



Theoretical and methodological bases of formation of petrochemical clusters

Bases teóricas y metodológicas de la formación de clusters petroquímicos

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ABSTRACT:

Ensuring the accelerated pace of economic development due to the growth of competitiveness of the industrial sector, as well as the need to improve the stability and profitability of business require the presence of adequately developed integration structures, both purposefully formed and self-developing. Petrochemical clusters, being an integral part of highly developed market economies, contribute to the increase of productivity, innovation, efficiency and competitiveness of both economic entities and spheres of economic activity, regions, and countries. The importance of cluster structures increases with the development of the market mechanism in line with global trends: globalization of economic relations, strengthening the position of major global actors, dematerialization of consumer goods, information, networking. The purpose of this article is to develop the theory of petrochemical clusters as a form of integrated structures, that is the most adaptive to the dynamically developing market economy, and to develop the conceptual foundations of their development management.

Keywords: industry, economy, petrochemical industry, clusters, theoretical and methodological basis, integration, economic structures, production development.

RESUMEN:

Para asegurar el ritmo acelerado del desarrollo económico debido al crecimiento de la competitividad del sector figuran, así como la necesidad de mejorar la estabilidad y la rentabilidad de las empresas, es preciso contar con estructuras de integración adecuadamente desarrolladas, bien formadas o bien desarrolladas. Las agrupaciones petroquímicas, que son parte integrante de las economías de mercado altamente desarrolladas, contribuyen al aumento de la pelea, la innovación, la eficiencia y la competitividad tanto de las entidades económicas como de las esferas de actividad económica, las regiones y los países. La importancia de las estructuras de los grupos temáticos aumenta con el desarrollo del mecanismo de mercado en consonancia con las tendencias mundiales: la globalización de las relaciones económicas, el fortalecimiento de la posición de los principales agentes mundiales, la desmaterialización de los bienes de consumo, la información y el establecimiento de redes. El propósito de este artículo es desarrollar la teoría de los conglomerados petroquímicos como una forma de estructuras integradas, que es la más adaptativa a la dinámica de desarrollo de la economía de mercado, y desarrollar las bases conceptuales de su gestión del desarrollo.

Palabras clave: industria, economía, industria petroquímica, clusters, bases teóricas y metodológicas, integración, estructuras económicas, desarrollo productivo

