Principles and Problems of Industrial Cluster Organization: On the Move to Effectiveness

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Abstract – This article provides reasoning for setting up industrial clusters with regard to economic security. Current study provides a system of principles for creation and functioning of firms within a cluster. The analysis applies to the mechanism of coordinating the interests of firm owners, and to the possibilities of its implementation. This article introduces a system of mathematical models that allow implementing major stages of cluster formation and development, including the choice of strategic management points, the setting of investment policy directions, and determining of the range and scale of output production. The research results in two major achievements: (1) coordination of interests expressed by firm owners within a cluster, and (2) cluster stretchment with the inclusion of firms and organizations that allow developing and implementing the innovation policy.

Keywords – cluster, firm, output, value chain, economic mechanism, state, mathematical model, security, implementation, investment policy, management strategy.

1. INTRODUCTION

The idea of setting up industrial clusters, as a voluntary association of firms, which maintain their own economic independence, is to improve economic conditions, and so to maintain economic security.

We define industrial cluster as a group of firms concentrated in one area and joint by business activities in development, production and sales of output, a group with same purpose or production technology. A firm to-be included into a cluster is selected from transport accessibility and share of output demanded by the cluster.

An industrial cluster differs from a traditional business by a set of features. Traditional way of doing business implies the centralization of asset ownership in a fixed part of the value chain. By contrast, any cluster is a value chain itself, where assets required for production are distributed between members of a cluster. Every member of a cluster can make decisions on the use of his own assets independently (Gereffi & Lee, 2016; Lund-Thomsen et al., 2016).

For coordination and development, firms within a cluster need to coordinate the activities of all agents in their own interests (Osipov):

- current points of interest – output range, scale and pricing for a debt-neutral and balanced supply of inputs for final output production.
- future-oriented activities – setting and realization of innovation and investment policy for the benefit of all cluster members, thus, minimizing a debt burden.

Managers and owners of firms within a cluster rely on economic mechanisms of cooperation more than on administrative forms of control. Coordinated activities of cluster members on a value chain can im-
prove final performance, first of all, for every owner, hence, being the main stimulus of cluster formation (Balland et al., 2016; Chabukdhara et al., 2016).

A cluster is characterized as a composite of links between producers and final consumers on one hand, and the state (legislative and executive branches of the government at federal, regional and local levels), input suppliers, infrastructure, scientific and academic institutions on the other (Figure 1).

By joining their efforts, firms within a cluster create major institutional structures that are able to successfully compete nationally and internationally (Felzensztein et al., 2014; Nadvi, 2015). Cluster model allows every firm within a cluster to specialize on a particular stage of a value chain and to gain a bigger shear on the market by increasing the output, thus increasing profitability, scale of output and revenues. Note that cluster effectiveness is based on the economic involvement of all member firms.

Finally, one can formulate the following definition of a cluster:

Cluster refers to an interaction of independent legal entities that coordinate and join efforts in value chains to produce and distribute a variety and quantity of goods determined by its members in order to maximize the income of every owner as a cluster member.

The outstanding feature of an industrial cluster is the lack of a control body, so its functioning is based on the following principles of self-organization (Ivakhnenko et al., 1976; Kotler et al., 2012; Gereffi & Lee, 2016):

- Principle of cluster architecture adaptation, realized during task-oriented structural changes (self-organization).
- Principle of synergy, which facilitates the emergence of positive externalities: more efficient use of potential of member firms and area, including increase of employment and tax payments. Externalities are expressed when an increase in competitiveness of one firm in a cluster increases competitiveness of all firms connected to it through a value chain. The result of this interaction is the synergistic effect of rising cluster competitiveness.
- Principle of vertical integration, according to which a cluster facilitates vertical integration of interests through intensification of interactions of small and medium enterprises for consecutive operations in value chains. As a consequence, transaction costs associated with the purchase of necessary resources, administrative costs and tax burden reduce, while profitability and competitiveness increase.
- Principle of horizontal integration allows distributing the output between the firms producing final output according to their competitive advantages and key competencies. This allows firms to specialize more narrowly, to increase production capacities and output.
- Principle of innovation acceleration facilitates the concentration of R&D, and so reduces the time and costs of a new product/technology creation, as well as the costs of associated equipment. At the same time, a network of strong connections between all members of a cluster and a coordinated innovation policy implementation are the prerequisites of innovation and its transformation into competitive advantages.
- Principle of investment synchronization allows coordinating investments that are relevant for a wide range of operations in a value chain. This allows speeding up the creation of new competencies, hence, increasing particular competitive advantages through joint investments into production of new goods, technology development and promotion of goods at the market, including:
  - staff education;
  - purchase of necessary equipment;
  - reengineering for a required task-oriented transformation of firm’s structure.
In the CIS countries, cluster development is not intensive enough due to a lack of experience in the industrial cluster formation (Zhemchugov & Zhemchugov, 2011; Ansoff, 2013). Thus, the purpose of this article is to consider factors that will contribute to the effectiveness of an industrial cluster.

