

Formation of Fundamental Architecture of Agro-Biotechnological Cluster as a Basis for the Development of Spatial Integration of Economic Entities

Ilya Pshenichnikov
*Volgograd State University,
Institute of Management and Regional
Economics,
Department of Management
Volgograd, Russia
econmanag@volsu.ru*

Margarita Postnova
*Volgograd State University,
Institute of Natural Sciences,
Department of Bioengineering and
Bioinformatics
Volgograd, Russia
postnova@volsu.ru,
http://orcid.org/0000-0001-6988-6389*

Veronika Epinina
*Volgograd State University,
Institute of Management and Regional
Economics,
Department of Management
Volgograd, Russia
econmanag@volsu.ru,
http://orcid.org/0000-0002-8771-3198*

Sergey Korobov
*Volgograd State University,
Institute of Management and Regional
Economics,
Department of Management
Volgograd, Russia
econmanag@volsu.ru,
http://orcid.org/0000-0003-1899-4237*

Alexey Bolkunov
*Volgograd State University,
Institute of Natural Sciences,
Department of Bioengineering and
Bioinformatics
Volgograd, Russia
bolkunov@volsu.ru,
http://orcid.org/0000-0002-5097-7958*

Abstract-In the framework of the study is justified the cost and labor intensity of innovations in the field of biotechnology as a need to integrate a large number of economic entities into economic phenomena. Serious shortcomings are revealed in the field of the architecture building of innovative clusters. Given the benefits and drawbacks of the centralized and decentralized control system of clusters, the authors proposed the fundamental architecture of innovative cluster formation, involving collective leadership of cluster by its participants in the form of consortium and take into account the feasibility of cluster using as a space for the new economic entities. The filtering mechanism of cluster participants is proposed in terms of their impact on the innovative cluster development. The improvement stages of diffusion processes of susceptibility by the cluster participants of innovative technologies are determined. The fundamental architecture of the agro-biotechnological cluster, taking into account the distribution between the participants of the integration association, is proposed.

Keywords: innovative cluster, diffusion of innovations, the fundamental architecture of cluster, agro-biotechnological cluster

I. INTRODUCTION

Under the conditions of the transformation of the national economic system and the application of the achievements of the sixth technological revolution, the priority is the interaction development of economic entities capable of producing innovative products in the sphere of strategically important industries. One of the strategically important industry structures in the context of the

technological revolution is the creation of innovative technologies in the field of biotechnology. Innovative projects in the field of biotechnology allow us to solve the problems concerning assurance of food security, to create artificial bio-elements that contribute to improving the efficiency of life activities society; to develop new pharmaceutical preparations.

The innovations reproduction in the field of biotechnology is very costly and labor-intensive, requiring the integration of many economic entities in economic processes. An effective integration mechanism, in this case, is cluster formation.

The cluster formation can be voluntary and compulsory nature, in which artificial integration associations are created with ultrashort life cycle and low susceptibility to innovation.

The characteristic disadvantages of the integration entities artificially created within the framework of the state cluster-based policy are:

- limiting of the cluster life cycle to the implementation of the points of the state tasks or the corresponding program;

- lack of interest of the cluster participants in the integration structure development;

- filling the cluster with participants, who are not to the full extent with the potential to form the appropriate backgrounds for the cluster development;

- the complicatedness of innovative processes diffusion in the activities of all cluster participants;

- limiting informing the cluster participants about the interaction system with each other in the framework of the created integration association.

With that, the initiative formation of innovative clusters requires appropriate support under the influence of the technological mode in the absence of direct external influence. The development of a new technological mode will become more intensive as the intellectualization of production becomes more complicated and the transition to a continuous innovation process.

Within the framework of the study, based on the works of many researchers [1-11], the search for the optimal form of interaction between the cluster participants based on:

- the differentiation of the functional areas of interaction between the cluster participants;

- improving the diffusion of innovation processes within the integration association;

- overcoming the geographical boundaries of cluster formation and inclusion in the integration process of economic entities located in different economic systems.

The research results were:

- formation of the fundamental architecture of the innovative cluster;

- development of a modification mechanism for the fundamental architecture depending on the potential of the integration association and its development strategy;

- improvement of methodological bases of diffusion of innovative processes among the participants of the fundamental architecture of the cluster;

- adaptation of the formed fundamental architecture for the creation of an agro-biotechnological cluster in the territory of the Volgograd region.

