Economic analysis of environmental externalities in decision-making on partnership in the implementation of the sustainable development goals

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Abstract: The purpose of the article is to determine the role of environmental costs in making decisions on cooperation in R & D in terms of implementation of the sustainable development goals. The authors consider two approaches to determining environmental costs. Environmental costs are interpreted in regards to economic theory and environmental accounting. The model of the oligopolistic market used to determine the benefits of cooperation in the development and implementation of projects related to environmental protection. It is shown that it is beneficial for firms to cooperate in R & D in the scope of environmental protection with other firms, scientific organizations and the government both in the domestic and foreign markets. The reasons are including reducing the cost of developing and implementing projects, increasing public welfare and implementing of sustainable development goals. The obtained results indicate the need for cooperation between economic entities, the government and international organizations both in the domestic and foreign markets to solve environmental problems, achieve sustainable economic growth and social well-being.

Keywords: R&D cooperation, environmental costs, sustainable development, environmental accounting.

1. Introduction
Sustainable development involves the harmony of economic, environmental and social areas. The world economy must strive for development, based on environmentally sustainable ground and take into account the interests of future generations. Countries, striving for economic growth, ignored the increasingly deteriorating state of the environment. This resulted in the deterioration of water and air quality, loss of biodiversity, the thinning ozone layer, rising global temperatures, and an increased number of diseases of the world population associated with the accumulation of harmful microparticles by the internal organs of humans. Improving the quality of the environment requires a number of efforts to be made by stakeholders. Besides, cooperation between governments, civil society, non-governmental organizations, the private sector and other institutions is essential.

2. Materials and methods
According to the definition of the European Commission, sustainable business innovation involves the production, development or use of innovations in food and services, production processes, and management methods. These processes are aimed to prevent or significantly reduce environmental risks, pollution, and other negative consequences of resource use during their life cycle [European Commission]. Sustainable innovation tends to be radical, and therefore depends on collaborative efforts
that go beyond traditional firm associations. Companies, research organizations, and government agencies should participate in a sustainable innovation process. Two concepts explain the need for cooperation. Firstly, the theory of stakeholders (traditional groups-suppliers, customers, employees; non-traditional groups-government, environmentalists, special interest groups) forms the basis for understanding the need for relationships with stakeholders to manage business more effectively. The second one is the theory of ecological modernization, according to which commercial organizations and individuals combine environmental concerns and solve environmental problems at the organizational level by integrating technologies and innovations [1]. These theories imply a strategic "green" orientation of firms, which implies a long-term commitment to produce environmentally friendly products and services in environmentally friendly or sustainable ways, in order to minimize negative social and environmental impacts during the product life cycle, and to implement programs to improve the environment in the past, present and future [2].

Companies can make efforts to improve environmental performance for a variety of reasons, from improved efficiency and compliance to broader strategic concepts of competitive positioning. The responsibility of business for its impact on society and the environment have been discussed in much research for a long time (for example, [3] - [6]). One of the central topics is conflicting priorities, on the one hand, increasing profits, increasing production, increasing market share, on the other hand, public welfare and achieving environmental indicators, and implementing of the sustainable development goals.

To ensure adequate environmental indicators, an instrument is required to identify and measure environmental costs – environmental accounting.

Accounting of environmental cost is used primarily for decision-making within the organization and covers such aspects as energy costs, water supply, waste disposal. Additionally, it involves the benefits of cooperation with suppliers that pay more attention to environmental issues, and the associated costs, as well as the consequences of non-compliance with environmental standards for the company's image. Environmental accounting involves two data streams: energy consumption, water use, and materials, including waste (physical data); the costs, benefits and savings associated with environmental protection (financial data). The main component of environmental accounting is environmental costs.

In economic theory, environmental costs refer to the costs associated with the activities of the company, which are not considered and reflected in the price of products.