1. Introduction

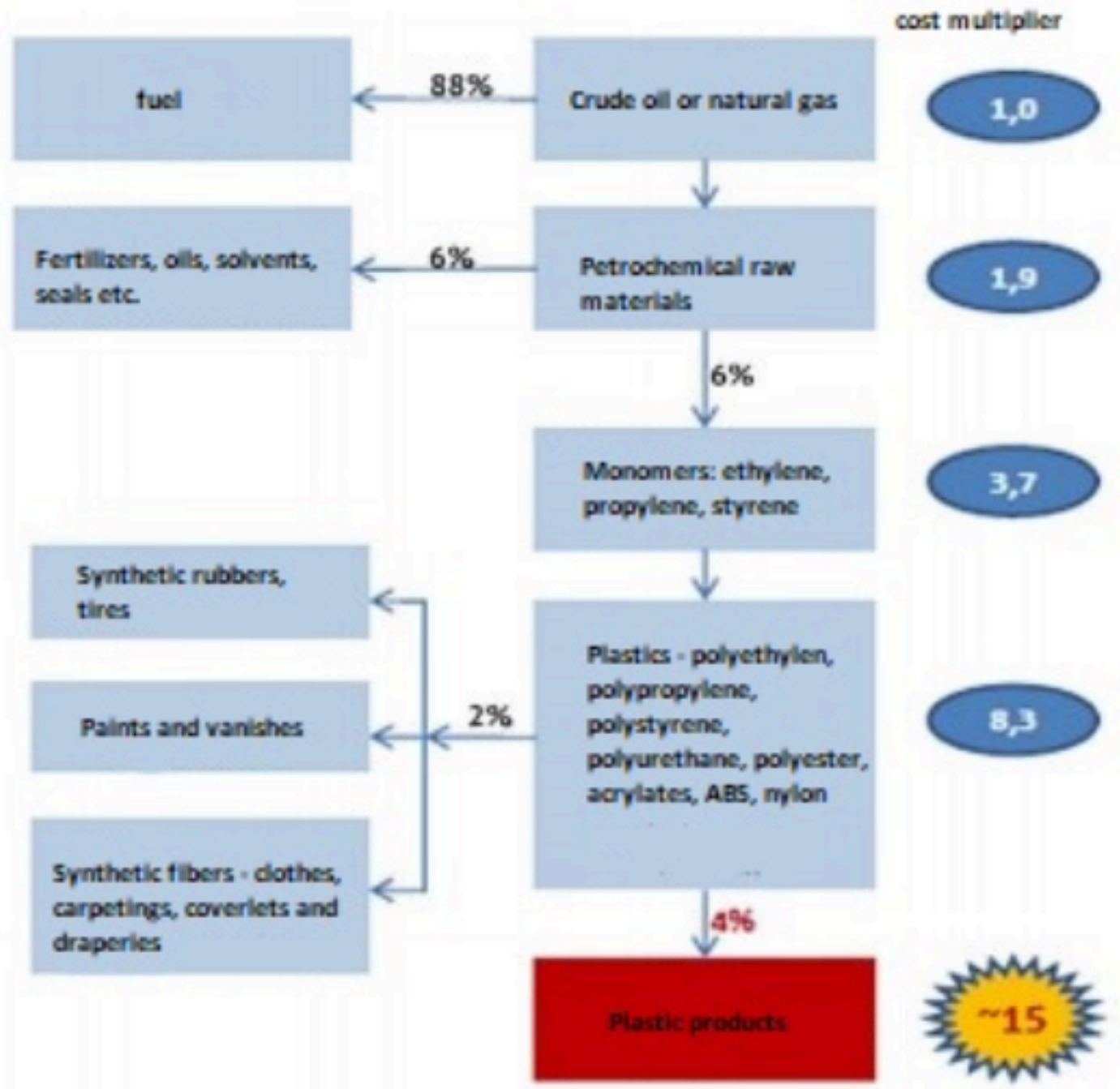
Petrochemistry is one of the key branches of the manufacturing industry, but it remains far from public understanding and proper discussion. Meanwhile, the produced products are used almost every minute. It is considered that among any five objects that surround us at any given time, four are created due to petrochemical industries. Oil and gas companies with petrochemical production and the possibility of obtaining a synergetic effect from the interaction of production of oil and gas and a petrochemical complex are studied. To a lesser extent, the literature reflects the experience of countries with a developed petrochemical industry in the design and construction of petrochemical production facilities, the implementation of petrochemical projects. This paper attempts to fill this gap.

In terms of its level of development, gas chemistry is far below petrochemistry. In addition to the "age" factor (it is no more than a decade as the term "gas chemistry" is actively used for an independent technological field, while the more familiar term "petrochemistry" describes a set of technologies with almost a century of history), there are fundamental differences between gas chemistry and petrochemistry (Behrens & Hawranek, 1991; Belosludov, Dyadin, & Lavrentev, 1991). Although there is no doubt that the majority of products traditionally produced from liquid hydrocarbons can be obtained from light alkanes in the corresponding gas chemical processes, which greatly differ from petrochemical. The greatest interest for the author of this research is represented by the enterprises processing directly natural gas (methane). The potential of such gas chemistry in the modern world, which has the instability of raw materials exports due to geopolitical tensions is quite large indeed, and its importance is difficult to overestimate. The main semi-finished product is a synthesis gas, and the end products are methanol and various products based on it. So, recently there are more and more gas chemical complexes, that besides traditional chemical syntheses based on natural and associated petroleum gas include GTL technology (gas to liquid) and a number of new syntheses (Ho, 2013).

