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CLUSTER COOPERATION MECHANISMS EVALUATION FOR WASTE PROCESSING OF THE FOREST COMPLEX OF SIBERIA

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ABSTRACT

The study subject is the approaches development for assessing cooperation in a cluster. Study purpose: a selection of tools to assess the characteristics of cooperative ties in a cluster for processing waste from a forest complex in Yenisei Siberia. Methods: Case analysis, questionnaire, survey, expert assessment, and a method of pair comparisons. Results: The following results have been substantiated: The emerging cluster for waste processing from the Yenisei Siberian forest complex; the situational factors; industry specialization; the goals of creating a cluster, and the interests of participants. As the cluster evolves, the directions and cooperation level of cluster members are the subject to change. The obstacles ranking for cooperation in the cluster is carried out as well. An aggregated indicator of the intensity of cooperative ties, based on five criteria, is proposed, which makes it possible to evaluate both industrial and innovative cooperation. In addition, it is proposed to determine the weighting factors situationally, depending on the target orientation of the cluster. Summary: it is shown that the desired value of aggregated cooperation indicator should be formed in the coordinate system, i.e. "innovation – sustainability". Evaluation and regulation of the indicator level can serve as a tool for making and implementing strategic decisions on cluster development priorities.
Keywords: cluster; cooperation; quadrant; innovation; waste processing of the forest complex.

JEL Classification: D02; L14; L73; Q53; Q01; R58.

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1. INTRODUCTION

The fourth industrial revolution has given us a phenomenon of a circular economy (Cooke, 2012a; 2012b; Perkins, 2003; Safarzyńska and van den Bergh, 2010; Sauvé et al., 2016; Schroeder et al., 2018), that is, economies with closed or "green" production chains in which waste is minimal or absent. The business models search and implementation that allow implementing the circular economy principles at the micro level in the global scientific community seems to be a complex and relevant research task (Kallis and Norgaard, 2010; Lacy and Rutqvist, 2015; Roos, 2014). For Russia, a country with significant resource potential, the task of building a circular economy is even more complex and requires the search for new organizational and managerial solutions that meet the goals of maintaining sustainable development and moving production to a new technological level. This formulation of the issue is especially relevant for nature-exploiting industries and resource regions, including the forest complex of the Yenisei Siberia.

It is interesting to note that over 60% of the Russian forested area is concentrated in Siberia. Forests not only provide wood processing industries with raw materials, but also create significant export opportunities that are underutilized due to insufficient implementation of technologies for deep and waste wood processing. Forests also perform social and environmental functions, creating conditions for the sustainable development of forest areas. The "anchor" enterprises closure of the region's forest complex in the post-perestroika period has become a limiting factor in the development of enterprise cooperation, product diversification, multi-purpose forest management, and the introduction of new technologies.

In the forest sector today, it is impossible to ignore the trends in the circular economy formation, whose main task is "design restoration" (Ellen MacArthur Foundation, 2012), based on management methods that do not reduce the regenerative capacity of ecosystems (Schroeder et al., 2018), and the forest sector profitability. In the forest complex, recycling can "introduce an innovative component" (Rubinskaya et al., 2016), and waste should be considered as "raw materials, economic efficiency, and environmental safety, which can be significantly higher than the primary raw materials" (Rubinskaya et al., 2016).

The "not to make it worse" motivation is difficult to implement if industry actors are not involved in cooperative interaction, also within clusters. Russia's resource redundancy complicates the problem. In Europe, with incomparably lower forest potential, according to the Helen MacArthur Foundation, the introduction of circular economy principles by 2030 will allow "reducing net resource costs by 600 billion Euros, annually increase resource productivity to 3% per year, and receive an annual net income of 1.8 trillion Euros" (Ellen MacArthur Foundation, 2015). According to estimates of the same fund, only 6% of the world's resources is recycled.

