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Elena I. Piskun [a], *Konstantin N. Brusnikin* [b]

[a] Sevastopol State University, Sevastopol, Russian Federation

[b] State Scientific Center of the Russian Federation, I. P. Bardin Central Research Institute of Ferrous Metallurgy, Moscow, Russian Federation

SPATIAL-RATING ASSESSMENT OF ENTREPRENEURIAL PERFORMANCE IN INDUSTRIAL PARKS OF RUSSIAN REGIONS[1]

Abstract. Analysis of statistics at the micro-level shows that the development trends of a large number of resident entrepreneurial structures of industrial parks are characterised by adverse dynamics. Accordingly, assessment of the performance of entrepreneurial structures and improvement of their management models in the general system of industrial parks become more relevant. This paper presents a methodological approach to the construction of a spatial-rating assessment of the performance of entrepreneurial structures in the system of industrial parks functioning. As a result, two groups of Russian regions were identified, among which a potential resident, when making a decision on the placement of production facilities, can choose a region taking into account its investment attractiveness and industrial activity. Two discriminant groups of industrial parks were determined, the condition of which can be defined as economically inefficient and efficient, by evaluating parks with low and high values of the park rating level in terms of attractiveness for external investors and resident entrepreneurial structures. The proposed methodological approach can be applied to improve the quality of decisions on the formation of differentiated strategies for sustainable development of both individual entrepreneurial structures in the system of industrial parks and their clusters, and regions as a whole. It is recommended for both enterprises and industrial parks when making decisions on the formation of strategies and development scenarios, as well as for federal and regional authorities when designing documents for the territorial development on the strategic and tactical level.

Keywords: spatial-rating assessment, discriminant model for spatial assessment, cluster analysis, regions' classification, industrial parks' categories, brownfield industrial parks, greenfield industrial parks, complex industrial parks, entrepreneurial performance

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ИССЛЕДОВАТЕЛЬСКАЯ СТАТЬЯ

Е. И. Пискун [а], *К. Н. Брусникин* [б]

[а] Севастопольский государственный университет, г. Севастополь, Российская Федерация

[б] ГНЦ РФ, Центральный научно-исследовательский институт черной металлургии им. И. П. Бардина, г. Москва, Российская Федерация

Пространственно-рейтинговая оценка деятельности предпринимательских структур в индустриальных парках российских регионов

Аннотация. Анализ статистики на микроуровне показывает, что тенденции развития большого числа предпринимательских структур — резидентов индустриальных парков характеризуются неблагоприятной динамикой. В этой связи актуализируются вопросы оценки эффективности деятельности предпринимательских структур и совершенствования моделей управления ими в общей системе индустриальных парков. В работе предложен методический подход к построению пространственной рейтинговой оценки эффективности деятельности предпринимательских структур в системе функционирования индустриальных парков. В результате были выделены две группы регионов Российской Федерации в зависимости от размещения потенциальным резидентом производственных площадей в регионе с учетом его инвестиционной привлекательности и промышленной активности. Также были получены две дискриминантные группы индустриальных парков, состояние которых можно определить как экономически неэффективное и эффективное путем оценивания парков с низким и высоким значением уровня рейтинговой оценки с точки зрения привлекательности для внешнего инвестора и предпринимательских структур-резидентов. Предложенный методический подход дает возможность повысить качество принимаемых решений по формированию дифференцированных стратегий устойчивого развития как отдельных предпринимательских структур в системе индустриальных парков, так и их кластеров, регионов в целом. Полученные результаты могут быть применены как предприятиями, так и индустриальными парками при принятии решений о формировании стратегий и сценариев развития, а также органами федерального и регионального управления при разработке документов развития территорий как в стратегическом, так и тактическом плане.

Ключевые слова: пространственно-рейтинговая оценка, дискриминантная модель пространственной оценки, кластерный анализ, классификация регионов, категории индустриальных парков, индустриальные парки типа браунфилд, индустриальные парки типа гринфилд, комплексные индустриальные парки, предпринимательская деятельность

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Introduction

Modern processes of the operation of entrepreneurial structures (ES) in the system of industrial parks (IP) are influenced by a large number of both external and internal factors that are characterised by a high level of uncertainty and a destabilising nature of the impact. In this regard, the issues of assessing the performance of entrepreneurial structures, management companies and improving their management models in the general system of industrial parks are becoming especially relevant. Innovative entrepreneurial structures (Lerner & Stern, 2016) ensure breakthrough economic growth of territories (Glaeser, 2009; Glaeser et al., 2012; Chatterji et al., 2013). «Industrial-technology parks focus primarily on filling the space with commercially efficient companies using modern technologies, attracting investment and creating jobs» (Wojewnik-Filipkowska & Kowalski, 2015). One of the ways to improve the performance of ES management in the system of IP operation is the use of a rating approach.

The specified approach is appropriate to use when evaluating objects that are multi-component. Such objects include entrepreneurial structures, whose activities are multifaceted and assessed by a significant number of groups of indicators that characterise the production, financial and economic, social and other aspects of their functioning. As a result of the use of the rating approach on the basis of a set of integral indicators, an entrepreneurial structure receives comprehensive information, which can be used:

— for internal monitoring of activity and comparison of its results with those of competitors,

— for informing interested stakeholders, such as banks, partners, investors, and so on.

This study uses a systematic approach, consisting in the fact that the object is considered as a complex system, including a set of interdependent and interrelated elements both inside and out-

side. Therefore, in the following presentation, entrepreneurial structures are considered within the system of industrial parks functioning.