The emergence of the world oil and gas chemistry refers to the 20s of the last century (Barinov & Zhmurov, 2007). The major boost for the development of this industry was in the US in the 50-60s of the last century. Large centers of oil and gas chemistry began to emerge in the States of Texas and Louisiana, the main centers of oil and gas production and processing of the USA. In the late 1950s, after the historical May Plenum of the CPSU Central Committee (1958), the intensive development of the petrochemical industry began in the USSR. Many of the developing countries due to the establishment of the petrochemical complex have been able to implement the first stage of technological development, which consequently helped them to proceed with implementation of high technologies in the field of electronics and telecommunications (Akulov & Rudakov, 2002; Arkin & Soloveychik, 2009). Developing countries with oil and gas resources established large-scale production of basic semi-finished products and petrochemicals for export mainly (Horsnell, 1997; Kerzner, 1999; Torkunov & Simonova, 2013).

Currently, in advanced technically developed countries, oil and gas chemistry consumes 8-10% of all produced oil and more than 5% of gas. In developing countries, this share is still lower-2.5-5.0%, and on average, 6.5-7.0% of oil is spent on the needs of the petrochemical complex in the world (Tan, 2013; Shirov, 2013). According to experts of the Association of chemical industry of Europe, the world market size amounted to \$3.6 trillion in 2012, and by 2015 it should be \$4.4 trillion. According to experts' forecasts, the expected annual growth rate of the global chemical industry will be 4.4% and by 2025 the world market size of chemical products will reach approximately \$6.8 trillion. The petrochemical industry can surely be called a cost multiplier. Moving up the technological chain from raw material to petrochemical semi-finished products, petrochemicals, polymers and products made of polymers, in the petrochemical industry there is a value growth of up to 8-15 times of the cost of the feedstock (Figure 1).

Figure 1
Value growth in the petrochemical chain



Source: Adapted by the author on the materials of OAO "Sibur"

At the moment, the petrochemical industry can be called one of the most dynamically developing in the world. In the total revenue of the world's largest oil and gas companies, such as ExxonMobi1, BP, Shell, To1a1, Chevron-Texas, Copoco-Philips and others, the share of the petrochemical sector reaches 10% and more (Taburchak & Tumin, 2002; Vinokurova, 2008). The petrochemical market is becoming increasingly globalized in terms of the spread of new technologies, availability of raw materials and markets; companies in the industry face common challenges, such as legislative regulation, pricing, and reducing the amount of "heavier" raw materials (Hristenko, 2008; Boush, 2011). Table 1 presents the forecasts of international experts of the European Council of the chemical industry on the growth of petrochemistry in the world economy. Table 1 indicates the forecasts of the market by type of products.

Table 1

The main historical and forecast indicators of the sector in the world economy

Characteristics	2007	2008	2015	2020	2030
Sector's share in global GDP, %	3,2	2,9	4	5,3	7,4
Share of world exports in global exports, %	10,9	7,7	13	15	20
Sector value of	1483	1242,4	1460,5	1682	2500

world exports, bln/year					
Sector output in the world, bln/year	2134	2044	3500	4200	6800
Consumption, %	6,1	-4,2	growth rate of over 4,4% per year		
Consumption, %	6	2	growth rate of over 3,6% per year		

Source: The European Council of the Chemical Industry (CEFIC), the annual bulletin for 2012

Historically, oil and gas companies, with few exceptions, were out of the process of forming oil and gas chemical sectors in their composition (Aleksandrov, 2008; Ananchenko, 2008; Alekseev, 2011). At the same time, and outside of these companies, there has not been a significant effort to develop these important sectors of the economy. The exception is the petrochemical company "Sibur", which itself does not produce gas or obtain naphtha, but is a specialized petrochemical company. In general, the volume of production of many types of oil and gas chemical products in Russia has declined in recent years, the technical level has decreased, the backlog has grown dangerously not only from the leading countries (USA, Japan, Western European countries) but also from developing countries (China, India, Brazil, Saudi Arabia, and others) (Arkin & Soloveychik, 2010; Antonov, 2011).

