MODELING THE PROCESSES OF REGIONAL DEVELOPMENT BASED ON GEOSTATISTICS METHODOLOGY

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Abstract
Paper deals with the economic essence of the main elements of geostatistics, study solves problems of spatial modeling regional development based on geostatistics and methodology of clusters. The purpose of this research is to adapt deterministic methods of geostatistics to the spatial modeling of regional industrial clusters. Particular attention is given to practical application of geostatistics methods for visualizing the monitoring network and its cluster structure. The paper offers model of industrial clusters of the Tatarstan Republic (region of Russian Federation) based on interpolation of data monitoring network, Delaunay triangulation and construction of Voronoi polygons.

Keywords: development, industrial clusters, spatial modeling, geostatistics
JEL classification: O1, R58

1. Introduction

In modern Russian practice remains a simplified approach to spatial localization of industrial clusters at the regional level, cluster development processes coincides with the administrative boundaries of region. An analysis of the spatial distribution of the points of economic growth of the leading world economies shows that industrial clusters rarely coincide within their borders with the region, subjects and institutions of economic development can be located within the boundaries of neighboring administrative units (Dzhindzholia et al., 2015). The insufficient level of the methodological tool for clusters spatial modeling significantly limits the possibilities of applied research of the Russian economic space in order to optimize strategies for industrial and innovative development of territories (Agafonov, 2010). Therefore, the development of methods for modeling and visualizing the development of clusters within the economic space of regions remains urgent (Artamonova and Hustalev, 2013). The solution of this scientific problem involves studying the processes of transformation of the internal structure of the economic space under the influence of clustering processes.

The author put forward a hypothesis about the possibility of practical application of the methodological tools of geostatistics as the central direction of the development of the conceptual foundations of clusters spatial modeling. Adaptation of basic methods and tools of geostatistics for problems of spatial modeling of clusters is focused on the following main aspects of this scientific problem:

formation of a system of formally clear quantitative criteria for the localization and agglomeration of production in order to identify clusters;

differentiation cluster from territorial production complexes, vertically integrated corporate structures and quasi-clusters;

formation of an empirical basis for investigating the spatial structure of regional industrial clusters;

development of unified methodological approaches to the selection of the metric and spatial resolution of the monitoring network;

consideration of the evolutionary dynamics of the development of industrial clusters through the comparison of changes in the internal structure of the cluster and the external manifestations of these changes in the economic space.

2. Data and method

Geostatistical analysis and visualization of the obtained results was carried out with the software tools QGIS 2.18. Information base of the research includes the materials of the Russian cluster Register compiled by the Russian cluster observatories of the Higher School of Economics (Moscow). Modeling of industrial clusters was carried out on the example of three clusters located on the territory of the Tatarstan Republic (region of Russian Federation):

cluster "New Materials" (number of participating organizations: 12, total number of employees: 27646 people),

"Food cluster of Tatarstan Republic " (number of participating organizations: 20, the total number of employees: 5023 people),

Agropolis "Alkiagrobioprom" (the number of participating organizations: 29, the total number of employees: 954 people).

As a basic characteristic of the organizational development of clusters is considered the average number of employees in cluster, which makes possible to compare the clustering processes in various spheres of economic activity.

In the Russian regions there are areas that are not covered by measurements of the economic value of ***Z***, which characterizes the dynamics of cluster development. Accordingly, interpolation values of the clustering efficiency indicators is the identification of the external effects of cluster economic activity on the basis of estimating the intermediate values of the values of the indicators from the available discrete set of known values. We describe the interpolation problem on some domain ***D*** for the system of points $x_i (i \in 0,1 \ldots, N)$ that do not coincide on the plane. Let the values of the function in question be known only at these points:

$$y_i = f(x_i) \quad y = 1, \ldots, N \quad (1)$$

Accordingly, the interpolation problem consists in finding a function ***F*** that:

