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CLUSTER ANALYSIS OF EXISTING TECHNOPARKS IN DEVELOPED COUNTRIES

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Abstract:
This article provides a cluster analysis of existing technoparks, the sample of which was built according to the completeness of the data presented on the official websites of the Ministry of Industry and Trade of the Russian Federation and the terms of operation. The analysis is carried out in order to determine the best components of the effectiveness of the development of the technopark movement in Russia. According to the analysis of this article, we can talk about a weak relationship between the three sub-indices: the activities of the management company, the activities of residents, the activities of regional authorities. The obtained data can serve as a starting base for further construction of an econometric model of the efficiency factors of technoparks.

Key words: *technopark, the effectiveness of technoparks, evaluation criteria technoparks, regional economy, innovations, cluster model*

INTRODUCTION

One of the main factors in the development of the Russian economy is the unfocusing of the state budget from the raw materials orientation, moving away from the primitive raw materials economy, and coming to a new, "smart" economy that will be aimed at producing unique knowledge, new things and technologies useful to society, creating the necessary conditions for the effective implementation of the innovation process [13]. New ideas and developments arising in the field of science should pass the stage of transition to the field of production as quickly as possible and turn into a commodity. That is, you need to understand that for a more effective functioning of the innovation sphere, it is necessary that the innovation cycle takes as little time as possible (from the emergence of an idea, knowledge to the commercialization of a product), and it is possible to accelerate the innovation cycle only by aggregating scientists and technologists. In this regard, the experience of various technopark structures as the most successful forms of integration of science and production is of great interest [6].

According to the VI annual review "Technoparks of Russia" of the Association of Clusters and Technoparks of Russia, 179 technoparks are currently operating and being created in 55 regions of the Russian Federation. Over the past years, the positive dynamics of the creation and development of technoparks has been maintained – their geography of their presence, the area of territories and premises is expanding. In the structure of established and operating technoparks, there is a predominance of industrial premises (from 35.9% in 2016 to 51.1% in 2019), which is explained by the increase in the number of industrial technoparks [16].

Industrial technoparks are one of the key elements of the industrial infrastructure that contributes to the development and development of the production of competitive products, the expansion of cooperation between small technology companies and large businesses, as well as the introduction of advanced production technologies.

When creating and operating technoparks, three entities are interconnected in the direct chain: the management company of the technopark, the residents of the technopark and the regional authorities. The advantages of an industrial technopark for these subjects can be represented in the following aspects [24]:

- for the site owner: more efficient management of the site and the existing infrastructure; the possibility of additional income from providing services to residents of the technopark; the possibility of hosting partners (suppliers or consumers of goods or services);
- for residents: cost reduction, release of funds for the implementation of high-tech projects, re-profiling; the possibility of obtaining a range of services in the "single window" format; access to the necessary industrial equipment;
- for the region: new growth points; increase of jobs number, increase of tax revenue; increase of the investment attractiveness of the region.

Despite the seemingly strong sides of technoparks, there are a number of weaknesses, one of which is the uneven development of industry in the regions of the Russian Federation, and as a result, the uneven distribution of technoparks (the largest number of them falls on the Central (50%) and Volga (20%) federal districts), the second, the uneven support of management companies and residents from state authorities, the next weak side can be the difficulty of attracting private investors at the initial stage of projects of residents of technoparks, there is also a lack of personnel in the regions and an insufficient level of competence in the development and promotion of innovative products [3].

For these reasons, it is extremely important to identify the factors of the effectiveness of technoparks through direct or inverse relationships between seemingly interrelated subjects of the technopark movement.

MATERIAL AND METHODS

In order to identify the factors of the effectiveness of the functioning of technoparks, it is necessary to determine an effective indicator that comprehensively assesses all aspects of the technopark's activities [15]. There is still no consensus on this indicator in the scientific and business community.

To date, a significant number of scientific papers devoted to the importance of various criteria for evaluating the effectiveness of technoparks have been published.

