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Investigation of Early Markers of Clustering: Experience in Applying Nonparametric Technique of Examination

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Abstract Article is devoted to the issue on early markers of formation of economic clusters, which are the specific regional conditions. In contemporary Russian economic reality, when the state implements the initiation of cluster projects in different geographical regions and economic sectors, particularly relevant is the task to analyze and identify the regional environment conducive to the successful cluster formation. In order to complete the task, authors propose to use non-parametric methodology of examination, allowing to analyze objects with a complex quality structure. Paper describes this technique, and tests it in an example of the emerging pharmaceutical cluster in the Volgograd region. Following the results of the study, a conclusion on the feasibility of establishing a cluster in the area, and the main insufficient conditions are identifies, the improvement of which will have a positive impact on the process of formation of the Volgograd pharmaceutical cluster

Keywords: *nonparametric examination, early markers of clustering, cluster formation, economic clusters.*

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1. Introduction

One of the urgent problems of the regional economy is the issue of identifying clusters, which is traditionally solved using the methods of calculating the localization coefficient, clustering method and the method of ‘input – output’ tables. However, in the Russian economic reality the formation of clusters does not follow the evolutionary process, but artificial one – with the direct participation of the governmental authorities. In addition to identifying functioning clusters, particularly relevant is the question of approving the establishment of economic clusters in a particular area. Under these conditions, the calculations of localization coefficients and clustering methods for determining cluster formations are not exhaustive because a cluster in a particular region might not yet exist. In our view, this issue is also relevant, and requires the development of a particular approach associated with the analysis of the early markers of clustering that exist in the certain area, which are the prerequisites or factors of regional clustering [5,6].

2. Theoretical Background

To solve this problem, authors propose a technique of early diagnosis of the clustering process, which is applicable in the Russian context. This technique will enable to identify the regions, which exhibit appropriate conditions for making the formation of economic clusters via state initiatives possible [9]. The proposed technique is a non-parametric examination, designed to support the evaluation of objects with a complex quality structure. The universality of this method enables to apply the study of early markers at any innovative cluster-evolving process regardless of industry sector. Application of a nonparametric examination method will help all stakeholders to objectify the process of clustering, and execute the right managerial decisions.

The ‘quality’ of a nonparametric examination is defined as a complex multi-piece property of the objects and phenomena, which may be described by a set of qualitative and quantitative indicators with some degree of certainty and eventually reduced to a single integral numerical value (i.e. indicator). This indicator will describe the ‘utility’ of the object to the user, the consumer or the researcher. The key point of the nonparametric examination is the correlation of ‘utility’ (i.e. what the subject is willing to pay or lose a certain resource), ‘price’ (i.e. what the subject is willing to spend for the acquisition of the required ‘utility’ properties of an object) and ‘environment’ of the system under study (i.e. the external factors that will largely determine the price of a particular object in a series of similar objects).

Technically the technique of nonparametric methodology consists of three main areas: 1) the definition of basic quality indicators and design of the questionnaire;

2) filling out the questionnaires by experts and approval of results; 3) ordinal and interval positioning of the 'price' of the studied object in a variety of similar objects, which is done by mapping the complex quality index on the axle of multiple 'prices'. The procedure of constructing and weighting of a directed graph, which is reflecting the complex quality of objects with complex structure, consists of ten basic steps.

1. Identifying the goal of the examination.
2. Formation of the group of experts.
3. Determination of the degree of confidence in each expert.
4. Determination of multiple quality indicators.
5. Formation of questionnaires containing questions and answers to determine the quality.
6. Processing questionnaires.
7. Construction of the hierarchical structure of individual indicators of quality – quality basis.
8. Determination of the relative importance of individual quality indicators in clusters and of clusters in respective groups.
9. Composition of the scale of assessments for each single quality indicator.
10. Evaluation of the elements of each scale.
11. Hierarchical synthesis (i.e. convolution) - determination of the weight of each element of the scale of the entire set of scales and assessments.

Application of this methodology to the assessment of regional situation starts with identification of key conditions of clustering. They may be different for each cluster formed. Thus, natural, geographical, geological, resource, manufacturing, research, infrastructure, financial and other conditions should be considered.