Theoretical Framework

The analysis of the approaches to the assessment and rating of industrial parks (Belenov & Smolyaninova, 2014; Krivorotov et al., 2016; Lyapina et al., 2019) existing in the economic environment made it possible to conclude that it is advisable to improve them using methods of economic and mathematical modelling. They provide a systematic assessment of the performance of entrepreneurial structures in the general system of industrial parks. Thus, among the generalising indicators that most fully reflect the real economic state of the operation of industrial parks and their process owners, residents and the management company, there are three main groups aimed at assessing the state of the industrial park, the state of entrepreneurial structures of the industrial park and the state of socio-economic development of the region where the industrial park is based (Sandler & Kuznetsov, 2015; Nikitaeva & Andryushchenko, 2018; Orlova, 2014; Simchera, 2008; Tatuev, 2015).

There are some shortcomings in the methods of constructing an information space for evaluation considered by scientists. Accordingly, insufficient justification of the chosen system of evaluation indicators is due to the imbalance of key performance indicators, a high level of subjectivity in assessing the share of significance of indicators in the final group of factors (Samostroenko & Shatokhina, 2016); the factors of park positioning in the rating system of industrial parks are not taken into account (Tikhanov et al., 2016); the general evaluation algorithm is insufficiently justified from the point of view of the systematic approach (Akberdina et al., 2017); unconvincing justification of ball intermediate assessments and the ranking of the influence of factors of the internal environment and the activities of residents of the industrial park in the comparative database is not taken into account (Plakhin et al., 2016). Other factors include separately considered indicators for assessing social and external efficiency (Samostroenko & Shatokhina, 2016), the share of residents in the economic activity of the region (Akberdina et al., 2017; Gupta, 2020; Greenstone et al., 2010). Also, there are separately distinguished groups of performance indicators of anchor residents and residents based on the territory of IP (Barrera et al., 2021), factors of production growth (Kuznetsova et al., 2019), indicators of the economic efficiency of the park residents, and the budgetary efficiency of the park residents (Samostroenko & Shatokhina, 2016). Within the framework of the above papers, there is no unified point of view, neither regarding the directions for assessing the ES performance in the IP operation system, nor regarding the choice of the most significant indicators that characterise them. Disadvantages of the existing approaches include the prevailing expert assessments of the synergistic effect of the ES performance (both the management company and residents), the budgetary efficiency of clusters of companies associated with resident companies, etc. This is partly due to the relatively short history of IP development, the lack of information support for assessing the ES performance in the IP operation system. However, further it is advisable to use a combined approach, which takes into account both conceptual (expert) and factual (statistical) information about the ES performance in the IP system.

The aim of the study is to develop a methodological approach in order to build a spatial rating of the performance of entrepreneurial structures in the system of industrial parks in Russian regions, which, based on the grouping of parks according to the state of their activities taking into account the economic state of the park operation environment, can be used improve the quality of decisions taken to manage the development of entrepreneurial structures of an industrial park.

Research Methods and Data

Methodology of spatial-rating assessment of entrepreneurial activity within the system of Russian regional industrial parks includes: stage 1 — establishment of a system of research indicators; stage 2 — grouping and research of regional factors of the ES performance in the IP system; stage 3 — development of a model for grouping industrial parks into categories; stage 4 — development of a model for identifying the class of an industrial park by the performance level of the IP residents. Further, we consider their content.

To build a rating assessment of an ES, it is necessary, first of all, to analyse the statistical information base of the study, which is the content of stage 1. As noted above, existing approaches to assessing the performance of entrepreneurial structures on the territory of industrial parks and the park management system as a whole have significant differences, therefore, the basic system of research indicators was formed on the basis of GIS data[1], as well as data of the Federal State Statistics

[1] Geographic information system. Industrial parks. Technoparks. Clusters. Retrieved from: https://www.gisip.ru/#!ru/ (Date of

Service[1], and includes 82 indicators characterising 16 categories of structural directions for assessing the economic development of an industrial park and its macro-environment. Due to the lack of informational support for a large number of indicators during the analysed period (2019), it became necessary to reduce the dimension of the information space.

The main goal of stage 2 is to study regional features of development and further grouping of regions depending on the degree of manifestation of industrial activity in the regions, and the structural orientation of regional processes.

The results of this classification make it possible to position IPs in relation to their external environment of operation, and to assess the investment attractiveness of the region for the placement and development of the ES in the IP system. Multivariate statistical analysis methods, hierarchical and iterative methods for the implementation of the grouping model were applied to perform reasonable grouping of regions and position regions in relation to their economic orientation.

At stage 3 of the methodology, models of spatial grouping of industrial parks are developed and the features of the park development are identified within each category — "brownfield", "greenfield", and "complex". These models can be used to assess the homogeneity and stability of groupings categories of industrial parks, as well as to identify the most significant features in this category of parks for the formation of strategies and scenarios for ensuring the sustainable development of ESs in the IP system.

The grouping models at stages 2, 3 were constructed using the methods of cluster analysis (Piskun & Khokhlov, 2019), which allows for grouping and comparison of multidimensional objects (parks) based on the numerical values of the features involved in their description. To quantify the differentiation or proximity of clusters, we used a set of metrics, that is, the similarity or difference between the classified objects is established depending on the metric distance between them. The most commonly used metric is Euclidean distance. However, to cluster objects in the space of both quantitative and categorical variables, the use of standard metrics is ineffective (Delgado et al., 2012; Delgado et al., 2014; Guryanova et al., 2018). Therefore, for the assessment, it is advisable to use the following options for metrics:

1) City block metric (Manhattan distance):

$$d_{ij} = \sum_{k=1}^{m} \left| x_{ik} - x_{jk} \right|. \quad (1)$$

2) Percentage of disagreement:

$$d_{ij} = VALUE \left| A \neq B_i \right|. \quad (2)$$

To implement the models at stages 2 and 3, we used clustering methods such as the hierarchical agglomerative and iterative "*k*-means" method, which advantage is the absence of restrictions on the number of objects and their characteristic features.