Thus, most experts are of the same opinion that the effectiveness of the technopark is measured by the effectiveness of residents. At the same time, it is necessary to understand that the technopark is an independent economic entity of the economy and its functioning should be evaluated regardless to the effectiveness of its residents' activities [10]. But it should be remembered that the main activity of the technopark management company is to manage the creation, development and operation of an industrial technopark, as well as to provide residents of an industrial technopark with the services they need to carry out manufacturing of industrial products, scientific and technical activities and (or) innovative activities in order to master the production of industrial products and commercialize the scientific and technical results obtained [9]. Therefore, the effectiveness of the residents of the technopark serves as a proxy for evaluating the effectiveness of the technopark (the more effective the residents, the more effective the management in the technopark). On the other hand, the effectiveness of a technopark resident depends only on the effectiveness of the resident's management. And with the competent management of a technopark resident, the choice of the technopark itself will depend on the effectiveness of the management of the technopark's management company [14]. Thus, the task of the effectiveness of the technopark's activities is reduced to finding an indicator that takes into account the effectiveness of the assistance of the technopark's management company in the effectiveness of the activities of their residents.

Kostyunina, G., Baranov, V. (2012) claim that the measure of the effectiveness of the technopark is the number of jobs created, and the effectiveness of the technopark is determined by the economic development of the region in which it is located. In our opinion, it should be remembered that a technopark is a commercial organization that derives income from providing services to residents, and a resident of a technopark is an enterprise or an individual entrepreneur whose purpose is to make a profit. For this reason, the creation of jobs for the technopark and the resident of the technopark is not a productive indicator of their activities, to a greater extent it can be called a social indicator of their functioning [7].

P. Sobkowic (2013) suggests evaluating the success of the technopark by the number of established companies launching new products or services, thereby speeding up the process of access and transfer of technologies, knowledge, experience and skills among the residents of the technopark [12]. The same opinion is shared by the authors Albahari and all (2012), seeing the effectiveness of the technopark in the number of resident companies as generators of innovative products of the technopark. In our opinion, this evaluation criterion cannot be considered a productive indicator, because it does not assess either the number of innovative products created or their commercialization on the market [1].

Not all innovations developed by residents can be brought to the market, and the creation of innovations in itself, as well as the creation of innovative companies, cannot be an end in itself. Since innovation is a new or significantly improved product (goods, service) or process introduced for use, a new sales method or a new organizational method in business practice, workplace organization or in

external relations [2, 4, 5], and innovative activity – scientific, technological, organizational, financial and commercial activities aimed at implementing innovative projects, as well as creating innovative infrastructure and ensuring its activities [5, 11] must be in demand by the market, i.e. commercialized-involved in the economic turnover of scientific and (or) scientific and technical results [5]. N. N. Lytaeva, V. S. Lipatnikov (2018) approach the effectiveness of technoparks through the total value of sales of products of residents of the technopark, mainly of an innovative nature. Taking into account the above authors' research, we can try to offer a cluster analysis of technoparks by three top-level sub-indexes (classification without training) [8].

The study considered three top-level subindexes:

s1 – the activity of the management company;

s2 – activities of residents;

s3 – activities of regional authorities.

Each upper-level subindex includes middle-level subindexes, which in turn include lower-level subindexes in accordance with Table 1.

The methodology of the statistical study included 3 main stages

Data transformation

In order to exclude the influence of the dimension of the values on the analysis result, data standardization was performed, as a result of which each lower-level subindex was reduced to an average value of 0 and a standard deviation of 1.

The middle-level subindexes were calculated as the arithmetic mean of the lower-level subindexes and were further standardized [18]. The top-level subindexes were calculated as the arithmetic mean of the middle-level subindexes and were also standardized. As a result, all subindexes have a single dimensionless scale.

Primary data analysis

Histograms of the distribution of subindexes were constructed and their main characteristics were determined (minimum and maximum values, median, coefficient of asymmetry).

Cluster analysis of technoparks by three top-level sub-indexes (classification without training)

To determine the number of clusters, the "elbow" method was used. The hierarchical clustering procedure was used with the following parameters: measuring the distance between objects – the Euclidean distance, measuring the distance between clusters – the unweighted average distance between all pairs of elements (in order to reduce the impact of outliers on the result of cluster analysis) [20]. Clustering by the K-means method was used to divide technoparks into clusters.

Source data

The sample was formed from 64 operating technoparks that provided a complete set of data to the state information system of industry of the Ministry of Industry and Trade of Russia (https://gisp.gov.ru/gisplk/), the period of operation of which is more than 3 years (in order to identify the dynamics of revenues, the creation of innovative products, the payment of taxes).

The study involved 20 technoparks (~31%) from 6 federal districts (Central, North-Western, Volga, Ural, North Caucasus and Far Eastern) and 13 regions of the Russian Federation. Table 2 shows the data of a sample of technoparks participating in the study [17].

