Innovative Industrial Clusters in the Context of Digitalization and Sustainable Competitiveness

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Abstract: To ensure Russia's sustainable competitiveness, it is necessary to create an infrastructure that allows creating globally competitive technologies and products. The authors suggest that industrial clusters can drive the country's sustainable economic and innovative development. The research methodology is based on the content of the concept of sustainable competitiveness and cluster theory. The study was carried out using the methods of regression analysis. The systematization of foreign and Russian researchers' ideas contribute to the conclusion that the cluster approach for ensuring sustainable development and competitiveness in the digital era is regarded as absolutely reasonable. In order to test the hypothesis of the study using regression analysis, a model has been built to assess the dependence and influence of the number of clusters in Russia Federal Districts on the main indicators of economic innovative development of these territories. The regression models constructed by the authors demonstrate a clear dependence of region economic and innovative development indicators on the clustering level. The authors of the present research recognize that clustering should be considered one of the basic elements in the system of national and regional sustainable competitiveness.

Keywords: Sustainable competitiveness, sustainable development, digitalization, innovation, industrial clusters.

INTRODUCTION

At present, sustainable development in Russia is based on the formation of real production and social infrastructure, which allows for the creation of globally competitive technologies and products (Caraka, Hafianti, Hidayati, Wilie, and Muztahid, 2019; Caraka, Tahmid, Putra, Iskandar, Mauludin, Hermansah, Goldameir, Rohayani, and Pardamean, 2018). The development of a digital economy based on fundamentally new production technologies and the use of renewable resources requires the implementation of organizational measures specifically aimed at the development of the companies capable of becoming leaders in new global technology markets (Markova, 2013; Tatarkin, 2013). In the conditions of the fourth industrial revolutions, and the developed countries' transition to the implementation of the Industry 4.0 strategy, the problems of the increasing competitiveness of industrial enterprises are becoming relevant and closely related to solving the problems of sustainable development.

The Executive Order of the President of the Russian Federation of May 7, 2018, No. 204 "On National Goals and Strategic Objectives of the Russian Federation through to 2024" (hereinafter, May Decree), determined the necessity of achieving breakthroughs in the fields of both science and technology, as well as socioeconomic development in the Russian Federation. The May Decree defines nine national development goals, outlines basic provisions of 12 national projects. Currently, these projects present a national strategy for sustainable development of the country. The economic growth requires the following: accelerated technological development, increased labor productivity, and the advanced introduction of digital technologies in the economic and social spheres. These measures should create the conditions for the Russian Federation to join the group comprising the world's five largest economies.

Innovative cluster formations must provide the solution for these problems. According to the world practice, the use of the cluster approach as a tool for the economic development of the leading countries contributes to their increased sustainability and competitiveness (Surya, Syafri, Abubakar, Sahban, and Sakti, 2020; Surya, Saleh, Syafri, and Ahmad, 2019; Bykanova, Akhmadeev, Kosov, Ponkratov, Osipov, and Ragulina, 2017; Vasiljeva, 2012).

The conception of this study: the authors suggest that, under the necessary conditions for sustainable competitiveness, industrial clusters can drive the country's sustainable economic and innovative development. Innovative clusters can also accelerate the development of the digital economy, the information society of individual companies, and cluster entities.

To confirm this statement, the authors studied and classified foreign and domestic works on the problems

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of theory and methodology. These materials also explored the practice of ensuring the formation, competitiveness, and sustainable development of the information society and digital economy, and analyzed the role of cluster formations in these processes. The study was based on information resources such as international databases and citation systems, including Scopus, Web of Science, Science Direct, Taylor & Francis, Research Gate, e-library, and the Russian Science Citation Index.

To confirm the hypothesis, a comparative and correlation-regression analysis of the development of industrial clusters in the Federal districts of the Russian Federation was also performed.

LITERATURE REVIEW

The concept of the sustainable competitiveness of socio-economic systems is a theoretical and methodological approach used by researchers and practitioners to implement the principles of sustainable development and solve the problem of competitiveness increase. Two primary areas have been identified in this problem study:

1) Sustainable socio-ecological-economic development.

2) The various methods, mechanisms, and tools of the competitiveness provision.

The cluster approach and the digitalization of production, economy, and society are essential to the competitiveness provision (Figure **1**). In the past, these were considered the only ways to increase the competitiveness of production facilities. Current research has pointed out the complementary nature of these approaches in ensuring sustainable development. Therefore, this study introduces a detailed analysis of the research done in each approach.