The disadvantage of many agglomerative methods of forming a cluster structure, as noted by numerous researchers, is that the result of groupings is not always the geometric heterogeneity of the cluster. Therefore, for this study, we chose Ward's method that levels this feature. The advantage of this method over others is the fact that the *k*-means method is convenient for processing large statistical populations than the initial set of estimated indicators of industrial parks, and has a fast convergence. According to the chosen functionality, such partition that allows reaching the extreme (minimum or maximum) value should be considered the best. It is possible to accept the calculation of the Fisher's exact test based on the total inter-cluster and intra-cluster variances as such functionality. In this case, the partition in which the sum of the intra-cluster (intra-group) variances is minimal at the maximum inter-cluster variance should be considered optimal.

The last stage 4 is aimed at recognising and predicting the performance class of an industrial park, taking into account its category, indicator features and positioning in the national rating. This recognition model is implemented by the learning classification methods. The construction of the model assumes that each industrial park can be represented as an object of a *k*-dimensional vector of values for assessing the state of the park:

$$x = (x_1, x_2, \ldots, x_k)^T. \quad (3)$$

The model can be applied to establish a rule according to which the values of an object x vector belong to one of two possible classes of the park performance — a set of states ϕ_i, $i = 1, 2 \ldots, l$. To construct a discrimination rule, the entire space R of vector values x is divided into clusters R_i, $i = 1, 2 \ldots, l$, so that when x falls into R_i, an object is assigned to a certain performance class of an industrial park ϕ_i. The discrimination rule is selected in accordance with the principle of optimality based on a priori information, where each n object is

access: 11.08.2021).

[1] Federal State Statistics Service. Retrieved from: https://www.gks.ru/ (Date of access: 13.07.2021).

represented by a k-dimensional vector of discriminant variables

$$x_j^i = x_{jl}^i, \ldots, x_{jq}^i, \ldots, x_{jk}^i. \quad (4)$$

Thus, the methodology proposed above for the spatial rating of the performance of entrepreneurial structures in the system of industrial parks makes it possible to group parks according to the ES performance level and position the selected groups relative to the economic state of the park mesic environment. The development of a model for grouping IPs within the framework of the proposed methodology makes it possible to assess the statistical significance of indicators that have the strongest impact on the formed clusters and to perform the rating of parks to select a strategy for the development of entrepreneurial structures in the system of industrial parks.

Results

In accordance with the proposed methodology for the spatial rating of the ES performance in the IP system, at stage 1, we established the basic information space of indicators for assessing the performance of entrepreneurial structures. This space includes indicators of the activity of industrial parks and their residents, as well as indicators of the park mesic environment — indicators of the economic development of the region. The indicators were selected in accordance with the following criteria: importance from the point of view of a potential investor, importance in elaborating a development strategy for anchor residents and entrepreneurial structures of an industrial park.

To form the final assessment system, the main indicators of the activity of industrial parks and their entrepreneurial structures are presented in the following categories: "Basic Services of the Management Company", "Activities of Residents", "State Support of the Park", "Tax Incentives for Residents of the Park", "Production Capacity" (includes indicators of subgroups: "Use of the Territory", "Industrial Property", "Office Property"), "Power Supply" (includes indicators of subgroups "Electricity in the Park", "Thermal Energy in the Park", "Treatment Facilities", "Gas Supply in the Park", "Water Supply"), "Infrastructure and Communications of the Park" (includes indicators of subgroups: "Communication in the Park", "Transport Accessibility"), "Labour Force Availability".

For a systematic assessment of the activities of industrial parks, we also included indicators that reflect the general state of the IP macro-environment, i. e. indicators of the industrial development of the region in which the park operates.

While implementing the tasks at stage 2, we performed spatial grouping of regions of the Russian Federation for 2019 according to the platform data[1] based on indicators regarding the economic state of the mesic environment of the ES performance in the IP system, reflecting the investment attractiveness of the region for locating the site of an industrial park or choosing an existing park in the region. Two clusters of regions were obtained using Ward's hierarchical method based on the Euclidean distance between objects (Fig. 1).

The analysis of clustering centroids shows that there are two groups of regions that have a homogeneous direction of economic activity. Thus, the first cluster is characterised by high values of indicators, reflecting the distribution of organisations according to the assessment of factors affecting investment activity, employment in the manufacturing industry, the amount of advanced production technologies used, and the dynamics of investment in fixed assets. The second cluster is characterised by high values of the distribution of organisations by assessing the goals of investment in fixed assets, industrial production indices, production indices by "Manufacturing" type of economic activity. The statistical significance of the information indicators involved in clustering and the ratio of intra-group and inter-group variances allows us to speak about the adequacy of the grouping (Fig. 2).

The analysis of the distribution and grouping of regions occurs unbalanced in clusters, which is actually due to two main factors: the geographical distribution of resources for industrial enterprises and the involvement of the region in the formation of trade and industrial ties.

Further, as part of the implementation of stage 3, 150 functioning industrial parks of the Russian Federation were grouped based on a spatial sample for 2019 according to the platform data. The results of hierarchical clustering for the "brownfield" category of industrial parks allowed us to distinguish two clusters of industrial parks, and the results of variance analysis showed a significant excess of inter-group variances over intra-group ones, a clear separation of clusters, as well as the statistical significance of the F-tests at the level of 99 %, which indicates the general adequacy of the classification.

This grouping made it possible to distinguish two clusters: No. 1 is a group of industrial parks

[1] Geographic information system. Industrial parks. Technoparks. Clusters. Retrieved from: https://www.gisip.ru/#!ru/ (Date of access: 11.08.2021).