Further on, in order to assess the importance of individual conditions a group of experts should be formed, which is based on selection of an expert committee from a previously formed list of experts, selected in accordance with the candidates' competences [2,3]. Furthermore, the expert (or a group of experts) is obliged to carry out an objective and comprehensive analysis of the materials submitted for examination. Expert is expected to take into account the latest achievements of domestic and foreign science and technology, to determine their compliance with normative legal acts of the Russian Federation and the subjects of the Russian Federation, normative and technical documents and provide an inference based on such materials; comply with the legislation of the Russian Federation and the legislation of the subjects of the Russian Federation; ensure the objectivity and validity of the conclusions made on the object of examination [4].

The task of the experts is to rank the conditions of clustering according to their importance for the determination of the key conditions that affect the efficiency of the process of economic clusters' formation. Thus, the existing conditions given a certain rank, depending on the strength of their influence on the clustering process. At this stage, major and minor conditions that will determine the direction of state influence will be revealed.

To confirm the accuracy of ranking, the next stage of the examination involves the method of paired comparisons, which allows to relate the conditions of importance to each other (i.e. correlation). After determining the ranks of various conditions, the quantitative assessment of conditions on a set of indicators is executed. Then a reference cluster is selected, which is a comparison level to a newly formed cluster, which allows to identify the bottlenecks and the missing conditions required (i.e. the cluster benchmarking).

3. Methodology

This technique has been applied to the evaluation of the conditions of formation of a pharmaceutical cluster in the Volgograd region. The examination objective was to determine the importance of the regional conditions of clustering. Based on examination, authors assessed the regional context as to conclude on whether the establishment of a pharmaceutical cluster in this area is expedient, as well as the degree of influence of certain conditions on this process.

In the examination took part the doctors, PhDs, professors of Volgograd State University and Volgograd State Medical University, as well as practitioners working in the field of pharmacy. During the study, a total number of 47 questionnaires were received and processed.

The authors have highlighted the conditions to be evaluated in the course of the examination, namely scientific, infrastructure, and manufacturing. Since pharmaceutical clusters are innovative in nature (i.e. high-tech), it is the presence of innovative conditions that is crucial to the success of their formation. While the natural and geographical environment was not taken into consideration by the experts, although influential in the formation of other types of clusters, such as tourism, where these conditions would have a high priority value.

Thus, the quality indicators that affect the success of the clustering process and subject to evaluation were the presence in the region of [1]:

- Secondary and higher educational institutions of medical and pharmaceutical profiles (A1);
- Basic Science (A2);
- Industrial production of raw materials for pharmaceuticals (A3);
- Industrial production of pharmaceuticals (A4);
- Small businesses (start-ups and small innovative firms) (A5)
- Support for public authorities (A6);
- Developed pharmaceutical distribution network (A7)(note that the values in brackets correspond to the Figure 1).

According to the proposed method, the successful cluster formation process is an additive function of the above factors:

$$Q = f\left(A1,\ A2,\ A3,\ A4,\ A5,\ A6,\ A7\right), \qquad (1)$$

where Q - is an additive index, which determines the 'quality' of the object studied [9].

Experts, who filled the questionnaires, were asked to rank the factors according to their impact on the success of building a pharmaceutical cluster in the region. The lowest possible grade would be 7, the highest is 1 (i.e. the factor of the greatest effect is ranked with 1, and the smallest – 7). Analysis of ranking provided by experts' evaluations was done by finding an average value of the median values [3,8].