According to the definition of the European Commission, environmental costs are the costs of actions taken by an economic entity and third parties on behalf of an economic entity in order to prevent, reduce or compensate for environmental damage caused as a result of operating activities [15]. They are highly diverse and the existing classifications depend on the goals of the research being conducted or the applied tasks being solved. Thus, environmental costs are divided into internal, which have a direct financial impact on the enterprise, and external, for which the enterprise is not responsible [12].

In environmental accounting, environmental costs are also classified according to various criteria: costs associated with the process of environmental management; costs by types of environmental activities; by types of current and capital environmental costs [8]. In this study, we consider environmental costs as the costs of environmental protection, based on Russian statistics, regardless of their innovativeness, the cooperation of stakeholders to jointly address environmental issues. The authors imply the indicator "efforts to develop and implement projects in the field of environmental protection" in order to determine the results of cooperation, primarily from the point of view of the use of new technologies in environmental protection. To highlight the dynamic aspect through the increment of the obtained results, we propose to use limit values. Therefore, our results show:

1. marginal air emissions (ME) = ΔTE/ΔQ, where ΔTE is the increase in total air emissions in %; ΔQ is the increase in output in %.

2. Marginal environmental protection costs (MEC)= ΔTEC/ΔQ, where ΔTEC is an increase in total environmental costs in %, ΔQ is an increase in output in %.

3. efforts to develop and implement environmental protection projects (EINT)= ΔEI/ΔQ, where ΔERD is an increase in environmental investment in %, ΔQ is an increase in output in %.
These indicators characterize the participation of firms in joint projects, including international cooperation (i.e., the increment of results associated only with participation in joint projects).

The use of these indicators enables to draw conclusions about whether environmental costs are an important tool for making informed management decisions aimed at harmonizing the economy and the environment.

Firms that participate in joint development and implementation of environmental projects, including at the international level, receive such benefits as joint financing of R & D, reducing the development and implementation time, eliminating duplication of R & D, reducing uncertainty and saving money, including achieving economies of scale. However, such cooperation also has drawbacks. The disadvantages of joint R & D are caused by transaction costs, which are associated with the integration of heterogeneous structures, decision-making processes and regulation of the use (assignment) of the results in joint R & D. R & D collaboration can also face research failure. Moreover, since it is difficult to observe the efforts of an individual partner, opportunistic behavior may occur.

The advantages of cooperative behavior have a theoretical basis. Hence, numerous researchers have devoted to incentives of firms to cooperation, some of which use oligopolistic models with strategic interactions between firms. In [7], a two-stage game model of the Cournot duopoly was presented. It deals with two types of agreements. The first one is R & D cooperation, which can be carried out at the so-called "pre-competitive stage": the companies exchange basic information and efforts at the R & D stage, but remain competitors in the market. The second type of agreement involves an extended collusion between partners, creating a common policy at the product level. The idea is to allow partners who cooperatively conduct research to control the processes and products jointly that embody the results of their collaboration, in order to jointly recoup their R & D investment. As a result, the authors of the work showed that joint R & D is below the socially optimal level, but at the same time it is above the non-cooperative level of R & D (when the coefficient of external effects is greater than½).

In [11], two features of the research and development activities of the company of an oligopolistic competitor are noted. The first feature is that a firm's R & D performance can spread positive externalities to other firms without any compensation, thereby negatively affecting the firm's incentive to commit to R & D. The second feature is the presence of many real examples of the implementation of joint R & D by oligopolistic competitors, fiercely competing in the commodity market.

Many studies demonstrate that firms can effectively collaborate in an intersectoral format, as well as outside the industrial sector includes scientific organizations and government.

In order to analyze the opportunities and results of cooperation in the real oligopolistic market, this study uses the example of the Russian steel market, represented by six firms: Novolipetsk Steel Complex (NLMK) (21.8% of the market), Evraz (16.66%), Magnitogorsk Steel Complex (MMK) (17.4%), Severstal (16.5%), Metalloinvest (6.8%), Mechel (5%). In total, these firms do not make up 100% of the market, but the shares of unaccounted firms are so small that they cannot affect the obtained results.