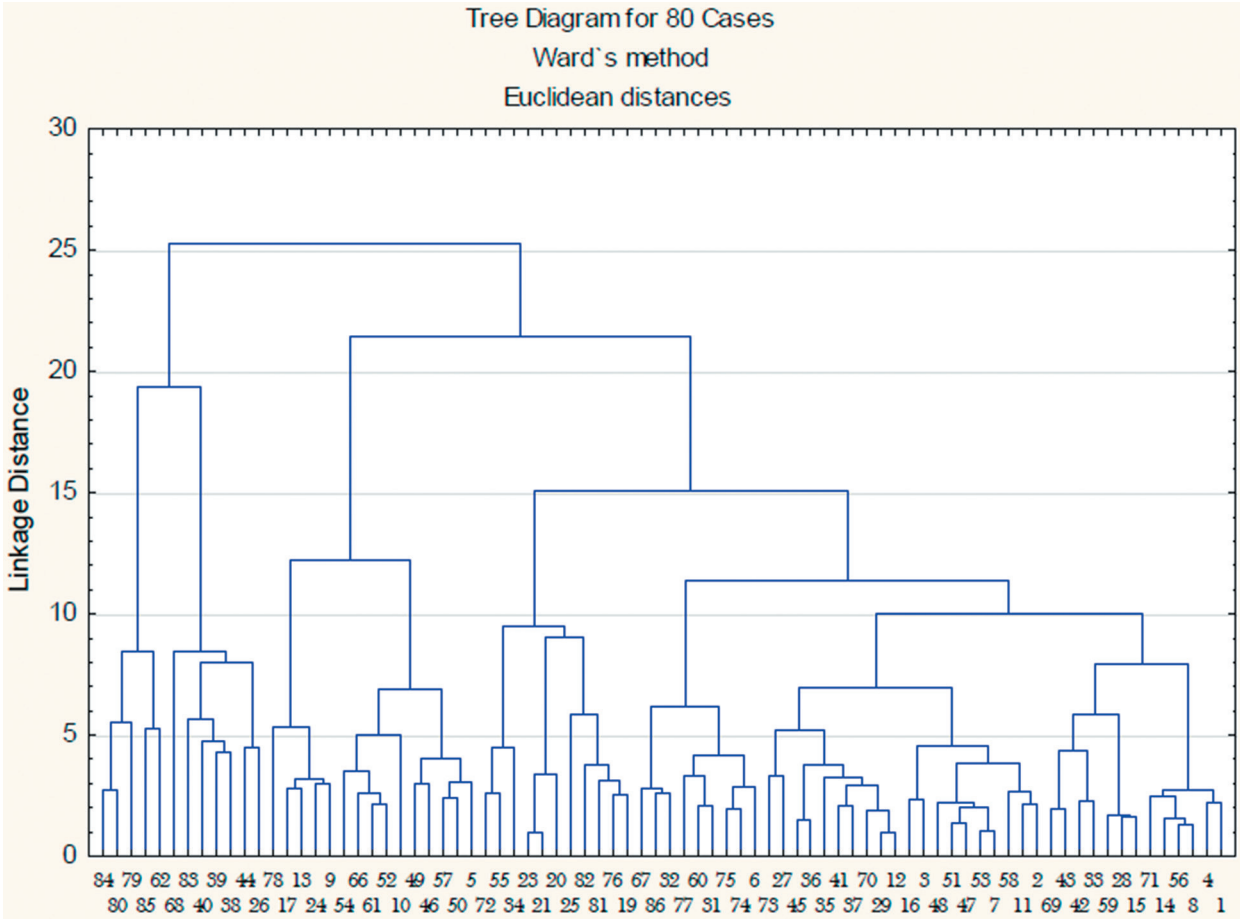


Fig. 1. *Tree diagram of the grouping of regions (source: Authors' calculations)*

Analysis of Variance (broad macro-indicators without Moscow)						
Variable	Between SS	df	Within SS	df	F	signif. p
x1	7,55343	1	71,44657	78	8,24627	0,005256
x2	3,04727	1	75,95274	78	3,12940	0,080801
x4	19,11448	1	59,88552	78	24,89633	0,000004
x5	3,93058	1	75,06942	78	4,08403	0,046722
x8	34,96693	1	44,03307	78	61,94028	0,000000
x10	1,05440	1	77,94560	78	1,05513	0,307503
x11	25,30809	1	53,69191	78	36,76590	0,000000
x12	19,20056	1	59,79944	78	25,04445	0,000003
x13	18,41715	1	60,58286	78	23,71195	0,000006

Fig. 2. *Values of variances and F-test for the grouping of regions (source: Authors' calculations)*

with a high level of support for resident entrepreneurial structures (K1), and No. 2 is a group of parks with a low level of support for entrepreneurial structures (K2). Cluster 1 is characterised by the presence of a high share of tax incentives in categories: income tax, transport tax, corporate property tax, and land tax. There are quite high values of indicators for the group of basic services of the management company, the number of residents and jobs created, the group for evaluating industrial and office real estate; water supply and railway interchange. The objects of the first cluster represent large functioning parks with energy-intensive technological processes involved in support programmes. Cluster 2 is characterised by rather low values of production capacity utilisation; participation in federal and regional government programmes, low values in the category of

