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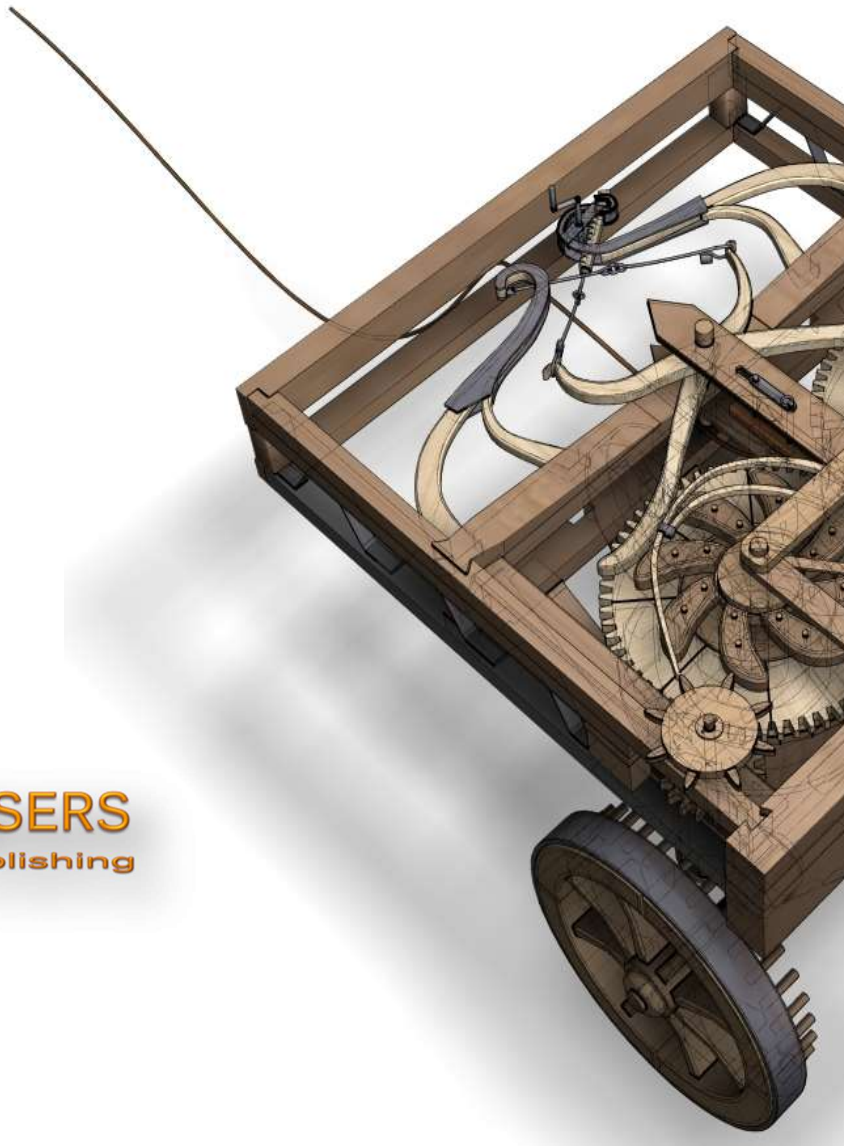

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Cluster Analysis of the Expenditures for Environmental and Technological Innovations in Sustainable Development Policy Formation

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Abstract

The major task of the present work is to identify the main problems of cluster analysis on environmental and technological innovations in the formation of regional sustainable development policy, as well as modeling the expenditures for technological and environmental innovations. The number of innovative enterprises increases rapidly, and they are developing at a rapid pace. Measures to reduce the impact on the environment, such as improving technological equipment, recycling waste, implementing technologies aimed at preserving natural resources, creating new types of products with long service life and the possibility of recycling, employing advanced purification technologies, etc. will require in the vast majority of cases not only financial expenditures but the implementation of innovative solutions.
The authors are intended to study out and optimize this work and improve the research framework.

Keywords: innovative enterprises; sustainable business; environmental regulation; economic growth; technological innovations; economic indicators.

JEL Classification: O32; O44; Q01.

Introduction

This study will show what the main problems are associated with the cluster analysis for the expenditures of environmental and technological innovations in the formation of regional sustainable development policy.

1. Methods

The analytical research field includes tools for analyzing the expenditures for environmental and technological innovations in the formation of a regional policy for the sustainable development of zones.

Today, taking care of the world around is becoming a priority for every human. There are more and more plants, factories, vehicles in Russia and the world in general, whose activities have a detrimental effect on nature and human health. Moreover, the requirements of consumers for the quality of goods are growing every year. Today, customers have become more literate and consciously choose the products they need, paying attention to both the corporate activities of the company, as well as methods of production and extraction of raw materials. Studies are confirming that the share of environmentally conscious consumers is growing every year. For example, 73% of respondents in the world demand environmental responsibility from business (Ecobureau GREENS 2018), a third of consumers (33%) now prefer to buy products from brands that, in their opinion, benefit society or the environment (Unilever 2017). In Russia, 62% of respondents are ready to change their consumption habits to reduce the harm that is caused to the environment (PublisherNews.Ru 2019; Danko *et al.* 2020a, 1163). All this indicates the relevance of the development of innovations that contribute to environmental protection and the implementation of resource-saving technologies (Danko *et al.* 2020b, 2851). The number of innovative enterprises, developing at a rapid pace, is constantly growing. In this context, a strong, competitive, and sustainable business can be called an enterprise that closely follows the trends of the industry, including environmental regulation (for example, the implementation of extended producer responsibility) and increasing requirements for transparency of product distribution on the part of customers. The Canadian media company Corporate Knights has created the Global 100 rating of enterprises engaged in sustainable development (Corporate Knights 2019). The 7,500 companies that do this better than others generate more than $1 billion in annual revenue, which means that such a business is one of the most profitable.

