Estimation of Innovative Clusters Efficiency Based on Information Management and Basic Models of Data Envelopment Analysis

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***Abstract*— Clusters and information management play an increasingly important role in the innovative development of regions and operational management. With the help of such structural entities, socially significant issues are being addressed, infrastructure development of the territories is being carried out, the investment climate is improving and various innovative projects are being implemented, new products, services, technologies are being created, the level and quality of life of the population is being raised. In our research we analyzed 24 innovative clusters created in the Russian Federation with the participation of the Ministry of Economic Development. We used econometric and statistical research methods. We analyzed financial investments made by both private investors and the state in the formation and development of clusters. After that, we compared the output parameters with the input financing and, based on the data envelopment analysis method, calculated the relative efficiency of the innovation clusters. We have identified 3 cluster benchmarks and made recommendations for improving the management system of the other clusters.**

Keywords— *clusters, data envelopment analysis, regional development, information management, operational management.*

1. Introduction

At present, the issue of cluster development and cluster approach continues to be relevant. In addition to the classical works on this area [1-3], there are new approaches to the goals and tools for the cluster formation and development. Thus, a number of authors believe that clusters perform a foreign economic function and influence the export policy of states [4]. There is also a point of view that clusters are independent subjects and the nature of their development, by analogy with enterprises, depends on the stage of the life cycle on which a particular cluster is located [5- 16]. There are also works in which the development of territories, regions and agglomerations is called as the main goal of the formation and development of clusters [6,7, 15]. Other authors believe that due to clusters a new "smart" economy is being created, and the clusters themselves contribute to the development of a knowledge economy and innovation [8-14].

In our research, we were guided by the latter point of view and analyzed the functioning of innovation clusters in Russia.

Methods

In our research we made a comparative assessment of the performance of 24 pilot innovation clusters based on the method of analyzing the functioning environment (Data Envelopment Analysis, DEA). The volume of funding and expenditures on research and development (R & D) were selected as input data. The output data are as follows: the number of participants in the clusters (organizations), the total number of employees, the gross revenue of organizations and the area of the territory on which the clusters are based. The choice of the above indicators is explained, on the one hand, by the principle of reasonable sufficiency, on the other hand, by availability. The choice of this list of clusters is due primarily to the allocation of additional subsidies from the federal budget to improve the existing technological infrastructure, create a favorable investment climate, expand markets for products and other goals. The full list of clusters includes 25 subjects, but due to insufficient data, we did not include the Sarovsky innovation territorial cluster in the sample, therefore, in our study, we analyzed 24 pilot innovation clusters

1. Results and Discussion

As a result of the conducted analysis, according to the input data, it was revealed that the total deviation of efficiency in terms of the total amount of allocated funds amounted to more than 1.3 trillion rubles. Such a difference may be due to a number of reasons, such as, for example, insufficiently fast payback of innovative developments and their specificity, secondly, in a number of clusters, research is largely research and commercialization of their activities is not a top priority. At the same time, this figure does not indicate an inefficient use of the budget, but only gives an estimate of the “excessive financing” of the clusters in accordance with the DEA methodology.

If we consider the output, it should be noted that the expected number of participants in all 24 clusters, subject to their maximum efficiency, should grow by 44% to more than 2.6 thousand. At the same time, the largest change, according to calculations, is assumed in the Kamsky innovation territorial production cluster - The increase should be more than 400 organizations. This may be due to the highest amount of financing among all the clusters, which is potentially aimed at increasing its attractiveness for investors and entrepreneurs. At the same time, the total number of employees of organizations is expected at the level of 800 thousand, which exceeds the current figures by 23%.

As a result of analyzing the performance of innovative clusters according to the DEA methodology, three benchmarks were identified - clusters that were included in the general sample and showed the most optimal performance in terms of evaluating performance over the entire period of operation, namely, Integrated processing of coal and industrial waste (Kemerovo region) , Petrochemical Cluster of the Republic of Bashkortostan and the Territorial Innovation Cluster “Titanium Cluster of the Sverdlovsk Region”. Thus, we can analyze the current position of innovation clusters relative to the selected benchmarks, pre-breaking them into three groups, depending on which of the selected benchmark clusters are the closest in terms of the remaining clusters.

Let us consider in more detail the results for the first group, where the Petrochemical Territorial Cluster of the Republic of Bashkortostan (benchmark 1) acts as a benchmark (Fig. 1).