Analysis of Variance (greenfield)						
Variable	Between SS	df	Within SS	df	F	signif. p
x3	19,16312	1	53,83688	72	25,6282	0,000003
x5	42,54952	1	30,45048	72	100,6081	0,000000
x6	12,61722	1	60,38277	72	15,0447	0,000230
x7	12,68722	1	60,31278	72	15,1457	0,000220
x8	9,14205	1	63,85795	72	10,3077	0,001980
x11	8,48729	1	64,51271	72	9,4723	0,002950
x12	16,89057	1	56,10943	72	21,6741	0,000014
x13	6,21825	1	66,78175	72	6,7041	0,011632
x14	16,61859	1	56,38141	72	21,2222	0,000017
x19	1,95718	1	71,04282	72	1,9836	0,163320
x20	2,08257	1	70,91743	72	2,1144	0,150268
x21	18,12041	1	54,87959	72	23,7733	0,000006
x22	7,98575	1	65,01425	72	8,8438	0,003999
x23	4,86817	1	68,13183	72	5,1446	0,026320
x25	8,97076	1	64,02924	72	10,0875	0,002198
x39	3,55903	1	69,44097	72	3,6902	0,058693
x41	1,89461	1	71,10538	72	1,9185	0,170304
x47	9,44124	1	63,55877	72	10,6951	0,001650

Fig. 3. *Values of variances and F-test for the "greenfield" group (source: Authors' calculations)*

tax incentives. This cluster reflects developing and small industrial parks that actually require support and further participation in federal and regional government programmes.

For the second category of industrial parks, "greenfield", there is a division of groups with an unbalanced concentration, which made it possible to draw preliminary conclusions about the existence of a cluster of parks with a greater degree of efficiency and intensification of the activities of entrepreneurial structures and park residents.

The analysis of centroids for the selected clusters of the "greenfield" category revealed the existence, as for the previous "brownfield" category, of groups of industrial parks with low and high levels of support for resident entrepreneurial structures (Fig. 4). Cluster 1 united efficiently developing parks with an expanded production base, a high level of activity of the management company and the use of production capacities of industrial parks, but low tax support.

Cluster 2 is characterised by an unstable position regarding the efficiency of using production facilities, while it has high tax incentives, but low indicators of infrastructure development, participation in regional and federal programmes, a low level of activity of the management company and the use of production facilities of industrial parks. However, it should be clarified here that for parks of the "greenfield" category, development on the territory of industrial facilities is more capital-intensive due to the need for the full development of the park territory. Therefore, the category of production capacities is actually one of the key ones when making management decisions for the development of entrepreneurial structures in the park.

Analysis of the composition of the "greenfield" category park clusters showed a significant imbalance of the selected groups with a predominance of the share of industrial parks in the second cluster, which indicates the need to intensify the pace of industrial production, increase the entrepreneurial activity of management companies, expand the logistics capabilities of the park and, accordingly, involve entrepreneurial structures in the overall process of the park activities in order to increase participation in federal support programmes.

For the third — "complex" — category of industrial parks, the following indicators are characteristic demarcation signs for the clusters ob-

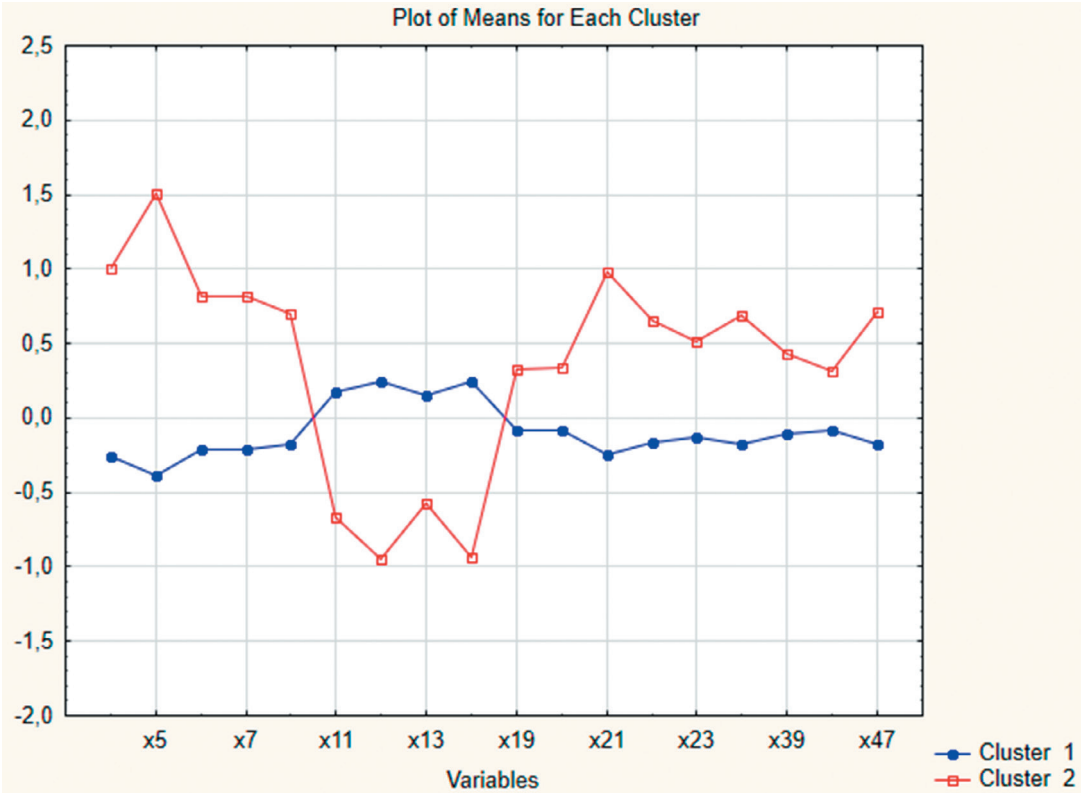


Fig. 4. *Diagram of averages for the "greenfield" category of parks (source: Authors' calculations)*

tained: leasing a land plot, construction of finished industrial buildings, the number of jobs created, the total and free territory, the free area of industrial real estate, the total area of office real estate for the accommodation of residents, the total and free electric power, the belonging of sewage treatment facilities, the presence of stormwater treatment facilities, free gas capacity, and distance to Moscow. Also, for this clustering, the industrial production index is statistically significant, which in its turn makes it possible to further focus on the influence of the synergistic effect of the sectoral interaction of the park and the region on the overall level of the ES performance in the IP system.