The processes, such as improving technological equipment (1), recycling of waste (2), implementing technologies aimed at preserving natural resources (3), creating new types of product with long service life and the possibility of recycling (4), applying modern purification technologies (5), developing new non-traditional environmentally friendly types of energy (6), and optimizing heat and electricity consumption (7) will require in the vast majority of cases not only financial expenditures but also the innovative solutions. This is reflected in the Decree of the President of the Russian Federation of 2018 "On the national goals and strategic objectives of the development of the Russian Federation for the period up to 2024" (Decree of the President of the Russian Federation 2018), which, in particular, specifies the national goal: "accelerating the technological development of the Russian Federation, increasing the number of organizations implementing technological innovations to 50 percent of their total number". To achieve these goals, the Innovation Development Strategy should be updated. In 2017, by the Decree of the President of the Russian Federation No. 176, the Environmental Security Strategy of the Russian Federation for the period until 2025 was approved. In 2018, by Order of the Government of the Russian Federation No. 84-r, the Strategy for the Development of Industry for Processing and Disposal of Production and Consumption Waste for the period until 2030 was approved (Sputnik News 2020).

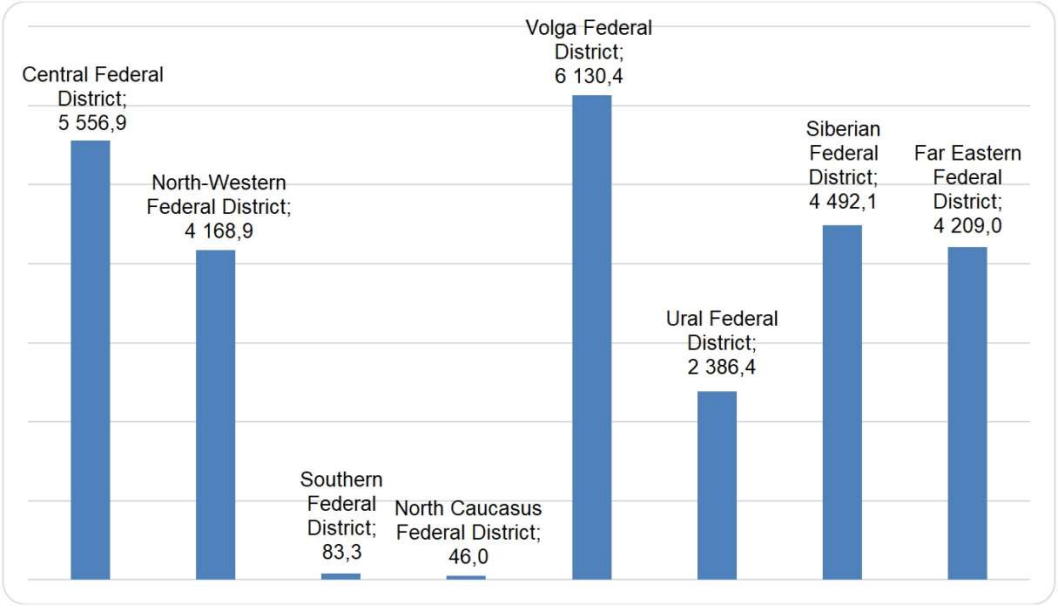
1.1 Expenditures for Technological and Environmental Innovations

Enterprises carry out environmental innovations intending to ensure compliance with current technical regulations, rules, and standards (requirements of environmental legislation), as well as the expected tightening of legal rules. Besides, an organization's economic innovations may be stimulated by the need to meet the requirements of the market (consumers), the availability of state grants, subsidies, or other financial incentives for the implementation of environmental innovations, or they may be motivated by voluntary adherence to general principles of environmental protection. The implementation of technological innovations is primarily aimed at improving economic indicators, as well as strengthening the competitiveness of the enterprise. But since today, technologies and products are quickly copied by competitors and become obsolete, it is more about an integrated approach that combines the product, the business model (as a way to create a product), as well as the organizational model (as a way to implement the business model by employees).

Since 2010, the Russian Federal State Statistics Service (Rosstat) has started collecting statistical data on the indicator "Special expenditures associated with environmental innovations", which since 2017 has been included in the "Comprehensive system of statistical indicators of environmental protection in the Russian

Federation, considering international recommendations". This indicator is understood as "The expenditures of production, technical and environmental measures if the main reason for their implementation is to increase environmental safety, improve or prevent negative impact on the environment" (Order of the Federal State Statistics Service 2017). These expenditures are formed at the expense of the current and capital expenditures of organizations.