Table 1

Subindexes of the upper, middle and lower levels

s1	s11	s111	Infrastructure. Availability of technological infrastructure.
		s112	Infrastructure. Availability of social infrastructure.
		s113	Infrastructure. Availability of engineering infrastructure.
		s114	Infrastructure. Types of technological equipment provided for rent by a resident
	s12	s121	Transport. Distance to the city center, km
		s122	Transport. Distance to the railway station, km
		s123	Transport. Distance to the airport, km
	s13	s13	Number of specializations
	s14	s141	Management. Provision of technopark residents with services, points.
		s142	Management. The volume of attracted direct investments per 1 sq. m. of the total area of the technopark premises, million rubles/sq. m.
		s143	Management. The level of occupancy of the area.
s2	s21	s21	Innovative activity. The amount of intellectual property objects registered by residents, units.
	s22	s221	Economic activity. The average annual growth rate of residents ' revenue, %
		s222	Economic activity. The average level of labor productivity, thousand rubles.
		s223	Economic activity. The average level of taxes of park residents per 1 employee, thousand rubles/person.
		s224	Economic activity. The volume of investments of residents in fixed assets per 1 employee of a resident company, million rubles/person.
		s225	Economic activity. The volume of industrial production of residents of the industrial technopark for 1 rub. investments of residents of the park, million rubles/ million rubles.
s3	s31	s31	Region. Points for the average rating of investment attractiveness for 2019, 2020, points.
	s32	s32	Region. Support programs, points.

Table 2
Data from technoparks

No.	Federal District	Region	Technopark	Year of creation	Site type	Form of ownership
1	Central	Moscow	Technopolis "Moscow"	2012	Brownfield	Private
2	North-West	Pskov region	Technopark " Electropolis"	2017	Brownfield	Private
3	Privolzhsky	Republic of Bashkortostan	Technopark "HTC UAI-Rosoil "	2009	Brownfield	Private
4	Central	Moscow	Technopark" Slava"	2008	Brownfield	Mixed
5	North-West	Saint-Petersburg	Technopark of St. Petersburg	no data available	Brownfield	State-owned
6	Privolzhsky	Republic of Mordovia	Technopark of the Republic of Mordovia	2012	Brownfield	State-owned
7	Central	Moscow oblast	Technopark "Skhodnya-Grand"	no data available	Brownfield	Private
8	Central	Moscow	Technopark" Strogino "	2007	Brownfield	State-owned
9	Central	Voronezh Region	Technopark" Commonwealth "	2007	Brownfield	Private
10	Uralsky	Sverdlovsk region	Technopark" Novouralsky"	2012	Brownfield	Private
11	Siberian	Novosibirsk region	Technopark "Scientific and Technological Park of Novosibirsk Akademgorodok" (Akadempark)	2010	Brownfield	Mixed
12	Central	Moscow	Technopark "Nagatino"	2015	Brownfield	State-owned
13	Central	Lipetsk region	Municipal budgetary institution " Technopark-Lipetsk	2012	Brownfield	Municipal
14	Central	Moscow	Technopark "Mosgormash"	2013	Brownfield	State-owned
15	North Caucasian	Stavropol Territory	Technopark " Monocrystal"	2016	Brownfield	Private
16	Central	Voronezh Region	Technopark " Cosmos-oil-gas"	2006	Brownfield	Private
17	Volga Far	Republic of Tatarstan	Technopark " KNIAT"	2003	Brownfield	Mixed
18	Eastern	Republic of Sakha (Yakutia)	State Autonomous Institution of the Republic of Sakha (Yakutia) Technopark "Yakutia"	2012	Greenfield	State-owned
19	Privolzhsky	Republic of Tatarstan	Technopark "Aviator"	2017	Brownfield	Private
20	Privolzhsky	Samara region	Technopark "Zhigulevskaya valley"	2014	Brownfield	State-owned

RESULTS OF THE STUDY

The values of the top-level subindexes are shown in Table 3.