A specific feature of this grouping for the category of parks, which takes into account the elements of the structures of the "brownfield" and "greenfield" parks, is that Cluster 1 includes parks that function effectively in regions with predominantly high rates of industrial production, mainly in the extractive industries. The parks of Cluster 2 belong to the regions with a high share of the manufacturing industry in gross regional product (GRP) and high values of jobs created for park residents and the intensity of utilised capacities. A distinct feature of this grouping is the insignificance of the category of tax benefits, which may indicate a focus on the development and deepening of economic and infrastructural ties of residents of the park with the region. Analysis of variance for clustering showed the statistical significance of grouping indicators according to the Fisher's exact test at the level of 95 %, which indicates a high level of model quality.

In the selected clusters of the categories "Brownfield", "Greenfield", "Complex" there is an imbalance in the distribution of industrial parks. This necessitates the formation of alternative strategies for the development of entrepreneurial structures, which would take into account economic trends in the region, the possibility of attracting investment, the performance of resident enterprises (Table 1).

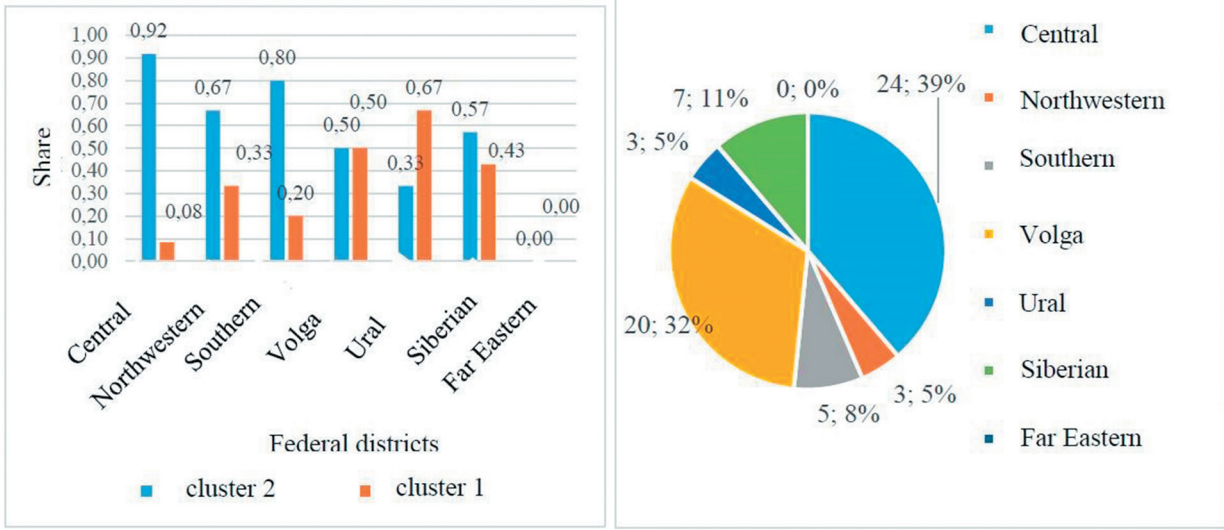
Equally important for assessing the ES performance in the IP system is also the IP positioning relative to its external environment of operation. The share distribution of IPs in clusters by regions and federal districts within certain categories showed that for the "brownfield" category, the concentration of IPs is observed in the Central

Table 1

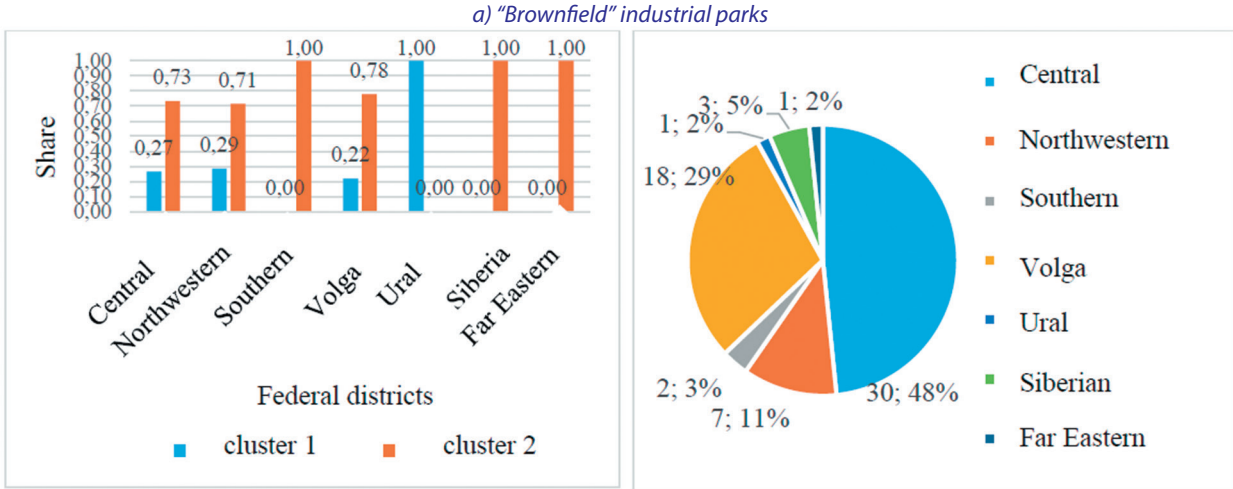
Cluster distribution of industrial parks

