

Artículo de investigación

Matrix Analysis of Obstacles to Innovation for Managing a Multisectoral Complex**Матричный Анализ Препятствий Инновационной Деятельности Для Управления Многоотраслевым Комплексом****Análisis matricial de obstáculos a la innovación para gestionar un complejo multisectorial**

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Ludmila V. Obolenskaya²⁰⁰**Igor G. Tyutyunnik**²⁰¹**Evgenia L. Moreva**²⁰²**Nataliya P. Simaeva**²⁰³**Abstract**

This paper examines obstacles to innovation in a multisectoral complex. The purpose of this study is to assess the criticality of these obstacles given the sectoral heterogeneity in order to differentiate innovative policies. The research is based on the methods of matrix analysis and mathematical processing of statistical data. Numerous publications on the use of matrix models in strategic planning and management of economic development served as the information and theoretical basis for this study. To achieve the goal of the study, the authors introduce the concept of the matrix of sectoral heterogeneity of obstacles to innovation. The approach to the formation and use of this matrix is shown by the example of the diversified agro-industrial complex (AIC). The results of the study may be of practical interest in determining the priority management measures of innovation policy.

Keywords: Obstacles to innovation, sectoral heterogeneity, matrix of sectoral heterogeneity, multisectoral complex, AIC, rank.

Аннотация

Предмет исследования – препятствия инновационной деятельности в многоотраслевом комплексе. Цель исследования – оценка критичности этих препятствий с учетом отраслевой неоднородности для дифференциации мер инновационной политики. Исследование опирается на методы матричного анализа и математической обработки статистических данных. Информационно-теоретическая база исследования – публикации по использованию матричных моделей в задачах стратегического планирования и управления экономическим развитием. Для достижения цели исследования вводится понятие матрицы отраслевой неоднородности препятствий инновационной деятельности. Подход к формированию и использованию данной матрицы демонстрируется на таком многоотраслевом комплексе как АПК. Результаты исследования могут представлять практический интерес с позиции определения приоритетных управленческих воздействий инновационной политики.

Ключевые слова: препятствия инновационной деятельности, отраслевая неоднородность, матрица отраслевой неоднородности, многоотраслевой комплекс, АПК, ранг.

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Resumen

Este documento examina los obstáculos a la innovación en un complejo multisectorial. El propósito de este estudio es evaluar la importancia de estos obstáculos dada la heterogeneidad sectorial para diferenciar políticas innovadoras. La investigación se basa en los métodos de análisis matricial y procesamiento matemático de datos estadísticos. Numerosas publicaciones sobre el uso de modelos matriciales en la planificación estratégica y la gestión del desarrollo económico sirvieron de base teórica y de información para este estudio. Para lograr el objetivo del estudio, los autores introducen el concepto de matriz de heterogeneidad sectorial de obstáculos a la innovación. El enfoque de la formación y el uso de esta matriz se muestra en el ejemplo del complejo agroindustrial diversificado (AIC). Los resultados del estudio pueden ser de interés práctico para determinar las medidas de gestión prioritarias de la política de innovación.

Palabras clave: Obstáculos a la innovación, heterogeneidad sectorial, matriz de heterogeneidad sectorial, complejo multisectorial, AIC, rango.

Introduction

To implement the new social development paradigm in a digital economy, it is necessary to eliminate obstacles to innovation. This implies addressing the task of their timely identification and relevance assessment for the prompt adoption of measures by state governing authorities.

When assessing the obstacles to innovation activities in a multisectoral complex (machine-building, metallurgic, agro-industrial, etc.), one must not overlook the problem of sectoral heterogeneity. Depending on the sector (industry), the distribution of obstacles in terms of their relevance may vary significantly. This also applies to the agro-industrial complex (AIC), which serves as an example of obstacles to innovation in this study.

Sectoral heterogeneity involves the processing of two-dimensional arrays of information. To ensure the convenience of analytical work and visibility of information for governing authorities, the authors suggest using appropriate tools.

