Assessment of the cluster structures functioning effectiveness in the agro-industrial complex: a methodological approach, practical implementation

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Abstract. The article actualizes the role of network and cluster interaction mechanisms in the development of the regional agro-industrial complex into the specific features of inter-firm interaction in agro-industrial cluster structures, the need to form a two-level algorithm for assessing the effectiveness of the functioning of agro-industrial clusters is indicated: stage 1 - assessment of the potential of cluster development of territories; stage 2 - assessment of the effectiveness of the functioning of cluster structures. Approximation of the proposed methodological approach is implemented on the example of the regions of the Siberian Federal District. The practical implementation of the methodological aspects of assessing the effectiveness of the functioning of cluster structures in the agro-industrial complex gives grounds for regional government bodies to make appropriate adjustments to the existing regulatory and strategic documents, as well as improve the tools and mechanisms of the cluster and investment policy being implemented, taking into account the specifics of the industry.

1. Introduction

Currently, in the agro-industrial complex of Russia, there are no large-scale transformations in the dynamics of growth in the quality of production, despite the presence of a significant number of federal and regional documents on the strategic development of agriculture.

The lack of mechanisms for network interaction of agricultural production, taking into account the appropriate state support, leads to a decrease in the number of operating large agricultural organizations, to a lack of innovation by small businesses, as well as to an extremely low quality of life of the rural population and an outflow of specialized personnel [1-3].

Studies [4–6] quantitatively prove the presence of a positive impact of the creation and further functioning of cluster structures on the innovative and investment development of regions. Possessing special advantages, cluster structures are able to stimulate technological and innovative processes, and, consequently, to ensure the growth of the competitiveness of agro-industrial enterprises.

To prove this hypothesis, it is necessary to form a methodological basis, including both an assessment of the cluster potential and an assessment of the effectiveness of the functioning of cluster structures.

The problem of the clustering processes development in the agro-industrial complex of territories in recent years has become the subject of research by many scientists and practitioners [7–12]. However, most of the works are limited to either the assessment of the cluster potential, or the analysis of the effectiveness of the clusters [4–6, 13–16].
Based on the foregoing, the purpose of the study is to form a methodological toolkit for a comprehensive assessment of the effectiveness of the functioning of cluster structures in the regional economy. Approbation of the proposed methodological approach was carried out on the example of the subjects of the Siberian Federal District and the agro-industrial clusters operating on their territories.

2. Methods
The study of the clusters functioning effectiveness is based on: 1) a systematic approach in the consideration and systematization of modern concepts for assessing the effectiveness of network and cluster interaction in the aspect of sustainable investment development of the regional economy [4, 5, 8, 9, 12, 14]; 2) methods for identifying groups of interrelated industries based on specialized input-output tables (input-output balance) and identifying significant cluster groups [15–20]; econometric methods and methods of expert assessment to assess the effectiveness of the functioning of cluster structures; 3) the method of parametric comparative analysis and matrix diagnostic analysis for assessing the degree of compliance of the cluster potential indicators with the parameters of the efficiency of the clusters.

Following the indicated approaches and methods, it is advisable to carry out a comprehensive methodological toolkit for assessing the effectiveness of the cluster structures functioning in a differentiated manner, namely, to distinguish between the procedure for determining significant cluster groups and assessing the effectiveness of the functioning of clusters. Consequently, the assessment algorithm will include three blocks: 1) assessment of the cluster potential in the agro-industrial complex of the territory; 2) assessment of the effectiveness of the functioning of agro-industrial clusters operating in the regions; 3) comparison of the results of assessing the cluster potential and the effectiveness of the functioning of agro-industrial clusters.

The algorithm for determining the cluster potential of territories is based on the implementation of five stages [21].

The first stage is the formation of a database for the categories “The number of employed people in the cluster group” and “The volume of products shipped in the cluster group”.

The second stage is to determine the indicator of significance in three aspects (by the number of people employed in the industry, by the volume of products shipped, by the degree of uniformity of the cluster group development).

The third stage is to determine the connectivity indicator in three aspects (average size by the number of people employed in the industry; average size by the number of products shipped; compound annual growth rate (CAGR) indicator).

The fourth stage is the determination of the efficiency indicator, the formation of which is carried out on the basis of particular indicators: “Average monthly salary of employees in the cluster group”; “Profit by cluster group” and “Investments in fixed assets by cluster group”.

The fifth stage is the formation of an aggregated indicator of the cluster potential of a territory by summing up indicators of significance, connectivity and efficiency.

As a result of determining the indicators of the cluster potential of the territory, depending on the number of analysed cluster groups, numerical values are formed. The minimum value of the cluster potential indicator is 0, the maximum value tends to a maximum, since the connectivity indicator depends on the number of intersections of cluster groups [21].

To determine the leading cluster groups, a threshold value is required, which is determined based on the sum of the average values of the aggregated indicators of significance, connectivity and efficiency. Thus, all cluster groups whose values are higher than the threshold are significant for the territory under consideration. In this case, potentially significant cluster groups are understood as cluster groups that within the territory have the greatest significance and potential for development, taking into account the geography of the territory, the structure of the GRP, the volume of investments and the volume of salaries of employees working in the analysed territory.