At the same time, the development potential of these sectors in the Russian Federation is expanding, in particular, due to the upcoming period of a sharp increase in the volume of extraction of natural gas rich in higher components, the need to solve the problem of utilization of associated petroleum gas (APG) resources, increasing the level of processing of raw materials and producing high conversion products for use inside the country, and for export to get rid of the dependence of simple export of raw materials (Yarullin, 2012; Hazova, 2013, 2014).

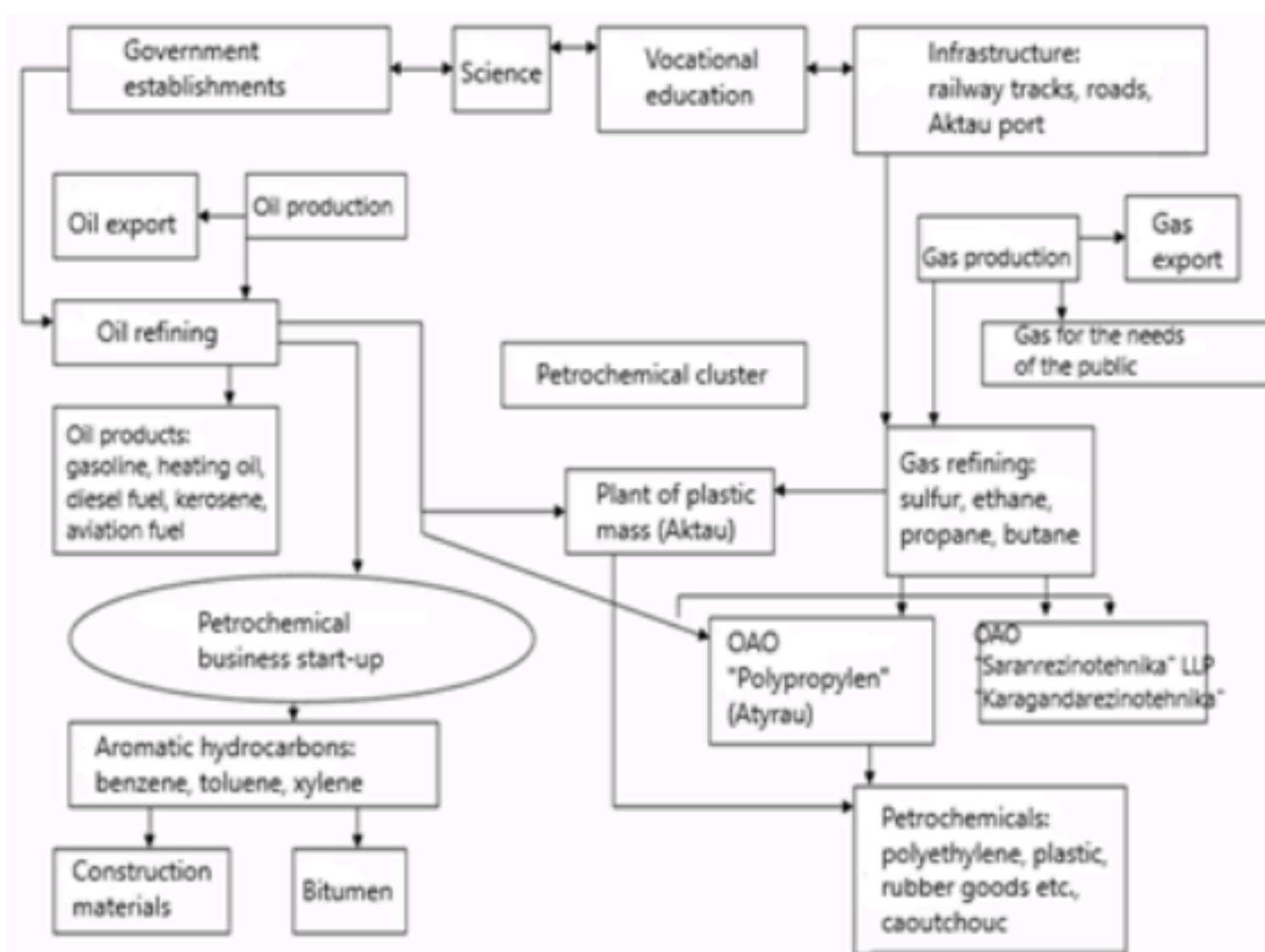
2. Methodology

In the global petrochemical industry, the trend towards integration through mergers and acquisitions is increasing (Tsipers, 2003). The petrochemical business has become truly global, in other words, when justifying the production of petrochemical products in any country, the principles of global commercialization, global and regional consumer demand, growth rates and outflows of capacities in different regions and countries should be taken into account.

