CLUSTER TRANSFORMATIONS IN THE REGIONAL SUPPLY CHAINS

Yulia Lukinykh
Krasnoyarsk Institute Of Economics – branch of St.Petersburg University of Management Technologies and Economics, Russia
E-mail: yulla@bk.ru

Valery Lukinykh
Krasnoyarsk State Agrarian University, Russia
E-mail: lukinih_vf@mail.ru

Natalya Tod
Krasnoyarsk State Agrarian University, Russia
E-mail: natashatod@rambler.ru

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Abstract

Analysis of the published research results allows us to identify the cognitive trend of reasoning associated with the transformation of cluster structures to supply chain structures. This is due to the evolution of the methodology of cluster formation, the increase in varieties of cluster manifestations and with different explanations of transformation processes in clusters.

A cluster is a complex concept that researchers often study fragmentally. At the same time, the cluster, as a categorical concept, is located in the space of administrative and methodological formats. It is often used in the design and formation of conceptual approaches to the management of territorial or branch economic systems as one of the ways to improve the innovative environment of the region. But, at the same time, the innovation of regional management is found in the field of logistics, namely: a modern integrative tool for effective management of goods distribution is a conceptual approach from the point of view of supply chain management. The study of the authors allows us to formulate a common and different in essence of two innovative approaches to the management of logistics meso-systems and to identify the process of transformation of clusters into the format of integrated supply chains.

Key words: supply chain, cluster, economic systems, goods distribution, regional logistics

1. INTRODUCTION

Supply chain management theory finds active application in practice. At the same time, practical variants of supply chains have outgrown the theoretical models of supply chains of different formats. In present market conditions, supply chains acquire the character of dynamic networks of complex configuration with a complex nature of communications. Another subject of this article – cluster - evolutionally develops in a similar scenario. Modern developed clusters can often be called project-oriented ones or logistics systems, because the degree of integration of cluster members is high. Both entities are more suitable for multi-functional and multi-level market segments.

The authors investigated the food sector of the market and, in particular, the agro-industrial complex of the Krasnoyarsk region. The results of the study allowed us to propose a hypothesis about the possibility of effective communications of cluster formations and supply chains. Within the framework of the study, the analysis of structural factors of objects was carried out, which allowed us to solve the problem of integration of different-format enterprises of the agro-industrial complex in the region, which leads to the effect of large-scale growth of enterprises` profitability, involved in cluster schemes, to the level of well-organized logistics systems of supply chains.

2. ROLE OF THE SUPPLY CHAINS IN THE REGION

In national and foreign literature one can find different definitions like “supply chain”, “logistics chain”, “logistics network”, “logistics system”. These concepts are not clearly distinguished and they are used as synonyms very often. However, some scientists consider such use as incorrect. For example, A.N. Sterligova distinguishes these concepts and relates them to the following groups: “supply chain” as a generalizing term, “logistics chain, system, and network” as the structure-forming terms (Sterligova, 2005). The majority of authors still do not distinguish these concepts. The terms “supply chain” and “logistics chain” used in this paper will be considered as synonyms.

In the ANNEX dictionary, a supply chain is defined as “the combination of all types of business processes (design, manufacture, sales, service, procurement, distribution, resource management, supporting functions) necessary to meet the demand for a product or service from the initial moment of raw materials or information receiving to the end user delivery” (Logistics chains).

The APICS dictionary provides two interpretations of the supply chain:

- process from purchasing finished products, related by companies: supplier-consumer;
- functions inside and outside the company, necessary in the value chain for the delivery of products and services to the consumer (Logistics chains).

A. Rodnikov gives the following definition: “a logistics chain is a linearly ordered set of natural and/or legal persons (suppliers, intermediaries, carriers, etc.) directly involved in bringing a particular batch of products to the consumer” (Rodnikov, 2000, p.78).

A. Shepeleva gives the following definition of the supply chain: "it is an ordered set of elements of the logistics system (a set of enterprises and organizations engaged in operations to bring the flow from one system to another), integrated by a material (information or financial) flow in order to analyze or synthesize logistics procedures" (Shepeleva, 2000, p.34).

We can distinguish the common points of all the definitions given above:

1) initial parameter of the supply chain formation is the order of the final consumer;

2) initial stage of the supply chain is to obtain feedstock;

3) final stage of the supply chain is the delivery of the finished product to the consumer;

4) supply chain is an integration of the main logistics functions from the inception of the information to the delivery of products or services to the end user;

5) supply chain is an interconnected sequence of units pairs (divisions of the company and / or its logistics partners) "supplier – consumer", according to which the goods are delivered to the end user;

6) supply chain includes material, information, financial and service flows.

Thus, further we will consider the supply chain as a ratio of three or more economic units directly involved in the external and internal flows of products, services, finances and information from the source of raw materials to the end user, in order to meet his/her needs.

The supply chain, in its essence, is a sequence of suppliers and consumers: each consumer then becomes a provider for the following links in the chain, and it continues as long as the finished product is received by the end user.

The supply chain can be viewed at different levels as the scale increases: for example, within a functional area of logistics of a particular enterprise, within a single enterprise, at the city, district, region level, etc.

V. M. Razdelkin in his work refers to the research of the University of Michigan, which states that in order to achieve effective results in global logistics it is necessary to focus on four key factors: integration, positioning, flexibility and measurability. Integration is achieved through the use of information technology to ensure that common information is shared by all partners in the global supply chain or channel.

Considering integration relations, the author notes that they act as a natural stage in the development of business relations and ultimately provide formation of a coherent business structure, which, in turn, acts as a dispatcher of integrated relationships and allows one to achieve a synergetic effect. The consolidation of integrated structures at an increasingly global level and the transition of integration from the micro level to the macro level can be seen as a characteristic phenomenon in today's environment.