II. MATERIALS AND METHODS (MODEL)

The article used research and practice materials necessary to study the process of cluster formation, and statistical data necessary to determine the potential of the regional economic system in the creation of the agro-biotechnological cluster [12].

The paper used the conclusions and conceptual provisions contained in the works of domestic and foreign scientists and practitioners in the field of cluster formation and the successful management of complex economic and social systems [13].

In this work were used the methods of comparative and system analysis, as well as a logical approach, providing the necessary research depth of the scientific challenge.

III. RESULTS AND DISCUSSION

The research consists of four interrelated logical parts.

A. Identification of conditions for the fundamental architecture formation of the innovative cluster

The identification of external and internal conditions for the innovative cluster formation involves the study of the economic and innovation potentials of regional economic systems with the aim of possible infrastructural changes for the implementation of effective integration associations.

The identification stages of the conditions necessary to identify potential opportunities for the formation of the innovative clusters are presented in Fig. 1.

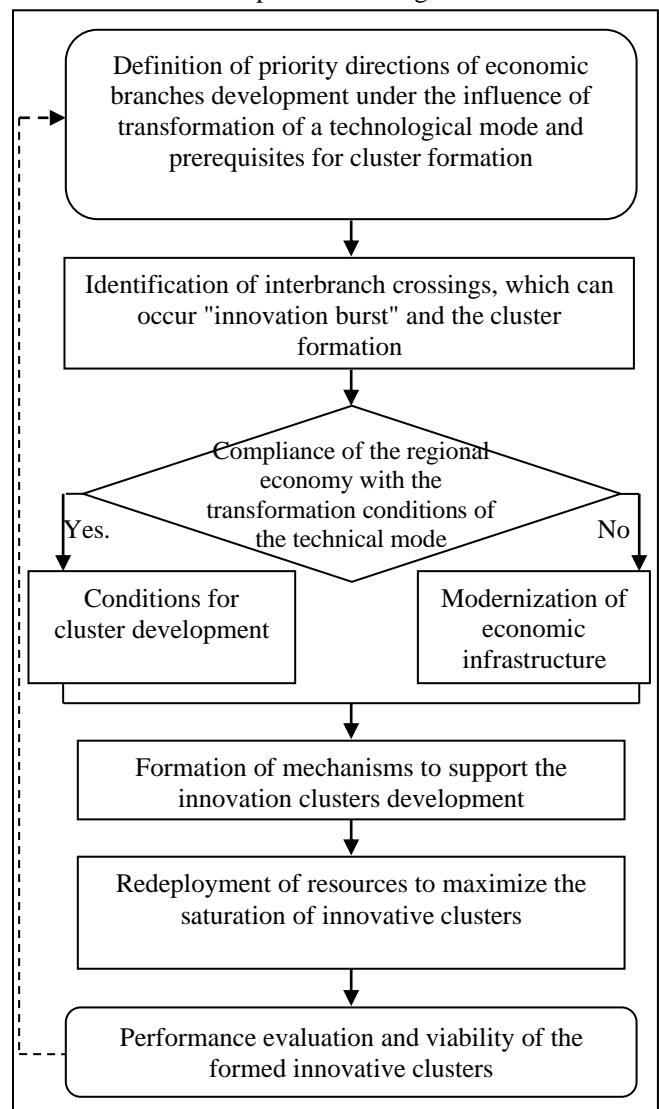


Fig. 1. Identification of external and internal conditions for the emergence of innovative clusters.

The definition of priority directions of economic development under the influence of technological mode change allows identifying digitalization strategic directions of the integration association control system.

The forecast formation of the branch economy development should be carried out based on the retrospective and prospective analysis of development of branches in the greatest degree correlating with the requirements of the technological revolution [14].

The second stage of identification conditions is to determine the development level of a regional economic system or systems. Within the framework of this stage are studied the innovative, marketing, economic, financial, technical and technological potentials of regional economic systems that will be involved in the process of cluster formation.

In case of poor condition of potential of regional economic systems involved in the cluster formation, there is redeployment of resources to offset of economic, working, financial and productive resources to those economic entities that will take an active role in the integration associations development and to create preconditions for improving the competitiveness of economic systems through the introduction of innovative technologies.

The basis for the redeployment of resources is the architecture building of cluster formation, which will take into account the reproduction mechanism of production economic entities, taking into account the new economic conditions provided by the change of technological mode.

Performance evaluation and viability of formed innovative cluster is based on modification research of the fundamental architecture of the innovative cluster, chosen depending on the potential development of the integration association.