Table 3
Values of top-level subindexes

No.	s1	s2	s3
1	-0.971	-0.537	2.1357
2	0.8367	0.5433	-1.724
3	0.0174	-0.933	-0.485
4	-0.19	3.5058	0.9275
5	2.3975	0.235	0.0137
6	0.6052	1.0303	-1.344
7	0.5287	0.5791	0.2334
8	-1.324	0.3462	1.3302
9	-1.487	-0.616	-0.485
10	-1.108	-0.002	-0.497
11	-0.267	-0.178	-0.228
12	-0.165	-0.289	1.1228
13	-0.476	-0.149	-0.119
14	0.0212	-0.114	1.135
15	0.315	-0.728	-1.152
16	-0.061	-0.433	-0.68
17	-1.188	-1.059	0.6361
18	0.2335	-0.736	-1.13
19	0.3548	-0.81	0.4043
20	1.9275	0.3429	-0.095

Figure 1 shows the distribution of technoparks in the coordinate system s1-s2-s3.

The primary analysis of Table 3 and Figure 1 shows that Technopark No. 4 stands out significantly in comparison with other technoparks in terms of the s2 subindex.

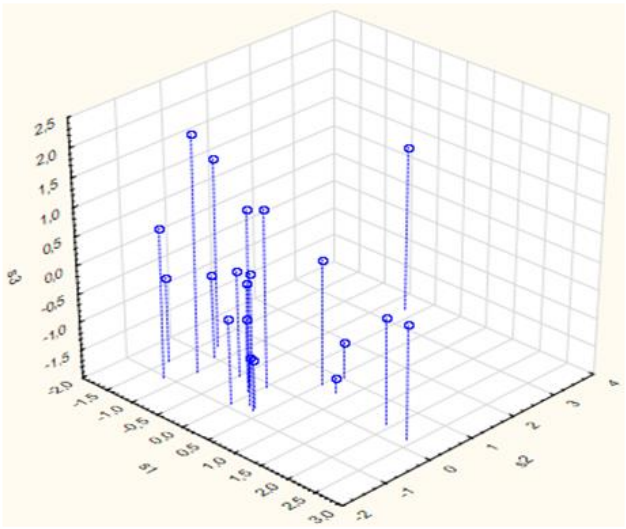

Fig. 1 Distribution of technoparks in the coordinate system s1-s2-s3

Figure 2 shows the histograms of the distribution of the top-level subindexes.

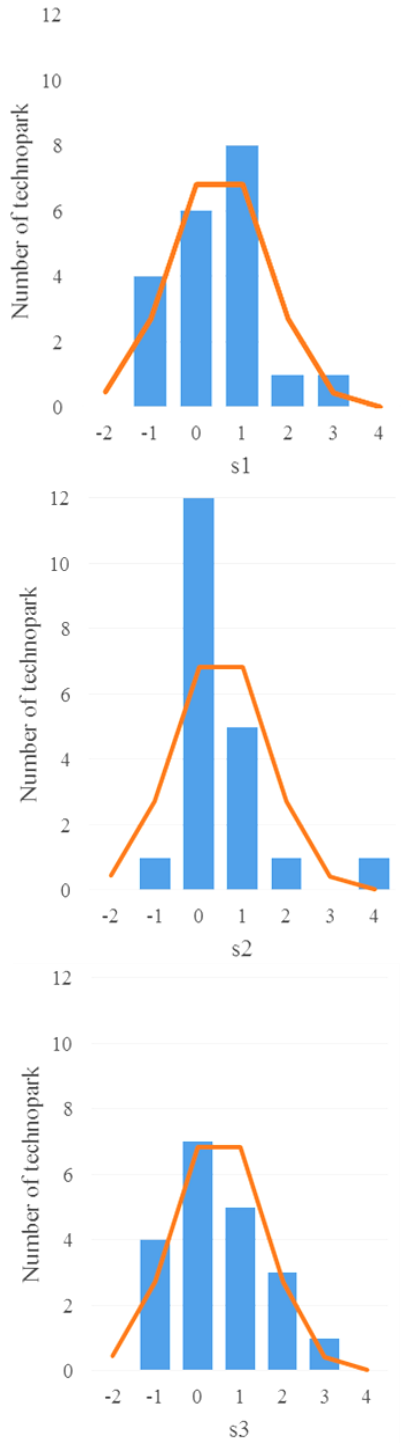

Fig. 2 Histograms of the distribution of top-level subindexes

It is necessary to pay attention to the presence of a positive asymmetry (skew to the left) of the distributions of all three subindexes [19]. This is due to the fact that a relatively small number of technoparks have values of subindexes s1, s2, s3, significantly exceeding their average values. According to Figure 2, it can be seen that from 60 to 80% of technoparks have subindex values close to the average values (from -1 to 1).