Integration in the oil and gas industry is manifested in the formation of alliances and other forms of cooperation. Along with significant changes in the forms of organization of production and management leading to serious consolidation, the process of searching for ways of cooperation in various fields of activity, especially cooperation in the form of scientific, technical and industrial cooperation, is being conducted in the oil and gas chemical complex (Gromyiko, 2007; Halova & Smirnova, 2013).

The structural and logical scheme for the formation of a petrochemical cluster is shown in Figure 2.

Figure 2
Schematic diagram of the formation of a petrochemical cluster



Source: compiled by the author

Table 2
Basic concepts of cluster formations

Author	Year	Source	Definition
M. Porter	1990	The competitive advantage of nations	An industrial cluster is a number of industries interacting as a buyer-supplier or supplier-buyer, as well as through common technologies, common procurement channels or distribution of general labor associations (Porter, 1998).
Schmitz	1992	On the clustering of small firms	A cluster is a group of enterprises belonging to one sector and operating in close proximity to each other.
Enright	1996	Regional clusters and economic development	Regional clusters are industrial clusters in which the participating firms are geographically close to each other.

S. B. Ahmetzhanova	2001	"Competitiveness of the food industry in Kazakhstan: theory, problems and the mechanism of provision".	The cluster is a community of geographically neighboring companies, closely related industries, mutually contributing to the growth of each other's competitiveness.
1. Alimbaev	2005	A methodological approach to choosing a cluster development strategy.	The cluster represents the process of industrial development in the form of horizontal links between firms that are maintained, mainly, not through the market and are not reflected in the price. Firms enter the market not as independent, autonomous producers, but as economic agents in a network of mutual relations relating to the sharing of equipment, a common fund, and resources, etc.
S. Aldiyarov, A. Bayzakov	2004	On the application of the economic method of cluster analysis in the mining and metallurgical complex of Kazakhstan.	The cluster is defined as an industrial complex, formed on a certain territory, the core of which is one or a limited number of leading manufactures, connected by a technological, and primarily organizational chain.
M.S. Tulegenova	2004	Cluster approach in the creation of integrated structures.	The cluster is an economic mechanism of combining competitive advantages with corporate and regional strategy in the production of domestic goods.
A.B. Aldashov	2005	"Clustering" is the dominant principle of regional economic policy.	The cluster ensures a constructive and effective dialogue between related companies and their suppliers, with the government, as well as with other institutions.

E. Zhatkanbaev, K. Bayzakova	2006	Formation of competitiveness of Kazakhstan: theory and practice.	The cluster combines the concepts of the quality of the economic environment and regional development with the desire to ensure harmony between competition and cooperation.
Z.S. Kenzhebaeva	2007	The economy of Kazakhstan in the context of globalization: theories, trends, and transformations.	Clusters are a group of interconnected competitive enterprises, industries of the same region, which are characterized by the proximity of location, a similar specialization of production, leadership positions.

Source: compiled by the author

3. Results

The results obtained in the process of solving the problem and achieving the goal of the study are specified in the following provisions.