The author distinguishes three levels of complexity of supply chain construction:

- Direct supply chain includes companies involved in the upward and downward movement of material flow. Such a chain includes suppliers and consumers, with vertical integration being the highest priority.

- The expanded supply chain, in addition to suppliers and consumers, includes intermediaries located nearby who are directly involved in the promotion of

the incoming and outgoing material flow of products, services and financial information.

- Full supply chain includes all organizations involved in the promotion of incoming and outgoing material flow of products, services, finances and information from the initial supplier to the end user (Razdelkin, 2015).

Supply chains have the following characteristics:

1) Dynamism. Supply chains are flexible structures.
2) Distribution of links in the supply chain geographically.
3) Incompatibility. The members of the supply chain use information systems with different architectures for planning and management.

Dynamism, distribution and heterogeneity of information in the supply chain lead to some difficulties in making effective management decisions. Therefore, let`s consider the term "cluster" (or "cluster structure") and related concepts, which are covered in this paper.

It is logical to start with the concept of "regional supply chain". Currently, the most common approach to defining a regional supply chain is a multiplicative approach. In this case, the regional supply chain is considered as a set of supply chains of all sectors of the region. The regional supply chain (within the industry) reflects the activities of enterprises of some industry in the region, their interaction with each other, with partners and with infrastructure units from the beginning of goods or information flow to the delivery of products or services to the end user. Thus, the regional supply chain (within the industry) consists of supply chains of the enterprises entering this branch, and, in turn, set of supply chains of all branches of the region makes the general regional supply chain.

The essence of the multiplicative approach is that economic entities do not act separately from each other, but build supply chains among themselves, organize the flows. This interaction in the supply chain has a multiplicative effect (Lukinykh, et al, 2017, p.247).

However, there is another approach to the definition of the regional supply chain, the so-called *investment (project) approach*. Donald J. Bowersox and David J. Kloss give the following definition of supply chain: "A logistics chain (or supply chain) is a single structure, in which business joins forces with its suppliers to efficiently deliver goods, services and information to the end users" (Bowersox, 2005, p. 243). This definition is similar to what we discussed above, but there is a difference. The fact is that these authors emphasize that the logistics chain " ... ceases to be a loose group of independent companies, and increasingly becomes a cohesive community, which joint efforts are aimed at improving overall efficiency and competitiveness. Essentially, the overall priorities shift from disjointed inventory management within the organizational framework of each individual participant to the management of a single flow of inventory throughout the supply chain...." (Bowersox, 2005, p. 244). This allows the chain members to increase its overall competitiveness through voluntary cooperation and partnership.

Participants in the supply chain are often united in the implementation of specific investment projects.

The investment approach does not deny the first approach, it includes and deepens it. It involves the division of an enterprise into activity areas, identify key

areas (major), transfer of non-core positions to other chain members (integration). At the same time, relations between the chain participants are formed on the principle of "client-service" (the principle of corporate relations).

Such understanding of the supply chain makes it possible to view the regional logistics chain not just as the sum of the supply chains of its participants, but as a single cohesive system that includes companies that:

1) are united by common goals, policies, programs, projects, etc.;
2) realize mutual dependence (participants have complementary resources and skills), which is the main incentive to strengthen cohesion in the supply chain;
3) make mutual investments in each other;
4) define open to a reasonable extent exchange of information;
5) develop the relationship;
6) clearly share the responsibility and establish the procedures for decision-making.

Unfortunately, nowadays regional supply chains are often perceived from the point of view of a multiplicative approach, which is unacceptable for the formation of cluster structures in the region. Therefore, we need to approach the issue of the formation of clusters in our region with the understanding of the logistics chain as a cohesive system based on cooperation and partnership (the second approach).

3. CLARIFICATION OF THE CONCEPT "PROJECT-ORIENTED CLUSTER" IN THE REGIONAL SUPPLY CHAINS

The concept of cluster was first introduced into the economy by the American economist Michael Porter. He defined the "industry cluster" (from the English "cluster" – swarm, bunch, cluster, group) as an informal community of industry and mixed companies characterized by the ability to mutually strengthen competitive advantages (Porter, 2005).

Cluster theory was continued in the works of another American scientist M.Enright, who created the theory of "a regional cluster" and gave the following definitions: "A regional cluster is an industrial cluster in which cluster member firms are geographically close to each other. The regional cluster is a geographical agglomeration of the firms working in one or several related branches of economy" (Enright, 1993, p.100).

Thus, following Enright's theory, competitive advantages are not created at the national level, as in Porter's, but at the regional level, where the main role is played by the historical prerequisites of the regions` development, the diversity of business cultures, and the organization of production.

In present paper, cluster structures will be considered at the regional level.

S.Filin, a leading expert of the national Fund for small and medium-sized enterprise development, gives the following definition of cluster in a broad sense: "it is a network of suppliers, manufacturers, consumers, infrastructure elements, research institutes, interconnected in the process of creating added value" (Filin, 2006).

There are several definitions of clusters, each emphasizes a particular aspect (priority) of its functioning (tab.1). For example, in an innovative process, a cluster

can be considered as a sustainable territorial-sectoral partnership, united by an innovation program for the introduction of advanced production, engineering and management technologies in order to improve its competitiveness. Or, an industrial cluster is a group of geographically adjacent and integrationally interacting companies and related organizations operating in a certain industry (diversified) and mutually reinforcing each other (Lukinykh et al., 2017, p.248).