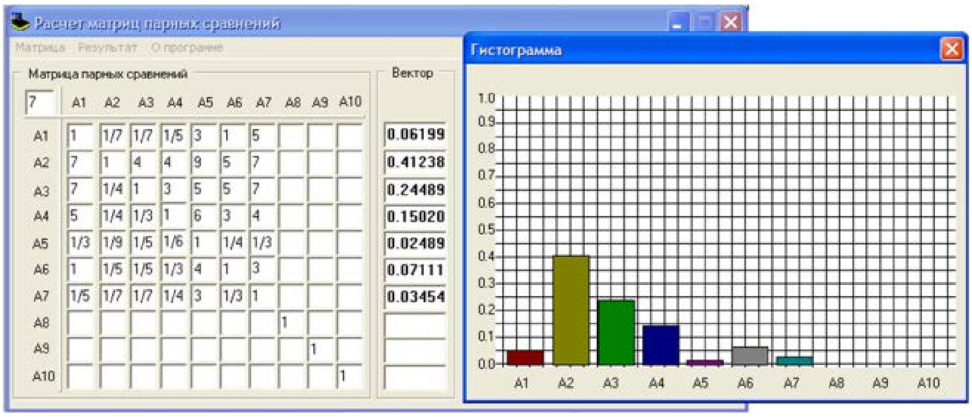

Figure 1. Ranking factors in the formation of the pharmaceutical cluster

4. Research Results

Thus, based on the increase in the average median value, the factors are located in a specific sequence (the number of factors in the list corresponds to the average of the median of 47 peer reviews, after the cut-off of noisy data):

1. A2 - basic science;
2. A3 - industrial production of raw materials for pharmaceuticals;
3. A4 - industrial production of pharmaceuticals;
4. A1 - the presence of higher and secondary educational institutions of medical and pharmaceutical profiles;
5. A5 - Small businesses (start-ups and small innovative firms);
6. A6 - Support of public authorities;
7. A7 - Developed pharmaceutical distribution network.

Because pharmaceutical clusters are classified as innovative, this ranking seems to be quite reasonable. A unique feature of this type of cluster is its formation around a scientific or research centers, which is the core of the cluster. Thus, placing the basic science in the first place seems natural. The distribution of the remaining rank is equally reasonable. At the top of the rankings, we find the industrial production of both the raw materials and drugs themselves, followed by educational institutions that train specialized professionals. The lowest level of importance have small businesses, public authorities and pharmaceutical distribution.

In the next stage of the study, we weight the factors of clustering by using the paired comparisons method, which enables to correlate their degrees of importance. The essence of the method is described in detail in [8,11]. The calculations were performed with the use of a software product [13]. Results of these calculations suggest that the upper part of the rating has not changed: 1. Basic Science (A2); 2. Manufacturing and production of raw materials for pharmaceuticals (A3); 3. Industrial production of pharmaceuticals (A4). But on the fourth place was replaced by the factor “support of public authorities” (A6), followed by “universities” (A1), “distribution” (A7), and “small businesses” (A5).

Analysis of the ranking distribution showed that the overwhelming value, according to experts, in the formation of a pharmaceutical cluster is basic science with the weighted value of 0.41. Then follow the average values of industrial raw material production – 0.24, the industrial production of pharmaceuticals – 0.15. Other factors have little impact: the public authorities – 0.07, universities – 0.06, distribution – 0.03, small businesses – 0.02.

Such a distribution of ranks indicate that the market categories dominate in the opinion of external experts, according to which the formation of a pharmaceutical cluster is perceived as a spontaneous and self-organizing process. In such circumstances, this ranking of factors has a crucial significance. Although, it should be noted that in the Russian realities we do not consider the evolutionary formation of the cluster, but the implementation of governmental initiatives, which influences the importance of a certain factor in the process of cluster creation.

Each factor is quantified on the basis of statistical data, or qualitatively, based on the opinion of the most competent group of experts. For example, the assessment of the factor A2 availability of sufficient “fundamental science” in the region and “number of patents and utility models per researcher”; factor (A1) “Universities” – “Number of universities per thousand persons” and “Number of postgraduate students per thousand persons”. Quantitative values are listed in Table 1.

Table 1. Evaluation of indicators of clustering factors

	Indicator	St. Petersburg	Volgograd
1	2	3	4
A1	Number of universities per thous.pers.	156/4.9 =31,8	16/1 =16
	Number of postgraduates per thous. pers.	15281/4.9 =3,12	2037/1 =2,03
A2	Public expenditure on basic science per researcher	7821,7/44676 =0,18	313,5/1805 =0,17
	Number of patents and utility models per researcher	2201/44676 = 0,05	414/1805 =0,23

Source: Rosstat

Without the possibility to quantify the factors, authors used the method of percentage estimates, as to weight their importance noted by the expert [7,8,9,10,11]. According to this method, a pairwise comparison of alternatives sets one of the alternatives as the reference point (i.e. the importance of 100 percent), while the second one has to be clearly worse (i.e. less than 100 percent), in order to execute the comparison (i.e. benchmarking). The evaluation result is the difference of values in percentage. Visually, this grading system is shown in Figure 2. Calculations and automation of the peer review process was carried out using specialized computer software [12]. St. Petersburg pharmaceutical cluster was set as a reference point, since it is the most successful and progressive cluster of this type in Russia according to experts. Hence, a comparison of St. Petersburg's cluster with an emerging pharmaceutical cluster in the Volgograd region was initiated. Fragment of detailed examination by a software system [12] is shown in Figure 2.