1. A set of characteristics of industrial clusters isolating from other forms of economic integration is distinguished, based on the universal properties of natural cluster structures (homogeneity, the combination of centrifugal and centripetal forces, fuzziness and mobility of boundaries, composition and structure, socialization of resources), which allows to consider industrial clusters as self-arising and self-developing entities that have a high level of adaptation to a highly variable environment due to natural properties (Smirnova et al., 2009).
2. A complex of distinctive features of industrial clusters that separate them from other forms of inter-firm integration is distinguished, which is based on the universal features of natural cluster structures, which makes it possible to determine the location of industrial clusters among other forms of integration associations and economic spheres of their most effective use (Granberg, 1985; Smirnova & Avanyan, 2009).
3. A definition of the concept of an "industrial cluster" was developed, unlike existing clusters based on selected features as a variety of natural cluster structures, which made it possible to characterize the industrial cluster as an institutionalised association of independent economic entities for the joint realization of business activities in the industrial sphere based on the proximity of the territorial, branch, cultural; complementarity of products, resources, processes; interconnectedness flows material, intangible, informational (Smirnova, 2009; Smirvona & Halova, 2012).
4. A set of concepts reflecting various aspects of the coherence of the phenomenon of industrial clusters as a fundamental characteristic of them is developed. The distinctive feature of this concept is the introduction of such concepts as "connectedness of territories", "connectedness of industries", "connectedness of cultures"; "Material connectedness", "intangible connectivity", "information connectivity"; "Product connectivity," "process connectivity," "resource connectivity," and a multitude of complex derivatives of connectivity, which allows us to describe the subject area of industrial clusters with the necessary degree of completeness.
5. A universal component composition of industrial clusters is proposed, the distinguishing feature of which is the allocation of components by the function they perform in a cluster

system, including components such as Production, Supply, Service, Consumption, Research, Export Training, and providing for the possibility of introducing new types of components formed in industrial clusters as a response to changes in the economic environment and the emergence of new intra-cluster functions, to allowing to carry out research of organizational structure and mechanisms of functioning and development of industrial clusters, and also to realize identification of clusters in industrial branches.

6. A system of models has been developed that reflect the organizational structure of industrial clusters, depending on their component composition, characterized by the introduction of the network nature of connectivity as an intra-element economic space (between economic entities implementing one function in an industrial cluster) and interelement (between economic entities that implement different functions in industrial cluster), which allows to investigate the mechanisms of functioning and development of industrial clusters, and also to improve the effectiveness of identification procedures, mapping, description and design clusters in industries (Alaev, 1983; Alfares et al., 2002).

7. A typological model of industrial clusters is developed, the distinguishing feature of which is the application of the criterion "composition of a two-component cluster-forming nucleus" that systematizes both identified and described industrial clusters and potentially possible varieties, taking into account the prospect of further complicating industrial clusters due to the evolution of the economic environment, varieties of industrial clusters, which allows development to make scientific ideas about the phenomenon of industrial clusters is adequate to its own development, and to set goals not only for the formation of industrial clusters with specified properties but also for the correction of their development.

8. A model for the operation of industrial clusters is proposed, which is characterized by a new content of the relations under consideration between their constituent parts, including, first, interelement relations of contradiction in all possible pairs of components; secondly, interelement relations of direct and reverse stimulation by supply and demand in a closed circular chain of cluster components; third, interelement relations of direct and reverse constraint in a star-shaped closed chain of cluster components, which allows to manage cluster development by influencing interelement relations.

9. A model of the life cycle of industrial clusters is proposed, which distinguishes four basic states (low-differentiated, competitive, growth, decline), characterized by the contradictions between the different levels of the cluster system objectives, which allows us to investigate the development of industrial clusters, relying on the idea that the basic states determine the potential of industrial clusters to implement one of the directions of development depending on the outcome of the resolution of the contradictions that unfolded in them between the goals of different levels.

10. A set of models for the development of industrial clusters, reflecting the evolutionary and revolutionary ways, is distinguished, complementing the notion of progressive and regressive trends with the concept of isogress, and also the notion that the possibility of realizing each of the three branches of development (progress, regress, isogress) is determined by the basic state, in which is an industrial cluster, which allows us to present the evolution of industrial clusters in the form of multiple transitions between three branches of development and four basic states (Vasilchenko, Glumskova, & Sekerin, 2006).

