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The Interdependence of Environmental Activities and Investment Attractiveness: Finances of Russian Metallurgy

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ABSTRACT

All countries now share a long-term vision of the importance of implementing technology development and transfer to improve climate resilience and reduce greenhouse gas emissions. Metallurgical enterprises play a significant role in achieving this goal, since they produce a large amount of carbon dioxide emissions into the atmosphere. In connection with the changing operating conditions and changing markets of presence, the issues of ensuring their investment attractiveness are acquiring obvious importance in the framework of the finances of Russian metallurgical companies. **The object of the study** is an assessment of the investment attractiveness of Russian metallurgical companies. **The subject of the study** is the relationship between the investment attractiveness of metallurgical companies and the results of their environmental protection activities. **The purpose of this study** is to identify the interdependence of environmental metrics and the investment attractiveness of steel companies. **The methodological basis** is a regression analysis of the impact of environmental metrics on the investment attractiveness of metallurgical companies. The authors chose the following indicators of environmental performance: CO_2 emissions, energy consumption, water recycling, waste. To assess the investment attractiveness of metallurgical companies, the following indicators were used: revenue, EBITDA, investment in R&D. The authors **concluded** that the environmental activities of companies have a significant impact on their investment attractiveness. **The scientific novelty of the study** lies in identifying the interdependence of environmental protection activities and the investment attractiveness of Russian metallurgy companies. **The results of the study can be used** by both Russian steel companies and institutional investors as part of the development of an investment strategy.

Keywords: environmental metrics; environmental protection; investments; corporations; strategic advantages; sustainable development; non-ferrous metallurgy

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INTRODUCTION

The practice of environmental activity of economic entities has been actively developing since the 1980s. Initially, the main focus of all investigations of EGS was on the definition of a business condition that allows for the maintenance aspects of sustainable development in ecological, social and governance matters [1].

For a long time, economic entities considered environmental investment projects only as attempts to gain some additional profit and were usually disappointed. It's important to note that in case of social or governance initiatives, we can trace a direct connection between the Key Performance Indicators (KPI) of a company and the results of such ESG-projects, thus, we can truly state that a company could be interested in them. But in case of environmental investment projects, the initiative usually comes from third parties and for a company, such projects could be too expensive and intensive to implement [1].

This led to a lag in the development of environmental investment projects, whose rapid growth occurred at the end of the 20th century. The current stage of environmental activities in the corporate sector is characterized by the formation of environmental analysis and audits. One of the main driving forces for companies' investment attractiveness is their reputation in terms of environmental impact. Thus, nowadays, we are speaking about so-called "exclusion policy", which is held by institutional investors and based on the carbon footprint of whole industries and distinct companies.

It would be fair in this case to refer to such industries: chemical and gas, pulp and paper and metallurgical. The world policy of minimizing the carbon footprint is aimed at reducing the negative consequences of enterprises' performance in these segments. For the chemical-gas and pulp-and-paper industries, models for replacing of the current principles of performance have already been determined. However, they are not applicable for the metallurgical industry. This could be explained by the limited nature of materials capable of replacing metal-containing products.[1]

That is why the authors decided to focus on the metallurgical industry and find out the interdependence of environmental metrics and metallurgical companies' investment attractiveness. Since, environmental investment projects are mostly considered in terms of their effectiveness and investment attractiveness is based on both on the effectiveness and profitability of their performance, we would like to identify the key environmental metrics that could describe and prove their effectiveness, and explore the connection between them and profitability indicators.

LITERATURE REVIEW

In the research literature, this direction was more distinguished as an independent one, and gained its significant influence after 1972, when the program of the UN General Assembly for the protection of the environment was established [2]. Since that period, research approaches have systematically moved from assessing the full impact on the ecological system at the level of specific states and nations to the level of specific economic industries and companies. This became one of the primary reasons for including of environmental aspect in the assessment of the investment attractiveness of companies [3].