In the reports of the World Economic Forum (Schwab, 2017) and a number of UN documents, the country's sustainable competitiveness is interpreted as a result of the complex impact of politics, institutions and factors that determine the level of productivity and provide an opportunity for future generations to satisfy their needs (United Nations, 2015; The Global Sustainability Competitiveness Index, 2017).

Over the last years, Porter and Heppelmann (2014) and Wernerfelt (2015) have made a contribution to the studying of the competitiveness of socio-economic systems. The problems of formation of management mechanisms for the socio-economic systems' competitiveness in the context of sustainable development was revealed in the works of the following researchers: Balkyte and Tvaronavičiene (2010), Boons, Montalvo, Quist, and Wagner (2013), dos Santos and Brandi (2014), Doyle and Perez-Alaniz (2017), Cavaco and Machado (2015), Meza-Ruiz, Rocha-Lona, Soto-Flores, Garza-Reyes, Kumar, and Lopez-Torres (2017), Popescu, Popescu, and Popescu (2015), Chen, Wu, Mao, and Li (2017), Zhang and London (2013), Zhu and Cheung (2017), etc.

It is worth highlighting the works of contemporary Russian researchers, devoted to the specified problem (Barmuta, 2010; Bobylev and Zakharov, 2011; Granberg, Danilov-Danilyan, Tsikanov, and Shopkhoev, 2002; Dorofeeva, 2011; Zuev, 2012; Kuznetsov and Bolshakov, 2013; Podlesnykh, 2012; Popkov, 2013; Toroptsev and Tatochenko, 2011; Ursul,

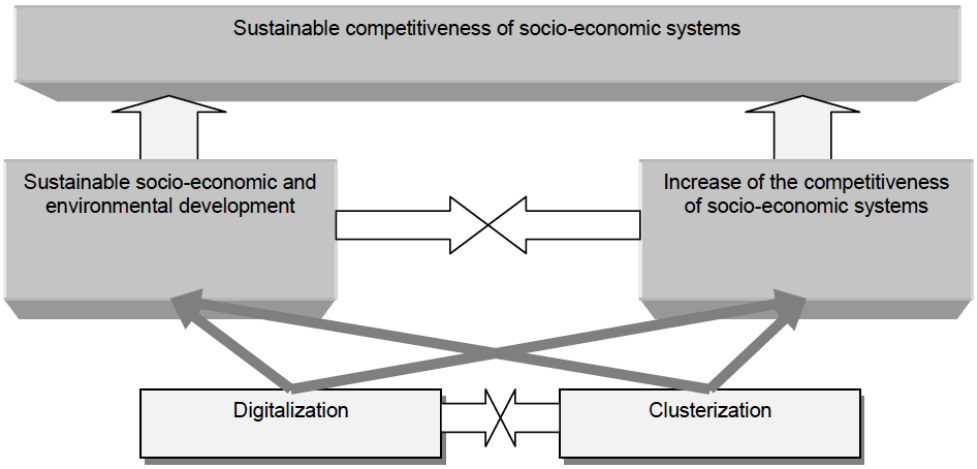

Figure 1: Approaches to the study of the sustainable competitiveness of socio-economic systems (elaborated by authors).

2011; Uskova, 2009; Khodakov, Petrov, and Sokolova, 2014).

There is no unified understanding of the aspect of sustainable competitiveness of enterprises among the experts in the specified sphere. Some researchers identify this concept with sustainable development and apply its characteristics for measuring the sustainable competitiveness, i.e., the criteria of social justice, environmental security and economic efficiency (Caraka, Lee, Kurniawan, Herliansyah, Kaban, Nasution, Gio, Chen, Toharudin, and Pardamean, 2020; Vasiljeva, Neskorodieva, Ponkratov, Kuznetsov, Ivlev, Ivleva, Maramygin, and Zekiy, 2020; Ivlev, Ivleva, and Ivleva, 2019). Another group of the researchers focus on the variety of competitive advantages of a sustainable competitive company. Contemporary theories of competitiveness (American, British and Scandinavian scientific schools) associate the effectiveness of programs for increase of the competitiveness of economic entities with the development of effective value added chains, the development of the ability to create innovations and the use of industry (or cluster) advantages.