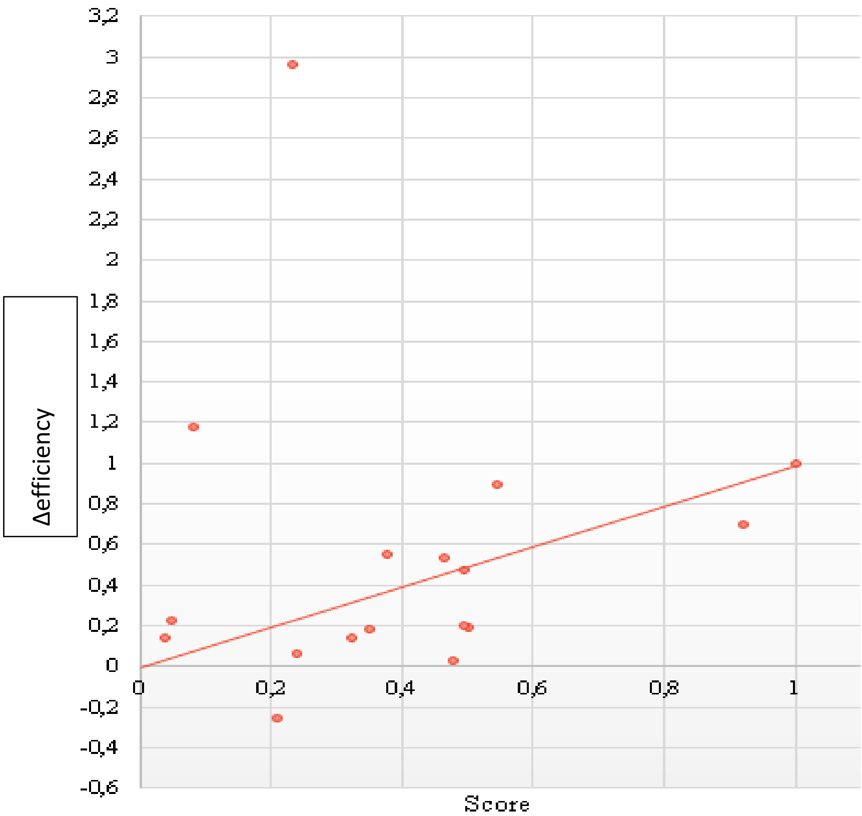

Fig. 1. Comparative evaluation of the effectiveness of innovation clusters relative to the benchmark 1

In this graph, the calculated cumulative efficiency indicator Score, which has values in the interval [0; 1], is deposited on the abscissa, the closer it is to 1, the more efficient the cluster is. On the ordinate axis, the lag from the benchmark is displayed, which a particular cluster must overcome in order to achieve an optimal state. Based on this, we see that the benchmark has coordinates [1; 1], and all other clusters that are included in the group have an offset position on the graph. In the group under consideration, the following clusters have the smallest difference in efficiency: Nuclear-innovative cluster of the city of Dimitrovgrad of the Ulyanovsk Region [0.476217; 0.027797], Altai Biopharmaceutical Cluster [0.237864; 0.061419] and the Cluster of Innovative Technologies of the Closed Territorial Department of Zheleznogorsk [0.037613; 0,139405], however, their total efficiency does not necessarily have to be high, which demonstrates the value of the first coordinate. So, the most approximate extremum is at the point [0,920162; 0.699552] and describes the performance of the Cluster of the medical, pharmaceutical industry, radiation technologies (St. Petersburg).

Next, we analyze the calculation results for the second group of clusters, for which the benchmark was the innovative territorial cluster titanium cluster of the Sverdlovsk region (benchmark 2) (Fig. 2.)