Speaking about the metallurgical industry, we should mention the following fundamental studies dedicated to investment attractiveness assessment in the environmental context:

- A. Galant and D. Kvek, who assessed the investment attractiveness in the regional context of a separate developing country — Croatia and identified directions for improving the existing methodology of such an assessment under the assumption of limited data [4];
- A. Akbar, H. Jiang, A.M. Qureshi, M. Akbar, who explored Chinese metallurgical companies in the context of emissions and identified the main features of government regulation of such companies' performance [5];
- M.B. Fakoya and K.T. Chitepo, who focused on metallurgical and mining companies that guarantee compliance with ESG-principles as a condition of their inclusion in the exchange index. The authors assessed the impact only through a narrow analysis of two fundamental indicators of emissions into the environment — the volume of carbon dioxide and the size of municipal solid waste generated. At the same time, the researchers found a relationship between the volume of industrial investments in environmental activities and the attractiveness of companies within the framework of the stock index [6];
- M. Sh. Shabbir and O. Wisdom, who assessed the relationship between the volume of investments in environmental projects and the KPI of companies in the manufacturing sector. The determining role for researchers was assigned to the assessment of standardized financial indicators within the pool of companies of related economic sectors [7];
- K. Theo, Y.B. Hutomo, G. Monroe, who considered the theory of stakeholders in relation to the performance of Australian mining and steel companies. The researchers determined that regulators and business entities are required to take environmental activities into account when planning to attract investment financing [3].

A number of works by Russian authors are also devoted to the issues of developing a financial mechanism for attracting investments in environmental projects, as well as determining the most significant tools for stimulating environmental activities. The most significant research results are presented by the following authors: E.B. Tyutyukina [8–12]; T.N. Sedash [8, 9, 11, 12]; D.A. Egorova [8, 13].

It's fair to say that research materials allow the authors to take into account an extensive methodological base and make some important notes and corrections of inaccuracies and assumptions established by other authors, to develop conclusions about the significance of environmental activities in the assessment of the metallurgical companies' investment attractiveness.

METHODOLOGY

Data

To confirm the relevance of this study and clarify the empirical basis of our calculations, we analyzed the metallurgical industry in Russia and abroad.

[1] Cross-border carbon regulation in the EU: how to prevent discrimination against Russian exporters. Analytical Report: Institute for Natural Monopoly Problems. Moscow; 2021:12.

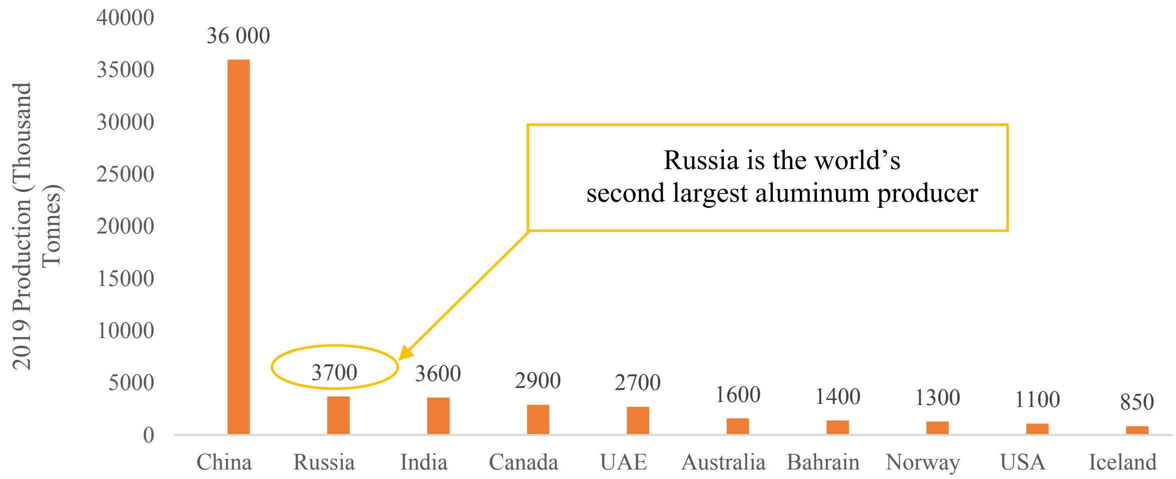

Fig. 1. **Top 10 Largest Aluminum Producing Countries in the World**

Source: Compiled by the authors on the basis of data from the annual publication "WORLD MINING DATA". URL: https://www.world-mining-data.info/ (accessed on 21.11.2022).

It should be noted that non-ferrous metal metallurgy's volumes of production are significantly lower than those of ferrous [14]. But the price of its products is much higher. Among them are heavy non-ferrous metals (copper, zinc, lead, nickel, chromium), lightweight (aluminum, magnesium, titanium), alloys (used as an additive to steel — tungsten, molybdenum, vanadium), and precious (gold, silver, platinum).

Let's take a look at the analysis of the main countries, that produce aluminum and compare them, in order to highlight the place of Russia in this ranking (*Fig. 1*).

