Analysis of the Investments Impact in the Field of Eco-Innovation on the Environmental Safety of Industrial Regions

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Abstract. The article analyzes the innovative activities of Russian enterprises that ensure the improvement of environmental safety, environmental protection and rational use of natural resources. Since the environmental safety of Russian regions is influenced by their sectoral structure of economic activity, a cluster analysis of Russian regions by the prevailing type of economic activity is carried out within the framework of the author's methodology. As a result of clustering, 7 clusters were identified. The assessment of the eco-investments’ impact on the environmental safety of territories was carried out using the example of cluster 1 “Industrial-diversified regions”. A regression analysis of the assessment of the eco-innovations’ impact on the environmental safety of regions was carried out using the example of the leading regions in cluster 1 in terms of the volume and dynamics of costs for eco-innovations. The constructed models demonstrate a significant relationship between the eco-innovation activities of enterprises in the evaluated regions and the costs of its implementation and regional environmental safety.

1. Introduction

One of the trends in the industrial development of modern Russia is the creation of the best available technologies, combining modern achievements of science and technology, resource conservation and the lowest level of negative environmental impact per unit of time or the volume of manufactured products [1].

The Action Plan for the implementation of the environmental safety strategy of the Russian Federation for the period up to 2025 also reflects the introduction of innovative and environmentally friendly technologies and the development of environmentally friendly industries [2].

Kononova E. interprets environmental innovations (eco-innovations) as the latest products, the latest technologies, production methods and social programs that ensure the interaction between environmental conservation and economic development [3, p. 210].

Almastyan N., Ratner S. understand eco-innovations (environmental innovations) as new developments that are simultaneously aimed at achieving a positive commercial effect - making a profit - and achieving a positive environmental effect [4, p. 1136].
Eco-innovations are also defined as innovations that lead to a decrease in negative environmental impacts, regardless of whether this effect is expected and requiring faster implementation of revolutionary technologies and more systematic application of affordable solutions, including non-technological ones [5].

The European Commission defines eco-innovation as the development of any new or significantly improved products (goods or services), processes, organizational changes or marketing decisions that reduce the consumption of natural resources (including materials, energy, water and land) and reduce emissions of harmful substances throughout life cycle [6].

A number of foreign researchers (Hojnik J., Ruzzier M., Manolova T., 2017) established a noticeable positive relationship between organizational eco-innovations and the economic efficiency of enterprises, in contrast to product and process innovations, and noted that the environmental component of innovation directly depends on the overall scope of the firm’s innovative activity, since it is supported by the necessary mechanism for creating, disseminating and using innovations. In addition, a relationship was found between the level of innovative activity of the business and the level of complexity of the created eco-innovation [7].

2. Data analysis
Russian enterprises do not sufficiently produce, distribute and use eco-innovations, unfortunately, which is confirmed by cross-country comparisons. So, in the international ranking of The Global Cleantech Innovation Index in 2017, Russia occupied the penultimate position (39th place among 40 countries in terms of the integral indicator) [8], but Russia rose to 27th place in the Emerging Cleantech Innovation indicator.

Approximately half of Russian organizations implementing environmental innovations introduce innovations related to reducing energy and material consumption of production, about 80% of organizations use innovations aimed at reducing environmental pollution (Table 1).

| Directions of eco-innovations | 2014 | 2015 | 2017 |
|------------------------------|------|------|------|
| Reduction of material costs for the production of a unit of goods, works, services | 50,1 | 45,3 | 41,8 |
| Reduction of energy costs for the production of a unit of goods, works, services | 55,4 | 55,8 | 51,0 |
| Reduce carbon dioxide (CO2) emissions | 41,8 | 43,0 | 37,3 |
| Replacing raw materials with safe or less hazardous | 45,0 | 40,5 | 34,5 |
| Reducing environmental pollution (air, land, water, noise) | 81,2 | 79,8 | 78,4 |
| The implementation of the secondary processing (recycling) of industrial waste, water or materials | 45,6 | 46,5 | 43,4 |

Pakhomova N., Richter K., Malyskhov G. and Bondarenko Yu., while analyzing the demand for eco-innovations, suggest evaluating its investment and consumer component, noting the positive foreign experience in stimulating private and public investments in green employment, clean energy and the transition to renewable energy sources, etc. [9].

22 trillion. dollars of the total assets of investing members of the Global Investment Coalition on Climate Change are invested, for example, in programs to preserve the climate and green economic growth; one of the largest US banks Wells Fargo committed in 2018 to allocate $ 200 billion by 2030 in projects related to the creation and use of clean technologies and renewable energy sources, in 2016 the world's first platform Luxembu The Riga Green Exchange (LGX) for accommodating companies
investing in ecology and environmental projects was created, green bonds worth 63 billion EUR were placed there during the first year of its operation [10, pp. 1767-1769].

In Russia, the volume of investments in environmental protection is insufficient and in a number of areas tends to decrease. For example, investments in fixed assets aimed at protecting the environment and rational use of natural resources over the past 9 years have only twice exceeded the 2007 value (in 2014 and 2015).