As part of the implementation of the first block, it is advisable to rely on the approved Methodological Recommendations for the implementation of cluster policy in the Russian Federation.
Following these Recommendations, clusters have five fundamental characteristics: the presence of competitive enterprises; geographical concentration and proximity; a large number of participants; the presence of interaction between cluster members and links; availability of competitive advantages for the development of the cluster.

Taking into account these characteristics, it is advisable to use the methodology, according to which for each of the specified characteristics of the cluster, it is necessary to develop criteria for their further assessment.

To assess the strength of the connection of the influence of the criteria, we use the Chaddock scale, according to which the values of the coefficients are interpreted as follows (table 1).

| Value       | Interpretation  |
|-------------|-----------------|
| from 0 to 0.3 | very weak       |
| from 0.3 to 0.5 | weak         |
| from 0.5 to 0.7 | average     |
| from 0.7 to 0.9 | high        |
| from 0.9 to 1  | very high      |

The assignment of coefficients will be made on the basis of statistical data and their analysis, taking into account the factors that influence the criteria. The assessment of the characteristics of the created cluster will be determined in accordance with the formula (1):

\[ M = \sum_{i=1}^{n} l_i K_{of}, \]  

where \( K_{of} \) is the coefficient of influence on the characteristic; \( M \) - characteristic; \( l_i \) - criterion (coefficient on the Chaddock scale).

Thus, the indicator of the efficiency of an industry cluster will be determined as the arithmetic mean of the final estimates for all characteristics. At the same time, it is proposed to consider that the activities of the cluster are most effective if the final score is more than 0.8 - in this case, the created cluster has a significant positive impact on both the development of the industry and the level of socio-economic development of the region.

Within the framework of the third block, it is proposed to form a correspondence matrix based on a coordinate system, in which the value of the integral indicator of the territory's cluster potential is fixed along the abscissa (X) axis, and the value of the coefficient reflecting the level of efficiency of cluster structures along the ordinate (Y). Thus, the use of a matrix approach will allow us to compare the two estimated parameters and identify territories that have the appropriate cluster potential and the presence of clusters that ensure effective activity.

3. Results

Approbation of the proposed methodological approach is implemented on the example of subjects of the Siberian Federal District (SFD), billing period: 2016-2018. Following the logic of assessing the cluster potential, the aggregated indicators were calculated (taking into account the obtained values of the particular indicators of significance, connectivity and efficiency), the results of the calculations are summarized in table 2.
Table 2. Results of assessing the cluster potential of the regions of the SFD (compiled by the authors).

| Regions            | Potential cluster groups                                                                 | Active clusters                                                                 |
|--------------------|------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------|
| the Altai Republic | Section A: Agriculture, forestry, hunting, fishing and fish farming;                      | No active clusters                                                                |
|                    | Section C: Manufacturing;                                                                 |
|                    | Section G: Wholesale and retail trade; repair of motor vehicles and motorcycles;          |
|                    | Section H: Transport and storage;                                                         |
|                    | Section P: Education                                                                      |
| Republic of Tyva   | Section B: Mining;                                                                       | No active clusters                                                                |
|                    | Section C: Manufacturing;                                                                 |
|                    | Section H: Transport and storage;                                                         |
|                    | Section P: Education;                                                                    |
| Republic of Khakassia | Section B: Mining;                                        | No active clusters                                                                |
|                    | Section C: Manufacturing;                                                                 |
|                    | Section G: Wholesale and retail trade; repair of motor vehicles and motorcycles;          |
|                    | Section H: Transport and storage;                                                         |
|                    | Section Q: Health and Social Services Activities                                           |
| Altai Territory    | Section A: Agriculture, forestry, hunting, fishing and fish farming;                      | Altai Biopharmaceutical Cluster;                                                 |
|                    | Section C: Manufacturing;                                                                 |
|                    | Section G: Wholesale and retail trade; repair of motor vehicles and motorcycles;          |
|                    | Section H: Transport and storage;                                                         |
|                    | Section P: Education                                                                      |
| Krasnoyarsk Territory | Section A: Agriculture, forestry, hunting, fishing and fish farming;                      | Innovation cluster of the Krasnoyarsk Territory                                   |
|                    | Section B: Mining;                                                                       | Technopolis “Yenissey”                                                           |
|                    | Section C: Manufacturing;                                                                 |
|                    | Section D: Supply of electricity, gas and steam; air conditioning;                        |
|                    | Section G: Wholesale and retail trade; repair of motor vehicles and motorcycles;          |
|                    | Section P: Education                                                                      |
| the Irkutsk Region | Section B: Mining;                                                                       | Baikal pharmaceutical cluster                                                     |
|                    | Section C: Manufacturing;                                                                 |
|                    | Section G: Wholesale and retail trade; repair of motor vehicles and motorcycles;          |
|                    | Section H: Transport and storage;                                                         |
|                    | Section P: Education                                                                      |
| the Kemerovo Region | Section B: Mining;                                        | Cluster “Integrated processing of coal and industrial waste”                     |
|                    | Section C: Manufacturing;                                                                 |
|                    | Section H: Transport and storage;                                                         |
|                    | Section P: Education                                                                      |
|                    | Section Q: Health and Social Services Activities                                           |
| the Novosibirsk Region | Section C: Manufacturing;                     | Biomedical cluster of the Kemerovo region                                         |
|                    | Section G: Wholesale and retail trade; repair of motor vehicles and motorcycles;          |
|                    | Section H: Transport and storage;                                                         |
|                    | Section P: Education                                                                      |
|                    | Scientific and production cluster “Siberian Naukopolis”                                  |
|                    | Innovative territorial cluster of information and biopharmaceutical technologies of the Novosibirsk region |
According to the information in table 2, Section A “Agriculture, forestry, hunting, fishing and fish farming” is a potential cluster group for the Altai Territory, the Altai Republic and the Krasnoyarsk Territory. At the same time, considering the structure of the GRP of the regions (with the exception of the Krasnoyarsk Territory), a high share of the agricultural sector should be noted. First of all, the agricultural specialization of the region is due to the predominance of the rural population.