Russia ranked as the world's second largest aluminum producer with around 3.6 million metric tons of aluminum produced, which is much lower than China's output in first place. The aluminum production in Russia is mostly dominated by RUSAL — one of the world's largest aluminums producing companies based in Moscow.[2]

In 2020, Russia exported $ 5,21B in Raw Aluminum, making it the 2nd largest exporter of Raw Aluminum in the world. In the same year, Raw Aluminum was the 10th most exported product in Russia. The main destination of Raw Aluminum exports from Russia are: Turkey ($ 793M), Netherlands ($ 618M), Japan ($ 565M), South Korea ($ 318M), and Italy ($ 251M). Russia Aluminum Exports was reported at 8042 247,604 USD thousand in Dec 2021. *Figure 2* shows the dynamics of aluminum export value in Russian Federation from 2010 to 2021.[3]

Let's compare main Russian aluminum producers by the amount of their revenue to highlight the role of RUSAL in the metallurgy industry in Russia (*Table 1*).

Speaking about environmental activities, we should note, that RUSAL was the first Russian company to join the UN Development Program (UNDP) to participate in the international initiative for minimizing climate change which assumed voluntary commitments to reduce greenhouse gas emissions. The Company introduced an internal assessment of the environmental impact of all new investment projects. By 2025, carbon dioxide emissions (in equivalent) at RUSAL aluminum smelters are forecast to have decreased by 15%, and at alumina refineries — by 10% (vs 2014).

About 90% of RUSAL aluminum is produced using electricity from renewable sources, which is supplied by hydraulic power plants in Siberia. The Company's production facilities adhere to the requirements of international environmental management system standard ISO 14001.[4]

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[2] URL: https://www.aluminiumleader.com/economics/world_market/ (accessed on 21.11.2022).

[3] URL: https://www.aluminiumleader.com/economics/world_market/ (accessed on 21.11.2022).

[4] National standard of the Russian Federation GOST R ISO 14001–2016 "Environmental management systems. Requirements and guidelines for use" (approved by order of the Federal Agency for Technical Regulation and Metrology dated April 29, 2016 No. 285-st). URL: https://docs.cntd.ru/document/1200134681 (accessed on 21.01.2021).

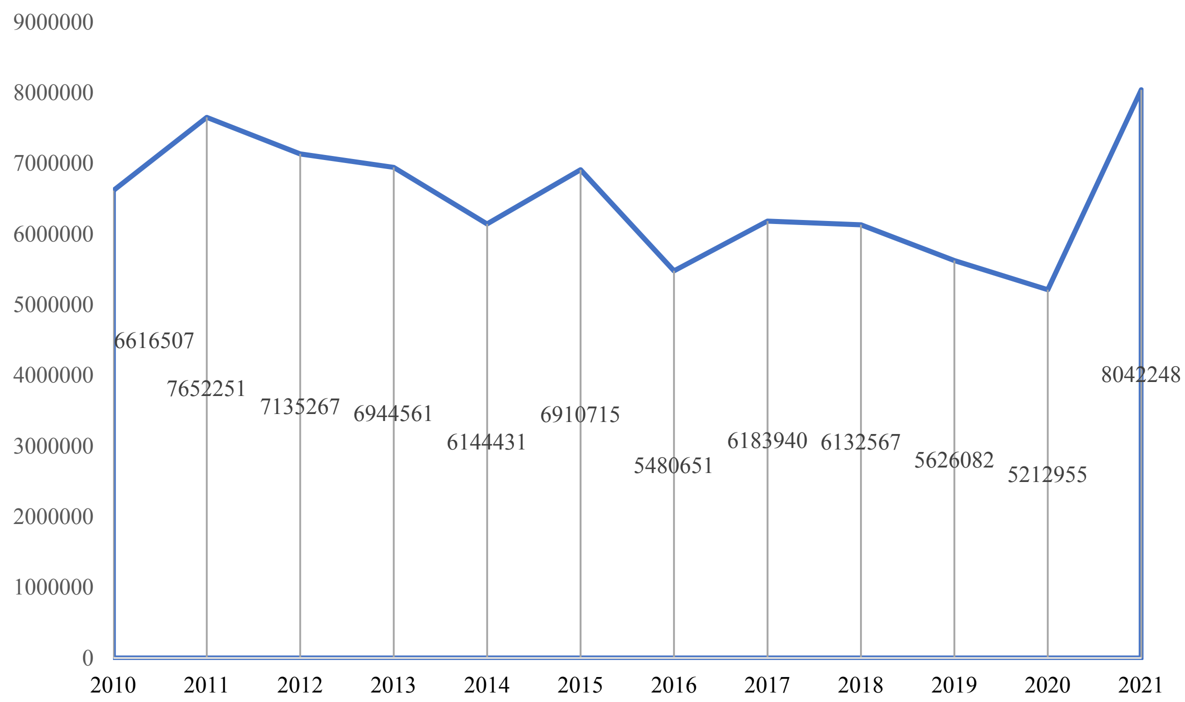

Fig. 2. **Export Value: Aluminum (Russian Federation), Thousand USD**

Source: Compiled by the authors on the basis of data from "All about Aluminium". URL: https://www.aluminiumleader.com/economics/world_market/ (accessed on 21.11.2022).