According to the report of the Ministry of Industry and Trade “On the financial mechanisms for introducing the best available technologies in Russia”, the volume of necessary investments to switch to the best available technologies in various industries will be approximately 8.2 trillion. rub. [11].

According to a survey conducted at the end of 2015 by the Russian Union of Industrialists and Entrepreneurs with the vast majority of companies (36%) that participated in the survey, the budget for environmental programs (excluding compliance with mandatory legislative requirements) does not exceed 100 thousand rubles, while that most of the companies participating in the survey (72.5%) are large businesses [12, p. 16].

In order to stimulate eco-innovation of Russian industry, Federal Law No. 219-ФЗ spells out measures to stimulate legal and individual entrepreneurs engaged in economic and (or) other activities to take measures to reduce the negative impact on the environment: offsetting fees for investments, reducing fees for negative ones environmental impact after the introduction of BAT, reimbursement of the interest rate on an investment loan against income tax, accelerated depreciation of BAT equipment [13].

If we consider the structure of current (operational) environmental costs by type of economic activity, we can see that the largest share of total costs is in the mining industry, the largest share of expenses for environmental services and investments in fixed assets for environmental protection manufacturing industry (table 2).

**Table 2. Structure of current (operational) environmental protection costs by type of economic activity in the Russian Federation in 2018.**

| Types of economic activity | The share of current expenditures on environmental protection (EP),% | The share of payment for environmental services,% | The proportion of the cost of major repairs of fixed assets for environmental protection,% |
|---------------------------|-------------------------------------------------|---------------------------------|---------------------------------|
| Mining                    | 15,34                                           | 22,70                           | 14,86                           |
| Manufacturing             | 41,93                                           | 27,14                           | 43,09                           |
| Water supply; water disposal, organization of waste collection and disposal, pollution elimination activities | 28,71                                           | 14,02                           | 24,97                           |
| Construction              | 0,41                                            | 3,35                            | 0,05                            |
| ...                       |                                                 |                                 |                                 |
| Other economic activities  | 0,57                                            | 3,96                            | 0,34                            |

M.A. Vlasova, E.E. Kononova include an insufficient amount of scientific and applied research in this area for modern challenges, an insufficiently developed assessment methodology the barriers to the introduction of eco-innovation in the Russian Federation, in addition to economic and legislative ones [14, p. 40].

To assess the impact of investments related to the environmental activities of industrial enterprises on the environmental safety of the region, we will use the author's methodology for assessing environmental safety, described in detail in [14, 15].
76 subjects of the Russian Federation were analyzed in the framework of testing the methodology (Sevastopol and the Republic of Crimea, the Chechen Republic, the Republic of Ingushetia, the Republic of Kalmykia and the Belgorod Region were excluded from the sample due to the lack of complete statistical data for the period under review, the Nenets Autonomous Okrug was examined together with the Arkhangelsk region, Khanty-Mansi Autonomous Okrug - Ugra and the Yamalo-Nenets Autonomous Okrug are considered together with the Tyumen region), the time period for the analysis is 2010-2017.

Since the level of ecological safety of a region depends on its industry specifics, the first stage of the study included the determination of groups of regions with a similar structure of gross value added (GVA) by type of economic activity (FEA) based on an algorithm for ascending hierarchical clustering, Ward's method, distance metric - Euclidean distance.

Clustering was carried out on the basis of data on the industrial structure of the GVA according to OKVED 2 (17 types of economic activity were identified: sections P, O, Q were combined, T and U were excluded from the analysis, since they did not take into account the economic activities of enterprises in the territories) created in the subjects of the Russian Federation in 2017 year.

As a result of clustering, 7 clusters were formed: “Industrial-diversified”, characterized by a predominant share of the manufacturing industry, a high share of the mining industry, an average level of trade and the mining sector (10 regions); “Trade-processing” - the prevailing share of trade, a high level of manufacturing industry, lack of mining industry (21 regions) “Transport and logistics” - the prevailing share of transportation and storage, the average level of other activities (7 regions); “Agrarian and tourist”, characterized by a high share of the social sphere, a high share of agriculture, etc., a very low share of industry (12 regions); “Manufacturing” - the prevailing share is the manufacturing industry, the average level of trade and the social sphere, the absence of extractive industries (21 regions), “Mining and social”, characterized by the predominance of extractive industries, the average share of the social sphere and a low proportion of other activities (9 regions); “Mining”, which is characterized by a maximum share of the mining industry (more than half of the GVA) and a low share of other activities (3 regions).

The grouping of regions by industry specifics and taking into account its impact on environmental conditions in the regions is necessary in order to determine the most important areas for application of forces and differentiate management tools for influencing regional environmental safety depending on the conditions of economic activity in the regions, which is confirmed by the works of other authors.