Next, let's move on to the results of cluster analysis. The first task was to determine the optimal number of clusters [23].

As a result of hierarchical clustering, the dependence of the cluster union distance on the number of clusters was obtained (Figure 3).

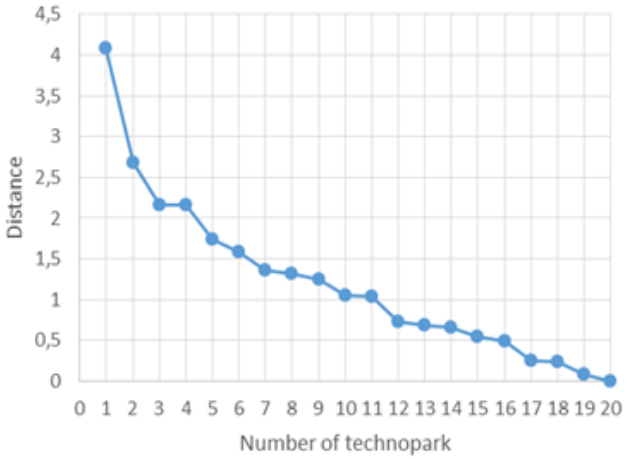

Fig. 3 Dependence of the cluster joining distance on the number of clusters

In Figure 3, the fracture point of the graph is clearly visible, corresponding to the number of clusters k = 3. As a result, 3 clusters were taken as a basis.

The division of technoparks into clusters was carried out using the K-means method with an indication of the number of clusters k = 3. The result of the partition is shown in Figures 4, 5.

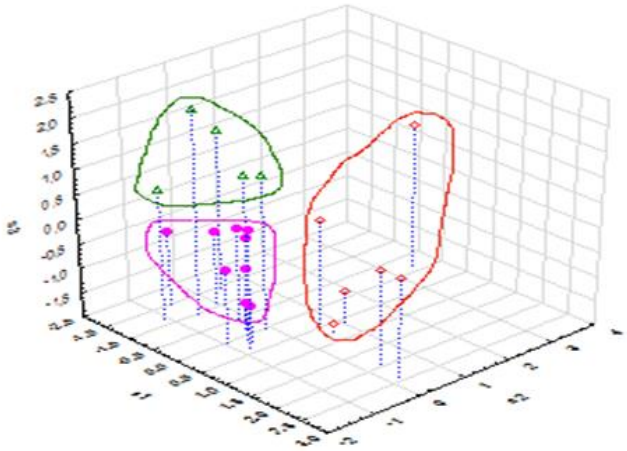

Fig. 4 The result of clustering by the K-means method

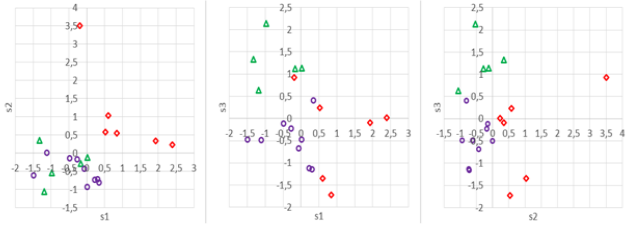

Fig. 5 The result of clustering by the K-means method

Table 4 and Figure 6 show the average values of each subindex for each of the three clusters.

Table 4
Average values of sub-indexes for each cluster

	Cluster 1	Cluster 2	Cluster 3
no. of technoparks	2, 4, 5, 6, 7, 20	1, 8, 12, 14, 17	3, 9, 10, 11, 13, 15, 16, 18, 19
s1 - Activities of the management company	1,017626	-0,725435	-0,275398
s2 - Activities of residents	1,039409	-0,330490	-0,509334
s3 - Activities of regional authorities	-0,331357	1,271961	-0,485741