Cluster theory was developed in the 90s of the 20th century due to the publications of Porter (2000), Sölvell, Lindqvist, and Ketels (2003), Enright (2003), Asheim (2001), Andersson, Hansson, Serger, and Sörvik (2004). It is worth highlighting the contemporary research on the issue by Brachert, Titze, and Kubis (2011), Martin, Mayer, and Mayneris (2011).

Cluster policy, institutional and instrumental support and development of cluster initiatives are investigated in the works of Russian scientists: Bortnik, Gokhberg, Klepach, Rudnik, Fomichev, and Shadrin (2015), Abashkin, Kutsenko, Rudnik, Sagieva, and Shadrin (2016), Gokhberg and Shadrin (2015), Achenbach (2013), Babkin (2018), Vertakova, Polozhentseva, and Khlynin (2014), Tretyak (2011), Charykova and Markova (2019), Yashin, Trifonov, and Koshelev (2016), etc.

However, despite the significant exploration of the issue, a number of theoretical and methodological problems in cluster theory remain unresolved. In particular, there is no certainty in the interpretation of cluster concept; the problems of the assessment of its effectiveness, sustainability and competitiveness have not been sufficiently studied.

It is worth highlighting that among the research on the industrial development problems, the works devoted to the digitalization of the global economy and the distribution of Industry 4.0 initiatives in various countries of the world and in Russia are of particular interest.

Schwab, the president of the World Economic Forum in Davos (Schwab, 2016; Schwab and Davis, 2018), has formulated the concept of the Fourth Industrial revolution. The term Industry 4.0 appeared in the context of the High-Tech Strategy 2020 of the German government in 2011. Today, many researchers regard the terms Industry 4.0, Fourth Industrial Revolution, and Digital Transformation as synonyms.

The authors of the present study also highlight the works of Russian researchers in this field, namely: Glazyev (2018; 2019), Averbukh (2010), the monographs “Digital Economy: Global Trends and Practice of Russian Business” (Medovnikov, Oganesyan, Styrin, Abdrakhmanova, Rozmirovich, Merkulova, and Bikbulatova, 2017), “New Technological Revolution: Challenges and Opportunities for Russia” (Knyaginin, 2017), “Development of digital economy in Russia as a key factor of economic growth and improvement of quality of life of the population” (Andreeva, Badal'yants, Bogatyreva, Boroday, Dudkina, Zubarev, Kaz'mina, Minasyan, Mironov, Strizhov, and Sher, 2018), “Digital Russia: a New Reality” (Aptekman, Kalabin, Klintso, Kuznetsova, Kulagin, and Yasenovets, 2017), “Digital economy: myths, reality, perspective” (Ivanov and Malinetsky, 2017).

The main directions of Russian research in this area relate to the readiness of domestic economy and business (especially, industry) for future changes and the prospects for ensuring sustainable development and competitiveness of the country, as well as its non-resource-based industrial sector under new conditions (Orlova, Gagarinskaya, Mikheeva, and Yelyakov, 2015).

The intensification of innovative clusters can solve the problem. However, in this regard, the sustainable competitiveness of clusters must be ensured (Figure **2**) (Guskova, Salimova, and Krakovskaya, 2015; Salimova, Guskova, Krakovskaya, and Sirota, 2019; Salimova, Biryukova, Shilkina, and Khakhaleva, 2018; Tyasti and Caraka, 2017; Yakhneeva, Agafonova, Fedorenko, Shvetsova, and Filatova, 2020).

Clustering in Russia has its own specifics. One of the goals of implementing cluster-development projects