The study is conducted in two stages: the first one determines the participation of firms in internal and external cooperation. This enables to identify the impact of external and internal interactions, forms of control on the environmental behavior of Russian firms. The second stage calculates the above-mentioned indicators in three time periods in order to show how much internal and external cooperation affects the environmental behavior of firms. Since this study was not aimed to determine the reasons for the behavior of a particular firm, the results will have limitations associated with determining the factors that affect this behavior.

3. Results
The analysis of the activity of Russian steel companies is presented in Table 1. The table shows that all considered companies are members of the World Steel Association (WSA), which pays special attention to environmental issues, sustainable development and climate, collects annual data on indicators of sustainable development. The members of the association "Russian Steel" take an active part in the work of the Committee on Ecology and Environmental Management of the Russian Union of Industrialists and Entrepreneurs, which is the main platform for consolidating the position of Russian business in relation to various environmental aspects. The companies participate in the implementation of national projects, including the "Science" project.
All companies reviewed annually disclose environmental indicators and publish environmental reports, except Mechel, whose availability of environmental information is very limited. We analyzed the environmental reports of firms disclosed in order to implement the Sustainable Development Goals and concluded that all companies keep detailed records of environmental costs, including the costs of implementing investment projects in the field of environmental protection (EP), current costs of EP, payments for negative environmental impact (EP), the costs of improving the level of skills and competencies of personnel in the environmental field, costs associated with waste management, and others. Disclosure of environmental information reduces the risks of opportunistic behavior in the implementation of joint projects.

Table 1. Environmental activity of enterprises of the Russian steel market

| Name of organization | Voluntary disclosure of environmental information | Voluntary certification of products | Participation in organizations | Cooperation with suppliers whose impact on the OS was evaluated during audits |
|----------------------|-------------------------------------------------|-----------------------------------|-------------------------------|--------------------------------------------------------------------------------|
| NLMK                 | Annually                                        | +                                 | WSA, “Russian Steel”, RSPP    | +                                                                              |
| Evraz               | Annually                                        | +                                 | WSA, “Russian Steel”, RSPP    | +                                                                              |
| MMK                  | Annually                                        | +                                 | WSA, “Russian Steel”, RSPP    | +                                                                              |
| Severstal           | Annually                                        | +                                 | WSA, “Russian Steel”, RSPP    | +                                                                              |
| Metalloinvest        | Annually                                        | +                                 | WSA, “Russian Steel”, RSPP    | +                                                                              |
| Mechel              | Not published                                   | +                                 | WSA, “Russian Steel”, RSPP    | No information                                                                  |

Source: compiled by the authors on the basis of firm reports on sustainable development
Companies pass voluntary certification, cooperate with suppliers whose impact on the operating system was evaluated during audits.

The results of the participation of Russian steel companies in the cooperation are presented in Table 2.
### Table 2. Results of participation in the cooperation