Table 1. Definitions of the term "cluster"

Name	Definition	Author
Cluster	Swarm, bunch, cluster, group	English-Russian dictionary
Industry cluster	Informal community of industry and mixed companies, characterized by the ability of mutual strengthening of competitive advantages.	M.Porter (Porter, 2005)
Regional cluster	A regional cluster is an industrial cluster in which cluster member firms are geographically close to each other. The regional cluster is a geographical agglomeration of the firms working in one or several related branches of economy.	M.Enrigh (Enright, 1993)
Cluster (general notion)	A network of suppliers, manufacturers, consumers, infrastructure elements, research institutes, interconnected in the process of creating added value	S.Filin (Filin, 2006)
Cluster in an innovative process	A sustainable territorial-sectoral partnership, united by an innovation program for the introduction of advanced production, engineering and management technologies in order to improve its competitiveness	A.Kharitonov (Kharitonov, 2009)
Industry cluster	A group of geographically adjacent and integrationally interacting companies and related organizations operating in a certain industry (diversified) and mutually reinforcing each other.	(Cluster development, 2006)
Cluster	A type of partnership in business, a group of enterprises operating in one or related industries, geographically located in one geographical region, interconnected in the process of creating a product(service) for the end user and mutually contributing to the growth of competitiveness of each other.	(Cluster development, 2006)
Project-oriented cluster	A group of companies operating in one or different industries, geographically located in one or different geographical regions, interconnected by supply chains of harmonized industries in the process of creating products (services) that are necessary for the implementation of a specific investment project in a particular region, and mutually contributing to the competitiveness growth of each other.	V.Lukinykh, N.Tod (Lukinykh &Tod, 2008, p.278)

Source: authors` development

The diversity of definitions of the term "cluster" in the economic literature testifies the following:

- insufficient scientific development of this concept is due to its relative novelty;

- intensive development of the terminological apparatus of cluster theory;
- cluster is a complex concept that researchers often study fragmentary.

In this paper we will consider the cluster as a type of partnership in business, as a group of enterprises operating in one or related industries, geographically located in the same geographical region, interconnected in the process of creating a product (service) for the end user and mutually contributing to the growth of competitiveness of each other (Cluster development, 2006).

In addition to the beneficial cooperation for all members of the cluster in the process of creating any product (service) for the end user, one shouldn`t forget about the main purpose of business – realization of profit by cluster members (in broader sense - capital accumulation).

The cluster includes a variety of companies specializing in a particular link in the chain of creation of a specific end product.

There are two main approaches to identifying cluster systems:

- *Industry approach*. It consists in the formation of cluster structures on the basis of interrelated industries. The enterprises entering into cluster are united by one general purpose, except receiving profit, - production of concrete goods or services (or groups of goods (services) of a related origin). For example, logging, wood processing enterprises, enterprises producing logging equipment, pulp and paper industry enterprises, chemical industry enterprises, various infrastructure elements (transport companies, distribution centers, financial institutions, insurance companies, etc.), research institutes, universities, etc. can be combined into a common forest cluster.
- *Focus-investment approach*. It consists in a temporary consolidation into a project-oriented cluster of small, medium and large businesses, concentrated around one center – the investment national project – and offering multidirectional goods and services necessary for the implementation of this investment project. Thus, a project-oriented cluster is a group of enterprises operating in one or related industries geographically located in one geographical region, interconnected in the process of creating products (services) necessary for the implementation of a specific investment project, and mutually contributing to the growth of each other's competitiveness (tab.2).

Table 2. Approaches to identifying cluster systems

Parameter	Industry approach	Focus-investment approach
Aim	Creation of a product (service)	Realization of investment project
Time period	Cluster is a constant structure	Cluster is a temporary structure
Goods (services)	Related origin	Different or related origin

Source: authors` development

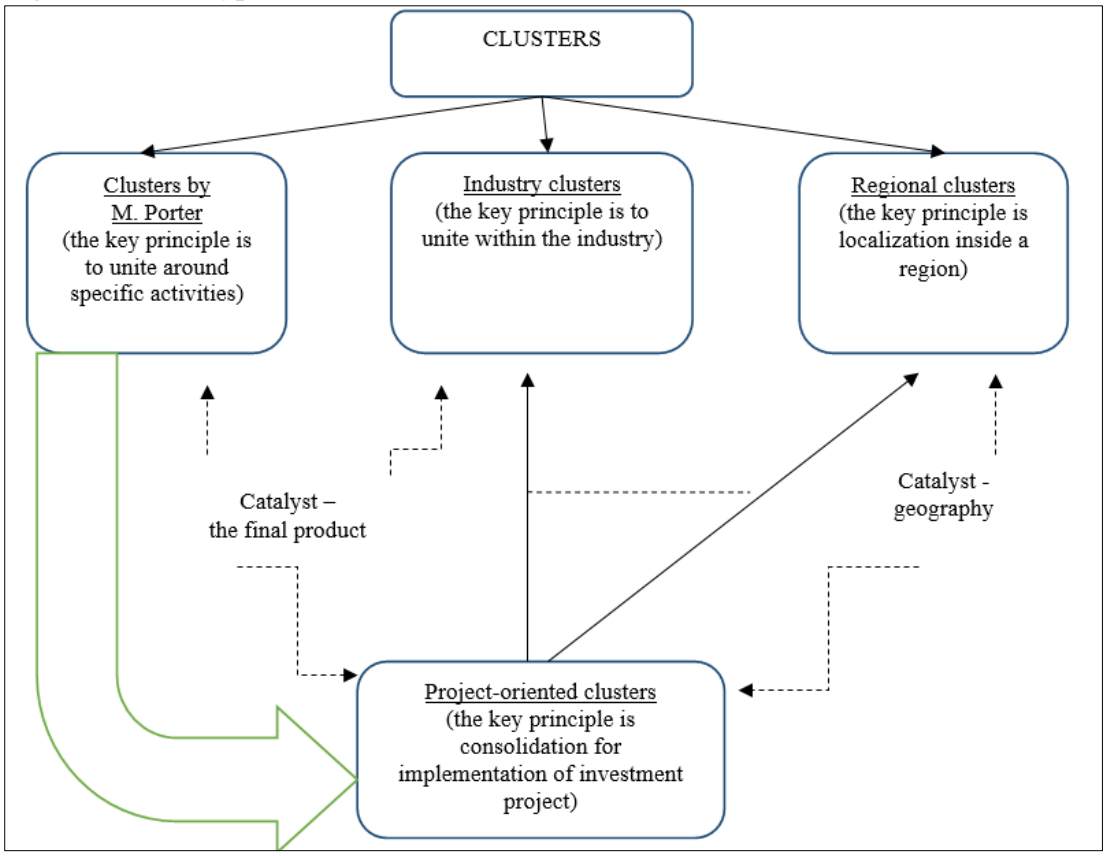
4. EVOLUTION OF THE TERM "CLUSTER" AND EVOLUTION OF CLUSTERS IN THE REGIONAL SUPPLY CHAINS