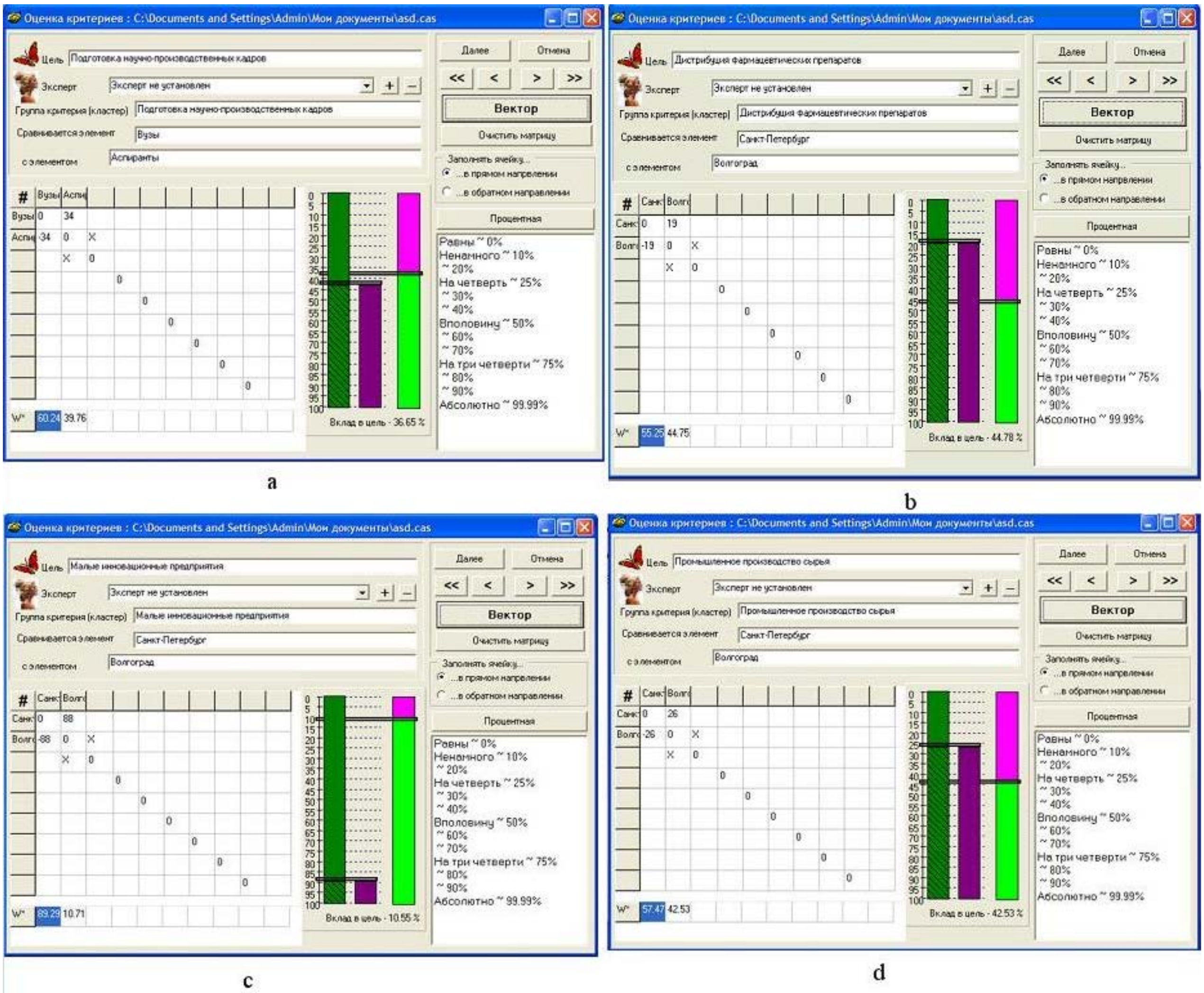

Figure 2. Fragment of an automatic detailed examination process

Table 2. Weighted and normalized values relative to the experts' assessments

Factor	Weight of the factor in a group of factors	Weight of the factor if a group of sub-factors	Synthesis of the alternative's weight to the respective factor: St. Petersburg	Synthesis of the alternative's weight to the respective factor: Volgograd
A1	0,062	0,602	156/4,9=31,8	16/1=16
		0,0373	0,665×0,0373=0,0248	0,335=0,0125
		0,397	15281/4,9=3118,57	2037/1=2032
		Procedure for adjusting the unit:		3118,6+2032=5155,57
				3118,57/5155,57=0,605
				2032/5155,57=0,395
		0,0246	0,605×0,0246=0,0148	0,395×0,0246=0,0097
A2	0,412	0,724	7821,7/44676=0,175	313,5/1805=0,173
		0,348		
		0,275	0,502×0,724=0,3634	0,497×0,724=24=0,3598
			2202/44676=0,0492	414/1805=0,229
			0,2782	
			0,177×0,275=0,0186×0,412=0,02	0,823×0,275=0,2263×0,412=0,0932
A3	0,245		0,574=0,1406	0,425=0,1041
A4	0,1502		22/4,9=4,49	3/1=3
			7,49	
			0,599=0,0899	0,400=0,06
A5	0,0249		0,892=0,0222=0,046	0,107=0,0027
A6	0,071		1	0,046
			1,046	
			0,956=0,0678	0,044=0,0031
A7	0,0345		0,552=0,0190	0,447=0,0154

Table 3. The sum of weights of the alternatives by factors, weighted according to the procedure of percentage estimates

Factor	Weight of the alternative to the respective factor	
1	2	3
	St. Petersburg	Volgograd
A1	0,0248	0,0125
	0,0148	0,0097
A2	0,03634	0,3598
	0,02	0,0932
A3	0,1406	0,1041
A4	0,0899	0,06
A5	0,0222	0,0027
A6	0,0678	0,0031
A7	0,019	0,0154
Sum of weights by factors	0,7625	0,6605
Sum by factors, weighted to units	0,536	0, 464
Sum by factors, weighted according to the percentage estimates technique	100%	86%

The peer ranking of alternatives for a variety of factors, held according to the established procedures [8], is followed by hierarchical synthesis of priorities' values. The essence of the hierarchical synthesis is to multiply the weights of the overlying elements of the hierarchy on the weight of the lower subordinate elements. Table 2 shows the preliminary weighted and normalized values of units to values of the expert assessments.