$$F(x_i) = y_i \quad y = 1, \ldots, N \quad (2)$$

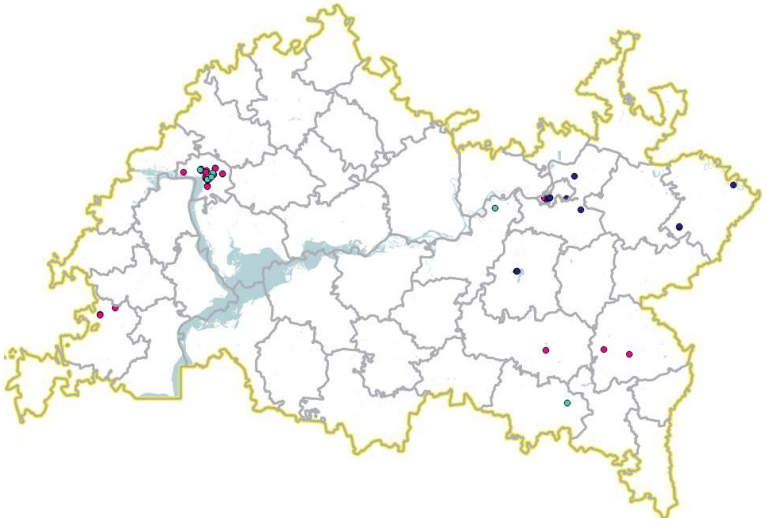
The use of deterministic interpolation models within the framework of the problem of spatial modeling of regional industrial clusters makes it possible to obtain a smoothed value of the economic value estimate at the point of space. The basic method for solving applied problems within the visualization of a monitoring network and its cluster structure is the Delaunay triangulation - the construction of triangles with vertices at measurement points, provided that the triangles are not intersected by edges and the minimum number of triangles that are obtuse. Thus, the Delaunay triangulation ***DT(S***) for a given set of points ***S*** on the plane is a decomposition into simplexes (triangles), for any of which all the points in ***S*** except for the points that are its vertices lie outside the circle circumscribed around the triangle.

Another approach to visualization of distributed data in space is the construction of Voronoi polygons. The Voronoi polygon P_i , constructed on the plane for a certain measurement point x_i, is characterized by the fact that it contains only those points whose distance from the point x_i is less than or equal to the distance to any other measurement point ***xi***. Note that the basis for constructing the Voronoi polygons lies in the neighborhood of the measurement points obtained during the Delaunay triangulation, the boundaries of each polygon P_i consist of segments of the middle perpendiculars drawn to the sides of the Delaunay triangles.

3. Analysis and Results

A comparative analysis of the basic theoretical approaches to the interpretation of the category "cluster" existing in economics has made it possible to conclude that the main distinguishing feature of the cluster is the geographical concentration of organizations in a certain field of activity. In the scientific literature devoted to the study of the processes of clustering economic space, the point is made that the organizations entering the cluster must be within one hour of movement in road transport, that is, in some conditional circle with a diameter of not more than 100 kilometers. Figure 1 shows the adaptation of the monitoring network to the tasks of identifying clusters within the administrative division of region on the example of the Tatarstan Republic.

Figure 1. Adaptation of the monitoring network of enterprises participating in clusters within the framework of the administrative division of the Tatarstan Republic



In the framework of the methodology of geostatistical analysis, the study of clustering processes is based on the allocation of a certain territory on which a number of measurements of a certain economic value ***Z*** are carried out. The spatial arrangement of the cluster participants causes an arbitrary character of the distribution over the region of the set of points at which the economic value ***Z*** was measured. Accordingly, Clustering the economic space of Russian regions is called randomly distributed minutes on the territory of dots ***(x, y)***, which measured the performance values of the cluster.

The Delaunay triangulation allows qualitatively isolating the segments of the analyzed space with a high density of measurements, also called "clusters" in geostatistics. From the point of view of the instrumentation of applied research, Delaunay's triangulation is the basis for constructing linear interpolation: the three vertices of triangles uniquely determine the plane within which the quantitative values of the function under consideration are calculated according to geometric principles. Figure 2 shows the Delaunay triangulation for the monitoring network of organizations participating in clusters of the Tatarstan Republic, there are two distinct centers of clustering processes in the cities of Kazan and Naberezhnye Chelny.