Next, it is necessary to analyse the presence and effectiveness of clusters in the Siberian regions. According to the Ministry of Economic Development of Russia, the Siberian Federal District ranks fourth in terms of the number of cluster associations. There are no clusters in the republics of Altai, Tyva and Khakassia.

Among the constituent entities of the district there are regions in which the values of the cluster potential differ from the already existing cluster structures. Thus, for example, in most regions, cluster structures specializing in agriculture are developing, while the cluster potential of this industry in the regions presented is low. To make a decision as to how important the procedure for determining the cluster potential is in the formation and development of cluster structures, the study assessed the effectiveness of their activities, the data are presented in accordance with table 3. The analysis of the effectiveness of cluster structures was carried out on the basis of open statistics for the group “Rural, forestry, hunting, fishing and fish farming”. In this regard, the clusters formed after 2016 were not analysed due to the lack of sufficient statistical and analytical data.

### Table 3. Performance indicators of agro-industrial clusters in the regions of the Siberian Federal District (calculated by the authors).

| SFD region             | Cluster                                      | 2016  | 2018  |
|------------------------|----------------------------------------------|-------|-------|
| Altai Territory        | Altai cluster of agricultural engineering    | 0.816 | 0.828 |
| the Kemerovo Region    | Agro-industrial cluster of the Kemerovo region | 0.638 | –     |
| the Omsk Region        | Agrobiotechnological industrial cluster of the Omsk region | 0.770 | 0.772 |

Attention is drawn to the importance of the agro-industrial cluster of the Kemerovo region, equal to 0.638 (the average level of efficiency). The Kemerovo Region is one of the regions where the value of the cluster potential does not correspond to the actual presence of the cluster (in the agricultural sector). The share of agriculture in the region does not exceed 4% in the gross regional product, there is a problem of a low level of transport and logistics development, specialized and social infrastructure in rural areas. It should be assumed that this is one of the main constraints on the development of the cluster and proves the significance of the results of the cluster potential.
However, in most of the analysed clusters, a high value of the effectiveness of their activities is noted. At the same time, in each cluster, there is a tendency for the indicator to grow. First of all, this proves that the formation of clusters as a mechanism of territorial development and a mechanism of sectoral and inter-sectoral integration can have a beneficial effect on the economic and social indicators of the region, as well as minimize the impact of economic instability on enterprises participating in cluster formations.

4. Conclusion
The proposed methodological approach to assessing the effectiveness of the functioning of cluster structures provides the following opportunities: 1) identification of the cluster potential of the territory, based on the determination of indicators of significance, connectivity and efficiency; 2) carrying out a procedure for regular monitoring of the effectiveness of the functioning of clusters operating in the territory of a constituent entity of the Russian Federation. Approbation of methodological tools on the example of agro-industrial clusters of Siberian regions gives reason to assert the need for regular monitoring, taking into account the appropriate information and methodological support.

As a result, practical recommendations have been formed for government bodies in regions with a dominant cluster development, allowing to maintain leadership positions: 1) creation of cluster development centres, unification of regional infrastructure organizations in a cooperation network; 2) creation of a permanent system of information interaction and stimulation of interaction between organizations and enterprises covered by the same industry; 3) support and initiation of cluster initiatives and cluster projects by providing subsidies, allocating targeted investments and grants on a competitive basis; 4) provision of tax benefits and reduction of administrative barriers; 5) promoting the marketing of products produced by the cluster association by promoting the brand of the cluster itself and the territory in which it is formed; 6) carrying out constant control and monitoring of the development of the activities of the clusters created on the territory.

For regions with no cluster structures in order to increase the level of their economic development, the following practical recommendations are proposed: 1) development of a mechanism and structure for the formation of a cluster association; 2) setting goals and developing appropriate information and analytical support for assessing the economic efficiency of the cluster's functioning; 3) identifying priority sectors in which a competitive cluster can potentially function; determination of the main directions of cluster development; 4) inclusion in the regional strategy of socio-economic development of provisions that allow regulating the activities of clusters.

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