Clustering can be seen as a form of circular economy in creating and developing technological chains; the accumulated Russian (Vasilieva et al., 2017; Kozhukhov et al., 2017; Rezanov, 2016; Smorodinskaya, 2014) and foreign experience (Fløysand et al., 2012; Haviernikova et al., 2016; Luhas et al., 2019; Njøs and Jakobsen, 2016) is a clear confirmation of this. It is noted that the solution to the problem of weak territorial enterprises cooperation of the Tomsk region forest complex is clustering, which will allow establishing the integrated wood processing (Kozhukhov et al., 2017). In Vasilieva et al. (2017), significant cluster groups for the Krasnoyarsk Territory were evaluated on the basis of localization and connectivity indicators, and a conclusion about the high clustering potential of the timber industry complex of the region was drawn, as one of the directions of the cluster core formation in the forestry complex is called the cooperation of processing industries, including the use of waste (Rezanov, 2016). Noting that "cooperation becomes the main mechanism for systems harmonizing"; Smorodinskaya N. V. shows the dependence of cluster innovation on the cooperative ties organization; moreover, the deployment of the "triple helix" of innovative interaction is possible in traditional industries (Smorodinskaya, 2014).

A number of authors compare the effects of clustering when they are deployed from top to bottom and from bottom to top, which affects the characteristics of participants cooperation (Fløysand et al., 2012), provides an assessment of cluster cooperation risks (Haviernikova et al., 2016), and discusses the innovative effects of cooperation development in related industries and knowledge cooperation (Njøs and Jakobsen, 2016). The work that is devoted to the Finnish forest complex study (Luhas et al., 2019), where the cluster concept has been successfully implemented, has been given a review of the cooperative (or network) cluster effects that are valuable to this study. Cluster creation productivity assessment requires some attention, regardless of the cluster initiative subjects, stage determination and cluster development prospects. The hybrid nature of this supra-organizational formation, with specific goals and coordination mechanisms, creates difficulties for targeted cluster management, because in essence it is the management of cooperative ties.

The level and mechanisms of participant cooperation that require analysis and evaluation, including the spatial-temporal context and the prospects for co-evolutionary development of the Yenisei Siberia regions, are the greatest research interests. The value of this study is the development of methodological approaches for assessing the level of cooperation, taking into account the cluster configuration, stages of

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its development, the need for smart specialization, and the overcoming of the technological stagnation of the industry, followed by the use of cooperation indicators in making strategic decisions in regulating the development of the cluster and introducing the principles of a circular economy at the micro level.

The study purpose is to find adequate tools for assessing the development of a cluster, primarily taking into account the directions, obstacles and the level of participants' cooperation, which would make it possible to make strategic decisions in the direction of building closed technological chains. The hypothesis of this study is the assumption that a set of directions and tools for regulating relationships in a cluster depends on industry specialization, cluster configuration, and the level of intra-cluster cooperation of participants.

2. METHODS

The systemic, situational and evolutionary approaches form the methodological basis of this study. Among the theoretical concepts necessary for a deep study of formation, development and cooperation in a cluster evaluation issues, taking into account its target orientation, within the framework of this study, are the concept of a quad-helix (or triple helix) (Carayannis and Grigoroudis, 2016; Smorodinskaya, 2011), the system-integration theory (Kleiner et al., 2008), the economic systems sustainability theory (Melnikova and Bezrukikh, 2017a; Melnikova and Bezrukikh, 2017b), and the circular economy concept (Accenture, 2014; Ellen MacArthur Foundation, 2015; Roos, 2014; Sauvé et al., 2016; Schroeder et al., 2018).

The system-integration theory by G. Kleiner offers a universal typology of economic systems, based on determining the boundedness / unboundedness of the system in time and space, and taking into account the position of the researcher (Kleiner et al., 2008). For the clustering initiator, the cluster appears to be a project-type system, limited in time and space, while in the study of cooperation, the cluster is a medium-type system. Emphasizing the growing popularity of the evolutionary approach to the study of clusters (using the time factor), a number of authors note the lack of attention to "local factors (or space factors), neglect of multi-scalar influences, and human factor underestimation" (Trippl et al., 2015). Taking into account "local factors", such as resources, interests of local residents, economic problems of territories, etc., implies the situational nature of each cluster, which makes it necessary to look for typing opportunities in the characteristics of cooperative ties.

Based on the evolutionary approach (Østergaard and Park, 2015), it was revealed that narrow industry specialization impedes updating (Cooke, 2012a; Cooke, 2012b; Martin, 2011; Njøs and Jakobsen, 2016). The conclusion in which the cluster environment develops and the level of trust between the cluster enterprises grows and "the area of cooperation and the methods for identifying its directions change" (Kostenko, 2016) is also based on the methodological basis of the evolutionary approach and is extremely important in the context of this study.