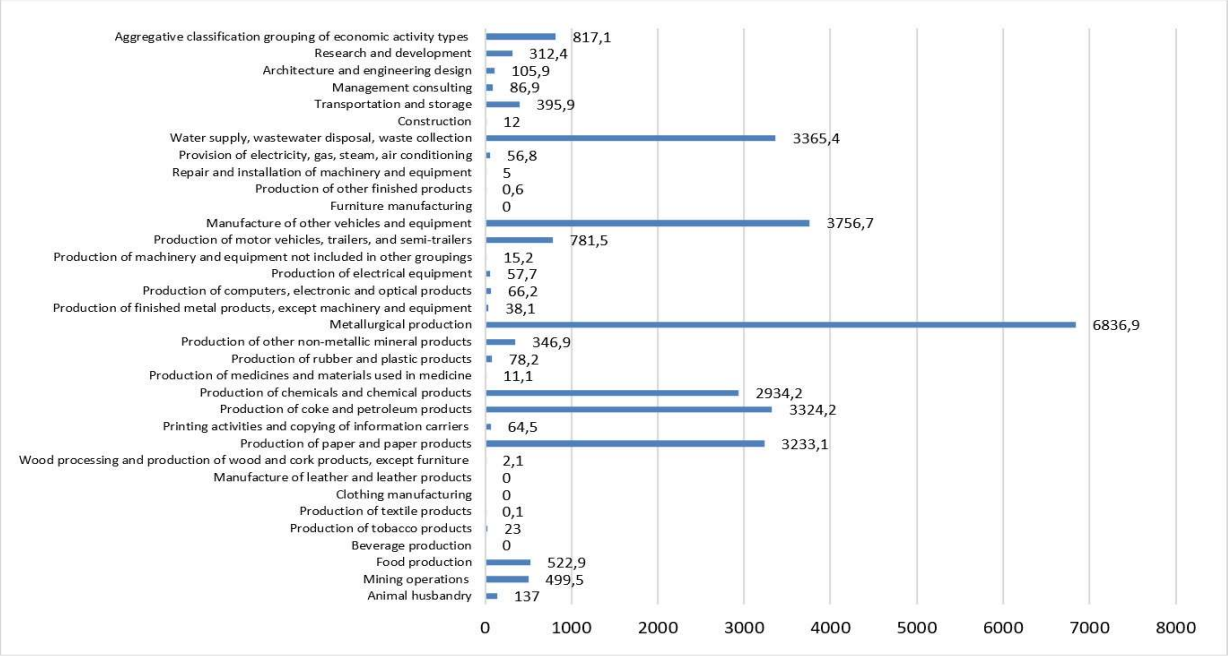
Figure 1. Special expenditures for environmental innovations for the entities of the Russian Federation in 2019, mln rubles



Source: Compiled by the authors based on Federal State Statistics Service (n.d.)

Most funds are invested in the Volga Federal District, and the Republic of Tatarstan (4,534,009 mln rubles). While considering these expenditures by industry, then the largest expenditures in Russia fall on manufacturing, namely, metallurgical production and the production of vehicles and equipment, as well as on water supply, wastewater disposal, waste collection and disposal, and pollution elimination activities (Figure 2).

Figure 2. Special expenditures for environmental innovations by industry in 2019, mln rubles



Source: Compiled by the authors based on Federal State Statistics Service (n.d.)

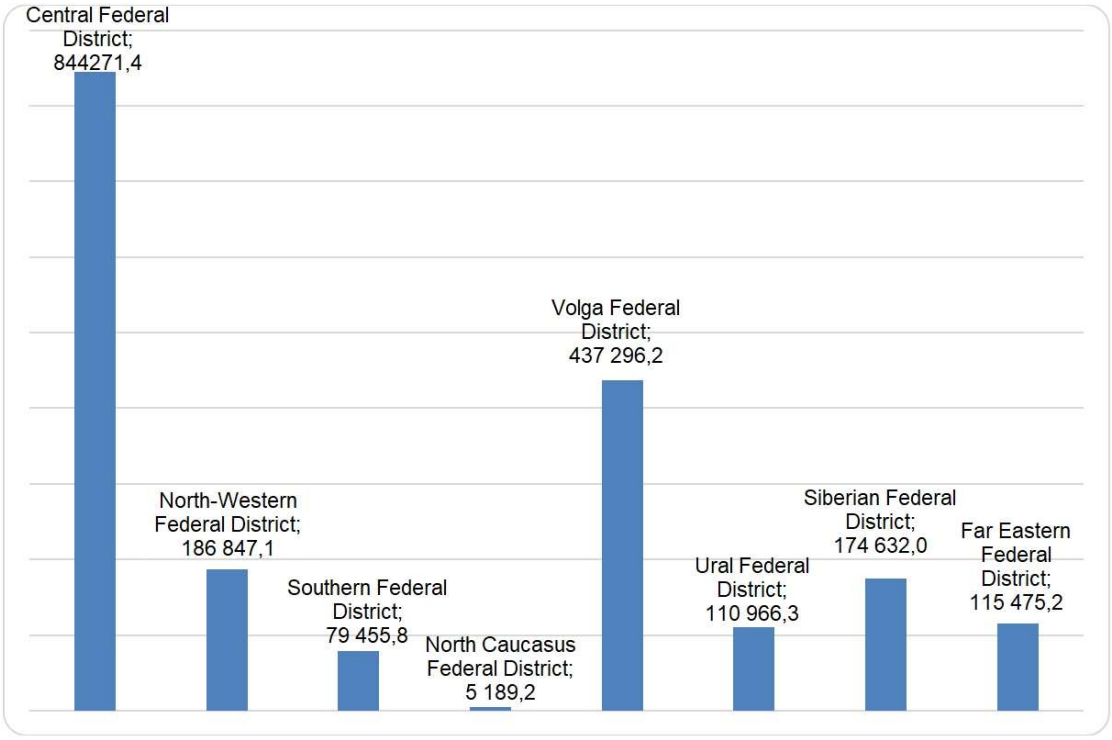
From the standpoint of regional management, it is possible to distinguish the industry locomotives of regional and national importance, to implement innovations right in these industry sectors. However, today,

innovations are closely related to the implementation of the concept of a closed-cycle economy, green technologies, one way or another aimed at environmental protection (Association of Innovative Regions of Russia 2018). Therefore, enterprises that are engaged in local-level industries, but have a significant impact on the environment, should also have access to financial resources and opportunities to implement the best available technologies to improve their operations.

The expenditures for innovation activities are the actual expenditures for implementing all types of innovative activities related to the process of developing and implementing technological innovations and other innovations performed in the organization. They also include current and capital expenditures, *i.e.* unlike environmental expenditures, for innovation expenditures, resource conservation is not necessarily their main goal. However, they can indirectly contribute to environmental safety being aimed at reducing stocks, decreasing the number of defective products and waste, or providing the possibility of waste recycling, etc.