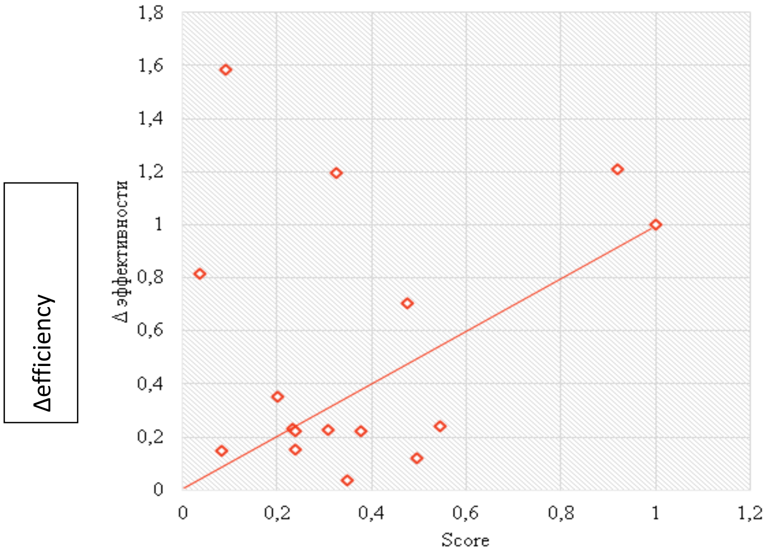

Fig. 2. Comparative evaluation of the effectiveness of innovative clusters relative to the benchmark 2

Analyzing the indicators for this group, we can observe that the closest to the benchmark in terms of aggregate efficiency is the cluster of the medical, pharmaceutical industry, radiation technologies (St. Petersburg), but already having a different coordinate on the ordinate axis - [0.920162; 1,207505], that is, in contrast to the previous group, the delta increased by more than one and a half times. Several clusters can be attributed to the minimum lagging behind the benchmark: Energy efficient lighting engineering and intelligent lighting control systems (Republic of Mordovia) [0.349719; 0.034958], Consortium Scientific, educational and industrial cluster Ulyanovsk-Avia (Ulyanovsk region) [0.495161; 0.116675] and Pharmaceuticals, medical equipment and information technology (Tomsk Region) [0.239513; 0.149701].

Finally, the third group included clusters with the benchmark "Integrated processing of coal and industrial waste" (Kemerovo region) (benchmark 3) (Fig. 3.).

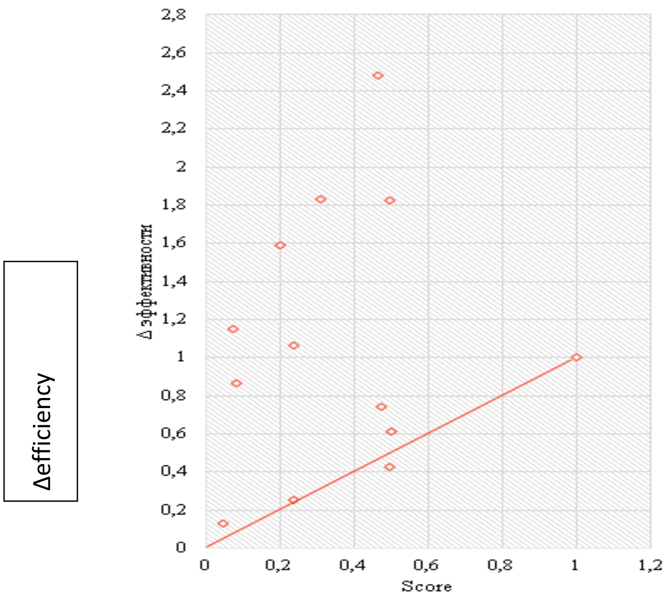

Fig. 3. Comparative evaluation of the effectiveness of innovative clusters relative to the benchmark 3

Note that in the group under consideration, the closest cluster in terms of total performance is the Pushchino Biotechnology Territorial Innovation Cluster [0.499755; 0.609533]. Quite close to the benchmark for the difference in efficiency are the cluster "Zelenograd" [0,049474; 0.131889], Altai Biopharmaceutical Cluster [0.237864; 0.253949] and the Consortium of the Ulyanovsk-Avia Scientific-Educational-Production Cluster [0.495161; 0.426187].

Further, we analyzed the data by comparing the actual input and output indicators of the clusters with the "optimal" data calculated by the Maxdea program in accordance with the DEA methodology. Figure 4 shows the total allocation of funds (input data).