Thus, we are going to focus on PJSC RUSAL's financial and non-financial information as the empirical basis for all our further calculations, measurements and conclusions to be able to extrapolate the results to other non-ferrous metallurgical companies in Russia. All the data is taken from official sources (official website of PJSC RUSAL, Bloomberg Finance L.P.).

Indicators

The environmental activity of any company proceeds from the intention to maintain a balance between the actual costs of innovation, the commercial benefits from its implementation and the change of the company's role in the eyes of stakeholders [15].

In this case, it is important to detect so-called imaginary environmental innovations aimed at one-time compliance with the ecological standards of functioning and positions of sustainable development [16, 17]. The authors presented a scheme of this correspondence in terms of interactions within the framework of the behavioral models of the organization's management in the figure (*Fig. 3*).

The authors' conclusions shown in *Fig. 3* establish under which behavior model the company receives the greatest benefits from its economic activities. In this regard, it is appropriate to consider that when focusing on long-term investments and operations to maintain environmental friendliness, companies gain a greater number of final benefits than with short-term (non-systemic) business models. This conclusion allows us to focus on the strategic model of organizing activities oriented toward sustainable development.

The system of indicators for evaluating environmental performance is rather poorly developed [18]. There is the international environmental assessment standard ISO 14031:2021 "Environmental management",[5] on the national level there is the National Standard.[6] The system of indicators has been developed, but the conditions and practice of their application have not been defined. In this work, we will be guided by our own scorecard developed on the basis

[5] ISO 14031:2021 Environmental management — Environmental performance evaluation — Guidelines. 2021. 44 P.

[6] National standard of the Russian Federation GOST R ISO 14001–2016 "Environmental management systems. Requirements and guidelines for use" (approved by order of the Federal Agency for Technical Regulation and Metrology dated April 29, 2016 No. 285-st). URL: https://docs.cntd.ru/document/1200134681 (accessed on 21.01.2021).

Table 1

Rating of Organizations (Aluminum Producers) by Revenue

Rank	Name	Indicators, million rubles		Region
		Revenue	Assets	
1	PJSC RUSAL Bratsky Aluminum Plant	114 123	115 435	Irkutsk region
2	JSC RUSAL Krasnoyarsk Aluminum Smelter	82 404	71 426	Krasnoyarsk region
3	JSC RUSAL Sayanogorsk Aluminum Plant	77 644	42 758	The Republic of Khakassia
4	JSC Arkonik SMZ	73 285	30 414	Samara Region
5	JSC RUSAL Ural	64 667	70 841	Sverdlovsk region
6	JSC Boguchansky Aluminum Plant	52 400	112 365	Krasnoyarsk region
7	JSC RUSAL Achinsk Alumina Refinery	33 671	25 908	Krasnoyarsk region
8	LLC Ural Plant of Non-Ferrous Casting	19 929	534	Sverdlovsk region
9	LLC Krasnoyarsk Metallurgical Plant	19 828	9 382	Krasnoyarsk region
10	JSC RUSAL Novokuznetsk Aluminum Plant	19 706	10 116	Kemerovo region

Source: Compiled by the authors on the basis of data from "Investing Port". URL: https://porti.ru/company/analysis/compare/MOEX:RUAL (accessed on 21.11.2022).

of ISO 14031:2021 "Environmental management". The indicators are divided into two groups — A and B (*Fig. 4*).

Due to the fact that environmental activities require additional costs, the effectiveness of corporations that have included elements aimed at improving and preserving the environment in their business processes remains questionable. In this connection, a hypothesis was put forward: *Environmental activities to reduce emissions do not positively affect the economic efficiency of the company.*

This hypothesis will be tested during the study of group B indicators, which are calculated indicators usually applicable in the framework of financial analysis, for example, gross margin.