Matrix models or matrices serve as a practical tool for analyzing two-dimensional arrays of information. Matrices are widely used in addressing management challenges in the economy. Depending on the specifics of the economic challenge, determined by the purpose and the object of study, different matrix models can be used (Ifediora, Idoko, Nzekwe, 2014; Madsen, 2017; Dmitrienko, Sakharov, Chertkov, 2017; Lee, Su, 2014). In some works, for example, in (Bellù, 2012), matrix models are considered in relation to the AIC.

This paper also suggests using a matrix model. Following the objectives of the study, it must comply with two requirements. First, it is

necessary to display the range of obstacles to innovative development. Here one can notice parallels with the SWOT analysis matrix (Ifediora, Idoko, Nzekwe, 2014), in which two out of four quadrants include obstacles to development: internal weaknesses and external threats. Secondly, to account for sectoral heterogeneity, a list of sectors of activity should be included in the matrix. In this case, there are parallels with matrices of intersectoral balance (Dmitrienko, Sakharov, Chertkov, 2017) and Social Accounting Matrices (OECD, 2005), which use structural division by sector of activity. In other words, the suggested matrix should combine separate structural divisions from classical matrix models.

National statistical data can serve as the information base for matrix analysis. The advantage of these data is their regularity. The Oslo Guidelines provide methodological guidelines for compiling and improving the list of observed obstacles to innovation (Oslo Manual, 2005). To consider the specifics of obstacles in developing countries, one can use recommendations from Bogota Guidelines (Bogota Manual, 2001). Based on the systematization of obstacles to innovation from these two Guidelines, the work (Obolenskaya, 2016) provides recommendations to improve the quality of collected data using the example of Russia, which may be useful for other countries. In view of the above, the content of this work is as follows:

- The authors introduce the concept of the matrix of sectoral heterogeneity of obstacles to innovation;
- A method of formation and use of the matrix using the example of the AIC is suggested;

- The proposed matrix is used to assess the obstacles to innovation, considering sectoral heterogeneity by the example of the Russian AIC.

Methods

In this paper, *the matrix of sectoral heterogeneity* of obstacles to innovation will refer to a rectangular matrix, in which the row names correspond to the obstacles of innovation, and the column names correspond to the sectors of a multisectoral complex (machine-building, metallurgic, agro-industrial, etc.). It is allowed to include an additional column in the matrix corresponding to the multisectoral complex in general. The matrix elements at the intersection of rows and columns are the ranks of obstacles to innovation. The rank column refers to the relative significance of obstacles to a particular sector or to the multisectoral complex in general. The rank row refers to the sectoral heterogeneity of significance of a particular obstacle.

The method of formation and use of sectoral heterogeneity of obstacles matrix includes several stages.

Step 1 implies selecting the object of analysis – a multisectoral complex, for example, the AIC.

Step 2 involves the formation of matrix rows and columns. The list of obstacles to innovation, tracked through the national statistical monitoring, serves as the matrix rows. If the list contains N obstacles, then accordingly the number of rows in the matrix equals N. The AIC in general and the list of the AIC sectors are selected as the matrix columns. If M AIC sectors are selected in this list, then the number of columns in the matrix will be equal to M+1. At the same time, the AIC in general (first column) will be considered as the base that will be compared with the rest of the matrix elements.

Step 3 involves determining the elements of the matrix of sectoral heterogeneity – the ranks of obstacles to innovation. The ranks are determined alternately by matrix columns.

The algorithm for calculating the ranks of obstacles is as follows. First, one should consider a specific column of the matrix corresponding to a specific sector of the AIC. Based on statistical data, the researcher defines the share of enterprises (% of all the surveyed enterprises in the sector) which rated the defined obstacle as significant, fundamental or essential. The obstacle with the highest ratio is assigned to rank

1 (the greatest significance), with the lowest ratio – to rank N (the lowest significance). This algorithm for calculating the ranks of obstacles is applied alternately to each sector of the AIC, as well as to the AIC in general.