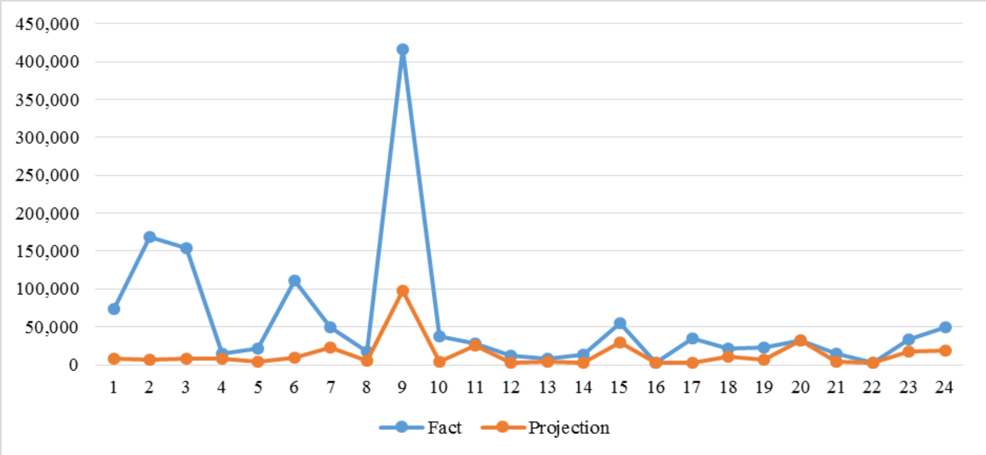

Fig. 4. Comparison of actual (Fact) and optimal (Projection) volumes of allocated funds, mln rub.

The cluster numbers are presented on the abscissa axis (see Table 1). Based on the presented graph, it can be concluded that in most cases it is advisable to reduce the funds allocated for the development of clusters. This conclusion may be due to the fact that the sample contains clusters from different industries and with different levels of complexity in organizing production, as a result of which benchmarks have relatively low initial costs and reflect a significant difference in the amount of funds allocated. The greatest difference is observed in the Kama innovation territorial production cluster - more than 4 times or by 319,147 million rubles.

Next, we consider the parameter characterizing the number of participants (output) (Fig. 5). Note that in this indicator there is the smallest number of "non-optimal" provisions, namely, 9 clusters at once without benchmarks are in the equilibrium point, which indicates a sufficient number of participants.

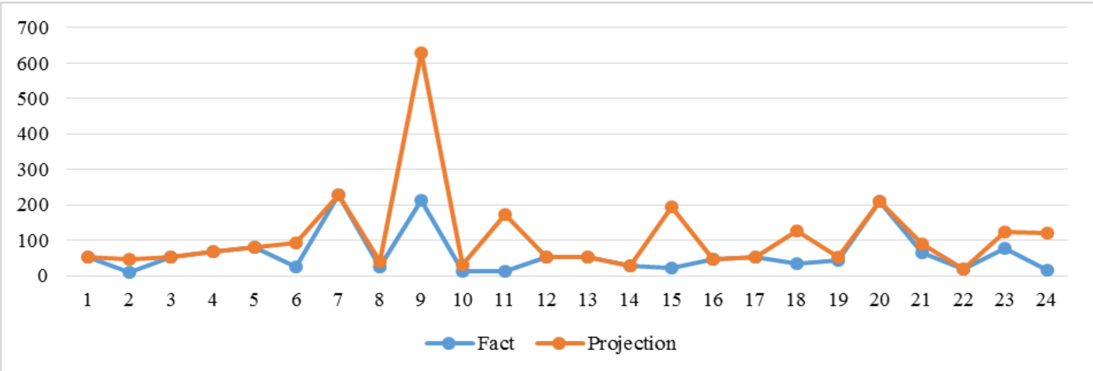

Fig. 5. Comparison of actual (Fact) and optimal (Projection) number of cluster members

Nevertheless, in half of the objects of research, changes are required, which in many cases relate to the repeated increase in economic entities of the cluster. It is noteworthy that in most of them there was also a significant excess of the allocated funds, which was shown by the analysis of the previous parameter, as a result of which it can be assumed that the excess funds should be directed to attracting and supporting new participants.

Analyzing the number of employees of enterprises participating in clusters, one can not but tell about the similarity of the dynamics of changes with the number of enterprises (Fig. 6).

