The integration processes effect on activation of innovation activities in the framework of Industry 4.0 concept

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Abstract. The manifestations of interregional differentiation reduce the sustainability and effectiveness of the innovative development that negatively affects the functioning of the national innovation system of Russia. Taking into account the high importance of integration, it seems obvious that it is impossible to increase the level of innovative development with no mutually beneficial cooperation, partnership, and balance of government regulations. Accordingly, the article is devoted to the study of integration processes, analysis of cluster forms of integration, development of recommendations for creation of the favorable environment for development of innovative processes in the Volga Federal District. The subject of study is the innovation processes which arise during the integration of the corporate structures. Herewith, the study logic reflects the following author's hypothesis – the integration provides for forming the corporate (cluster) structures and facilitates the activation of innovative processes. In turn, this promotes applying the advanced supra-brunch basic technologies and development of fundamentally important processes in the framework of the Industry 4.0 concept, namely: information, process, economic, social, etc. Promotion of integration processes and innovation activity facilitate strengthening the competitive advantages of economic entities of the cluster and increasing the innovation potential of the regions.

1. Introduction
The innovative development of integrated economic systems is currently quite important factor in the innovative development of the national economy. Among the papers of foreign scientists shall be first of all noted the method developed by F. Kronthaler, which is based on a hierarchical cluster analysis of factors [1]. In addition, the theoretical aspects of the innovation development of economic systems were considered in details in the papers of Galbraith J. [2], Douglas N. [3], Porter M. [4], A. J. Strickland, A. A. Thompson [5], Christian Ketels [6], Ya. Cook, P. Myers [7], Warner M. [8]. Tanaka H. [9] presented a type of competition counter strategy based on the development of integration in the market hyperspace. Hamel G., Prahalad K. K. substantiated the theory of the scale effect and the translational force of growth impulses [10]. Theoretical and practical aspects of innovation processes in the regional economic system are rather deeply studied by domestic scientists: Gubanov S. [11], Golova I. [12], Shubat O., Shmarova I. [13], Glaziev S. [14], Gagarina G., Gubarev R. [15], Tatarkin...
The author [17] notes that in recent years there has been an increase in innovation activity in economic systems where organizational and functional tools do not change, however, the process of joint interaction is intensifying that creates favorable conditions for the development of corporate structures and the economy of their locations.

The unevenness of regional economic development in Russia is mainly due to structural problems — an imbalance between consumption and production [11]. S. Yu. Glaziev, for example, associates this change in the reproductive structure of the economy with process shifts in production and economic systems, considering that their discrepancy reduces the efficiency of management [14]. According to Chris Freeman, the General Purpose Technologies can be used in most economy sectors, as well as in a variety of activities [18].

Foreign experience shows that the operation of enterprises and integrated structures based on the principles of Industry 4.0 concept, as well as the development of digital economy transformation processes have a beneficial effect on the intensification of innovation activities and the regional economy development, primarily, in the area of cost optimization, responding to external and internal factors.

As the analysis shows, the nature of cause-effect relations of integration and innovation processes is not sufficiently updated, which, in turn, determines the relevance of the stated topic of the article. In addition, currently, the digitalization is the main factor to form sustainable interaction of economic entities on a real-time basis that, in turn, is a condition for a more flexible response and their adaptation to globalization trends.

The purpose of the article is to develop theoretical positions in assessing the impact of integration processes on the activation of the innovation activities of economic agents in regional economic systems in the framework of the Industry 4.0 concept. This objective predetermined the solution of a number of tasks: to systematize the main aspects of the economic systems formation; to determine the level of innovative development of the regions of the Volga Federal District (VFD); in order to develop innovative processes in the format of Industry 4.0 concept, propose a mechanism to stimulate integration processes that facilitate the intensification of innovative development in the region.

The obtained results can serve as a methodological basis for the implementation of the main provisions of the Industry 4.0 concept and the objectives of the Digital Economy of the Russian Federation program.

2. Methods of research
To solve the problems, the following methods were used: methods of complex economic analysis, system analysis and synthesis of corporate governance and optimization of management decisions, expert assessment method, economic and mathematical modeling.

In accordance with the above aspects, in order to solve the global problems of regional economic development, a particular interest in the prevailing conditions is the approach to assess the impact of integration processes on the activation of regional innovation activities and the creation of sustainable interaction in a single information space.