Figure 2. Delaunay triangulation for the monitoring network of organizations participating in clusters of the Tatarstan Republic

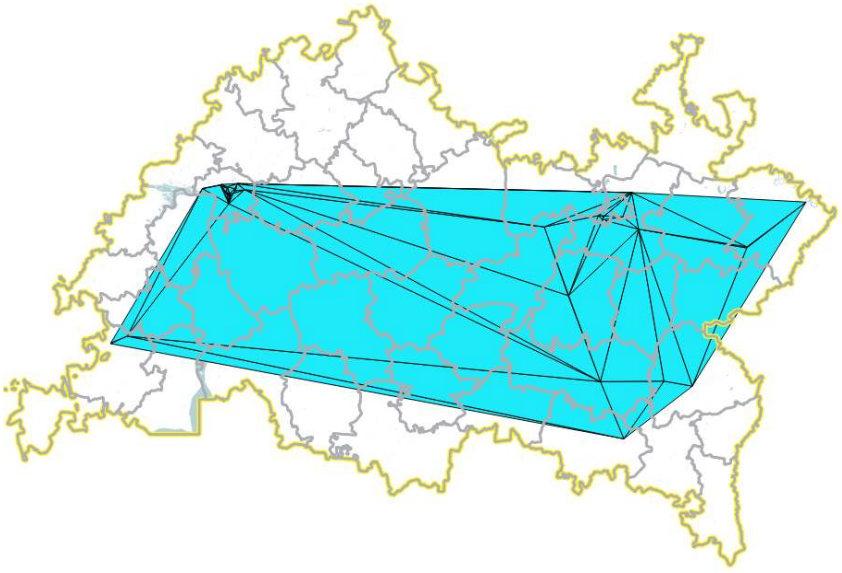


Figure 3 shows the Voronoi polygons constructed for the monitoring network of organizations participating in clusters of the Tatarstan Republic.

Figure 3. Voronoi polygons, built for the monitoring network of organizations participating in clusters of the Tatarstan Republic

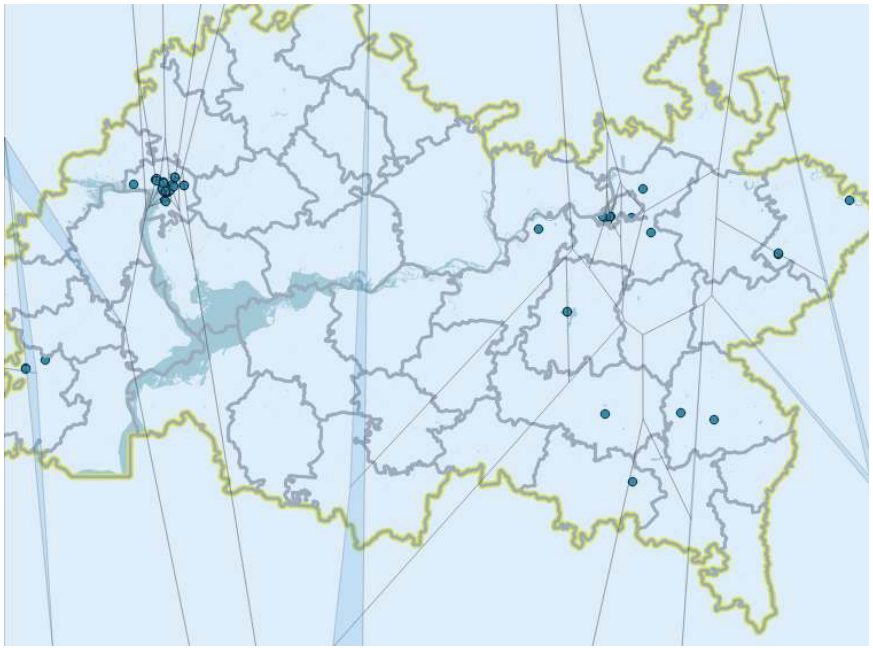


Figure 4 shows the values of such an index of cluster development of the territory as "the number of employees of cluster member organizations" obtained on the basis of interpolation of the heat map, giving an idea of the spread of the externalities of the processes of clustering the economic space of the region, in particular, the creation of jobs.