B. Methodical bases of fundamental architecture formation of innovative cluster

For the effective development of the innovative cluster, a necessary condition is to find a balance between a centralized and decentralized control system. The centralized system does not allow the innovative cluster participants to develop independently and creates prerequisites for the "donation" of innovative technologies from small enterprises-cluster participants to large industrial enterprises, assuming the absence of reproduction of new economic entities.

Control of innovation clusters with a low centralization level leads to the following architecture disadvantages of the innovative cluster: general interaction principle with the external environment is violated; there is no innovation system into the activities of each cluster participant; the effectiveness of strategic decisions is reduced; efficiency of reproduction of new economic entities is reduced.

In the framework of the study, the authors proposed an architecture for the formation of an innovative cluster, assuming collective cluster leadership by its participants in the form of a consortium.

Under the fundamental architecture of the innovative cluster (Fig. 2), it is necessary to understand the stable system of participant's interaction of integration association connected among themselves by the achievement of the uniform purpose and distributed on sub-clusters with the various functional mission.

The presented fundamental architecture of the innovative cluster allows to distribute economic entities - cluster participants according to their potential sub-clusters:

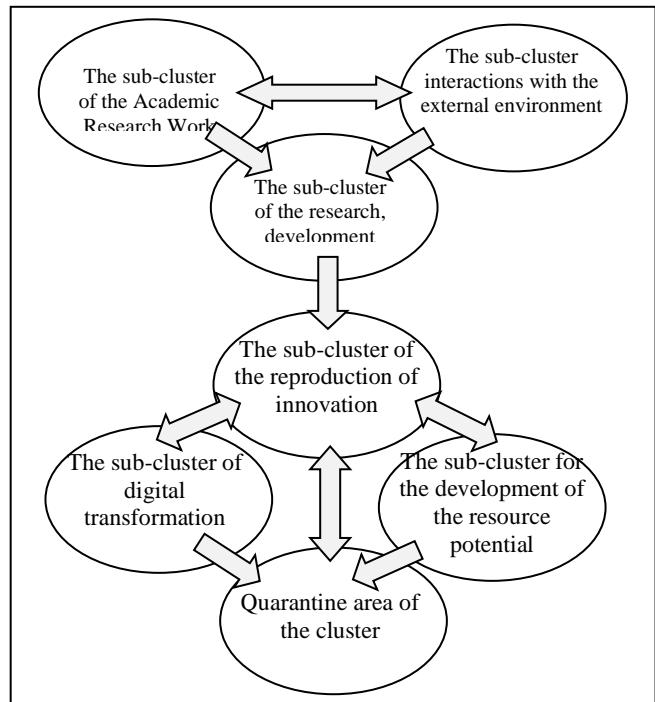


Fig. 2. The fundamental infrastructure of the innovative cluster.

- sub-cluster of scientific and research developments is a set of cluster participants who have the opportunity to conduct research and development, creation and development of pilot production of high-technology products;

- sub-cluster interactions with the external environment is a set of cluster participants, can conduct scientific and research and competences skills in establishing a system of preventive marketing for recreation and realization of products innovative cluster;

- sub-cluster of research and development is a set of cluster participants in the form of innovative enterprises engaged in the process of improving innovative technology and its transformation into a commercial product;

- sub-cluster innovation reproduction is a group of cluster participants from among industrial enterprises with the corresponding potential for series manufacturing of innovative products;

- sub-cluster of the digital transformation is a set of economic entities within the cluster that contributes to the virtualization of the integration association and the formation of the foundations for the creation of a cloud system for control material and non-material flows between the cluster participants;

- sub-cluster of the resource potential development is a set of economic entities that contribute to the development of scientific and technical, personnel, production, economic and financial potentials of the cluster participants;

- the quarantine area of the cluster is a set of economic entities that do not have sufficient economic potential for instant entry into the cluster but have such opportunities in

the future when certain parameters of their economic, innovation and production activities change.

The quarantine area of the innovative cluster within the framework of the fundamental architecture assumes the presence of a filtering mechanism of economic entities. Filtering is based on the identification of the innovative potential of new cluster participants and the need for innovative enterprises by the cluster itself. The filter strategies are shown in Fig. 3.