Group A indicators are divided into four subgroups. The first describes the change in the performance of the corporation over time. The general calculation formula has the form (1). Any indicator can be subjected to such an analysis.

$$\Delta A = A_i - A_j, i > j, \quad (1)$$

where ΔA — is the absolute change of the indicator; $A_{i,j}$ — is the value of the indicator at the moments of time i and j.

The second subgroup describes the growth rates of indicators, the nature of mutual changes and their unidirectionality. Formulas for calculation and their description are presented in *Table 2*.

Indicators from different areas can be, for example, revenue and emissions, so using formula (3) we can determine the quantity of emissions per ruble of revenue. Hypothetically interrelated indicators can be research and development costs (R&D) and emissions, so using formula (4) we can explore the degree of increase or reduction in emissions achieved through investments in R&D.

The breadth of research on these indicators is usually underestimated, so, for example, in formulas (3, 5) it is permissible to use $i, j_A \neq i, j_B$, which allows you to determine the effects with a time lag. So, for example, the hypothesis about the effect of R&D spending in the period i on the quantity of emissions in the period $i+3$ can be tested, which is fair since it's impossible to obtain "instant" results from investments.

The third subgroup, indicators of elasticity, characterizes the degree of sensitivity of indicators, their ability to adapt to changes in each other. Formulas for calculation and their descriptions are presented in *Table 3*.

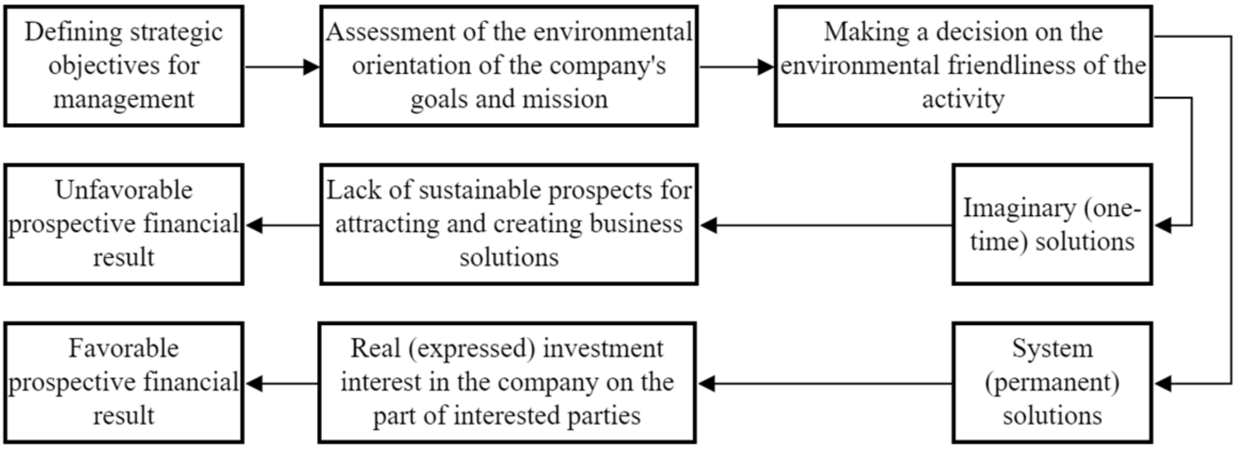

Fig. 3. **Models of the Organization's Management Behavior During the Implementation of Environmental Decisions**

Source: Compiled by the authors.

