/2019/date/2019-03

[40] Sustainable Society Foundation (2018). *Sustainable Society Index*. Retrieved July 05, 2022, from http://www.ssfindex.com/ http://ssi.wi.th-koeln.de/

[41] UNDP. (2019). New UN Global Climate report 'another strong wake-up call' over global warming: Guterres . Retrieved June 25, 2022, from https://news.un.org/en/news/topic/sdgs/date/2019/date/2019-03; UNDP. (2020). Sustainable Development Goals. Retrieved June 25, 2022, from https://www.un.org/sustainabledevelopment/; UNDP. (2021). The Sustainable Development Goals Report. Retrieved May 05, 2022, from https://unstats.un.org/sdgs/report/2021/The-Sustainable-Development-Goals-Report-2021.pdf

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