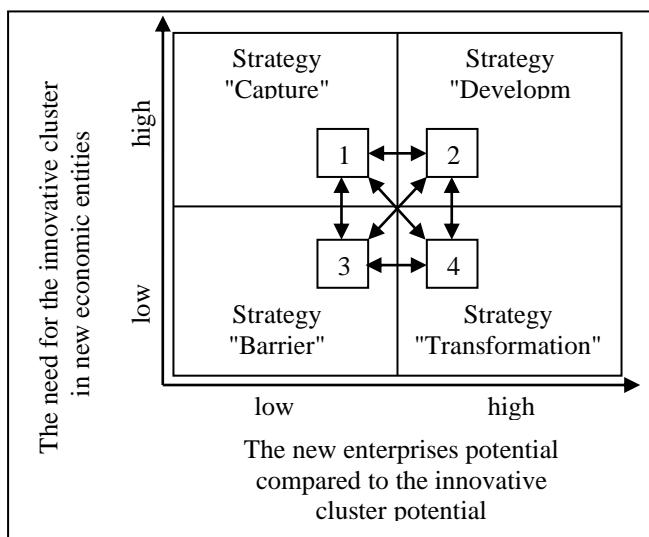


Fig. 3. Filter strategies of selection and redeployment in a cluster of economic entities.

The filtering of economic entities is based on the comparison of the innovative potential of each new participant of the cluster and its impact on the development of the innovative potential of the integration association as a whole.

The strategy "Capture" involves the use of innovative products and technologies created by new participants of the cluster for the production needs of existing participants of the cluster and primarily for large industrial enterprises subject to significant obsolescence and physical deterioration.

The strategy "Development" provides for the reproduction of new production business units within the cluster through the use of innovative products and technologies of new participants of the cluster. In this case, the fundamental architecture is an incubation paradigm.

The strategy "Transformation" implies the transformation of the innovative cluster structure through the use of innovative technologies of new cluster participants to replace inefficient innovative solutions of existing cluster participants. In this case, the new participants of the cluster become the development locomotive of the integration association.

The strategy "Barrier" implies the transformation of the potential of an economic entity when entering the cluster with the help of a quarantine area, or there is a refusal to use the services of this economic entity within the cluster, as this can negatively affect the integration association development as a whole.

The use of filter strategies allows to select economic entities when entering the cluster, to adapt the fundamental architecture of the innovative cluster, to create prerequisites for perfecting diffusion processes.

C. Improving the diffusion of innovation processes within the fundamental architecture

To improve the innovative cluster efficiency, it is necessary to determine and optimize the susceptibility of innovative processes and technologies by the participants of the integration association.

The determination of the potential susceptibility of the innovative cluster participants to the diffusion processes necessary to produce step-by-step identification, including the definition of innovative potential of the cluster as a whole, the innovative potential of each new cluster participant, identification of barriers and restrictions in case of the innovative technologies used by the cluster participants.

The determining process of innovative processes diffusion within the fundamental architecture of the innovative cluster is presented in Fig. 4.

The improving vector of the innovative processes diffusion should be oriented to the activities of either all cluster participants or individual cluster participants or interacting sub-clusters.

To effectively assess the innovative processes implementation in the activities of economic entities requires the formation of "stress indicators" that facilitate the identification of potential barriers and restrictions for the diffusion processes implementation and identify the solvency of the economic entity as a result of diffusion.

Stress indicators are qualitative and quantitative indicators of the receptivity of innovative processes by the cluster participants depending on the transformation of the conditions of their activities within the sub-clusters and the transformation by the external environment, which requires adaptation of economic conditions depending on evolutionary changes.

Stress indicators are the reference values of innovations rejection and the barriers emergence to the innovative cluster development as a whole. Stress indicators are determined separately for each indicators block of a potential cluster: labor, financial, logistics, production, scientific and technical resources of the integration association.

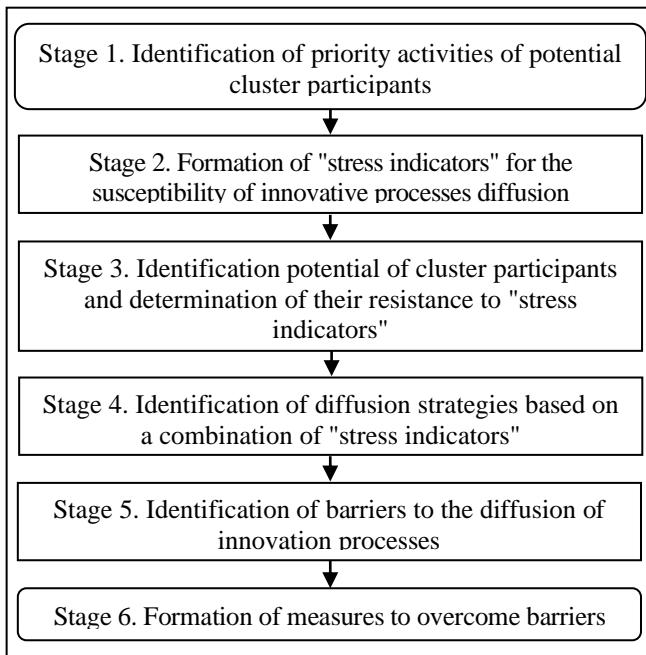


Fig. 4. Stages of determining the susceptibility of cluster participants to the diffusion of innovative processes.