Figure 4. Heat Map values of the "number of employees of cluster organizations" for the Tatarstan Republic

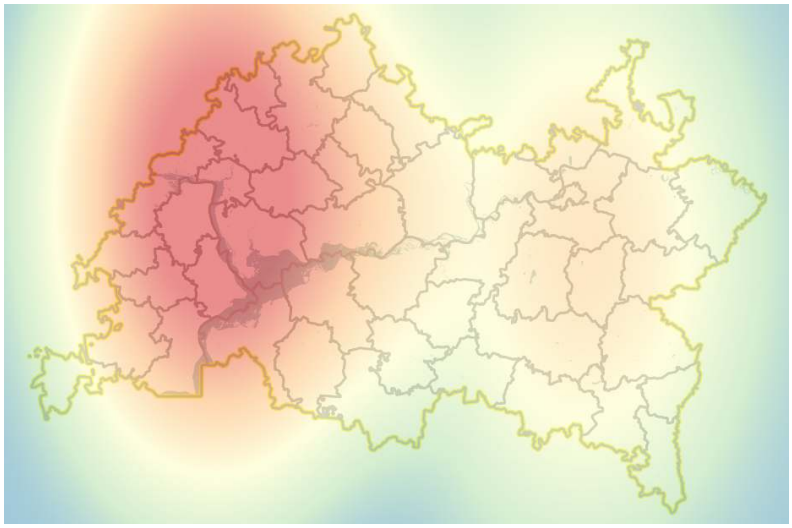
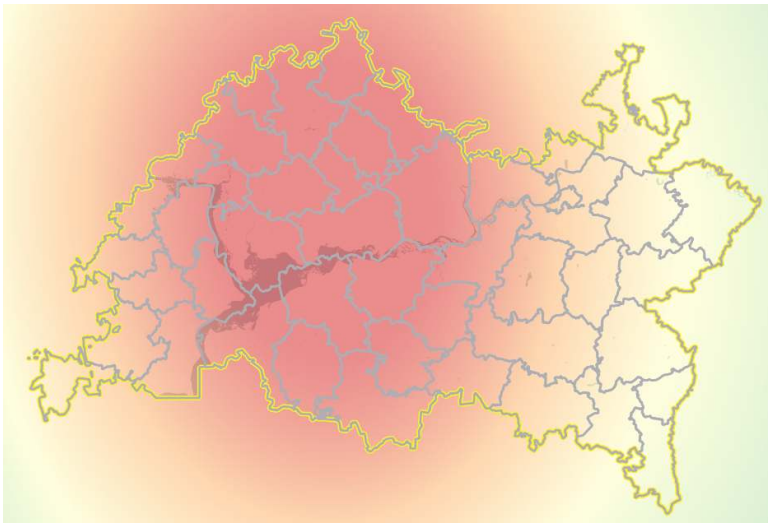


Figure 5 presents the forecasted heat map, subject to the formation of high-tech production in the city of Chistopol, which creates 200 jobs and participates in the technological chains of the clusters under consideration.

Figure 5. The forecasted heat map of the indicator value "the number of employees of cluster organizations" for the Tatarstan Republic



Getting a smoothed evaluation is applicable to the study of the institutional environment of the cluster and the territory of the spread of external social and economic effects of implementing cluster initiatives. At the same time, to solve narrowly specialized problems within the framework of the policy of forming and developing regional industrial clusters, obtaining a smoothed evaluation may not be sufficient for a full-fledged analytical support for the adoption of managerial decisions.

An alternative to the use of deterministic models is stochastic modeling, which makes it possible to reproduce the initial variability of measurements of the economic value under study in the framework of the equally probable realization of spatial function in the territory. The estimation of the equally probable realization of the spatial function on the territory makes it possible to consider its variability, to assess the probabilities and risks of implementing the cluster policy behind it. Stochastic modeling can be applied to solve complex problems of spatial modeling of regional industrial clusters, for example, to calculate the extent of the boundary of the internal "core" of the cluster.