2. METHODS

Theoretical and methodological basis of this research includes some provisions of the regulation theory concerning the sustainable development of industrial production in the context of diverse business forms and integration processes of enterprise development.

The conclusions originated from the generalization of domestic and foreign materials. Research methods used were the abstract-logical, analytical, and economic-statistical methods.

3. RESULTS

Developing of a mechanism that would coordinate the operations is required to create a cluster and ensure its effectiveness. This entity can function on the contract that determines rights, competencies and required resources in different spheres of activities. This organization has to include owners that make all decisions and managers representing interests of all firms of a cluster. Managers are to prepare and present to the owners both emerging problems and the ways to solve them. As soon as the owners accept the solution, managers implement it according to the allocated resources and their competencies. Managers are responsible for implementation of the decisions in due time and for the efficient use of resources.

Thus, functioning of a coordinating organization has to create institutional field for determining of problems in due time and development of the mechanism to solve them. Thus, a coordinating organization includes the cluster Council that includes owners of all firms of a cluster. Besides that, the management system has to consider the role of executive body that prepares and realizes taken decisions through the required executing agents, including the cluster members.

The first task that directly considers solving of cluster development issues is to distinguish the perspective strategic action fields (Ansoff, 2013), forecast their potential and a possible share that the firm aims to capture. Strategic action field (SAF) is a separate market segment characterized by homogeneous consumer demand of particular goods, where a firm sells or plans to sell its output.

To conduct analysis and optimization of firm’s activities in a short term, Boston Consulting Group matrix (Glagolev & Morozov, 2015) (Figure 2) and General Electric – McKinsey matrix (Naylor, 1986) (Figure 3) can be used.

The BCG matrix is based on the two hypotheses:

- The biggest competitor has the higher profitability selling at the market price and its financial flows are the largest.
- The growing market indicates an increased demand of firms in financial resources for development, renewal and expansion of production, and intensive advertising.

If hypotheses are fulfilled, then we can highlight four groups of SAFs that correspond to different goals and financial requests:

- **“Question marks”** (fast growth/little share). It is necessary to increase its market share for a given good or stop financing.
- **“Stars”** (fast growth/high share) – market leaders requiring financing to maintain high share of a dynamic market.
- **“Cash cows”** (slow growth/high share). Strategic goal – “collecting yields”.
- **“Dogs”** (slow growth/little share). Priority for this good is cutting down investment and modest existence.
General Electric (GE) / McKinsey matrix has wider opportunities due to the increased size (3×3) and allows analyzing:

- attractiveness of SAF
- firm’s position in competition.

The X axis of the GE – McKinsey matrix plots competitive advantage of a field-firm. One can distinguish:

- key factors of success for every SAF;
- relative importance of presented factors;
- influence of each factor, for example, at 5-point scale: 5 – if a good has a very strong competitive position in analogous field, 1 – if the position is weak.

The Y axis of the matrix presents attractiveness of business environment at the similar scale.

As a result, McKinsey matrix enables the analysis of output variety according to SAF. Hence, three groups were formed:

- winners (above the main diagonal);
- losers (below the main diagonal);
- middle group (the main diagonal).

The GE – McKinsey matrix illustrates the application of portfolio analysis method targeted at the creation of cluster development strategies and allows getting answers to the following questions:

- Which goods of a cluster are the most promising and which will be bringing losses in a long-term perspective?
- Which goods have to increase their competitiveness and which are top-priority?
- How to distribute resources within a company between goods the most efficient way and for which goods resources have to be cut down due to their unattractiveness?

The “attractiveness of a SAF” indicator is a market characteristic, on which one can rely. A “position in competition” indicator is an estimate of cluster’s possibilities and depends on the results of its performance.

The instruments described above allow evaluating and distinguishing the most perspective SAFs. Moreover, they allow making a choice of these fields for each kind of goods broader than that of production capacities of the industrial cluster. However, the question of an optimal choice remains open.