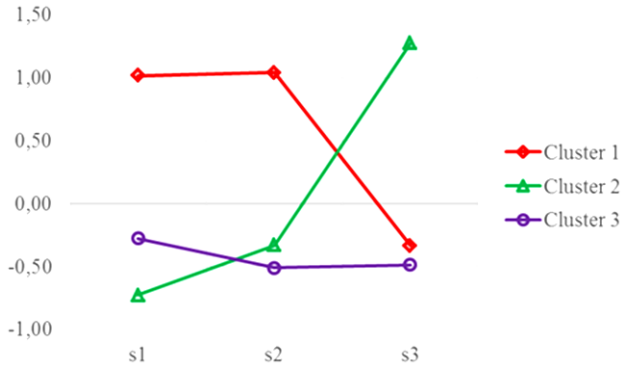

Fig. 6 Average values of subindexes for each cluster

Table 5
Clustering results

Cluster	Technopark	Region	Characteristics of the cluster
Cluster 1	Technopark "Electropolis"	Pskov region	With a slightly lower than average level of activity of regional authorities and significantly higher than the average level f activity of residents, the level of activity of the technopark's management company is significantly higher than average.
	Technopark "Slava"	Moscow	
	Technopark of St. Petersburg	Saint-Petersburg	
	Technopark of the Republic of Mordovia	Republic of Mordovia	
	Technopark "Skhodnya-Grand "	Moscow oblast	
	Technopark "Zhigulevskaya valley"	Samara region	
Cluster 2	Technopolis "Moscow"	Moscow	At a level significantly higher than the average level of activity of regional authorities and slightly lower than the average level of activity of residents, the level of activity of the management company is significantly lower than the average.
	Technopark "Strogino"	Moscow	
	Technopark "Nagatino"	Moscow	
	Technopark "Mosgormash"	Moscow	
	Technopark "KNIAT"	Republic of Tatarstan	
	Technopark "KHTC UAI-Rosoil"	Republic of Bashkortostan	
	Technopark "Sodruzhestvo"	Voronezh Region	
Cluster 3	Technopark "Novouralsky"	Sverdlovsk region	With the level of activity regional authorities below the average and even more below the average of residents, the level of activity of the management company is slightly below the average.
	Technopark "Scientific and Technological Park of Novosibirsk Akademgorodok (Akadempark)"	Novosibirsk region	
	Municipal budgetary institution "Technopark-Lipetsk"	Lipetsk region	
	Technopark "Monocrystal"	Stavropol Territory	
	Technopark "Cosmos-oil-gas"	Voronezh Region	
	State Autonomous Institution of the Republic of Sakha (Yakutia) Technopark "Yakutia"	Republic of Sakha (Yakutia)	
	Aviator „Technopark"	Republic of Tatarstan	

DISCUSSION

Nevertheless, we adhere to the opinion of the authors who consider the effectiveness of technoparks to be a complex effective indicator that takes into account the effectiveness of the management company itself and the effectiveness of the residents of the technopark.

Based on the results of the analysis, the following two conclusions can be drawn:

1. With high performance indicators of management companies and residents of the technopark, the level of activity of regional authorities is slightly below average. Therefore, with slightly lower standard operating conditions in the region, the total activity of the technopark is high [22]. The regional authorities, seeing the economic, financial and social indicators of the technopark's activity (including the management company and residents), do not create additional preferences for the subjects of the technopark movement.
2. Seeing the activity of the management companies of technoparks as significantly below the average and slightly below the average activity of residents, the regional authorities create favorable conditions for improving these indicators. In another case, when the activity of regional authorities is significantly higher than the average, the management companies of technoparks have the lowest level below the average and the activity of residents is slightly below the average [21]. This may indicate the low efficiency of the proposed preferences of the regional authorities.
3. At the lowest below average level of activity of regional authorities, the activity of management companies of technoparks is slightly below average and the activity of residents is below average. It can be assumed that the regional authorities, seeing the activities of the management companies of technoparks slightly below the average and the activities of residents below the average, do not offer additional preferences to the subjects of the technopark movement.

At least, such conclusions can be reached based on the data provided by management companies to the Ministry of Industry and Trade of the Russian Federation. You can see the correlation between the presented indices in Table 6.

Table 6
Correlation analysis of sub-indices

	S1	S2	S3
S1	1,000000	0,193031	-0,330023
S2	0,193031	1,000000	0,087914
S3	-0,330023	0,087914	1,000000

The correlation matrix shows that there is no strong correlation between the sub-indices.

CONCLUSION

Today, industrial technoparks are an important tool for the development of high-tech sectors of Russian industry with high growth potential.

The conducted cluster analysis of the technopark movement indicates the determination of a complex effective indicator of the activity of the technopark movement as a whole. Thus, the sub-indices presented above have a weak correlation between them.

Our research was limited to the data provided by the management companies of technoparks and the results were obtained for a sample of technoparks that provided the full amount of information, therefore, registration errors are possible in the presented analysis, excluding representativeness errors.

Another area of future research is the construction of an econometric model of the efficiency factors of technoparks.

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