In the research papers of modern authors there is still a dispute about a catalyst for the cluster creation. Experts ' opinion is divided into two: "catalyst – geography", "catalyst – the final product". Since the 90s, the trend has changed in the direction of the first, then in the direction of the second. The authors A.Kolesnikov and N.Khazaliya (Kolesnikov & Khazaliya, 2016) noted that in 1992 the emphasis was on industry clusters geographically united.

By 2000, the cluster is based on the idea of exclusively industrial orientation of cluster firms within a certain sphere of activity (focus on the final product). And in 2005, the emphasis is made again on the geographical component. Now the focus has changed again and most of the authors speak about the final product as a catalyst. That`s a good tendency, since borders of a cluster are "blurred" gradually; the cluster goes beyond geographical borders, expands a sphere of activity and a zone of presence, goes to the world market, in global supply chains that promote increase of competitiveness of the organizations – participants of the cluster, and the state as a whole.

Having analyzed modern sources of information from 2010 to 2017, it is possible to distinguish the following main types of clusters: clusters by Porter, industry, regional, project-oriented clusters (Fig.1).

Figure 1. Main types of clusters



Source: authors` development

In recent years, the concept of "innovative cluster" has become widespread. First of all, this is due to the state policy in Russia, to the adopted Development Program until 2020, which provides creation of 25 innovative clusters in the country.

Innovative cluster is a set of closely located companies that have a common technological and scientific base, logistics and infrastructure chains; their mutually beneficial activities are based primarily on the use of the existing advantages of simultaneous action of various market mechanisms that allow quite quickly and efficiently produce and distribute new knowledge and technology (Babkin, 2017).

All models of cluster structures are characterized by geographical localization. Geographical localization of the main cluster participants, as well as transport and information infrastructure, make it possible to implement the interaction between the cluster participants – cooperation, exchange of technologies, ideas, know-how, trained personnel. Currently, due to the development of transport networks and modern means of communication (Internet, e-mail), the boundaries of clusters are expanding.

Any cluster assumes a synergetic effect, which means that the cluster's potential exceeds the sum of the individual components ' potentials. This is the result of effective cooperation of the enterprises who are participants of the cluster, allowing them to use the capabilities of the partner, the combination of cooperation and competition, proximity of manufacturers and consumers, etc. Symbiosis of two processes takes place in the cluster: competition and cooperation. Due to the constant small conflicts related to competition between cluster members, the system is being optimized. Through the exchange of information, ideas, specialists, technologies, sharing of common resources and opportunities, cluster members receive tangible benefits, and as a result, the system is developing.

Consequently, participation in the cluster allows the enterprises to acquire such competitive advantages as:

- expansion of the product line without increasing investments in inventory;
- diversity and relative accessibility within the cluster of different sources of technological knowledge facilitates the combination of production factors and becomes a prerequisite for effective innovation (companies included in the cluster are faster to learn about new techniques, technologies or supply opportunities, thanks to the constant exchange of information and personal contacts; an isolated firm is forced to spend more time and money on information);
- opportunities for successful launch of a new product in the shortest possible time without compromising the rest of the business (due to concentration and availability of any resources necessary for the formation of the enterprise, including information);
- improving the quality of customer service;
- lower costs and increase of margin profit, which allows for a more aggressive pricing policy, etc. (Lukinykh, et al., 2017).

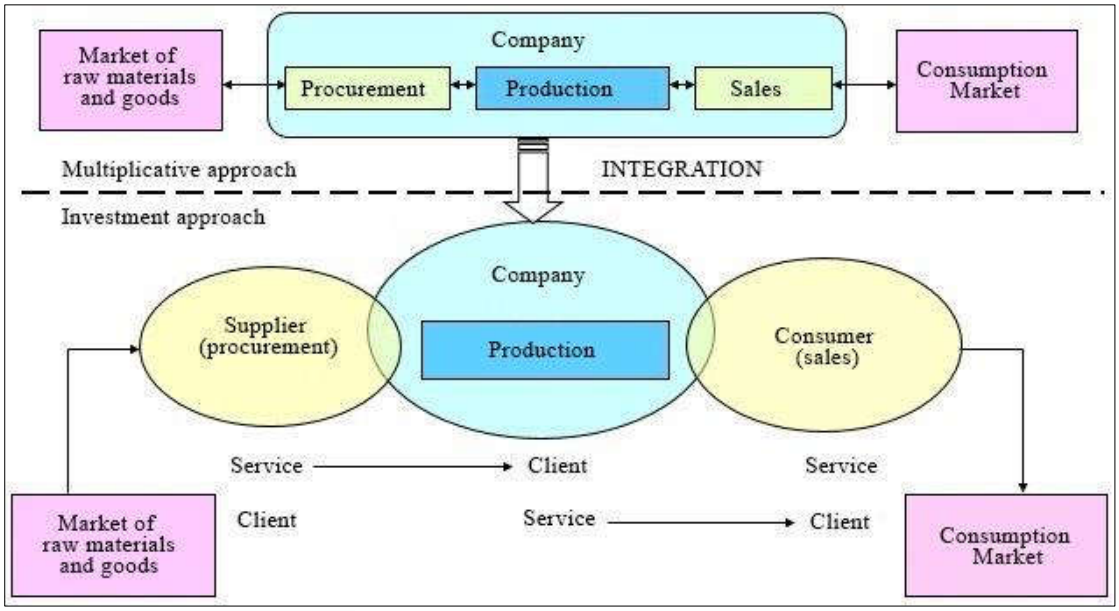
Clusters play the role of "growth points" for the economy of certain regions. When one or more economic entities achieve competitiveness in the market, they extend their influence to the immediate environment: suppliers, consumers, competitors, and infrastructure. In turn, successes of the environment have a positive impact on the further growth of competitiveness of the economic entity. At present time population of cluster approach is high: large multinational companies while