To solve the arising problem, let us suppose a set of SAFs, where sales of cluster output are possible – \( J \). \( I \) is a set of goods produced by the cluster.

For each good \( \forall i \in I \) capacity of each SAF was determined as \( \forall j \in J \cdot d_{i,j} \), while the scale of output Competitive advantage of each SAF and good, the price \( c_{i,j} \).

The independent variable is quantity of sales of good \( i \) in SAF \( j \) - \( x_{i,j} \). Besides that it is assumed that for every good \( \forall i \in I \) capacity of all SAFs is higher than its scale of output:

\[
\sum_{j} d_{i,j} > b_i \quad \text{for} \quad \forall i \in I
\]  

Then, the task of determining the optimal set of perspective SAFs is a maximization of revenue from sales of cluster output in a given set of SAFs:

\[
\sum_{i} \sum_{j} c_{i,j} x_{i,j} \rightarrow \text{max}.
\]  

At the same time, the following constrains are binding:

- The amount sold in all SAFs cannot exceed the produced amount of each good \( \forall i \in I \)

\[
\sum_{j} x_{i,j} \leq b_i
\]  

- Sales of each good \( \forall i \in I \) cannot exceed the capacity of each SAF \( \forall j \in J \)

\[
x_{i,j} \leq d_{i,j}.
\]
The obtained solution of the maximization problem allows determining the optimal set of SAFs. The second task that ascertains the development of a cluster is determining the vision (Zhemchugov & Zhemchugov, 2011) of firms, i.e., such a state of a firm, which appears to be the most suitable for the demands of the market in terms of variety and scale of output according to the forecasted demand. Furthermore, according to the concept of shifting from narrow specialization to vertical integration, several specialized firms of the cluster can join the value chain. The results of these operations have to ensure the execution of subsequent operations of the value chain. Formulation of this task implies existence of a set of firms of a cluster \( J \), that are required for production of a set of goods \( I \). For each good \( i \in I \) amount of goods produced, \( b_i \), is determined. Besides that, each good \( i \) is related to a vector of costs \( \{a_{i,j}\} \), required for production of a unit of output and sales price \( c_i \). Expenditures of each firm \( j \in J \) are limited \( d_j \).

Then, the task of choosing the optimal maximum output of goods of a cluster \( \{x_i\} \), when the cost of output is maximized, i.e.

\[
\sum_i c_i x_i \rightarrow \max
\]  

given the constraints:

- The planned scale of output is limited by opportunities of each firm of a cluster, i.e.

\[
\sum_j a_{i,j} x_i \leq d_j \quad \forall j \in J ,
\]

- The produced quantity of each good is limited, i.e.,

\[
x_i \leq b_i \quad \forall i \in I
\]

Solving the problem allows determining the optimal output variety from the use of resources that firms of a cluster are endowed with.

At the same time, the relationship between the sales price \( c_i \) and output costs \( \sum_j a_{i,j} \) determines the profitability of goods \( \forall i \in I \). The relationship between revenue \( \sum_i c_i x_i \) and production costs \( \sum_i \sum_j a_{i,j} x_{i,j} \) characterizes the profitability of a cluster.

The third task is determining the investment and innovation policy, which will ensure evolutionary transformation of a structure of firms of a cluster according to the current vision and minimization of attracted investments. Let us suppose a given set of types of produced goods \( I \) and a set of firms in a cluster that are involved in its production \( J \).

The amount of goods produced, \( x_i \), is assumed to be an independent variable. For each output variety \( \forall i \in I \) the scale of output has constraints \( b_{i,j,\min} \leq x_i \leq b_{i,j,\max} \) that are determined by efficient use of equipment that is planned to be installed or currently used equipment and technology of a firm \( j \in J \).

Besides that, for each output variety \( \forall i \in I \) the vector \( \{a_{i,j}\} \), which determines per unit capital investments into production is set. Then the task of setting the investment policy of a cluster can be formulated as a minimization of investments in organizing a given scale of production, i.e.

\[
\sum_i \sum_j a_{i,j} x_i \rightarrow \min
\]

At the same time, the technical constraints of output scale for each type of production are binding \( b_{i,j,\min} \leq x_i \leq b_{i,j,\max} \) for \( \forall j \in J \). The suggested models of the three tasks allow choosing the suitable way of development of core firms of a cluster in interactive mode.