| Company name, years | Marginal emissions to the atmosphere | Marginal costs of environmental protection | Efforts to develop and implement projects in the field of environmental protection | Production, million tons |
|---------------------|--------------------------------------|-------------------------------------------|---------------------------------------------------------------------------------|--------------------------|
| NMLK                |                                      |                                           |                                                                                 |                          |
| 2017                | 0,16                                 | -1,2                                      | -14,84                                                                          | 17,08                    |
| 2018                | -0,28                                | 17,33                                     | 58,37                                                                           | 17,5                     |
| 2019                | 0,41                                 | -1,43                                     | 0,23                                                                            | 15,6                     |
| Evraz               |                                      |                                           |                                                                                  |                          |
| 2017                | 0,05                                 | 12,47                                     | 33,03                                                                           | 14,03                    |
| 2018                | 7,23                                 | -0,58                                     | -0,59                                                                           | 13,01                    |
| 2019                | 1,32                                 | *                                         | *                                                                               | 11,95                    |
| MMK                 |                                      |                                           |                                                                                  |                          |
| 2017                | -0,49                                | 11,82                                     | 24,49                                                                           | 12,86                    |
| 2018                | 0,37                                 | -19,52                                    | -26,53                                                                          | 12,66                    |
| 2019                | 0,37                                 | 1,54                                      | 7,34                                                                            | 12,46                    |
| Severstal           |                                      |                                           |                                                                                  |                          |
| 2017                | 9,28                                 | 410,08                                    | *                                                                               | 11,65                    |
| 2018                | 0,23                                 | -11,14                                    | *                                                                               | 12,04                    |
| 2019                | 10,79                                | -6,65                                     | *                                                                               | 11,85                    |
| Metalloinvest       |                                      |                                           |                                                                                  |                          |
| 2017                | -1,74                                | 0,59                                      | 2,16                                                                            | 4,76                     |
| 2018                | 0,51                                 | 1,62                                      | 18,82                                                                           | 5,05                     |
| 2019                | -1,94                                | -1,41                                     | 6,48                                                                            | 4,87                     |
| Mechel              | *                                    | *                                         | *                                                                               | 4,27                     |
| The scope           |                                      |                                           |                                                                                  | 3,88                     |
|                      |                                      |                                           |                                                                                  | 3,61                     |

* no information

Source: compiled by the authors on the basis of sustainable development reports and Rosstat data

The table demonstrates decreased air emissions in scopes in the studied period. However, in 2019 the reduction in air emissions occurred due to a decrease in production volumes, so the limit emissions have a positive sign. We should note that the rate of reduction in air emissions by Evraz has repeatedly exceeded the rate of reduction in production volume (the limit emissions are significantly greater than 1). Despite the fact that the rate of emission reduction is higher than the rate of production growth not for each individual company, the effect of cooperation in the industry is very significant, the total amount of emissions decreases during the studied period. In 2017, the rate of decline in total emissions for the industry was almost 6 times faster than the rate of production growth.

Marginal costs and efforts for the development and implementation of environmental protection projects change in a one-way manner. This is caused by the fact that the investment is part of the total cost of the environmental protection. Let us note, that the more effort a firm puts into developing and implementing projects, the lower the rate of environmental protection costs compared to the volume of output. In 2017, the joint efforts of the companies repeatedly exceeded the volume of output growth in the industry, which reflects the performance of Evraz, MMK, Metalloinvest. In 2019, the efforts of
enterprises decreased compared to the previous period, due to significant capital construction costs in 2017-2018.

Analyzing the data in the table, we can conclude that the joint efforts of firms to develop and implement projects of firms lead to a decrease in the growth rate of costs for environmental protection, which is an advantage of cooperation. The air emissions in industry are steadily declining, but there is still the potential to increase the rate of emissions reduction.

4. Conclusion

Full assessment and consideration of environmental support is required in order to achieve environmental performance in the implementation of the Sustainable Development Goals. On a global scale, due attention to environmental costs contributes to the preservation and restoration of the environment and the development of society. Firms are also interested in taking into account the environmental costs created in the course of their activities. The reasons for the interest of firms may be the desire to increase profits by reducing environmental costs, and the desire to create a positive image to attract consumers, or the need to comply with the requirements of environmental legislation. Taking care of the environment is knowledge-intensive expensive activity that requires significant efforts from firms, the public and governments. However, cooperation in the implementation of R & D in the field of ecology can have a positive effect on the company. Cooperation enables to reduce the cost of developing and implementing projects at the expense of scale, reduce the risks of unsuccessful research, and achieve faster environmental performance within the framework of the Sustainable Development Goals.