distributing their assembly productions choose under other equal conditions those regions where clusters of suppliers are created (Mitenev, 2006).

There are several approaches to cluster formation. The most common is industry approach. We have proposed a focus-investment approach, which consists in temporary consolidation into a project-oriented cluster of small, medium and large businesses, concentrated around one center– the investment project – and offering goods and services necessary for its implementation (Lukinykh et al., 2017).

Project-oriented clusters assume their creation on the basis of integrated supply chains, which implies an understanding of the supply chain from the point of view of an investment rather than a multiplicative approach (Fig. 2). It involves the principle of specialization, i.e. division of enterprises into activity spheres and identification of key areas to focus on them, as well as the principle of integration, i.e. transfer of non-key positions to other participants in the chain for whom they are focal. This provides a greater synergy effect than simple cooperation.

Figure 2. Approaches to the formation of project-oriented clusters based on integrated supply chains



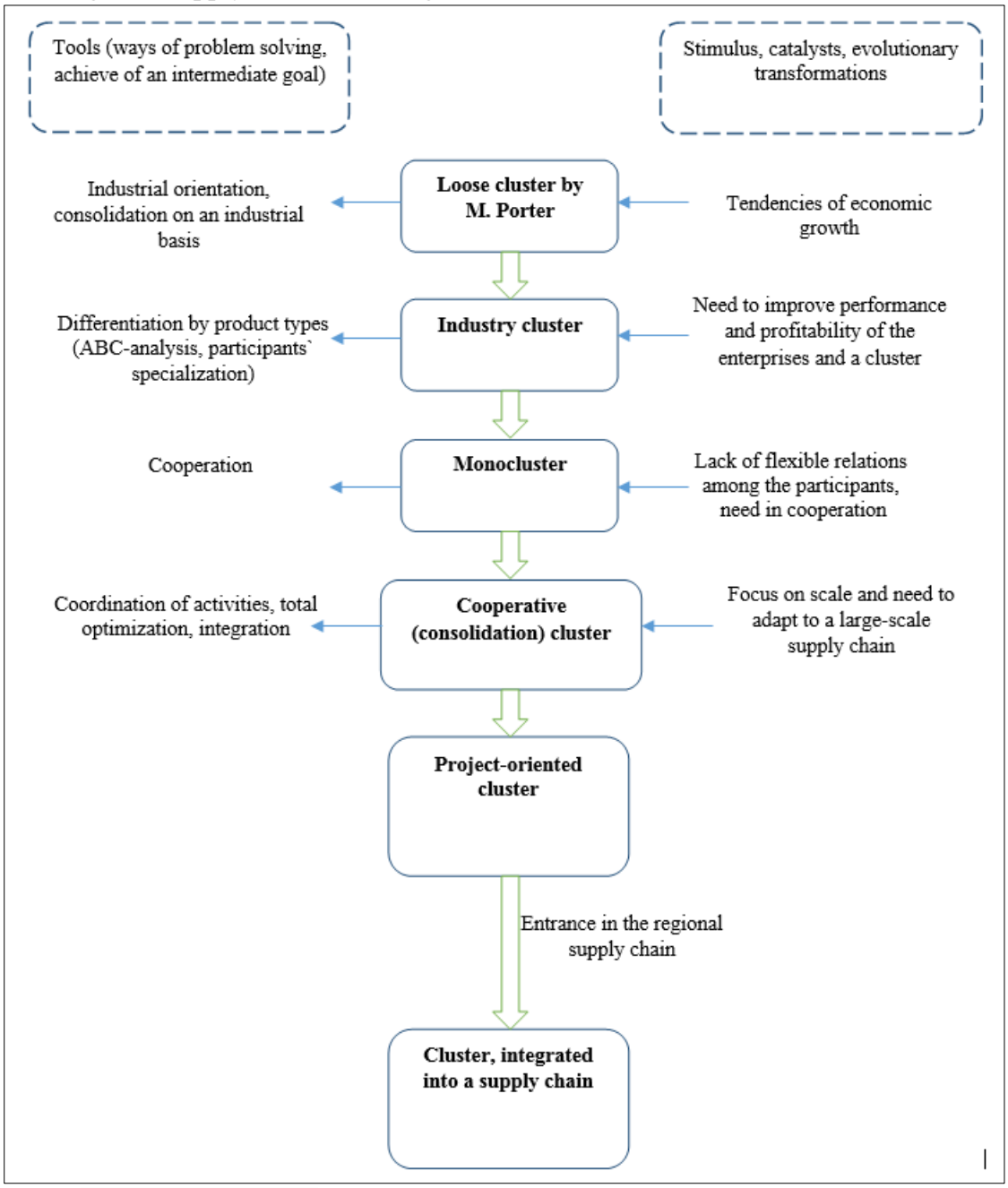
Source: authors` development

The greatest interest to clusters is shown now in agro-industrial complex (AIC). The main advantages of clusters` creation in AIC are: stimulation of innovation; optimization of production processes; costs minimization; reduction of the product cost; effect of synergy and scale; investment increase; development of industry and new technologies; a closer relationship between AIC and science; increase of employment and living standards; competitiveness increase of the enterprises and the region.