At the final step, the formed matrix is used as a tool for analyzing the significance of obstacles, against the sectoral heterogeneity.

Based on the rank values for the AIC in general, all obstacles are divided into three groups:

- Most significant;
- Medium significant;
- Least significant.

Then the researcher analyzes the deviations of sectoral ranks from the base value – the AIC rank in general – for each obstacle (row). This step reveals sectors, where an obstacle is much more critical than for other sectors. The revealed deviations are considered as a signal for the adoption of priority industrial policy measures.

Results

The matrix of sectoral heterogeneity of obstacles to innovation, formed using the example of the Russian AIC, is the result of the method described above. Whereas, one must consider that the AIC includes the following (Order of the Ministry of Agriculture of Russia № 168, 2016; NACE Rev. 2, 2008):

- Agriculture;
- Processing of agricultural raw materials (food industry, etc.);
- Production of capital goods for agriculture (machinery and equipment, etc.); rural construction;
- Scientific and other infrastructure required for the functioning of the AIC.

The federal statistical observation data served as the information base for the formation of the matrix of sectoral heterogeneity of obstacles to innovation (Order of Rosstat № 563; Official Website of Rosstat, n.d.). The authors covered a sample of Russian enterprises that assessed the obstacles to innovation in 2018 over the three-year period from 2015 to 2017. The researchers chose a tabular presentation of the matrix as shown in Table 1.

Table 1. Tabular form of the matrix of sectoral heterogeneity of obstacles to innovation by the example of the Russian AIC

AIC and its sectors	AIC	AIC sectors				
Obstacles to innovation	C	1	2	3	4	5
MOST SIGNIFICANT to the AIC						
Lack of own funds	1	1	2	3	1	
The high cost of innovation	2	3	1	1	3	
Lack of financial support from the state	3	2	4	2	2	
High economic risk	4	4	3	4	4	
MEDIUM SIGNIFICANT to the AIC						
Lack of qualified personnel	5	6	7	6	9	
Low demand for new products, works, services	6	1 0	5	5	6	
Low innovative potential of an enterprise	7	8	6	7	1 2	
Uncertainty of economic benefits from the use of intellectual property	8	1 1	8	9	5	
Regulatory risks associated with providing constancy of agricultural products quality	9	7	9	1 3	1 6	
Inadequacy of legislative and regulatory documents regulating and promoting innovative activity	10	1 6	1 1	8	7	
LEAST SIGNIFICANT to the AIC						
Natural and climatic, biological risks associated with living systems used in agricultural activities	11	5	1 4	1 4	1 4	
Inadequacy of the innovation infrastructure (mediation, information, legal, banking, and other services)	12	1 4	1 0	1 0	8	
Lack of market information	13	1 3	1 2	1 5	1 0	
Undeveloped cooperation links	14	1 5	1 5	1 1	1 1	
Lack of information about new technologies	15	1 2	1 3	1 2	1 3	
Delayed effects of scientific and technological innovations in agriculture	16	9	1 6	1 6	1 5	
Note: AIC sectors (columns No. 2-5)						
Agriculture (2)	Manufacture of machinery and equipment for					
Food industry including the production of	agriculture and forestry (4)					
beverages and tobacco (3)	Research and development (R & D) in science and					
	engineering (5)					

Source: calculated based on Rosstat data (Official Website of Rosstat, n.d.).

The rows of the sectoral heterogeneity matrix refer to 16 obstacles to innovation, monitored by the Russian system of federal statistical observation. The rows are arranged in decreasing order of significance of obstacles in the AIC in

general. Furthermore, the obstacles are divided into three groups: the most significant for the AIC, the medium significant and the least significant.

The columns of the sectoral heterogeneity matrix refer to the AIC and its four significant sectors. When selecting AIC sectors for the analysis of sectoral heterogeneity, the authors considered the availability and integrity of statistical data.