A comparison with the critical values of stress indicators allows predicting the susceptibility of innovative cluster participants.

D. The formation of the fundamental architecture for agro-biotechnological cluster

Fig. 5 is presented the capacity dynamics of the Russian biotechnology market in 2016-2018 and its projected value in 2019-2020, based on existing trends.

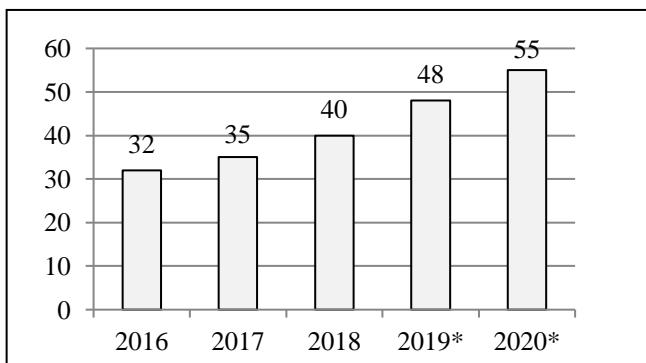


Fig. 5. The capacity of the Russian biotechnology market, billion dollars.

The creation of an agro-biotechnological cluster in the Volgograd region will allow the existing groundwork in the field of agricultural science, biotechnology and the real sector of agriculture to create a basis for the constant development and introduction of new technologies based on the latest science achievements by "growing" competitive business based on modern research conducted at the high-technology level.

This will complement the existing agro-industrial complex with new economic entities using science-intensive nature-like technologies based on genomic science, bioinformatics and digital processing of big data to recreate the system of intensive breeding work, the introduction of

production with deep processing of agricultural products and the transition to the latest technologies for processing other natural resources, as well as waste extensive production. In this integration process of the agro-biotechnological cluster "Volgograd" will become the "core" of the association and the leading platform for the production implementation of innovative projects of agro-industrial orientation.

The cooperation core in the framework of the fundamental architecture of the agro-biotechnological cluster is the agro-biotechnological park, which includes the industrial and experimental-industrial site in the field of creation of new generation bioproteins supplements for fish breeding and livestock breeding; the formation of research and production base for the reproduction of microbiological catalysts well recoveries for oil production. Table. 1 is presented the competence areas of participants of the agro-biotechnological cluster.

TABLE I. COMPETENCE AREAS OF PARTICIPANTS OF THE AGRO-BIOTECHNOLOGICAL CLUSTER:

Name sub-cluster	Sub-cluster participants	Functional (competence) of participants
The sub-cluster of the Academic Research Work	VolSAU; VolSU; similar organizations specializing in scientific and educational activities in the field of biotechnology	Conducting fundamental research in the field of agro-biotechnologies
The sub-cluster interactions with the external environment	Marketing institution	Market performance research, identification of actual requirements in the agricultural market and the field of biotechnology
The sub-cluster of the research and development	Small innovative enterprises, independent engineering companies	Transformation of fundamental research into applied innovation; laboratory research
The sub-cluster reproduction of innovation ("the cluster core")	Agro-biotechnological technological park	Creation of a production site with the equipment necessary for implementation and scaling of technologies developed by small innovative enterprises
The sub-cluster of digital transformation	IT companies; firms engaged in the implementation of Internet things and smart equipment	Providing technological park with equipment and software in the field of creation of technological and production processes with minimal participation of labor resources
The sub-cluster for the development of the resource potential	VolSU; training centers; consulting companies	Training, refresher course and advanced professional training of cluster specialists and technological park
Quarantine area of the cluster	Consulting company	Formation of measures for the development of economic, financial, marketing potentials of cluster participants

The formation of the fundamental architecture of the agro-biotechnological cluster will allow delineating the interaction spheres between the participants of the integration association, identifying areas for improving diffusion processes and solving the commercialization problem of biotechnological innovative projects.