Since agribusiness is not a homogeneous object of management, therefore, the divergence of activities included in its composition makes it necessary to study a number of specialized approaches to integrated management. Fig.3 shows the process of transformation of the so-called “loose” cluster into a project-oriented cluster. The

stated technique is already observed in practice in the agro-industrial complex of Krasnoyarsk region (Russia). Such structures are created by business representatives intuitively, which reinforces the relevance of our research.

Figure 3. Process of transformation of a "loose" cluster into a project-oriented one in the integrated supply chain of the region



Source: authors` development

What is the essence of the problem? Individual farmers cannot meet the conditions for entering the goods flows of large network structures, they do not reach

quality and quantity of the produced goods and, as a consequence, they cannot be integrated into the supply chain.

This problem stimulated them to create a monocluster. How did this process look like? At first the enterprises began to work on the principles of cooperation in the format of loose, and then an industry cluster in the field of dairy production. Their individual flow capacity did not correspond to the conditions of entering the market of network structures. However, desire and understanding of the need to increase profitability of their enterprises forced them to look for alternative options for embedding in these supply chains. This led to the rigid specialization of the participants and creation of a monocluster. Through further coordination, total optimization and integration, they have achieved a level of synergy, quality and quantity of produced milk, which has become interesting for the network structures and allowed the cluster to "join" in their supply chain. This is the level of the project-oriented cluster.

5. METHODOLOGICAL TOOLS FOR PROJECT-ORIENTED CLUSTER MANAGEMENT

To evaluate the efficiency of the proposed cluster model, the econometric method of statistical dependence equations was chosen. The proposed method allows on the basis of identifying the relationship between the cluster key parameters and cluster effective indicator to assess / predict the quantitative change of the effective indicator due to the quantitative changes in the key parameters under the condition of a stable relationship. This method has been tested by the authors of the present paper (Tod, 2010, p.235) as well as confirmed in the papers of other researchers (Belova, 2014; Beybalaeva, 2015; Vorontsov, 2017).

An important stage in the formation of the project-oriented cluster is the evaluation of its performance, which is carried out twice: at the modeling stage and in the process of the cluster operation.

The project-oriented cluster consists of a set of integrated supply chains, therefore, speaking about the assessment of the cluster performance, in fact, we are talking about an integrated assessment of the efficiency of supply chains within this cluster.

To assess the effectiveness of the project-oriented cluster it would be possible to apply existing methods of assessing the supply chains effectiveness, or effectiveness of the integrated structures. But in research publications methods are evaluative, simplified, or bulky and impractical. In the first case, the obvious positive results are listed from the creation of supply chains or clusters (increase in production volume; increase in profit; reduction in cost; increase in profitability; increase in labor productivity; reduction in the duration of the logistics cycle; improvement of product quality; increase in the volume of attracted investments; increase in the number of skilled workers, etc.). In the second case, massive methods of complex calculations, inconvenient in practical application, are proposed.

In addition, the methods proposed do not solve the problem of identifying the dependence degree of the effective indicator of the project-oriented cluster on the key

parameters of the supply chains in its composition and do not consider the following question: due to the quantitative changes of which parameters the improvement of the effective indicator of the project-oriented cluster occurs. To solve these problems, the authors propose two methods – ABC analysis and econometric method:

- on the basis of the ABC analysis, the selection of participants of the future project-oriented cluster is made and supply chains are built (identification of the key revenue position of the enterprise for subsequent specialization and selection of one participant from several competitors);
- for each enterprise, as a central link of a certain supply chain, a key parameter is identified, reflecting its specialization in the cluster and industry affiliation;
- the correlation and sustainability indicators of the relationship between the selected key parameters of enterprises and the effective indicator of the cluster are evaluated; thus, it is possible to build a hierarchy of parameters according to the degree of importance, as well as to determine the role of each enterprise and its chain in the cluster by the level of their influence on the effective indicator;
- assessment of parameter values potential of the enterprises in the supply chain is made with the aim of determining their optimum values for making effective management decisions;
- identification of the relationship between key parameters and the effective indicator allows to predict the quantitative change of the effective indicator due to the quantitative change of the main parameters under the condition of a stable relationship.

Selection of participants of the future structure is carried out by ABC-analysis. When choosing from several companies that produce the same product (service), necessary for the implementation of the investment project, preference should be given to the company, in which this product (service) is part of the group “A”. In this case, the company will be advantageous to abandon the production of a number of goods (services) of group “B” and (or) “C” and focus on the production of the necessary cluster for the implementation of the project of goods (services) of group “A” and, accordingly, receive more income. In this case, it is possible to significantly “shift” the structure “20%-30%-50% “ towards an increase in the percentage of the group “ A” due to a significant reduction in risks, as participation in the project-oriented cluster guarantees the company that a new volume of its goods (services) will be necessarily implemented within the framework of this investment project. Thus, the cluster will include specialized and highly efficient enterprises of the region.

Economic efficiency of the project-oriented cluster is estimated on the basis of econometrics. Econometrics includes statistical and mathematical methods, such as summary and grouping of information; variational and variance analysis; regression and correlation analysis; statistical equations of dependence; statistical indices, etc.