The elements of the sectoral heterogeneity matrix are the ranks of obstacles to innovation in the AIC and in its sectors. Rank 1 refers to the most significant obstacle (in the AIC or in its sector), while rank 16 refers to the least significant obstacle.

Discussion

The matrix formed in the previous section allows evaluating the significance of obstacles to innovation in the AIC, given the sectoral heterogeneity in three blocks of obstacles:

- Most significant to the AIC;
- Medium significant;
- Least significant.

The block of most significant obstacles for the AIC. This block can be called "financial" as it includes obstacles to innovation associated with finances and financial risks.

The obstacles under consideration turned out most significant (ranks 1-4) not only to the AIC in general but also to its sectors. At the same time, there is a slight manifestation of sectoral heterogeneity for all four obstacles. In each of the four matrix rows, the sectoral ranks deviate from each other and from the AIC in general by 1-2 points.

The block of medium significant obstacles for the AIC. This block includes obstacles that are the most significant to the AIC (ranks 5-11) outside the financial block. The top three most important obstacles are:

- Lack of qualified personnel (rank 5);
- Low demand for new products, works, services (rank 6);
- Low innovative potential of an enterprise (rank 7).

In this block, sectoral heterogeneity manifested itself to the greatest extent. The sectoral ranks of each obstacle vary widely. For instance, the sectoral ranks of obstacle "lack of legislative and regulatory documents" vary from 7 to 16.

The following example is a vivid demonstration of the sectoral heterogeneity. For the R & D sector, the obstacle "regulatory risks associated

with agricultural products" is the least significant (rank 16). On the contrary, in the agricultural sector, this obstacle ranked third (rank 7) among the obstacles of this block.

The block of least significant obstacles for the AIC. This block includes the least significant obstacles (ranks 11-16) if applied to the AIC in general. However, one should not ignore the sectoral heterogeneity in this block.

The sectoral heterogeneity in this block has manifested itself mainly in the fact that for a certain sector the obstacle turned out to be much more critical than for the rest. For example, the obstacle "natural-climatic, biological risks" ranks among the last (rank 14) for all the AIC sectors under consideration except for the agricultural sector. For this sector, this obstacle outstrips in importance (rank 5) all other obstacles.

The method of formation and use of the matrix of sectoral heterogeneity of obstacles to innovation, demonstrated here by the example of the Russian AIC, can be applied to other countries.

Conclusion

1. In line with the matrix approach to solving economic problems, the authors introduce the concept of the matrix of sectoral heterogeneity of obstacles to innovation. This matrix is a convenient and illustrative tool for analyzing the obstacles to innovation in a multisectoral complex against their sectoral heterogeneity.
2. The researchers suggest a method for the formation of this matrix, including statistical data processing, ranking, and grouping. In this work, they have formed a matrix of sectoral heterogeneity of obstacles to innovation by the example of a specific multisectoral complex – the Russian AIC.
3. This study evaluates the significance of obstacles to innovation in the AIC and its sectors based on the example under consideration. At the same time, the authors define three groups of obstacles: the most significant for the AIC, the medium significant and the least significant. The first group consists of obstacles related to finances and financial risks. Outside the financial block, the top three obstacles in terms of importance for the AIC were the lack of qualified personnel; low demand for

new products, works, and services; low innovative potential of an enterprise.

4. The authors analyze sectoral heterogeneity in these three groups of obstacles. The financial block of obstacles was least affected by sectoral heterogeneity. The block of obstacles that are medium significant for the AIC was the most affected. In this block, the sectoral ranks of each obstacle vary widely. However, they may differ significantly from the rank of the AIC in general.
5. Sectoral heterogeneity should be evaluated and considered when developing economic policy measures to neutralize obstacles to innovation. The matrix of sectoral heterogeneity discussed in this article by the example of the Russian AIC could serve as a useful assessment tool.

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