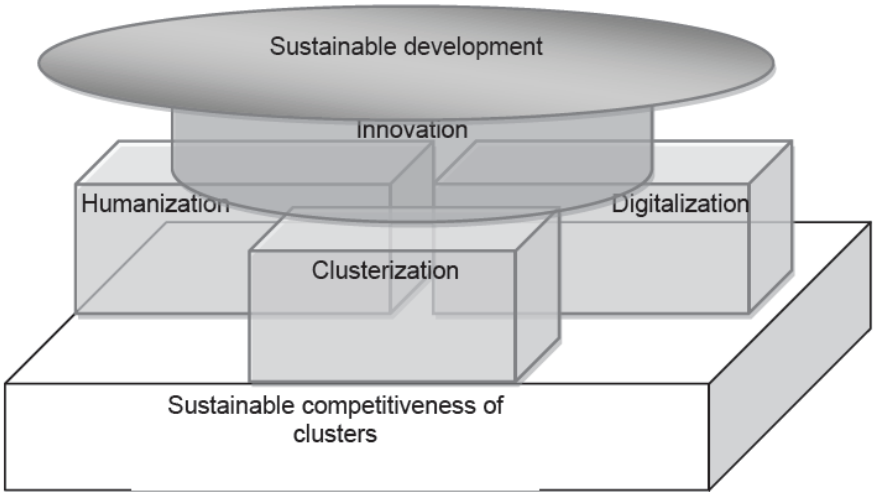

Figure 2: The significance of sustainable competitiveness of innovative clusters for sustainable development ensuring (elaborated by authors).

in Russia is to overcome various barriers and problems that hinder the effective interaction of enterprises and organizations. The use of cluster theory in the real economy of Russia contributes to the creation and development of clusters, which should become new points of economic renewal and growth. Industrial clusters really can become supporting elements of Russia's economic transition to innovative and sustainable development. The correlation and regression models constructed by the authors demonstrate a clear dependence of region economic and innovative development indicators on the clustering level.

MATERIALS AND DATA

The research methodology is based on the content of the concept of sustainable competitiveness and cluster theory. The study was carried out using the methods of regression analysis.

Regression analysis is a set of statistical methods used for the estimation of relationships between a dependent variable and one or more independent variables (Chen, Dewi, Huang, and Caraka, 2020). It can be utilized to assess the strength of the relationship between variables and for modeling the future relationship between them. Simple linear regression is a model that assesses the relationship between a dependent variable and an independent variable (Caraka, Chen, Lee, Toharudin, Rahmadi, Tahmid, & Achmadi, 2021; Kurniawan, Hadumaon Siagian, Yuniarto, Ilmi Nasution, and Eko Caraka, 2019). The simple linear model is expressed using the following equation:

$$Y = a + bX + \epsilon \quad (1)$$

where Y – Dependent variable, X – Independent (explanatory) variable, a – Intercept, b – Slope, ϵ – Residual (error). The model was validated using Fisher's and Student's criteria.

In the process of research the number of clusters in the Federal District of Russia is used as X. As of 2019, 44 clusters functioned in the Russian Federation. Their distribution by federal district is presented in Table **1**.

Table 1: Cluster Formation in the Federal Districts

Federal district	2019
Central	12
Northwestern	8
Southern	1
North Caucasian	2
Privolzhsky	15
Ural	5
Siberian	4
Far Eastern	1
Total	44

Source: Ministry of Industry and Trade of the Russian Federation, n.d.

The leaders in terms of the number of clusters are: Ulyanovsk region (3), Saint Petersburg (3), Republic of Tatarstan (3), Voronezh region (2), Omsk region (2), Kaluga region (2), Penza region (2), Chelyabinsk region (2), Sverdlovsk region (2) (the average value for the subjects of the Russian Federation with industrial clusters is 1 clusters) (Ministry of Industry and Trade of the Russian Federation, n.d.).

The indicators selected as the resulting features (Dependent variable) were selected taking into account their significance for the economic and innovative development of the region:

- Turnover of enterprises and organizations in all types of activities, trillion. rub. (Y1);
- Investments in fixed assets, mln. Rub. (Y2);
- The number of high-performance jobs in the off-budget sector of the economy, thous. (Y3);
- Volume of innovative goods, works, services, mln. Rub. (Y4).

Data were collected based on official information from the Federal State Statistics Service of the Russian Federation (n.d.), Russian Association of Clusters and Technoparks (n.d.), and Geoinformation System "Industrial Parks. Technoparks. Clusters" of the Ministry of Industry and Trade of the Russian Federation (n.d.).

RESULTS

In order to test the hypothesis of the study using regression analysis, a model has been built to assess the dependence and influence of the number of clusters in Federal Districts on the main indicators of economic innovative development of these territories (Table **2**).

According to Table **1**, 4 one-factor models of linear regression dependence were built. The choice of the model is due to statistical data: the presence of clusters is recorded in 8 federal districts. The results of checking the obtained regression equations for reliability are shown in Table **3**.