4. Discussion

Alternative methodological approaches focuses on the construction of cluster organizational schemes (Gimadeeva, 2015; Krivenko, 2014)) and abstract graphical modeling

or affect a separate quantitative aspect of cluster development (Kireeva, 2015; Markov, 2015; Matafonova, 2016). Among these approaches, the basic organizational model of O. Solvell's cluster, developed on the basis of the balance of supply and demand (Sölvell, 2009.), the E. Feather model of cluster and regional specialization (Feser, 1998), the institutional model of the cluster of K. Ketels and J. Lindquist (Ketels, Lindqvist and Sölvell, 2012), should be singled out. Also in the Russian economic literature, the current trends in the formation of clusters with mixed industry specialization and territorial clusters are practically not considered.

The fundamentals of applying geostatistics methods for solving applied problems in various spheres of scientific knowledge are systematized by J.Matheron (1968), M.Kanevsky (1999), R.V. Arutyunyan (1999), V.V. Demyanov and E.A. Savelieva (2010). However, the methodological aspects of spatial modeling of regional industrial clusters on the basis of geostatistics have not yet received sufficient coverage in the economic literature (Natashkina and Ermolaev, 2014; Naydyonov et al., 2015; Pugacheva and Baranov, 2013).

The application of geostatistics methods allows us to consider the regional industrial cluster as a territorial economic system of the environmental type, which has the following set of characteristics: a complex dualistic structure, openness and flexibility of border configuration, plastic adaptability, interactive nature of cooperative and collaborative processes. Structural features of a territorial industrial cluster as a mesoeconomic system determine the need to use for methodological support of solving problems of identification and classification of clusters of an integrated approach on the basis of a combination of the advantages of macro- and microeconomics instruments. An objective limitation of the macroeconomic approach in the identification of clusters is an increase in the degree of methodological assumptions in determining the spatial boundaries of cluster segments and their industry specialization. The use of the microeconomic toolkit makes it possible to identify the core enterprises of the core of the regional industrial cluster and their interrelations, the methodological advantage of this approach to identifying cluster entities at the regional level is the construction of a logical sequence of stages of clustering the economy of the regions (Larionova, Napolskikh,.and. Yalyalieva, 2015).

The organizational prerequisite for support of cluster infrastructure is adoption of regional and municipal programs for social and economic development and the provision of subsidies for development of technology parks (Kireeva, 2015; Gimadeeva, 2015). Technology parks is a complex of real estate and infrastructure that provides conditions for the efficient operation of a number of small and medium-sized industries. Technology park is managed by a single operator, the main service is to lease or purchase land and premises, as well as provide the necessary transport, logistics and telecommunications infrastructure.

The adoption of government programs to support the development of clusters should include mechanisms for public-private partnership. In this case, the regions have the right to establish benefits for the payment of taxes and fees. The possibility of granting tax privileges at the regional level within the framework of the creation of special economic zones is an effective tool for the development of clusters.

One of the areas of support for the development of clusters is the identification and minimization of administrative barriers. Implementation of the principle of "one window" when obtaining a building permit and conducting state expertise of project documentation is an important factor in attracting investment in the cluster.

5. Conclusion

The first and fundamental stage of geostatistical research, regardless of the scope of application, is the analysis of the data distribution, which makes it possible to determine the presence of observation and emission errors in the data, and also at the initial stage to reveal the basic statistical regularities and correlation of the values of the investigated quantities. In this case, the monitoring network is called a cluster network if it has segments with a significantly higher measurement density of the investigated quantities than the rest of the observation area. If the identified segments with an increased measurement density in turn are characterized by higher or lower values of the investigated value, it becomes necessary to perform the procedure of declustering in order to obtain representative statistics and to exclude errors in mean values, variations, etc. Thus, the methodological toolkit of

geostatistics as an interdisciplinary area is highly complementary to the cluster as an economic category and can be used to develop the conceptual foundations of spatial modeling of regional industrial clusters.

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