References

[1] Andersen M, Massa I 2000 Ecological modernization — origins, dilemmas and future directions Special Issue: Ecological Modernization 2 4 p 337-345.
[2] Albino V, Azzurra B, Dangelico R 2009 Environmental Strategies and Green Product Development: An Overview on Sustainability-Driven Companies Business Strategy and the Environment 18 2 pp 83 – 96.
[3] Barnett M L 2017 The Business Case for Corporate Social Responsibility. Business & Society 58(1). DOI: 10.1177/0007650316660044
[4] Kostyukova E I, Germanova V S, Frolov A V 2020 Development of the conceptual foundations of tax management Proceedings of Voronezh State University Series: Economics and Management 2 pp 66-74 DOI: 10.17308/econ.2020.2/2902
[5] Sapozhnikova N G 2019 Economic category of the report about sustainable development of the corporate Proceedings of Voronezh State University. Series: Economics and Management 4 pp 159-163
[6] Shershneva E G, Kondyukova E S, Emelyanova E V 2018 Role of banks in ecological modernization of economy Proceedings of Voronezh State University. Series: Economics and Management 2 pp 173-179
[7] D'Aspremont C, Jacquemin A 1988 Cooperative and Noncooperative R&D in Duopoly with Spillovers available at: https://www.di.ens.fr/~aspremon/Claude/PDFs/dAsp88a.pdf
[8] Erokhina V, Lesina T 2015 Environmental costs. Actual issues of accounting and analysis, available at:http://naukovedenie.ru/PDF/87EVN415.pdf
[9] Longhofer W, Jorgenson A 2017 Decoupling reconsidered: Does world society integration influence the relationship between the environment and economic development? Social Science Research 65 pp 17-29
[10] Sarkis J; Cordeiro J J, Brust D V 2010 Facilitating Sustainable Innovation through Collaboration: A Multi-Stakeholder Perspective Springer
[11] Suzumura K, Yanagawa N 1993 Cooperative and non-cooperative R&D in an oligopoly with spillovers:strategic substitutes versus strategiccomplements, available at: http://hermes-ir.lib.hit-u.ac.jp/hermes/ir/re/7794/HJeco 0340100010.pdf
[12] Todea N, Stanciu I C, Udrea A-M 2011 Accounting Policies On Environmental Costs And Their Calculation Method In The Entity, Annals of DAAAM & Proceedings of the 22nd International DAAAM Symposium 22 pp 653-654.
[13] Van der Byl C A, Slawinski N 2015 Embracing Tensions in Corporate Sustainability. Organ. Environ 28 pp 54–79.
[14] Whiteman G, Walker B, Perego P 2013 Planetary Boundaries: Ecological Foundations for Corporate Sustainability J. Manag. Stud. 50 pp 307–336.
[15] European Commission. Funding programmes and open calls. URL: https://ec.europa.eu/info/research-and-innovation/funding/funding-opportunities/funding-programmes-and-open-calls_en (data accessed: 10.11.2020).
[16] Official website NLMK. CSR reports. URL: https://nlmk.com/ru/ir/reporting-center/csr-reports/(data accessed: 10.11.2020).
[17] Official website EVRAZ. Sustainability reports. URL: https://www.evraz.com/ru/sustainability/data-center/sustainability-reports/ (data accessed: 10.11.2020).
[18] Official website MMK. Annual Reports. URL: http://eng.mmk.ru/for_investor/annual_reports/(data accessed: 10.11.2020).
[19] Official website Severstal. CSR and Sustainability Reports. URL: https://www.severstal.com/eng/sustainable-development/documents/reports/ (data accessed: 10.11.2020).
[20] Official website Metalloinvest. Sustainable Development Reports. URL: https://www.metalloinvest.com/development/csr-reports/ (data accessed: 10.11.2020).
[21] Official website Mechel. Environmental Control. URL: https://www.mechel.ru/development/environmental/ (data accessed: 10.11.2020).
[22] Federal State Statistics Service. Environment. URL: https://rosstat.gov.ru/folder/11194 (data accessed: 10.11.2020).