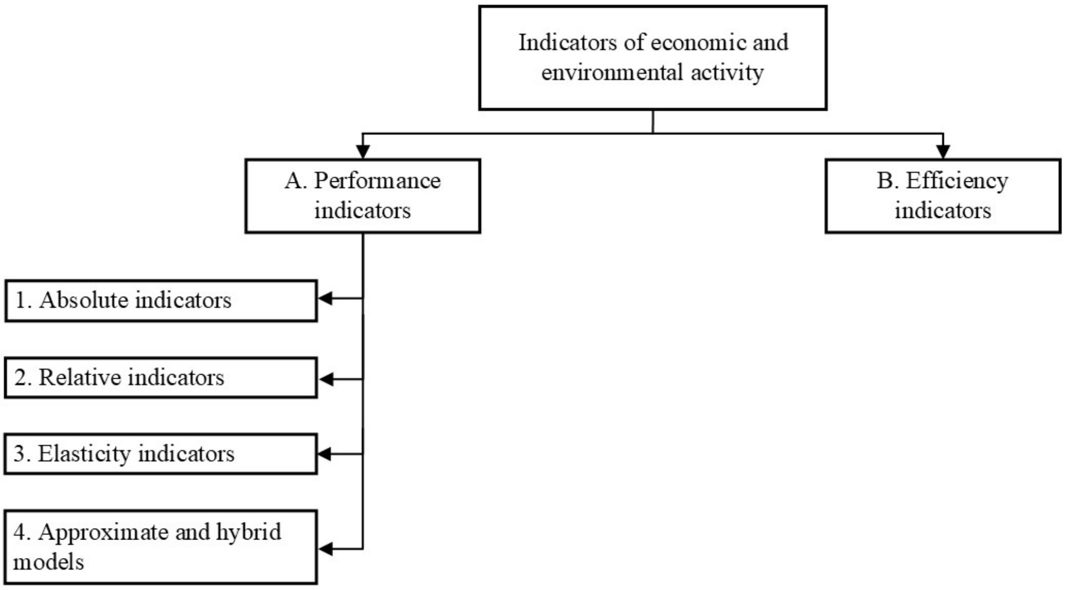

Fig. 4. **The System of the Economic and Environmental Performance Indicators of the Company**

Source: Compiled by the authors.

Any indicator, preferably hypothetically related, can be investigated this way. A significant advantage of the study of elasticity is its versatility and ability to combine indicators, due to the fact that $E_{B(A)} = \frac{\partial \ln A}{\partial \ln B}$, you can get the elasticity of the combined indicator $A_i \times A_j$ for B as $E_{B(A_i \times A_j)} = E_{B(A_i)} + E_{B(A_j)}$ regardless of the values of A and B, which allows you to expand the ongoing research.

The last, fourth group — approximate and hybrid models, can characterize both the measure of sensitivity and the mutual direction of changes in indicators. These models are represented, in particular, by various types of regression models, stochastic and differential models, their configurations (e.g., inverse differential equations) and their combinations with each other, and other models.

The simplest regression model is a linear one, represented by formula (2).

$$y = \beta_0 + \sum_{i=1}^{n} \beta_i x_i + \xi, \qquad (2)$$

Table 2

Indicators of the B-2 Group of Economic and Environmental Activities of the Company

Formula number, name	Formula	Characteristic
(2) growth rate	$T_A^{'} = \sqrt[i-j]{\frac{A_i}{A_j}} - 1, i > j$	Characterizes the change in the indicator in fractions of its own initial value for a period of time *i – j*, any indicator can be studied
(3) direct effect	$p_{A,B} = \frac{A_i}{B_i}$	Characterizes how many units of indicator A fall on one unit of indicator B at time i, can describe any indicators, it is preferable to explore indicators from different areas
(4) average direct effect	$\overline{p_{A,B}} = \frac{\overline{A}}{\overline{B}}$	Similar to the direct effect, but characterizes how many units of indicator A fall on one unit of indicator B on average
(5) marginal effect	$\beta_{A,B} = \frac{\Delta A}{\Delta B}$	Characterizes the increase in indicator A when indicator B changes by one, can describe the relationship of any indicators, it is preferable to investigate hypothetically related indicators

Source: Compiled by the authors.

where y — the dependent variable; x_i — the regressors that hypothetically affect the value of y; β_0, β_i — the model coefficients; ξ — and is the model error.

It is still necessary to carry out an assessment for each indicator separately, and then combine the results using elasticity. The adequacy of such measurements is achieved by the absence of dimension of the elasticity indicator.

RESULTS

We have calculated the indicators for the metallurgical holding PJSC RUSAL. The sources of information were the holdings reports, press releases and data from the Bloomberg news agency. The results are reflected in *Table 4*.

Since the Bloomberg platform was the only source of non-financial information for analysis, the authors were limited to a sample of data for the period 2018–2020. It was for this period that data on CO_2 emissions, energy consumption, secondary use of water, and waste were disclosed in the Bloomberg Finance L.P.

An analysis of the change in indicators over time was directly carried out: absolute growth and growth rate for the entire period were calculated (*Table 5*).

No decrease in emissions is observed over the entire period of time, the amount of water reused has increased, relatively to the total consumed (~3%[7]), which is negligible.

Let's calculate the direct effect and the marginal effect for all pairs of financial indicators with environmental ones. Thus, according to the authors' calculations, in 2020, 1$ of revenue accounted for 4.62 kg of CO_2 emissions, 20.4 kWh of electricity consumed, 3.54 liters of reused water (which is only 3% of water consumption), 13.7 kg solid waste. For $ 1 of EBITDA in 2020, these figures are 10 times higher, and for $ 1 of investment in R&D — 526 times higher.