For example, Treiman M.G. identifies the main types of industrial enterprises for which eco-innovation is most relevant: firstly, these are large industrial enterprises and enterprises being a part of the industrial complex, and secondly, these are resource-supplying enterprise [17, p. 111].

E.A. Merzlyakova, T.S.Kolmykova note the significant regional and intraregional differentiation in the speed of adaptation and implementation of environmental innovations that has developed in the Russian Federation and propose for regions with a high potential for the introduction of circular reproduction systems to support scientific developments in this area, improve innovation infrastructure, stimulate technological entrepreneurship, and for regions with a predominance of manufacturing industry - to attract investments in high-tech industries with the massive introduction of the principles of closed and waste-free production [18, p. 111].

The impact of eco-investments on the ecological safety of the territory will be assessed using industrial diversified regions of the first cluster as an example: Belgorod Region, Kursk Region, Republic of Karelia, Murmansk Region, Republic of Khakassia, Republic of Tatarstan, Udmurt Republic, Samara Region, Perm Region, Krasnoyarsk Region.

Table 3 presents the dynamics of costs for eco-innovation in the regions of the first cluster.
Table 3. Current (operational) costs for research and development to reduce the negative anthropogenic environmental impacts of the regions in the industrial diversified cluster in 2012-2018, thousand rubles [19].

| Regions in the Cluster 1                  | 2012    | 2013    | 2014    | 2015    | 2016    | 2017    | 2018    | Growth rate, % |
|-------------------------------------------|---------|---------|---------|---------|---------|---------|---------|----------------|
| Belgorod region                           | 13 781  | 9 311   | 8 817   | 8 585   | 8 332   | 10 611  | 7 296   | 52.94          |
| Kursk region                              | 0       | 0       | 0       | 0       | 0       | 1 735   | 608     | -              |
| Republic of Karelia                       | 4 516   | 1 027   | 711     | 272     | 166     | 98      | 2 17    |                |
| Murmansk region                           | 303 993 | 113 462 | 35 933  | 35 137  | 20 096  | 12671   | 11 838  | 3.89           |
| Republic of Tatarstan                     | 24 951  | 110 438 | 72 983  | 116 239 | 119 646 | 81 214  | 59 166  | 237.13         |
| Udmurt republic                           | 4 074   | 2 584   | 6 672   | 7 122   | 7 014   | 6 565   | 16 667  | 409.11         |
| Perm region                               | 16 424  | 27 925  | 38 349  | 148 350 | 203 855 | 128 865 | 23 764  | 144.69         |
| Samara Region                             | 31 233  | 23 365  | 23 004  | 8 831   | 6 179   | 662     | 1 786   | 5.72           |
| The Republic of Krasnoyarsk                | 13 560  | 14 142  | 6 174   | 12 430  | 7 663   | 11 396  | 7 392   | 54.51          |

The data in table 4 indicate that 4 regions are the leading regions in terms of total environmental research costs, i.e. the Republic of Tatarstan (RT), the Udmurt Republic (UR), Perm Region (PR), Krasnoyarsk Region (KR), but the latter demonstrates the negative dynamics of development costs to reduce the negative impact of regional economic activity on the environment. Therefore, regression analysis will be carried out in three regions of the cluster.

Alenkova I.V., Mityakova O.I. propose to use three groups of indicators to measure the effectiveness of the environmental innovations introduction: indicators of environmental investment activity, indicators of the dynamics of changes in the environmental load of enterprises and indicators of innovative and environmental activity. As the authors note, the proposed system of indicators will allow enterprises to assess their position in the rating of environmental performance in a regional or sectoral context and the dynamics of the environmental development of an enterprise, however, in our opinion, it does not allow assessing the impact of indicators of these groups on each other [20], therefore, the next stage of our work will be a regression analysis.

The regression model takes into account the influence of five variables on the integral indicator of environmental safety in the region: $X_1$ – the proportion of organizations that have implemented innovations that increase the environmental safety as a result of the use of innovative goods, works, and services by the consumer associated with a reduction in energy consumption (energy consumption) or loss of energy resources (as a percentage of total number of organizations implementing environmental innovations); $X_2$ – the proportion of organizations that have implemented innovations that ensure increased environmental safety as a result of the use of innovative goods, works, services by a consumer related to the reduction of air pollution, land, water resources, noise reduction (as a percentage of the total number of organizations that have carried out environmental innovations); $X_3$ – the proportion of organizations that have implemented innovations that ensure increased environmental safety as a result of the use of innovative goods, works, and services by the consumer related to the improvement of the possibilities of recycling (recycling) of goods after use (as a percentage of the total number of organizations that have carried out environmental innovations); $X_4$ – special costs associated with environmental innovations per organization, million rubles; $X_5$ – current (operational) environmental protection costs, thousand rubles. The constructed models show a significant relationship (determination coefficients of 0.95, 0.98, and 0.67 for RT, UR, PR, respectively) between the eco-innovative activities of enterprises in the regions being evaluated and the costs of its implementation and regional environmental safety.
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