Cluster number	Share in the category of parks		
	Brownfield	Greenfield	Complex
Cluster 1	0.27	0.20	0.21
Cluster 2	0.73	0.80	0.79
Total parks	62	74	14

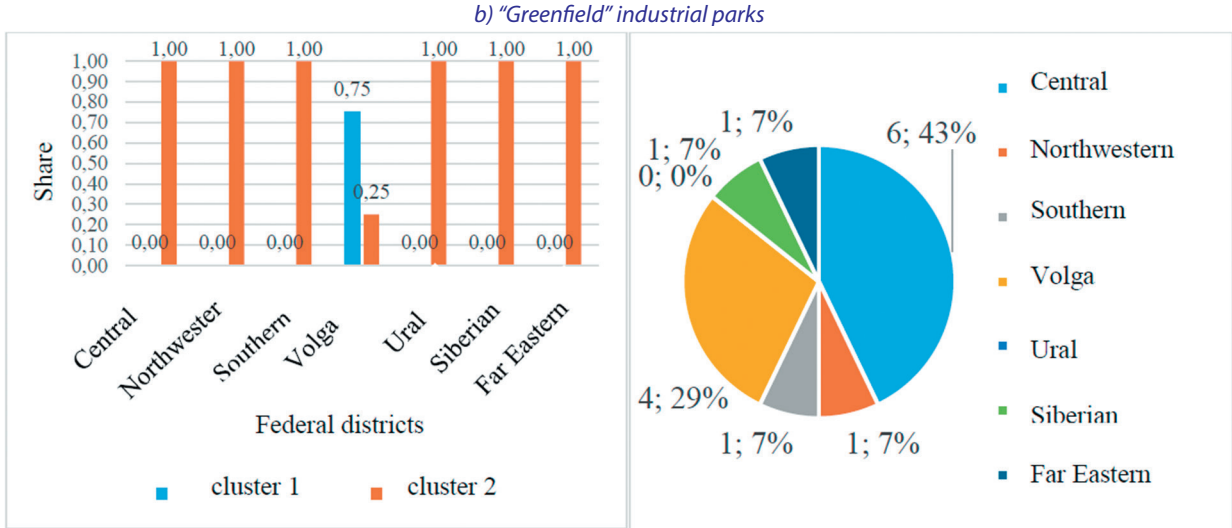
Source: Authors' calculations.



a) "Brownfield" industrial parks



b) "Greenfield" industrial parks



c) "Complex" industrial parks

Fig. 5. *Distribution of industrial parks (source: Authors' calculations)*

(39 %), Volga (32 %) and Siberian Federal Districts (11 %) (Fig. 5a).

As seen from Figure 5, the IP ratio for the "greenfield" category is similar to the previous group, whereby the highest concentration of IPs is observed in the second cluster. This distribution is confirmed by the need to intensify the rates of not only industrial production in these

Table 2

Statistical characteristics of discrimination

$N = 42$	Discriminant Function Analysis Summary No. of vars in model: 12; Grouping: shared cluster (2 grps) Wilks' Lambda: .06194 approx. F (12.29) = 36.602, $p < .0000$					
	Wilks' Lambda	**Partial Lambda**	***F*-remove (1.29)**	***p*-value**	**Toler**	**(*R*-Sqr.)**
x_3	0.082	0.755	9.43	0.005	0.329	0.671
x_{10}	0.066	0.943	1.76	0.195	0.763	0.237
x_{11}	0.183	0.339	56.60	0.000	0.244	0.756
x_{19}	0.074	0.842	5.44	0.027	0.070	0.930
x_{20}	0.140	0.443	36.49	0.000	0.135	0.865
x_{22}	0.069	0.901	3.18	0.085	0.105	0.895
x_{26}	0.080	0.777	8.33	0.007	0.427	0.573
x_{30}	0.083	0.746	9.86	0.004	0.621	0.379
x_{35}	0.080	0.774	8.47	0.007	0.224	0.776
x_{36}	0.086	0.721	11.22	0.002	0.253	0.747
X_{rating}	0.072	0.858	4.79	0.037	0.534	0.466
$X_{category}$	0.068	0.916	2.66	0.114	0.836	0.164

Source: Authors' calculations.

clusters, but also the overall economic development, and to establish stable economic ties in the federal district. The unevenness and imbalance in the distribution of industrial parks both in spatial terms and in the states of their economic development confirm the need for individual positioning and rating of parks in relation to key factors of the external and internal environment, and taking these factors into account when forming a development strategy for residents of the park, since they have a significant impact on the ES performance in the IP system.

At the final stage (stage 4) of the proposed methodology, we built a model for assessing and predicting the performance class of industrial parks. To implement the tasks of this stage, we built a discriminant model based on an additional grouping of IPs taking into account such characteristics of industrial parks as the type of park, the rating of investment attractiveness and the rating of the IP attractiveness among ES residents of the IP. The following indicators turned out to be statistically significant at the level of 90–95 % for this model: lease of finished production premises (x_3), participation in regional state programmes (x_{10}), income tax incentives (x_{11}), existing production facilities intended for the accommodation of residents (x_{19}), free area of industrial real estate (x_{20}), total area of office real estate intended for accommodation of residents (x_{22}), heat source (x_{26}), gas capacity (x_{30}), distance to the nearest city (x_{35}), distance to the regional centre (x_{36}), category of industrial parks ($X_{category}$), position of the industrial park in the general rating (X_{rating}). General adequacy is confirmed by the statistical characteristics of the general and partial Wilks' lambda values, the p-value and the *F*-test at the level of 95 % (Table 2).