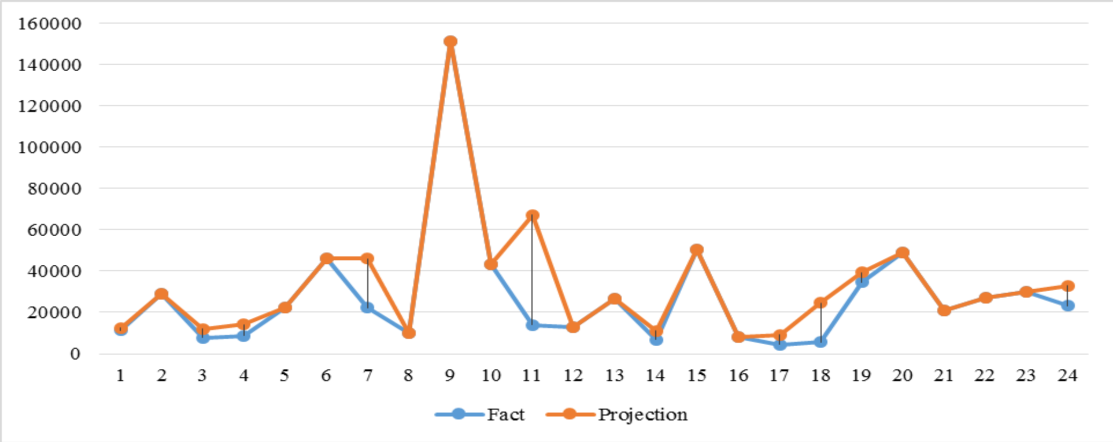

Fig. 6. Comparison of actual (Fact) and optimal (Projection) number of employees of cluster enterprises

Thus, already more than half of the clusters (14) are optimal in terms of the number of people employed in enterprises. We can assume that in the case of a proportional increase in the number of employees and the number of enterprises, or an extensive increase in production, this ratio will not change, and with the attraction of new investments, the position of benchmarks may shift.

Considering the efficiency of use of the territory on which the clusters are based, we also note a potential trend aimed at its increase for 16 clusters (Fig. 7).

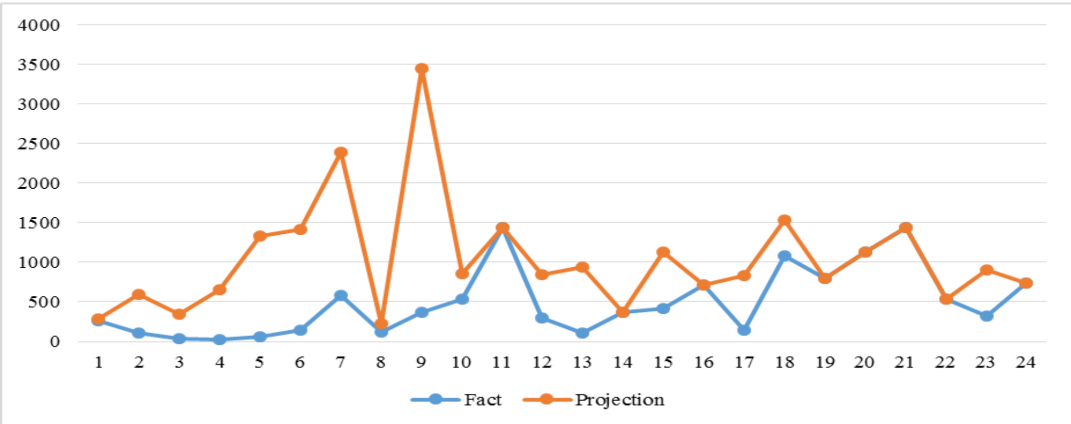

Fig. 7. Comparison of actual (Fact) and optimal (Projection) area of territories

However, despite the prevailing trend in the recommended cluster size, we note the fact that the expansion of the territory entails both positive and negative consequences. The positive factors include an increase in production capacity and, as a result, an increase in output, its quality, as well as possible differentiation and access to new markets. On the other hand, transaction costs will increase, which will be reflected in the increase in costs for logistics, coordination and accommodation.

2. Summary

The final indicator characterizing the output data was the volume of revenue of enterprises that are part of clusters (Fig. 8). In accordance with the results obtained, only 6 clusters, including benchmarks, generate 24 from a satisfactory level of revenue; for the rest, the estimated values are one and a half times higher than the actual values. The Scientific and Production Cluster of Siberian Science is the largest lagging behind in this indicator, where revenues are 11.5 times lower than the optimal value, which can be justified by high-tech production and low investment attractiveness of the industry.