3. Obtained results
When systematizing the main aspects of cluster-type economic systems, it is obvious that integrated relations can be classified according to the cooperation range [17]:

— holding, which are formed to create process chains and accumulate the assets;
— associative, aimed at establishing more sustainable industry relations, eliminating duplicate functions, lobbying industry and corporate interests;
— cluster — for innovation policy on the terms of mutually beneficial economic and social partnership.

In this case, it is impossible not to note the existence of barriers that limit the formation and development of economic systems. Depending on the features of their functioning, the range of limitations can be represented as follows:

— in relation to holdings, — the influence of antimonopoly policy;
— in associations — limiting corporate individualism;
— in clusters — locality of functional interaction in accordance with the brunch and geographical specificity.

Based on the systematization of integration processes, it is obvious that the integration barriers are ‘smoothed’ by the motives for creating integrated systems. In turn, this promotes applying the advanced supra-branch basic technologies and development of fundamentally important processes in the framework of the Industry 4.0 concept, namely: information, process, economic, social, etc.

The substantiation of the integration orientation of the regional economy development consists in the formation of more efficient, rational and effective cooperation that, in turn, facilitates the formation of an innovative platform for the strategic region development.

To identify integration and innovation activity in the Volga Federal District, the authors performed a comparative analysis of indicators reflecting the volume of high-tech products (services) and a share of organizations that produce them. Herewith, the study logic reflects the following author's hypothesis — the integration provides for forming the corporate (cluster) structures and facilitates the activation of innovative processes. In turn, this promotes applying the advanced supra-branch basic technologies and development of fundamentally important processes in the framework of the Industry 4.0 concept.

The subjects of the study are the administrative territories of the Volga Federal District (Figure 1).

On the basis of the Pareto model 80/20; the subjects of the Volga Federal District are systematized according to the criterion of innovative activity, which made it possible to identify three groups of regions.

The first group A: — innovative advanced. This group includes: Republic of Tatarstan, Samara and Nizhny Novgorod Regions. An average volume for production of innovative goods over past 5 years amounted to more than 150 billion rubles; density of innovative organizations — up to 20%.

The second group B — innovative developed. This group includes: Perm Region and Republic of Bashkortostan. An average volume of innovative products over past 5 years amounted to 97.6 to 116 billion rubles; density of innovation activity organizations is up to 11.3%.

The third group C is innovative developing. This group includes all other administrative territories of the Volga Federal District: Mari El Republic, Mordovia, Udmurt Republic and Chuvash Republic, Regions: Kirov, Orenburg, Penza, Saratov and Ulyanovsk. An average volume of innovative products over past 5 years amounted to 5.5 to 29.7 billion rubles; density of innovation activity organizations is from 23.1% to 3.2%.

In order to activate innovation processes within the Volga Federal District, the authors proposed a mechanism to stimulate integration activity (Fig. 2).
Figure 2. Mechanism of integration processes stimulation promoting activation of innovative development in the region in the framework of concept Industry 4.0.
On the basis of the considered theoretical aspects necessary for formation of a cluster integrated system, the authors proposed the possible scenarios for the interaction of cluster entities in real time under the conditions of implementing the principles of the Industry 4.0 concept and digitalization processes (Fig. 3).

Figure 3. Interaction of cluster subjects under the implementation of Industry 4.0 principles and digitalization processes.

Subjects in links 1, 2, 4 can be considered on industrial basis:
1 — suppliers of raw materials for industrial enterprises
2 — industrial enterprises producing final products
3 — logistics entities (carriers, warehouses, control centers, etc.)
4 — intermediaries (distributors, commission agents, dealers, brokers, etc.)
5 — payment and investment structures (banks, investment funds)
6 — educational and research structures of different sectoral policies
7 — audit, consulting structures – infrastructure for subjects of various industries
8 — repair, service structures (individual in accordance with the specifics of repair and preventive maintenance, but can be the same contractors for many customers of different industries)
9 — coordinators for all subjects of the cluster, both for industrial enterprises and infrastructure organizations being the part of the clusters. The focal points can be presented by various agents contributing to sustainable interaction, such as information centers, research and educational institutions, etc.

Coordination of the conditions for subjects’ interaction in a single information space with the cluster approach of integration is aimed at the intensity of product distribution, cost reduction and activation of innovative processes.

The criteria for cluster interaction efficiency are sales growth, cost reduction, growth in high-tech production. Let’s consider the formation of a complex criterion for the cluster integration efficiency.