As a result of modelling, we obtained two discriminant groups of industrial parks, the state of which can be defined as economically inefficient ($Y_1 = 1$) and efficient ($Y_2 = 2$). This division was achieved by evaluating parks with a low and high value of the rating level in terms of attractiveness for external investors and resident ESs. Analysis of the squared Mahalanobis distances to the centres of the selected groups and the values of the posterior probabilities confirmed the correctness of assigning objects to discriminant groups. The general view of the rating forecast model can be represented as follows:

$$\begin{cases} Y_1 = \\ = 4,287x_3 - 1,225x_{10} - 2,142x_{11} + \\ +0,596x_{19} - 0,739x_{20} - 0,166x_{22} + \\ +1,801x_{26} - 1,7492x_{30} + 0,119x_{35} - \\ -0,856x_{36} + 1,128x_{rating} - \\ -1,219x_{category} - 4,931; \\ Y_2 = \\ = 20,15x_3 + 3,94x_{10} - 20,34x_{11} + \\ +9,99x_{19} - 76,96x_{20} - 5,21x_{22} - \\ -10,80x_{26} + 12,94x_{30} + 11,63x_{35} - \\ -11,10x_{36} - 4,20x_{rating} + \\ +1,79x_{category} - 24,09. \end{cases}$$

The resulting system of discriminant equations can be used to forecast the performance class of new industrial parks and determine among them the most attractive for the placement of resident entrepreneurial structures from the point of view

of external entrepreneurial structures which are potential residents of industrial parks (IP). The procedure for forecasting the performance class can be represented as follows. First, the values of IP indicators are substituted into discriminant functions, namely: leasing of business-ready industrial premises (x_3), participation in regional state programmes (x_{10}), income tax incentives (x_{11}), existing production facilities intended for the accommodation of residents (x_{19}), free area of industrial real estate (x_{20}), total area of office real estate intended for accommodation of residents (x_{22}), heat source (x_{26}), gas capacity (x_{30}), distance to the nearest city (x_{35}), distance to the regional centre (x_{36}), category of industrial parks ($X_{category}$), position of the industrial park in the general rating (X_{rating}). Next, a comparative analysis of the values of discriminant functions is performed and, based on the highest value of the function, the evaluated park is attributed to the selected performance classes.

Conclusion

The proposed methodology for building a spatial rating of the performance of entrepreneurial structures in the industrial park operation system can be applied for grouping and rating IPs to improve the quality of decisions made on the formation of sustainable development strategies differentiated for each cluster, of both individual ESs in the system of industrial parks, and their clusters, and regions in general.

In accordance with the proposed methodological approach, we have developed grouping models that can be used to assess the statistical significance of indicators that have the strongest impact on the formed IP clusters and to perform the rating of parks in order to select an adequate strategy for the development of entrepreneurial structures in the system of industrial parks of the regions of the Russian Federation.

These studies are recommended for use by entrepreneurial structures. Using the proposed and proven methodology, entrepreneurial structures can improve the quality of decisions, namely:

— based on the identified two groups of regions that have a homogeneous orientation of economic activity, a potential resident, when making a decision on the placement of production facilities, can choose a region considering its investment attractiveness, industrial activity, and the structural orientation of regional processes;

— within the selected clusters of each category — "brownfield", "greenfield", "complex" — groups with certain characteristics and performance indicators were obtained, which allows entrepreneurial structures to choose the one that will ensure the building of an effective strategy and scenarios for providing their sustainable development;

— the resulting system of discriminant equations makes it possible to forecast the performance class of new industrial parks and determine among them the most attractive for the placement of resident entrepreneurial structures from the point of view of external entrepreneurial structures-potential residents of industrial parks (IPs).

Based on the results obtained using the proposed methodological approach, federal and regional authorities can receive information on the performance of both industrial parks and entrepreneurial structures in the functioning system of IPs, taking into account the economic state of the regional environment, which can be used to design territorial development documents both on the strategic and on the tactical level.

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About the authors

Elena I. Piskun — Dr. Sci. (Econ.), Associate Professor, Professor, Department of Tourism, Service and Hotel Business, Sevastopol State University; Scopus Author ID: 57193735474; Researcher ID: S-7867–2017; http://orcid.org/0000-0002-4397-8143 (33, Universitetskaya St., Sevastopol, 299053, Russian Federation; e-mail: lenapiskun@mail.ru).

Konstantin N. Brusnikin — Deputy Head of Department for the Implementation of Scientific Developments, State Scientific Center of the Russian Federation, I. P. Bardin Central Research Institute of Ferrous Metallurgy; https://orcid.org/0000-0003-3870-0750 (23/9, 2, Radio St., Moscow, 105005, Russian Federation; e-mail: k.brusnikin@mail.ru).

Информация об авторах

Пискун Елена Ивановна — доктор экономических наук, доцент, профессор кафедры «Туризм, сервис и гостиничный бизнес», Севастопольский государственный университет; Scopus Author ID: 57193735474; Researcher ID: S-7867–2017; http://orcid.org/0000-0002-4397-8143 (Российская Федерация, 299053, г. Севастополь, ул. Университетская, 33; e-mail: lenapiskun@mail.ru).

Брусникин Константин Николаевич — заместитель начальника управления по внедрению научных разработок, Государственный научный центр РФ, Центральный научно-исследовательский институт черной металлургии им. И. П. Бардина; https://orcid.org/0000-0003-3870-0750 (Российская Федерация, 105005, г. Москва, ул. Радио, 23/9, стр. 2; e-mail: k.brusnikin@mail.ru).

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