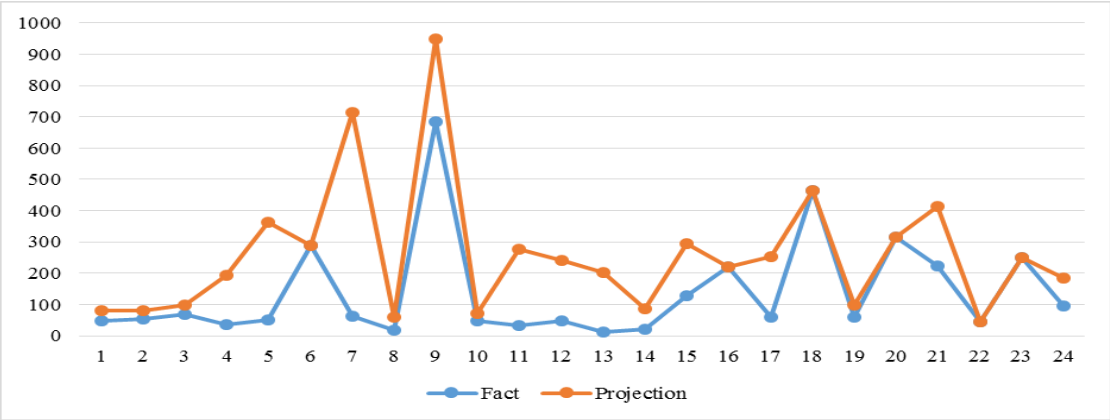

Fig. 8. Comparison of actual (Fact) and optimal (Projection) volumes of gross revenues of enterprises

The final indicator of the analysis was the amount of funds allocated for research and development (R & D) (input data). Considering the dynamics of deviations in this indicator, we note a multidirectional trend. None of the considered clusters has a shortage of funds spent on R & D, the opposite situation is observed when expenses should be reduced. The explanation of this paradoxical conclusion can be that investments in high-tech industries do not produce results in the short term, which affects the aggregate indicator of cluster efficiency. This type of investment can be defined as venture capital investment, which in most cases is directed by the state.

Table 1. List of innovation clusters and benchmarks

№	DMU	Score	Benchmark (Lambda)		
			Petrochemical territorial cluster of the Republic of Bashkortostan	Titanium cluster	Complex processing of coal and industrial waste
1	Pharmaceuticals, biotechnology and biomedicine	0,210	-0,256		
2	Cluster of innovative technologies ZATO Zheleznogorsk	0,038	0,139	0,814	
3	Cluster "Zelenograd"	0,049	0,222		0,132
4	Biotechnological innovation territorial cluster Pushchino	0,500	0,189		0,610
5	Innovative territorial cluster of nuclear physics and nanotechnologies in the city of Dubna	0,201		0,347	1,588
6	Cluster "FIZTECH-XXI"	0,083	1,177	0,143	0,863
7	Research and Production Cluster Siberian Science	0,465	0,534		2,483
8	Energy efficient lighting and intelligent lighting control systems	0,350	0,182	0,035	
9	Kamsky innovation territorial production cluster	0,234	2,959	0,231	
10	Aerospace cluster	0,092		1,586	
11	Cluster of medical, pharmaceutical, radiation technologies	0,920	0,700	1,208	
12	Pharmaceuticals, medical technology and information technology	0,240		0,150	1,065
13	Nuclear Innovation Cluster of the city of Dimitrovgrad of the Ulyanovsk Region	0,476	0,028	0,703	0,741
14	Biopharmaceutical cluster	0,238	0,061	0,218	0,254
15	Shipbuilding Innovative Territorial Cluster	0,547	0,893	0,241	

16	Complex processing of coal and industrial waste	1,000			1,000
17	New materials, laser and radiation technologies (Troitsk)	0,074			1,152
18	Nizhny Novgorod industrial innovation cluster in the field of automotive and petrochemistry	0,495	0,203		1,826
19	Innovative territorial cluster rocket engine "Technopolis" New Star "	0,324	0,141	1,194	
20	Petrochemical territorial cluster of the Republic of Bashkortostan	1,000	1,000		
21	Development of information technology, instrument making electronics, telecommunications and information and telecommunications in St. Petersburg (Information technology direction)	0,309		0,226	1,832
22	Titanium cluster	1,000		1,000	
23	Consortium Scientific, educational and industrial cluster Ulyanovsk-Avia	0,495	0,477	0,117	0,426
24	Innovative territorial cluster of aviation and shipbuilding	0,377	0,553	0,217	