While analyzing the distribution of innovation expenditures in the districts of the Russian Federation, we can see that, as well as in the case of environmental expenditures, investments are directed mostly to the Central, Volga, and Siberian districts (Figure 3).

Figure 3. Expenditures for innovative activities of organizations by entities of the Russian Federation in 2019, mln rubles



Source: Compiled by the authors based on Federal State Statistics Service (n.d.)

If not considering research and development, among the industry sectors, transportation and storage (228,822.7 mln rubles), mining (154,655 mln), production of coke and petroleum products (140,265.9 mln), metallurgical production (133,045 mln) were distinguished in 2019, which also echoes the expenditures of environmental innovations.

1.2 Extent of the Prior Research Problem

Over the past two years, more than 100 scientific articles have been published in peer-reviewed journals on the topic of environmental innovations in Russia, more than 2,500 articles on sustainable development of the region; dozens of theses on these issues have been defended. About 250 articles on the role of innovation in the sustainable development of the region have been published in journals indexed in the Web of Science and Scopus databases.

The problems of the theory and practice of assessing the sustainability of the territorial socio-ecological and economic systems development are considered in the works of G. Atkinson, C. Mourato, P.J.G. Pearson, T.J. Foxon, T.H. Morrison, V.I. Gurman, I.P. Glazyrina, I.S. Guseva, A.Yu. Davankova, D.Yu. Dvinina, I.A. Zabelina, I.M. Potravny, E.V. Ryumina, and A.A. Chub.

Atkinson (2018) notes that although the regional local level of authorities cannot fully ensure sustainable development, it is an integral element of this process, and can make a significant contribution to the sustainable development of the region. Zhou Yu. (2019) has shown a relationship between technological innovations and environmental regulation, which, when used together and with a certain intensity of environmental regulation, contribute to increasing the level of environmental efficiency of the region. In particular, it was revealed that an increase in environmental taxes by 1% led to an increase in technological innovations related to the environment, on average by 0.57 and 0.78%, respectively for high-and middle-income countries (Karmaker *et al.* 2021).

W. Chen and Y. Lei (2018) found that in countries with higher CO2 emissions, technological innovation becomes a critical element in improving energy efficiency and reducing energy consumption.

L. Aldieri (2019) argues that incentives that promote greater integration between different industries play a decisive role in the implementation of innovations in the field of waste management.

The results of the study by M. Ahmad (2020) confirm that the active use of natural resources and high rates of economic growth increase the ecological footprint. In these conditions, technological innovation affects the sustainable development of organizations, actively reducing their impact on the environment.

We believe that to ensure the implementation of the sustainable development concept at the macro level, it is necessary to improve the activities of all subsystems of the organization at the micro-level, which requires developing new technologies, improving the quality of the final results of activities, and implementing new more effective management techniques (Tsenina *et al.* 2019, 213).

From the perspective of the sustainable development strategy implementation in the region, it seems necessary to establish a relationship between the activity of enterprises in the field of environmental safety with the expenditures of technological and environmental innovations (Skorobogatykh *et al.* 2018, 343; Germanovich *et al.* 2020, 965).

The purpose of the present study is to classify regions by similar characteristics based on the following variables that characterize the activity of a particular region (Tsenina *et al.* 2019, 213):

- the proportion of organizations that have implemented innovations aimed at improving environmental safety, including in the production of goods, works, and services (in 9 areas);
- expenditures for technological innovations of organizations;
- special expenditures associated with environmental innovations;
- the volume of innovative goods, works, and services.

The regions can be integrated into groups that have similar approaches to solving environmental safety issues, the level of activity of organizations in this area in the region, the investment volumes in innovations in certain areas related to reducing the negative impact on the environment.

2. Methodology

A common method for determining groups is cluster analysis, which allows combining objects that are homogeneous in terms of certain criteria. The IBM SPSS Statistics computer program was used to identify clusters.

The data for the study were obtained from the Rosstat database (Federal State Statistics Service n.d.). At that, 58 regions of the Russian Federation were selected as test objects, because, 27 regions were eliminated in the course of primary processing, due to the incompleteness of the indicators necessary for the analysis. The analyzed period of economic activity was from 2010 to 2019.

When conducting cluster analysis, the following two sets of variables, characterizing the activity of a particular region, were selected:

1. The share of organizations implementing innovations that improve environmental safety in the production of goods, works, and services in the following areas:

- X1 – Reducing material expenditures per unit of goods, works, and services (%);
- X2 – Reducing energy input per unit of goods, works, and services (%);
- X3 – Reducing emissions of carbon dioxide (CO2) (%);
- X4 – Replacing hazardous raw materials with safe or less hazardous materials (%);
- X5 – Reducing environmental pollution (%);
- X6 – Increasing the volume of secondary processing (recycling) of industrial waste, water, or materials (%);
- X7 – Reducing losses in energy resources (%);
- X8 – Reducing pollution of land and water resources, reducing noise levels (%);
- X9 – Improving the possibilities of recycling goods after use.

2. Other variables:

- X10 – The expenditures on innovative activities of organizations (mln rubles);
- X11 – Special expenditures associated with environmental innovations (mln rubles);
- X12 – The volume of innovative goods, works, and services (mln rubles).

Due to different measurement units of studied indicators, the source data were pre-standardized. Since the features are equally informative and significant for further analysis (Table 1), the distance between objects was calculated using the method based on the Euclidean distance.