From a practical point of view the suggestions can be aggregated by considering a
cluster as a complete system that enables scaling up of competitive advantages through implementation of active innovation policy, which leads to an increase of key competencies.

4. Discussion

Many specialists suggest considering the term “cluster” from a standpoint of a “4C” concept (Prokhorov, 2007; Yasheva):

1) concentration of firms in a particular area (reduced transport costs)
2) competition of firms within a cluster for consumers and maintaining their loyalty (common goals to attract consumers);
3) cooperation – urge to involve related industries and local institutions to maintain competitiveness of the output at external market (coordination of joint operations within value chains of goods);
4) competitiveness – expansion of a market share through increased efficiency based on specialization and complementarity of cluster members (specialization within the product range).

Within a cluster one needs to highlight key firms that produce output, for which members join their efforts (Porter, 1998; Tsikhan, 2003; Zhemchugov & Zhemchugov, 2011). These firms are characterized by the presence of cooperation within value chains of homogeneous goods, but at the same time each firm is specialized in a particular operation of this value chain. It is important to note that industrial cluster is characterized by use of the same inputs. Thus, one of common forms of a cluster foundation is “supplier-consumer” relationships.

According to Maskell (2001), horizontal size of a cluster determines a number of firms producing similar output, while vertical size is a number of firm levels that are connected through value chains (Fig. 4). Maskell argues that cluster growth slows down as efficiency decreases due to inclusion of new firm into the cluster. Besides that, input prices both within and outside the cluster affect the size.

Porter claims that emergence of a competitive advantage of a cluster is a result of four interrelated factors that affect companies within clusters. This model is called “The National Diamond” due to a number of groups of advantages (Fig. 5):

- production factors: natural and financial resources, human capital, physical, information, scientific and technologic infrastructure, legislative system;
- presence and actual state of strategic zones of management: efficiency, price, requirements for conditions of use of output, its quality and compatibility with tendencies of development;
- environment characteristics – opportunities of competing and supporting firms, including sources of production and consumption of inputs, intermediates, equipment, technologies, innovations;
- internal competition of cluster members during distribution of revenues, profits and investments in the context of determination and implementation of cluster strategy, including use of legal framework and traditions of doing business.

Based on the presented principles it is natural to suggest Porter’s model (Fig. 3) as a basis for every industrial cluster. Porter’s model illustrates that competitiveness can increase due to:

- combination of advantages of mass production with production of small series of goods for fast renewal of output variety;
- prerequisites for intensification of cooperation connections inside spatially concentrated small and medium enterprises, what allows to consider the effect of market mechanisms for every participant in order to equally compete with big firms, reducing their advantage from scale economies.

5. CONCLUSION

Emergence of prerequisites for cluster creation is revealed when the future leaders
of a cluster, that are already holding a substantial market share, are distinguished. Later, the leader aiming to increase its efficiency aims to bring suppliers, consumers and competitors into its sphere of influence.

This promotes activation of interaction between the involved firms, regardless of their size and, as a consequence, positively influences the further growth of competitiveness of the leader. As a result a cluster is formed – a group of geographically interconnected and interacting firms and organizations that complement each other, act in a particular field and are characterized by common interests and activities.

Cluster offers the most favorable conditions for the development of narrowly-specialized firms, both of cluster cores and supporting their activities. An increase in the effectiveness of firms that develop and supply equipment, technologies, required components, is achieved through the expansion of the market. Besides that, a transition takes place from one-time supplies to single firms for systematic maintenance of well-functioning firms with a large scale of output, and so the cluster occupies the larger share of the market.

Having bigger opportunities to implement active investment policy with lower risk firms of a cluster are interested in highly efficient equipment that fits their requirements to the biggest extent. This equipment has to meet the requirements of a technology that fits the controlled part of the value chain the most, starting from used inputs.

Future research in the considered field should include a more precise description of the architecture of a cluster in order to produce a strategy of cluster development and form an efficient innovation and investment policies.

Thus, functioning of a cluster creates spacious, but tough for participating narrowly-specialized small and medium enterprises market. These firms implement active innovative policy that is based on expanding investment opportunities, what, in the end, becomes a source of additional competitive advantages.

REFERENCES


Figure 1: The Structure of a Cluster
Figure 2: BCG matrix

Figure 3: GE – McKinsey matrix
Figure 4: Possibilities for vertical and horizontal growth of a cluster

Figure 5: Michael Porter’s “National Diamond” model (Diamond Model and Clusters).