Let’s assume that:
\( k \) — organizations entering the integrated interactions, a number of which is \( k = 1, 2, 3, 4, 5, 6, 7, 8, 9 \);
\( N_k \) — economic entities of the cluster; \( \text{id} \) — an indicator reflecting the interests of cluster economic entities cooperation; \( iU; iZ; iM; iF; \), — parameters of cooperation, where \( U \) — sales growth; \( Z \) — decrease in variable costs, \( M \) — decrease in transaction costs, \( F \) — growth of innovations; \( \Delta R \) is a complex criterion for the effectiveness of cluster cooperation.

Coordination of the cluster entities interests in order to promote sales growth:
Where $k_n^\mathcal{U} \in N_k$ — sales in terms of cluster interaction;
$\sum_{k} U_k$ — sales for ‘local’ enterprises.

Coordination of cluster subject interests in order to reduce variable costs:

$$i_z = \frac{Z_k n(1,2,3,4,5,6,7,8,9) k \in N_k}{\sum_{k} Z_k}, \quad 1 < 0$$  \hspace{1cm} (2)

Where $Z_k n \in N_k$ — variable costs of enterprises in terms of cluster interaction;
$\sum_{k} Z_k$ — variable costs in ‘local’ enterprises.

Coordination of cluster entities interest in order to reduce transaction costs:

$$i_M = \frac{M_k n(1,2,3,4,5,6,7,8,9) k \in N_k}{\sum_{k} M_k}, \quad 1 < 0$$  \hspace{1cm} (3)

where $M_k n \in N_k$ — the transaction costs of enterprises in terms of cluster interaction;
$\sum_{k} M_k$ — transaction costs of ‘local’ enterprises.

Coordination of the cluster entities interest with the aim of innovative development:

$$i_F = \frac{F_k n(1,2,3,4,5,6,7,8,9) k \in N_k}{\sum_{k} F_k}, \quad 1 > 0,$$  \hspace{1cm} (4)

where $F_k n \in N_k$ — enterprises profit in terms of cluster interaction;
$\sum_{k} F_k$ — ‘local’ enterprises profit.

Then the complex criterion of cluster integration efficiency is as follows:

$$\Delta R = \left\{ R_i^n n \in N_k, I \in i_n \left( i_z; i_M; i_U; i_F \right) \right\}, \Delta R_i^N \to \max \hspace{1cm} (5)$$

Thus, a single information digital space formed on the basis of the cluster approach will facilitate elimination of duplication, flexible interaction, maximizing use of the resource potential, which, in turn, will ensure the implementation of the Industry 4.0 concept formation and development principles.

Cooperation in the economic cluster format based on the coordination of multilateral economic interests provides for large-scale innovative activities aimed at improving information technology, upgrading information and communication support, creating the digital technology platforms and using advanced supra-brunch basic technologies.

The introduction of the proposed mechanism into the practice of regional management will facilitate creating the favorable environment for the formation of sustainable economic relations and mutually beneficial cooperation, which will positively affect the activation of innovation processes within the Volga Federal District (VFD). In this case, in the midterm prospective, an annual increase in the innovation development index is expected in all regions of the Volga Federal District (VFD).

Thus, as a result of the study:
— the main aspects for forming the cluster integration were systematized;
— uneven innovative development of the Volga Federal District regions was identified;
— mechanism of integration processes promotion that facilitates the activation of innovative development in the VFD region in the form of the Industry 4.0 concept.
— possible scenarios for the interaction of cluster subjects in real-time mode were proposed under the conditions of implementing the principles of the Industry 4.0 concept and digitalization processes;
— proposed a comprehensive criterion for cluster integration efficiency.

The obtained results can serve as a methodological basis for the development and implementation of regional innovation development programs.

4. Summary
It is shown that the integration processes effect on activation of innovation activities in the framework of the Industry 4.0 concept
Promotion of integration processes and innovation activity facilitate strengthening the competitive advantages of economic entities of the cluster and increasing the innovation potential of the regions.
The implementation of the Industry 4.0 concept principles in the integrated cluster structures facilitates the growth of the innovative goods volume, thus, creating the conditions for increasing the competitive advantages of the region.

5. Trends of further studies
Currently, in accordance with the concept of the digital economy, transition to a new format of intercorporate interaction is needed, which will serve as a technological breakthrough and increase the competitive advantages of region economic entities. Therefore, the authors see further research in the mechanism development for the integration development of industrial enterprises combined by a single information space within the digital platform.

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