Table 1. Pearson's matrix of paired coefficients of mutual conjugacy

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}
X_1	1	0.714**	0.393**	0.292	0.083	0.238	0.514**	0.295*	0.311*	-0.063	-0.063	-0.031
X_2	0.714**	1	0.373**	0.414**	0.079	0.315*	0.655**	0.301*	0.406*	-0.019	-0.011	0.028
X_3	0.393**	0.373**	1	0.222	0.260*	0.226	0.305*	0.263*	0.435**	0.074	-0.050	-0.080
X_4	0.292*	0.414**	0.222	1	0.369**	0.367**	0.282*	0.315*	0.018	0.026	-0.008	0.044
X_5	0.083	0.079	0.260*	0.369**	1	0.210	-0.037	0.384**	0.098	0.031	0.183	0.058
X_6	0.238	0.315*	0.226	0.367**	0.210	1	0.230	0.151	0.443**	0.007	0.137	0.055
X_7	0.514**	0.655**	0.305*	0.282*	-0.037	0.230	1	0.411**	0.301*	0.353	0.135	0.065
X_8	0.295*	0.301*	0.263*	0.315*	0.384**	0.151	0.411**	1	0.135	0.124	0.201	0.163
X_9	0.311*	0.406**	0.435**	0.018	0.098	0.443**	0.301*	0.135	1	0.029	0.131	0.078
X_{10}	-0.063	-0.019	0.074	0.026	0.031	0.007	0.053	0.124	0.029	1	0.333*	0.918**
X_{11}	-0.063	-0.011	-0.050	-0.008	0.183	0.137	0.135	0.201	0.131	0.333*	1	0.364**
X_{12}	-0.031	0.028	0.080	0.044	0.058	0.055	0.065	0.163	0.078	0.918**	0.364**	1

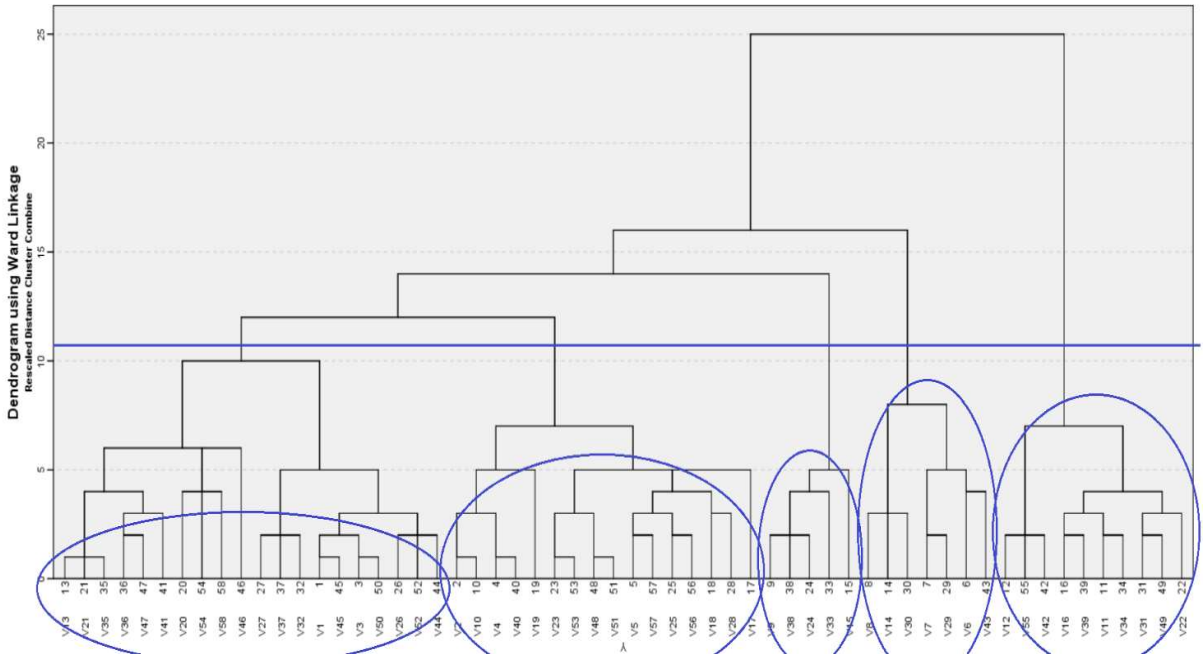
** The correlation is significant at the level of 0.05 (pair correlation)*

*** The correlation is significant at the level of 0.01 (pair correlation)*

The analysis was carried out using Ward's hierarchical cluster analysis. This method was used because the optimal number of clusters is a priori unknown. Hierarchical algorithms allow tracing the process of building groupings and illustrate the subordination of clusters formed at different stages of work. The Ward method was used because it is the most resistant to data noise and restores the data structure well.

As a result of clustering, a dendrogram was constructed (Figure 4).

Figure 4. Dendrogram of regional clusters



Source: Compiled by the authors

When analyzing the dendrogram a strong hierarchy was observed and five isolated groups could be identified (Table 2).

Table 2. Average values of variables in clusters

No	1	2	3	4	5
Clusters (Regions)	Moscow, Moskow Region, Nizhny Novgorod, Saint Petersburg, Tatarstan	Astrakhan, Belgorod, Buryatia, Vladimir, Volgograd, Irkutsk, Kaliningrad, Kirov, Kurgan, Leningrad, Mordovia, Omsk, Perm Territory, Samara, Sakhalin, Sverdlovsk, Tula, Tyumen, Chelyabinsk, Chuvashia	Bryansk, Voronezh, Kaluga, Oryol, Komi, Arkhangelsk, Vologda, Novgorod, Krasnodar Territory, Rostov, Penza, Altai Territory, Novosibirsk, Tomsk, Primorsky Territory, Khabarovsk Territory	Kostroma, Kursk, Lipetsk, Yaroslavl, Kabardino-Balkar, Stavropol Territory, Ulyanovsk	Smolensk, Tver, Karelia, Murmansk, Bashkortostan, Udmurt, Orenburg, Saratov, Krasnoyarsk Territory, Sakha Republic
X_1	53.2	49.3	57.1	64.8	40.6
X_2	59	54.4	61.9	68.4	47.7
X_3	45.1	41.3	44	46.3	30.5
X_4	46.2	40.2	43.2	52.4	32.9
X_5	77.4	75.9	73.6	76.1	67.9
X_6	42.7	49.4	38.9	59.6	34.2
X_7	58.3	49.8	58.8	64.2	47.8
X_8	62.4	57.8	58.8	59.9	47
X_9	26.6	27.9	26.9	37.1	22.9
X_{10}	102,380.3	18,727.31	6,822.038	5,964.919	10,793.03
X_{11}	889.22	544.96	110.68	427.23	158.638
X_{12}	308,858.2	54,076.21	23,577.57	24,612.06	26,452.25