11. The concept of managing the development of industrial clusters in the form of a system of models is proposed. It is distinguished by a methodological approach based on the influence on the flow and resolution of contradictions, first, between the goals of different levels in the intra-cluster system of goals; secondly, between the components of the industrial cluster, which makes it possible to improve the efficiency of cluster development management, since an understanding of the mechanism of self-development of industrial clusters based on inter-sectoral and interelement contradictions makes management impacts more adequate to the nature of the managed object (Batoroev, 1974; Behrens & Hawranek, 1991).

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The theoretical significance of the research lies in the development of the theoretical foundations for the formation and development of economic clusters systematically reflecting the fundamental aspects of the cluster phenomenon of economic nature and the possibility of further development of scientific ideas about it, starting from a new theoretical platform. The practical importance of the work determines the possibility of applying the results obtained in the practice of clustering industrial branches, as well as other economic spheres, in particular through procedures such as the identification of cluster structures, their mapping, description, diagnostics, and the design of artificially created regional industrial policies clusters.

4. Conclusions

The main conclusions and prospects of the study can be represented by the following positions:

1) in the article the scientific problem is solved - the level of scientific ignorance about the essence of industrial clusters is reduced, which reduces the gap between the practice of industrial clustering and theoretical understanding of the cluster phenomenon. The boundary of his knowledge lies beyond the limits of industry and the economy as a whole since clustering processes are widely manifested in various environments in inanimate, living nature and society. The transfer of knowledge about atom-molecular clusters from physics to economics made it possible to obtain a detailed description of the abstract object that is the subject of study of the scientific theory of industrial clusters (Blauberg & Yudin, 1973 Bepalov et al., 2010);

2) to solve the problem of increasing the validity and effectiveness of cluster projects implemented in industrial sectors, it is established that clusters of economic nature have the following universal characteristics: a) component-element composition, organizational structure, depending on the level of industrial cluster development and formed components in it; b) typology of varieties of industrial clusters, differing in the composition of the two-component cluster-forming nucleus; c) the mechanism of functioning based on the relations of stimulation, restriction, and contradictions between cluster components; d) patterns of progressive, isogressive, progressive development, depending on the basic state of the industrial cluster, and the realization of an evolutionary or revolutionary path (Smirnova & Buzurtanova, 2010; Feygin et al., 2011);

3) in the formation of the methodological platform of research, the synthesis of functional, system-structural, system-functional, system-target, system-evolutionary approaches, the principles of intellects and homeostatics was made, which allowed obtaining such basic units of the scientific theory of industrial clusters as a model of an abstract object reflecting the subject of study; axiomatic complex, acting as a set of basic postulates; consequences from theory; application to the theory in the form of a model for managing the development of an industrial cluster by influencing the contradictions between the objectives of different levels in the system of goals and between components in the cluster structure: a) inside the cluster core; b) between the core and its environment; c) inside the environment of the cluster core;

4) as a result of the conducted research, it was possible to expand the usual framework that limits the understanding of the essence of the cluster phenomenon in the economy and the industrial sphere and its fundamental aspects: structural, functional, objective, evolutionary, organizational, managerial.

Further development of research problems is expedient to implement in the following areas.

1. In scientific activity, the most promising and relevant work is the development of scientific ideas about the conditions and factors for the transformation of various forms of economic

integration into industrial clusters and vice versa; the search for approaches to the quantitative measurement of the spatial localization of industrial clusters, the search for their optimal territorial boundaries; necessary for ensuring a long progressively isogressive development of infrastructure and institutional elements; understanding of possible negative effects, which can be carried by industrial clusters; search for the most effective instruments of impact on intra-cluster cohesion, interelement relations and contradictions within the goals system and between cluster components (Kalkman & Keller, 2012; Telegina, 2013).

2. In teaching activity, it seems expedient to develop and introduce topics devoted to the phenomenon of clusterization in the economy and the industrial sphere, to the academic disciplines on economics, organization and management in the industrial sectors, state and municipal management, the theory of the firm, the world economy; special course "Basics of industrial clustering" for undergraduates and postgraduates studying in the direction of "Economics".

3. In practical organizational and managerial activities, the developed models would be appropriate to apply in the framework of a variety of cluster projects implemented by both executive government bodies and initiative groups in the industrial sector.

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