3. Conclusions

Thus, we analyzed the activities of 24 innovation clusters of the Russian Federation created in various sectors of the economy based on basic models of data envelopment analysis method. As a result of the evaluation and analysis of the comparative efficency of these clusters, we found leading clusters, we called them benchmarks, on the basis of the ratio of output parameters (number of cluster subjects, participants' revenue, etc.) and input (financing). We also identified the clusters closest to the identified benchmarks and outsider clusters. The research also provides recommendations on the transformation of input and output parameters to achieve maximum relative efficiency of innovative clusters.

Acknowledgements

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References

[1] Porter M.E. Clusters and the new economics of competition, Harvard business review, Volume 76, Issue 6, 1998 Nov-Dec, Pages 77-90

[2] Harford J. What drives merger waves?, Journal of financial economics, Volume 77, Issue 3, September 2005, Pages 529-560

[3] Bresnahan T., Gambardella A., Saxenian A. 'Old economy' inputs for 'new economy' outcomes: Cluster formation in the New Silicon Valley, Industrial and Corporate ChangeVolume 10, Issue 4, 2001, Pages 835-860

[4] Rodnyansky D., Yasnitskaya Y., Polyakova O. Energy clusters and their value in export policy, SGEM 2016, BK 2: POLITICAL SCIENCES, LAW, FINANCE, ECONOMICS AND TOURISM CONFERENCE PROCEEDINGS, VOL III , pages 205-211

[5] Menzel M., Fornahl D. Cluster life cycles-dimensions and rationales of cluster evolution, Industrial and Corporate Change, Volume 19, Issue 1, 22 July 2009, pages 205-238

[6] Audretsch D. Agglomeration and the location of innovative activity, Oxford Review of Economic Policy, Volume 14, Issue 2, 1998, Pages 18-29

[7] Rodnyansky D., Yasnitskaya Y., Koryakina T. Assessment of cluster policy implementation effectiveness in the Russian regions, REVISTA PUBLICANDO Volume 4, Issue 13, 2017, pages 502-514

[8] Cooke P. Regional innovation systems, clusters, and the knowledge economy, Industrial and Corporate Change, Volume 10, Issue 4, 2001, Pages 945-974

[9] Tallman S., Jenkins M., Henry N., Pinch S. Knowledge, clusters, and competitive advantage, Academy of Management Review, Volume 29, Issue 2, April 2004, Pages 258-271

[10] Carlsson B., Jacobsson S., Holmen M., Rickne A. Innovation systems: Analytical and methodological issues, Research Policy, Volume 31, Issue 2, 2002, Pages 233-245

[11] Audretsch D., Feldman M. Innovative clusters and the industry life cycle, Review of

Industrial Organizationm Volume 11, Issue 2, 1996, Pages 253-273

[12] Suleri, J., & Cavagnaro, E. (2016). Promoting Pro-environmental Printing Behavior: The Role of ICT Barriers and Sustainable Values. *Dutch Journal of Finance and Management, 1*(1), 38. https://doi.org/10.20897/lectito.201638

[13] Pontes, L. B., & Albuquerque, A. B. (2017). Managing Database Services: An Approach Based in Information Technology Services Availabilty and Continuity Management. *Journal of Information Systems Engineering & Management, 2*(1), 1. https://doi.org/10.20897/jisem.201701

[14] Yazdani Chamzini, A., Motalebian Chaleshtori, M., & Bakhshinejad, M. (2016). Effect of the Quality of Accruals on the Investment Efficiency of the listed Companies in Tehran Stock Exchange. *UCT Journal of Management and Accounting Studies, 4*(4), 17-23.

[15] Abdul Rahman, S. (2019). Example Construction as a Devise to Reveal Awareness of Calculus Integration. *International Electronic Journal of Mathematics Education, 14*(1), 233-241. https://doi.org/10.29333/iejme/3999

[16] Ali, S. M., Reddy, V. V. K., & Kalavathi, M. S. (2019). Coupled random PWM technique for dual inverter fed induction motor drive. *International Journal of Power Electronics and Drive Systems*, *10*(1), 58.