IV. CONCLUSION

The transition to the fundamental architecture of the formation and development of innovative clusters requires improving the efficiency of diffusion processes in the use of economic entities of innovative technologies tailored to the peculiarities of the distribution of the participants of the integration association between sub-clusters and construction of interaction system, which is the guide of innovative technologies, material and immaterial flows between the participants of the integration association.

The use of the fundamental architecture in the formation of the agro-biotechnological cluster will allow:

- to form a stable external competitive advantage of the agro-biotechnological cluster;
- to increase the transparency of the interaction of the economic subject entering into structure of agro-biotechnological cluster;
- to create an effective selection mechanism of economic entities for the development of the cluster potential;
- to form a reproduction system of innovative technologies within the agro-biotechnological cluster.

The proposed fundamental architecture of the agro-biotechnological cluster allows creating preconditions for redeployment the current concept of cluster formation taking into account changes in economic conditions and demand in stable clustered structures that create high-tech products and having the ability to life extension by diffusion of innovative technologies to further increase production capacity.

Modification of the fundamental architecture of the agro-biotechnological cluster will allow to dynamically change its structure and adapt to new achievements of the technological revolution.

REFERENCES

- [1] A. Dzhindzholia, E. Popkova, and L. Shakhovskaya, "Cluster as an innovative and organizational form of state regulation of business," in American Journal of Applied Sciences, vol. 24, no. 11, pp. 814-819, 2015. DOI: 10.3844/ajassp.2015.814.819.
- [2] B. Cao, F. Glover, and C. Rego, "A tabu search algorithm for cohesive clustering problems," in Journal of Heuristics, vol. 21, no. 4, pp. 457-477. DOI: 10.1007/s10732-015-9285-2.
- [3] G.S. Merzlikina, I.V. Pshenichnikov, and E.D. Zherebov, "Diffusion of innovation processes as the basis for the viability of a regional innovation cluster," in Scientific and Technical Journal of SPPU, no. 6, pp. 54-63, 2016. DOI: 10.5862/JE.256.5.
- [4] J. Cortright, "Making sense of clusters: Regional competitiveness and economic development", Brookings Institution, Washington, 2013.
- [5] M. Porter, "Location, Competition, and Economic Development: Local Clusters in a Global Economy," in Economic Development Quarterly, no. 14, pp. 15-34, 2000.
- [6] M. Storper, "The Regional World: Territorial Development in a Global Economy", Guilford Press, 2012, 338 p.
- [7] O. Solvell, "Clusters: Balancing Evolutionary and Constructive Forces", Ivory Tower Publishing, Stockholm, 2011.
- [8] P. Cooke, "Regional Innovation Systems, Clusters and the Knowledge Economy," in Industrial and Corporate Change, no. 3, pp. 37-42, 2015. DOI: 10.1093/icc/10.4.945.
- [9] P. Desrochers, "Cluster-based economic strategy, facilitation policy and the market process," in The Review of Austrian Economics, vol. 17, no. 2-3, pp. 233-245, 2004. DOI: 10.1023/B:RAEC.0000026833.26220.2d.
- [10] S.A. Korobov, V.O. Moseiko, E.Yu. Marusinina, E.G. Novoseltseva, and V.S. Epinina, "The substance of a rational approach to entrepreneurship socio-economic development," in Contributions to Economics, pp. 207-223, 2017. DOI: 10.1007/978-3-319-45462-7_24.
- [11] Z. Yang, P. Hao, and J. Cai, "Economic clusters: A bridge between economic and spatial policies in the case of Beijing," in Cities, no. 42, pp. 171-185, 2015. DOI: 10.1016/j.cities.2014.06.005.
- [12] V.G. Lizunkov, O.T. Ergunova, and E.Y. Malushko, "Forming system of strategic innovation management at high-tech engineering enterprises", in IOP Conference Series: Materials Science and Engineering, Vol. 177, no. 1, Article number 012046, P. 1-7, 2017.
- [13] R. Ferreira, V.G. Lizunkov, and E.V. Politsinskaya, "Formation of entrepreneurial competencies of university graduates in conditions of transition to the universities of the third generation", Novosibirsk State Pedagogical University Bulletin, Vol. 7, Iss 6, pp. 195-211, 2017.
- [14] N. Davis, O. Ergunova, V. Lizunkov, and E. Malushko, "Phenomenon of migration and its manifestations in the modern world", in European Proceedings of Social and Behavioural Sciences", vol. 26, pp. 550-556, 2017.