An important requirement for the use of statistical and mathematical methods is the study of small sets of enterprises, which would make it possible to ensure the representativeness of the findings. This requirement is met by the method of statistical equations of dependence. The difference between this method and the least squares method is as follows:

1) the initial term of the dependence equation has a real economic sense (it is the minimum or maximum value of the effective indicator);

2) values of the parameters for individual factors and signs and for single-factor and multi-factor dependence equations are the same;

3) the sum of linear deviations of theoretical values of the effective indicator from the actual values should be minimal.

On the basis of the methodology of statistical equations of dependence, the normative calculations of the dynamics of the main socio-economic indicators of the Krasnoyarsk territory (Russia) were carried out to identify the trends in the economy of the region and the intensity of the use of key parameters (factors) (X_i) that affect the formation of the gross regional product (GRP) of the Krasnoyarsk territory per capita (Y), (thousand rubles). The following parameters are selected:

X_1 - population at the end of the year, thousand people;

X_2 - average per capita income per month, billion rubles;

X_3 - fixed assets in the economy at full book value (at the end of the year), billion rubles;

X_4 - retail trade turnover, billion rubles;

X_5 - public catering turnover, billion rubles;

X_6 - paid services to the population, billion rubles.;

X_7 - investments in fixed capital, billion rubles.;

X_8 - foreign trade turnover, billion rubles.

Indicators X_1 should reflect the main parameters of the cluster (the key parameters of the specialized supply chains that make up the cluster, which affect the effectiveness of the cluster or region), but in this example, socio-economic indicators of the region are considered as X_1 parameters; and as an effective indicator of the development of the region – GRP per capita (without taking into consideration the creation of the cluster structure). It should be noted, that the main goal of this study is not specific final figures, but the presentation of the calculation method itself, which is proposed to assess the effectiveness of the project-oriented cluster.

The values of the factor values (X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8) and the effective indicator (Y) are presented in the tab. 3.

Table 3. Social and economic indicators of the Krasnoyarsk region

Years	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	Y
№ 1	3000,90	2773,30	406,80	48,60	2,80	12,30	25,50	3706,90	71,30
№ 2	2942,00	5508,80	693,10	89,80	5,90	29,50	37,20	3758,30	92,40
№ 3	2925,30	6407,70	750,50	105,80	7,30	35,70	49,10	4719,10	124,60
№ 4	2906,20	7665,00	823,50	126,60	8,90	42,90	71,40	5689,00	151,60

Source: authors` development

When assessing the impact of the project-oriented cluster indicators on the level of regional development, it is not accidental that GDP per capita and average per capita income are proposed as effective indicators. The fact is that these indicators reflect two key aspects of the development of the region: the average per capita

income reflects the purchasing power of the population of the region, and GDP per capita – the ability of industry to meet the needs of the population. These indicators should be balanced and have a tendency of growth. By identifying the relationship of the main parameters of the cluster with these key indicators using the proposed method, it is possible to identify the factors that need to be changed to increase these indicators and establish a balance between them.

According to table

3, the parameters of one-factor equations for each factor and the effective indicator are calculated. The calculation of the equation parameters is performed using the following formulas:

• direct dependence:

with an increase in the factor and effective indicators

$$y_x = y_{\min} \cdot \left(1 - b \cdot d^{\frac{x_i}{x_{\min}} - 1} \right)$$

when reducing factor and effective indicators

$$y_x = y_{\max} \cdot \left(1 - b \cdot d^{1 - \frac{x_i}{x_{\max}}} \right)$$

• inverse relationship:

with an increase in the factor indicator and reducing effective indicators

$$y_x = y_{\max} \cdot \left(1 + b \cdot d^{\frac{x_i}{x_{\min}} - 1} \right)$$

with a decrease in factor and increase in effective indicators

$$y_x = y_{\min} \cdot \left(1 + b \cdot d^{1 - \frac{x_i}{x_{\max}}} \right)$$

where y_x - the theoretical value of the effective indicator; $y_{\min}$ - the minimum value of the effective indicator; $y_{\max}$ - the maximum value of the effective indicator; b - the parameter of the equation of the one-factor linear relationship factor and effective indicators.

Depending on the type and direction of the relationship, the parameter is based on the following formulas:

- with an increase in the factor and effective indicators

$$b = \frac{\sum(\frac{y_i}{y_{\max}} - 1)}{\sum(\frac{x_i}{x_{\min}} - 1)}$$

- with an increase in the factor indicator and reducing effective indicators

$$b = \frac{\sum(1 - \frac{y_i}{y_{\max}})}{\sum(\frac{x_i}{x_{\min}} - 1)}$$

- with a decrease in factor and increase in effective indicators

$$b = \frac{\sum(\frac{y_i}{y_{\min}} - 1)}{\sum(1 - \frac{x_i}{x_{\max}})}$$

- with a decrease in factor and effective indicators

$$b = \frac{\sum(1 - \frac{y_i}{y_{\max}})}{\sum(1 - \frac{x_i}{x_{\max}})}$$

To assess the stability of the relationship of each of the key parameters with the effective one, we should calculate the stability coefficients, which are determined by the formula:

$$K = 1 - \frac{\sum|d_y - b \cdot d_x|}{\sum d_y},$$

where d_y – the size of deviations of the comparison coefficients of empirical values of the effective indicator; $b \cdot d_x$ – the size of the deviations of the comparison coefficients of the theoretical values of the effective indicator.