3. Results

In general, organizations in all regions are characterized by focusing their efforts to reduce environmental pollution (atmospheric air, land, water resources, and noise reduction) and, to the least extent, to replace raw and other materials with safe or less dangerous ones and reduce carbon dioxide emissions into the atmosphere.

The clusters obtained from 58 regions can be characterized as follows (Table 3).

Table 3. Composition and characteristics of clusters

	The regional composition of the cluster	Characteristics of the cluster
1	Moscow, Moscow Region, Nizhny Novgorod, Saint Petersburg, Tatarstan	the highest amount of organizations' expenditures for technological and environmental innovations; the largest volume of innovative goods, works, and services, a high proportion of organizations whose innovations provide an increase in environmental safety (including in the production of goods, works, and services) in all areas of environmental safety (with an emphasis on reducing environmental pollution compared to other clusters).
2	Astrakhan, Belgorod, Buryatia, Vladimir, Volgograd, Irkutsk, Kaliningrad, Kirov, Kurgan, Leningrad, Mordovia, Omsk, Perm Territory, Samara, Sakhalin, Sverdlovsk, Tula, Tyumen, Chelyabinsk, Chuvashia	mid-level of organizations' expenditures for technological and environmental innovations; mid-volume of innovative goods, works, and services; a low proportion of organizations whose innovations provide an increase in environmental safety in all areas. Improving the recycling technologies of goods after use is the only area in which enterprises are most active.
3	Bryansk, Voronezh, Kaluga, Oryol, Komi, Arkhangelsk, Vologda, Novgorod, Krasnodar Territory, Rostov, Penza, Altai	the low amount of organizations' expenditures for technological innovations, and the lowest level for environmental innovations; the lowest volume of innovative goods, works, and services among all clusters, the average number of organizations whose innovations provide an increase in

	The regional composition of the cluster	Characteristics of the cluster
	Territory, Novosibirsk, Tomsk, Primorsky Territory, Khabarovsk Territory	environmental safety; the regions of this cluster pay most attention to reducing energy input (energy consumption) or loss of energy resources.
4	Kostroma, Kursk, Lipetsk, Yaroslavl, Kabardino-Balkar, Stavropol Territory, Ulyanovsk	the low amount of organizations' expenditures for technological innovations, and the lowest level for environmental innovations; low volume of innovative goods, works, and services; a very high proportion of organizations whose innovations provide an improvement in all areas of ensuring environmental safety.
5	Smolensk, Tver, Karelia, Murmansk, Bashkortostan, Udmurt, Orenburg, Saratov, Krasnoyarsk Territory, Sakha Republic	the low amount of organizations' expenditures for technological innovations, and the lowest level for environmental innovations; low volume of innovative goods, works, and services; the lowest proportion of organizations whose innovations provide an increase in environmental safety in the production of goods, works, and services in all areas of environmental safety.

4. Discussion

Our research shows that the expenditures for innovative activities of organizations are associated with the proportion of enterprises engaged in reducing air pollution, land, water resources, and reducing noise levels, *i.e.* many enterprises prefer to invest in innovative technologies in this area. There is a relationship between the investment volumes in technological and environmental innovations. Enterprises create not just innovative products but invest in technologies and tools that will allow reducing the burden on the environment, using resources and materials more efficiently, and so on.

Since the expenditures on innovation and environmental activities are interrelated, regional policy should also consider programs to support innovation, considering the goal-setting of environmental programs.

The results of cluster analysis can be interpreted as given below.

The 1st cluster unites regions in which an average of 102,380 mln rubles was invested from 2010 to 2019 in technological innovations (63% of investments in all clusters), 889 mln rubles in environmental innovations (41%). About 70% of the total volume of innovative goods, works, and services were produced. In other words, large investments in innovation were justified, since they contributed to an almost proportional production volume of innovative products. It is natural that this cluster, which bears such large expenditures related to environmental innovations, includes Moscow, the Moscow Region, and St. Petersburg. In 2019, these three entities of the Russian Federation occupied the top three positions in terms of gross regional product (GRP) output. At that, manufacturing industries accounted for a large share of the GRP in these regions.

Tatarstan is among the top ten in terms of GRP, but along with manufacturing industries, this region is engaged with mining. Confirmation of the active position of Tatarstan regarding the implementation of innovations is the fact that in 2019 Tatarstan became the leader in Russia in terms of the number of Technology and Innovation Support Centers (TSCs). The regional network of TSCs covers 22 organizations. At that, nine TSCs were established in Moscow and St. Petersburg (Federal Institute of Industrial Property n.d.).

The effectiveness of innovation activity is determined by the innovation infrastructure. The Federal Institute of Industrial Property (FIIP) is actively involved in the implementation of the regional policy conducted by Rospatent (Federal Intellectual Property, Patent and Trademark Service) aimed at intensifying inventive and innovative activities in the regions. However, the coverage and availability of patent data in some regions of the country are limited.