In 2020, direct effects will be greater than the average effects over the past three years, which, against the backdrop of a decrease in revenue, indicates a negative trend in environmental performance. Given the lockdown caused by the COVID-19 pandemic, there was no need to increase production due to the presence of large stocks. However, RUSAL's figures are 45% better than the industry average.[8]

It is noteworthy that the changes in the volume of waste, electricity consumption and EBITDA within the study period are unidirectional, so it's necessary to pay attention to these indicators when calculating elasticity (*Table 6*).

[7] Bloomberg Finance L.P. URL: https://www.bloomberg.com/europe (accessed on 25.01.2022).
[8] Bloomberg Finance L.P. URL: https://www.bloomberg.com/europe (accessed on 25.01.2022).

Table 3

Indicators of the B-3 Group of Economic and Environmental Activities of the Company

Formula number, name	Formula	Characteristic
(6) simple elasticity	$E_{B(A)} = \beta_{A,B} \times p_{A,B}^{-1}$, $i_A = i_B, j_A = j_B$	Characterizes the sensitivity of indicator A to changes in indicator B at the moment i
(7) medium (arc) elasticity	$\widetilde{E_{B(A)}} = \beta_{A,B} \times \overline{p_{A,B}}^{-1}$, $i_A = i_B, j_A = j_B$	Characterizes the sensitivity of indicator A to changes in indicator B on average over time interval $i - j$

Source: Compiled by the authors.

Table 4

Performance indicators of PJSC RUSAL

Index	The source of information
CO_2 emissions, tons	Bloomberg Finance L.P.
Energy consumption, MW/h	Bloomberg Finance L.P.
Secondary use of water, m^3	Bloomberg Finance L.P.
Waste, tons	Bloomberg Finance L.P.
Revenue, thousand $	Annual reports of PJSC RUSAL
EBITDA, thousand $	Authors' calculations
Investments in R&D, thousand $	Bloomberg Finance L.P., PJSC RUSAL Sustainability Reports

Source: Compiled by the authors.

It can be seen that according to data, with an increase in energy consumption by 1%, the volume of solid waste increases by 1.1%. With a 1% increase in EBITDA, electricity and solid waste consumption increases by 1.7 and 1.8%, respectively.

The results of the study of the elasticity of emissions for investment in R&D are also interesting. Thus, in 2020 with a change of 1%, they decreased: CO_2 emissions by 3.6%, electricity consumption by 3.7%, solid waste by 4%. It can be concluded that the investments are effective and this is reflected in the reduction of emissions by 3–4%. The reduction in revenue in 2020 due to the pandemic made it impossible to adequately interpret the results of elasticity with this indicator.

Let's calculate the elasticity of the total environmental damage with respect to EBIT and investments in R&D. As described, for elasticity in this case, the summation of indicators is sufficient, without entailing the appearance of uninterpretable data. In 2020, with an increase in EBIT by 1%, the total environmental damage increased by 5.1%; with an increase in investment in R&D by 1%, the total environmental damage decreased by 11.3%. In the case of arc elasticity, due to the decline in financial performance from 2018 to 2020, the elasticity values are meaningless.

As a study of the A-4 group indicators "Approximate and hybrid models" we used a simple pairwise regression (including non-linear). EBIT (EBIT) and R & D investment (RD) acted as regressors in different models, as they did not give pandemic-related distortion in 2020. The dependent variable was the amount of solid waste (W). To improve the quality of the model, we took quarterly figures from 2014, the data source was Bloomberg Terminal.

The models look like this:

$$W = \beta_0 + \beta_1 EBIT + \xi, \qquad \text{(Model 1)}$$

Table 5

Analysis of performance indicators of PJSC RUSAL over time

Index	2020	2019	2018	Average for 2018–2020
CO_2 emissions, tons	39 532 299.58	24 799 322.95	24 428 359.41	29 586 660.65
Δ, tons	+14 732 976.63	+370 963.54		
T', %	+27.2			
Energy consumption, MW/h	175 020 833.63	106 733 188.33	137 191 488.27	139 648 503.41
Δ, MW/h	+68 287 645.29	–30 458 299.94		
T', %	+12.9			
Secondary use of water, m^3	30 334 092.81	18 784 653.24	18 045 049.91	22 387 931.99
Δ, m^3	+11 549 439.57	+739 603.33		
T', %	+29.6			
Waste, tons	117 750 264.81	69 067 842.17	73 871 614.87	86 896 573.95
Δ, tons	+48 682 422.64	–4 803 772.70		
T', %	+26.3			
Revenue, thousand $	8 566 000.00	9 711 000.00	10 280 000.00	9 519 000.00
Δ, thousand $	–1 145 000.00	+569 000.00		
T', %	–8.7			
EBITDA, thousand $	849 000.00	653 000.00	1 994 000.00	1 165 333.33
Δ, thousand $	+196 000.00	– 1 341 000.00		
T', %	–34.7			
Investments in R&D, thousand $	16 300.00	18 000.00	14 700.00	16 333.33
Δ, thousand $	–1 700.00	+3 300.00		
T', %	+5.3			