The next step in the calculation is the sum of weights of the synthesized alternatives for each relevant factor A1-A7. In essence, the production of values of the additive index Q, which determines the 'quality' of the research object according to the formula (1). The analyzed alternatives were the conditions of formation of pharmaceutical clusters in the Volgograd region and the city of St. Petersburg.

5. Conclusion

Identification As it was mentioned earlier, if we consider the St. Petersburg's pharmaceutical cluster as the standard (i.e. 100% according to the method of percentage estimates [9,10]), then the results of the expert and the statistical analysis of the situation in Volgograd is estimated at 86%, which suggests the presence in the region of sufficient conditions for cluster formation. Thus, the decision to form a pharmaceutical cluster in the Volgograd region seems reasonable. However, at the same time, the analysis revealed a slight lag from the reference point by the markers related to educational institutions of relevant profile, industrial production of pharmaceuticals, as well as a significant difference in the number of small businesses and support factors of public authorities. It is in these areas the efforts should be focused the most, as to achieve the goal of creating a pharmaceutical cluster in the area of study.

Thus, the technique of nonparametric examination was successfully tested for the analysis of the early markers of the formation of a pharmaceutical cluster in the Volgograd region. Although we believe that its capabilities are not limited to clusters of this particular industry, but are universal and can be applied to the study of clusters' prerequisites at any territory or sector.

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