The Nizhny Novgorod Region also did not accidentally get into the 1st cluster, which is confirmed by the fact that in 2019 it became the leader among the entities of the Russian Federation in the implementation of lean manufacturing tools (Information Portal: Future of Russia. National Projects 2019). The Effective Region project was launched in 2017 by Rosatom State Corporation (2019). Rosatom specialists help the regional authorities in applying the methods of the production system at enterprises. Their ultimate goal is to increase labor productivity, implement lean technologies, and improve work processes. Increasing labor productivity is one of the priorities in the development of Russia. The competitiveness of the Russian economy, the standard of living of the population, and the country's position in the international arena largely depend on labor productivity. According to the public organization "Green Patrol", the Nizhny Novgorod Region has risen from 2020 to 2021 in the environmental rating of the entities of the Russian Federation by 13 positions (All-Russian public organization “Green Patrol” n.d). This

huge breakthrough for the industrial region was influenced by the elimination of environmental damage accumulated for decades since the Soviet period (RIA News 2020).

The results of the composition of this cluster are aligned with the ranking of the entities of the Russian Federation according to the Russian regional innovation index in 2019, where Moscow, Tatarstan, St. Petersburg, Nizhny Novgorod, and Moscow regions were included in the top six regions in terms of innovative development (Gokhberg 2020) as well as with the rating of innovative regions of Russia (the rating is formed by the Association of Innovative Regions of Russia (2018)) in 2018, where St. Petersburg, Tatarstan, and Moscow were the leaders, and the Nizhny Novgorod Region was among "strong " innovators group and took the 8th place.

Specialists of the Institute for Statistical Studies and Economics of Knowledge (ISSEK) form the Russian Regiona Innovation Index (RRII) since 2012. The rating is formed by the Association of Innovative Regions of Russia, created in 2010 with the support of the Ministry of Economic Development of the Russian Federation, Rusnano, and the Russian Academy of National Economy and Public Administration under the President of the Russian Federation to promote innovative economic, scientific, technical, and educational projects.

Obviously, organizations in the regions of this cluster are investing in expensive technologies. At that, the proportion of organizations in this cluster that were engaged in innovations in environmental activities is quite comparable with the proportion of active organizations in other clusters. But the innovation expenditures incurred by organizations in this cluster are much higher than those of organizations in other clusters.

The 2nd cluster united the regions in which the expenditures for environmental innovations prevail over technological expenditures by 25 and 13% of the total expenditures in all clusters. The average volume of innovative goods, works, and services produced during the analyzed period correlates with the expenditures of technological innovations and amounts to 12%. In most of the regions assigned to this cluster, the manufacturing industry prevails. Apparently, some few enterprises of the regions are engaged in environmental protection activities, bearing tangible expenditures, mainly aimed at the implementation of secondary processing (recycling) of industrial waste, water, or materials.

The 3rd cluster consolidated the regions where very little was invested in innovation (5% of the total expenditures in all clusters), with the lowest share of the volume of innovative goods, works, and services. The organizations of this cluster are not very active, but most of them are working towards reducing material and energy expenditures (including for the production of a unit of goods, works, and services). Significant industries for the regions of this cluster are meat production, crop production, food, as well as, basic engineering industry, pulp and paper products, and water purification and distribution, and waste treatment. As known, paper production and heavy industry pollute rivers, and this is probably related to intensive activities in water purification and waste treatment. The paper industry, like the rest of the above-listed industries, is looking for ways to save energy and could produce almost half of the energy it consumes by combusting generated solid waste. However, as one can see, waste recycling is not very popular among the enterprises of this cluster.

The 4th cluster incorporated regions where organizations were characterized by very low expenditures for technological and environmental innovations, a low volume of produced innovative goods and services, and the highest proportion of organizations implementing innovations to improve environmental safety among all clusters. The regions of this cluster are characterized by consumer goods manufacturing.

The 5th cluster united the regions with very low expenditures for technological and environmental innovations of organizations and the lowest proportion of organizations implementing innovations to improve environmental safety in all six industry areas.

Based on the conducted clustering, the following five main approaches can be distinguished in different groups of regions in terms of investing in innovations and improving the environmental situation:

1. High expenditures for innovative activities and efforts related to environmental innovations, a large number of organizations that increase environmental safety in the production of goods, works, and services;
2. High expenditures for innovative activities and efforts related to environmental innovations, a small number of organizations that increase environmental safety in the production of goods, works, and services;
3. Small investments in innovations, though in priority areas, for example, to reduce material and energy expenditures (including the production of a unit of goods, works, and services);
4. Low investment volume in innovations, but a large number of organizations that increase environmental safety in the production of goods, works, and services;
5. Small investments in innovations, as well as a small number of organizations that increase environmental safety in the production of goods, works, and services.

It is necessary to pay attention to the regions of the 5th group and analyze the reasons since this approach can be described as passive. Besides, repeated studies after a certain period, using the clustering method can

help to track the regions' ranking dynamics, as well as changes in approaches to improving environmental safety in the production of goods, works, and services in general. Each of the above five approaches should be coordinated with specific measures of environmental regulation in the regions to choose more effective measures aimed at stimulating environmental protection measures and developing environmental innovations. From the perspective of developing measures to support environmental innovations at the federal district level, one can attempt to analyze why a particular region is in a cluster with small investments and/or has a small number of active organizations participating in environmental activities. This may happen due to the lack of enterprises' financial resources, the inaccessibility of financing, the presence of single-industry towns, etc.

In further studies, we also plan to establish a relationship with environmental performance indicators, considering the regional policy being implemented.

Clustering of regions helps to identify the main approaches to investing in innovations and link this with the activity of enterprises in the field of resource conservation. Considering the update of statistics, repeated clusterization will give different results of the cluster composition. In each case, it is advisable to carefully analyze the transition of a particular region from a cluster with one approach to a cluster with a different approach.