Source: Compiled by the authors based on Bloomberg materials Finance L.P., PJSC RUSAL Annual Reports, PJSC RUSAL Sustainability Reports; authors' calculations.

$$W = \beta_0 + \beta_1 RD + \xi, \quad \text{(Model 2)}$$

$$W = \beta_0 EBIT^{\beta_1} + \xi, \quad \text{(Model 3)}$$

$$W = \beta_0 RD^{\beta_1} + \xi. \quad \text{(Model 4)}$$

The interpretation of all these models was questioned since the results were inconsistent. In an attempt to specify a meaningful model, Model 5 was compiled with a time lag of three years, by successively eliminating regressors.

$$W_t = \beta_0 + \beta_1 RD_{t-5} + \xi. \quad \text{(Model 5)}$$

The simulation results are as follows: $W_t = 14804 - 0,42 * \mathrm{RD}_{t-5}$, this suggests that R&D investment yields results (negative impact on emissions) only in the fifth year. The model and its coefficients are statistically significant at a significance level of 0.05. The coefficient of determination is 0.51.

Using regression, we tested the previously set hypothesis that "Environmental activities to reduce emissions do not have a positive effect on the economic efficiency of the enterprise", for which we use the volume of emissions as a regressor, and return on equity (ROE) as a dependent variable. Data source: Bloomberg Terminal.

$$ROE = \beta_0 + \beta_1 W + \xi. \quad \text{(Model 6)}$$

The simulation results are as follows: $ROE = 46.8 + 0.33W$, this suggests that with an increase in emissions by 1 million tons, ROE grows by 0.33%, thus, our initial hypothesis is accepted: environmental activities to reduce emissions do not have a positive effect on economic efficiency. The model and its coefficients are statistically significant at a

Table 6

Matrix of Positive Simple Elasticity of the Chosen Indicators

	Energy consumption, MW/h	Waste, tons	EBITDA, thousand $
Energy consumption, MW/h	–	1.1	0.59
Waste, tons	0.4	–	0.56
EBITDA, thousand $	1.7	1.8	–

Source: Authors' calculations.

significance level of 0.05. The coefficient of determination is 0.48.

So, we can conclude that in 2020, RUSAL's environmental performance showed worse results than the average for the last three years, but better than those of industry peers. For sustainable development purposes, in particular the environmental aspect, RUSAL needs to focus on a commensurate increase in EBITDA and investment in R&D, then, based on our forecast, there will be a net reduction in emissions of 4–5% per year. However, it is worth considering that the environmental return on investment in R&D occurs around the fifth year. In addition, the activity of the company to reduce emissions affects the return on equity negatively.

CONCLUSION

The authors in the first sample received a 9 by 9 matrix with marginal effect coefficients, and this is far from the limit of the variety of combinations. The algorithm for calculating and interpreting indicators, whose "financial" component has undergone negative changes, is subject to improvement, since the meaningfulness of the values calculated under this condition is doubtful. In addition, the linear nature of these indicators can be considered a disadvantage.

Approximate and hybrid models, such as regression, can be used to address the linearity issue. However, in this case, the process of calculating elasticity indicators becomes more complicated, especially when using multiple regression models. The undoubted advantage of regression is the calculation of all coefficients (except for the total elasticity) "in one iteration", without the need to recalculate the coefficients separately for each indicator.

In the future, it will be relevant to adapt stochastic models to the needs of environmental assessment in order to take into account the probabilities that describe the degree of success of ongoing environmental activities, determine the significance and weights of certain environmental indicators. Modeling based on differential equations will allow taking into account not only the temporal change of variables, but also their relationship with each other in time. Fuzzy modeling can solve the problem of linking the space of prerequisites in stochastic modeling with the space of conclusions, which are the consequences of the occurrence of certain events in terms of probability.

The need for these models draws our attention to the creation of a software package for analyzing and modeling the environmental activities of an enterprise, with the aim of automating calculations, using machine learning models, stochastic, differential modeling and fuzzy logic models.

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