The obtained statistical equations of dependence of the resulting indicator with factor values and calculated values of the stability coefficients of the relationship of these indicators are presented in tab.4

Table 4. The parameters of dependencies equations and the values of the stability coefficient

Indicators		Equations parameters	Stability coefficient
X_1	The population at the end of the year, thousand people	$y_{x_1} = 71{,}3 \cdot (1 + 28{,}4 \cdot d_{x_1})$	K_1=0,7588
X_2	Average per capita income per month, billion rubles	$y_{x_2} = 71{,}3 \cdot (1 + 0{,}53 \cdot d_{x_2})$	K_2=0,7869
X_3	Fixed assets in the economy at full book value (at the end of the year), billion rubles	$y_{x_3} = 71{,}3 \cdot (1 + 0{,}84 \cdot d_{x_3})$	K_3=0,7257
X_4	Retail trade turnover, billion rubles	$y_{x_4} = 71{,}3 \cdot (1 + 0{,}59 \cdot d_{x_4})$	K_4=0,8057
X_5	Public catering turnover, billion rubles	$y_{x_5} = 71{,}3 \cdot (1 + 0{,}44 \cdot d_{x_5})$	K_1=0,8202
X_6	Paid services to the population, billion rubles	$y_{x_6} = 71{,}3 \cdot (1 + 0{,}37 \cdot d_{x_6})$	K_1=0,7896
X_7	Investments in fixed capital, billion rubles	$y_{x_7} = 71{,}3 \cdot (1 + 0{,}68 \cdot d_{x_7})$	K_1=0,8922
X_8	Foreign trade turnover, billion rubles	$y_{x_8} = 71{,}3 \cdot (1 + 2{,}64 \cdot d_{x_8})$	K_1=0,7366

Source: authors` development

It can be seen from tab.4, that there is an average and a high level of relationship stability between the main parameters and the effective indicator ($K > 0{,}7$). The presence of a stable connection indicates the reliability of the parameters of the calculated equations of the dependence of the main and effective indicators. Thus, if $K > 0{,}7$, we select all eight factors ($X_1 - X_8$) for reliable normative calculations of the degree of indicators use intensity in dynamics.

Normative calculations of the factor use intensity in the dynamics are made by the following algorithm:

1) determine the difference between the ratio of the coefficient of comparison of the GRP value corresponding to the next period, with the previous one

$$d_{y_н} = \frac{y_k}{y_{\min}} - 1$$

where $k = 2{,}3{,}4$ – ordinal numbers of the values of the effective indicator;

2) find the size of the deviations of the comparison coefficients of factor indicators from one by dividing the resulting difference by the parameters of the dependence of individual factors;
3) the optimal levels of factors that could provide the actual level of performance in a given year is determined by subtracting from the unit the deviations of the comparison coefficients of factors, the values of which are reduced (X_1), and by addition to the unit the size of the deviations of the comparison factors, the values of which increase ($X_2 - X_8$), followed by multiplication by the maximum level of the factor, the values of which are reduced, and the minimum values of the factors, the levels of which increase.

The results are presented in table 5

Table 5. Comparison of actual and optimal levels of factors

Indicators		Actual value	Optimal value	Ratio of the optimal level to actual	Years
X_1	The population at the end of the year, thousand people	2942,00	2969,64	1,009	2
		2925,30	2921,93	0,999	3
		2906,20	2881,93	0,992	4
X_2	Average per capita income per month, billion rubles	5508,80	4309,30	0,782	2
		6407,70	6653,35	1,038	3
		7665,00	8618,85	1,124	4
X_3	Fixed assets in the economy at full book value (at the end of the year), billion rubles	693,10	549,56	0,793	2
		750,50	767,43	1,023	3
		823,50	950,11	1,154	4
X_4	Retail trade turnover, billion rubles	89,80	72,66	0,809	2
		105,80	109,38	1,034	3
		126,60	140,16	1,107	4
X_5	Public catering turnover, billion rubles	5,90	4,67	0,791	2
		7,30	7,52	1,030	3
		8,90	9,91	1,114	4
X_6	Paid services to the population, billion rubles	29,50	22,01	0,746	2
		35,70	36,83	1,032	3
		42,90	49,26	1,148	4
X_7	Investments in fixed capital, billion rubles	37,20	36,58	0,983	2
		49,10	53,48	1,089	3
		71,40	67,65	0,947	4
X_8	Foreign trade turnover, billion rubles	3758,30	4122,31	1,097	2
		4719,10	4756,26	1,008	3
		5689,00	5287,83	0,929	4

Source: authors` development

The table shows that the factors X_1 (population at the end of the year), X_7 (investment in fixed capital) and X_8 (foreign trade) tend to reduce the intensity of their use to ensure the growth of GRP per capita Y at the end of the study period. For all other factors, there is a trend of increasing intensity of their use to form the value of GRP per capita.

Thus, the presented calculation method can be used to evaluate the effectiveness of the project-oriented cluster. This will allow to identify the relationship between the key parameters of the cluster (key indicators of specialized supply chains within the cluster) and the effective indicator of the cluster, to determine the optimal values of these parameters, as well as to predict the quantitative change in the effective indicator in the future due to the quantitative changes in the key parameters. The results allow to make a conclusion about the possibility of using the presented method of statistical dependence equations to assess the effectiveness of such a multi-component economic structure as a project-oriented cluster, as well as the possibility of using this method for modeling the economic parameters of local areas.

6. CONCLUSION

The proposed format of the project-oriented cluster, the method of assessing quality of integration communications and assessing impact of external factors allows us to initially build the cluster structure and relationships between its participants on the principles of construction and operation of the integrated supply chains (high degree of specialization and competence of the participants, the principles of total optimization at all levels, the principle of coordination, cooperation and integration, total quality control), this makes it easier to enter existing regional supply chains to expand the scope of activities and, consequently, to increase the effectiveness and efficiency of its activities.

Accordingly, project-oriented clusters are highly flexible structures due to specialization, coordination, cooperation and integration. Project-oriented clusters are not only potential “points of growth” for the region`s economy, but also a possible solution to one of the main problems of small and medium-sized enterprises, in particular in the agribusiness sector - entering the market of large network structures for the implementation of its finished product.

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