In any case, knowing the main five approaches to investment and the activity of enterprises, the region can choose the most optimal approach for itself. For example, it makes no sense to activate most enterprises in the region if the regional leading industries are related to the provision of services (education, tourism, the film industry, etc.), but it makes sense to concentrate on a few enterprises involved in consumer goods manufacturing, and selectively support or stimulate their environmental activities, considering the specifics of pollution. At that, it should be remembered that the innovation supporting policy (including financing) can be directed to environmental measures.

Conclusions

Environmental protection has become one of the most important issues of the last decades. The harmful impact on nature from manufacturing enterprises, and especially from transport companies and heavy industry enterprises, increases every year.

First of all, it is large organizations that, in addition to their main activities, should also be engaged in the process of resource conservation, that is, implement certain technologies, systems, and solution methods to ensure sustainable development. In Russia, ecologization is still considered a new and insufficiently developed area. Therefore, the state should support first of all, individual entrepreneurs, and small organizations in the development of environmental projects, possibly through the issuance of subsidies, donations, and grants. The state should work to increase the level of the population’s awareness of the need to implement green technologies. Along with obtaining environmental efficiency, companies should get also economic efficiency.

We reviewed statistical data on the expenditures of environmental and technological innovations in the Russian Federation by region and industry, which are carried out at the expense of current and capital expenditures of companies.

To determine approaches in the regional policy of sustainable development, we conducted a clustering of regions (using the example of 58 regions of the Russian Federation) based on the following variables that characterize the activities of a particular region:

- the proportion of organizations that have implemented innovations aimed at improving environmental safety in the production of goods, works, and services in 8 industry areas;
- expenditures for technological innovations of organizations;
- special expenditures, associated with environmental innovations;
- the volume of innovative goods, works, and services.

As a result of the conducted research, five clusters of regions were distinguished. Each of the clusters is characterized by a certain level of expenditures for technological and environmental innovations and the proportion of organizations that have implemented environmental innovations. The characteristic of clusters reflects the approaches in the regions to investing in innovations that improve environmental safety.

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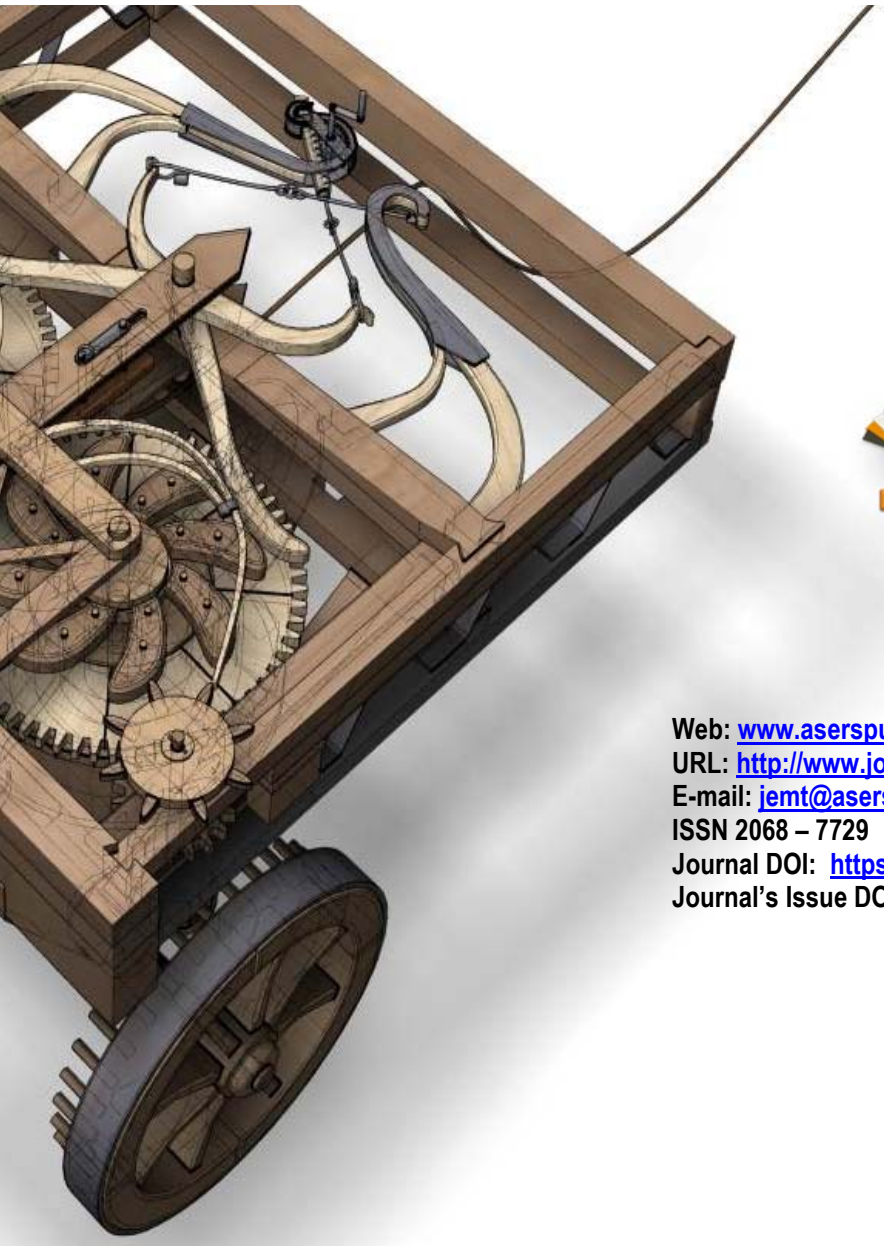

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