Analyzing the parameters of the regression models presented in Table **2**, it should be noted that all regression equations are reliable according to Fisher's criterion (Fobl.> Fcr.) With a probability of 94% and higher. All coefficients of the variables are reliable according to the Student's test with a high probability, as evidenced by the P-values. Thus, all the obtained equations can be recognized as reliably reflecting the relationship between the analyzed resultant and factorial features.

The values of the correlation coefficients indicate a noticeable effect (according to the Chaddock scale correlation table) of the number of clusters on investment in fixed assets. The influence of the factor

Table 2: Data for the Regression Model

Federal district	X	Y1	Y2	Y3	Y4
Central	12	78.80	5 662 681.70	5 016.72	1 425 670.34
Northwestern	8	24.50	2 012 133.10	2 065.87	591 698.76
Southern	1	13.90	1 319 012.10	1 214.69	196 630.56
North Caucasian	2	2.80	610 839.60	297.49	44 225.51
Privolzhsky	15	30.00	2 690 313.40	3 239.46	1 716 539.30
Ural	5	23.50	2 911 027.90	1 722.43	501 088.92
Siberian	4	18.60	1 789 244.80	1 728.34	248 562.00
Far Eastern	1	9.20	1 575 853.60	960.01	138 966.47

Source: Elaborated by authors based on calculation using the data of the Russian Association of Clusters and Technoparks (n.d.).

Table 3: Criterions of Regressions Models Statistical Significance

Model	R	R^2	F	Significance F	t_{a1}	P	E
$y_1 = 6.275+3.15x+\varepsilon$	0.694	0.482	5.577	0.06	2.362	0.06	0.630
$y_2 = 1108702+202114.44x+\varepsilon$	0.756	0.572	8.027	0.03	2.833	0.03	0.728
$y_3 = 3643067+873331.89x+\varepsilon$	0.796	0.634	10.395	0.02	3.224	0.02	0.592
$y_4 = -89989+116319.61x+\varepsilon$	0.955	0.912	62.731	0.0002	7.920	0.0002	1.185

Notes: R - correlation coefficient; R^2 - determination coefficient; F – Fisher criterion; Significant of F (allows you to check the significance of the regression equation); t_b - Student`s criterion; P – P –value; E – Elasticity coefficient.

under consideration on the turnover of enterprises and organizations in all types of activities and the number of high-performance jobs in the non-budgetary sector of the economy is high, and on the volume of innovative goods, works, services is very high. All correlation coefficients are statistically significant with a 95% probability according to Student's t test

According to the values of the elasticity coefficients, it can be argued that with an increase of 1% in the number of clusters in federal turnover of enterprises and organizations in all types of activity will increase by an average of 0.751%, investments in fixed assets will increase by an average of 0.522%, and the number of high-performance jobs in the off-budget sector of the economy - by 0.59%. Particular attention should be paid to the influence of the number of clusters on the volume of innovative goods, works, services, since the value of the elasticity coefficient is greater than 1, which indicates a significant dependence of this resulting feature precisely on the development of cluster formations.

CONCLUSIONS

The cluster theory suggests an alternative way of competition, whereby all cluster members acquire new competitive advantages through the development of internal relations and cooperation; therefore, they compete more successfully in the global environment. In this context, cluster becomes the main business entity of the so-called “innovation economy” as a form of interindustry structure for its members, comprised of various forms of organization, relations, and types of interaction. Accordingly, the problem of sustainable competitiveness development should be solved with the framework of cluster structure as an integrated socio-economic system.

The economic science reflects various aspects of sustainable development and increasing competitiveness as well as digitalization and clusterization. However, we have to admit that there are minimal works devoted to the comprehensive study of the problems of ensuring sustainable competitiveness of innovative clusters (in industry, in particular) in the context of the formation of a digital economy.

The authors of the present research recognize that clustering should be considered one of the basic elements in the system of national and regional sustainable competitiveness. The cluster approach for ensuring sustainable development and competitiveness in the digital era is regarded as absolutely reasonable, taking into account the ability of clusters to accumulate financial, infrastructural, human and other resources necessary for major production changes. Additionally, it is necessary to note the clusters’ ability to generate a synergistic socio-ecological and economic effect not only in relation to the competitiveness and sustainability of the cluster as a whole and its participants, but also for the region and the country.

Thus, cluster activity helps to improvement the regions economic development and to increase its accumulated economic potential. The study showed that regions with the best cluster initiatives have created a better business climate, innovative infrastructure, and other prerequisites for successful digital transformation and sustainable development.

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