The correction vector of cluster projects implementation environment and areas of external cooperation is set by the concept of quadruple helix (Carayannis and Grigoroudis, 2016), which assumes a coordinated interaction between society, state, business, and science (Smorodinskaya, 2011; Smorodinskaya. 2014; Shestak and Tyutyunnik, 2017). Taking into account the importance of the environmental motives of the clustering process in the forestry complex and the severity of the environmental problems in this traditional industry, untwisting the quad-spiral of interaction in the cluster is a prerequisite for the innovative transformation of the industry, achieving "green" development goals. Cluster cooperation and innovation guidelines should not undermine the sustainability of individual cluster members, both in perception and in reality.

The most modern views on the relationship between specialization and innovation are reflected in the concept of "smart specialization" (European Commission, 2014), which refers to the coherence of industrial, innovation and educational policies. In order to achieve meaningful cluster development, the conceptualization and debugging of cooperative cluster interactions is necessary. The concept of "smart specialization", despite its attractiveness, is difficult to implement and requires "the development of new sophisticated technologies based on local capabilities" (Balland et al. , 2018), and therefore, the development of external relations for the cluster based on the concept of a quad-helix.

The system-integration theory (Kleiner et al., 2008) allows considering the co-dependence of economic systems and the content of cooperative ties, including business models sustainability (Melnikova and Bezrukikh, 2017; Melnikova and Bezrukikh, 2017) of individual participants and cluster interaction as a whole. The cluster strategic goal is formulated as the task of managing such target interaction parameters in the cluster as innovation, sustainability, environmental and social orientation, the ratio of specialization and diversification, localization boundaries, and the intensity of cooperation. The main attention is paid to assessing the intensity of cooperation, which means a certain level of balance between the independence of participants and their coordinated co-evolution.

The information base for this work includes research by domestic and foreign authors, questionnaires and data surveys of participants in the emerging cluster and experts, and the case analysis results of clusters at different stages of development. Twelve cases were selected, involving foreign experience as well, and the preference was given to clusters in nature-exploiting industries; paradoxical examples were not ruled out and the correction of research tasks and reformatting of analysis parameters were allowed. The questionnaire results were processed with the method of pairwise comparisons.

The study algorithm includes the following steps: clarifying the content of "cluster" concept and the meaning of cooperation in the cluster based on literature analysis; selection of cases for a qualitative analysis of cluster evolution; consideration of the co-dependence content dialectics and the level of cooperation and cluster evolution directions; analysis of the impact of cooperation parameters in the cluster; manifestation of innovative effects in cluster development; the study of the motivational field of participation in the cluster; obstacles and preferred patterns of interaction; the importance component of knowledge in cooperation and the level of informal contacts for cluster development; designing an integrated indicator for assessing the intensity of cooperation in a cluster, taking into account the comparative importance of obstacles to cluster development; and cooperation management in the cluster to process the forest complex waste.

3. RESULTS

A content analysis of the cluster concept allows identifying a number of definitions, such as interconnection, interaction, interdependence, and complementarity, that are present (together or separately) in all considered definitions of the cluster and can be reduced to the concept of "connectivity" and the processes of cooperation in the cluster. The concept cluster varies according to the topic of interest to a particular author (Chernova, 2014). Depending on the research tasks being solved, the range of methodological approaches used in the study of clusters changes, i.e. the emphasis shifts from, for example, industry to territorial aspects, and vice versa (Kolesnikov and Khazaliya, 2016). Nevertheless, the issues of cluster participants' cooperation are inherent in all studies, regardless of their focus.

The following definition of a cluster seems to be most appropriate, focusing on the interaction of participants, i.e. "a cluster is a set of organizations and institutions interacting in a certain field of activity, competition and cooperation, which leads to an increase in the competitiveness of each of them due to factors such as the aggregate efficiency (or exchange of knowledge and information, and network effects), training and economies of scale" (Kolesnikov and Khazaliya, 2016). The most important aspect of the projected cluster is the innovative component and understanding of the cluster as a form "modernization of the territory's economy and a factor of its sustainable competitiveness" (Komov and Yakovenko, 2016).

The connections between the elements of the system (in this case, the cluster) are the memory that stores the past of the system (Thurner et al., 2018). The cluster attractiveness and the technology used in it lead to the accumulation of a critical number of participants (Arthur, 1994). As a result, the level of demand increases (Luhas et al., 2019; Safarzyńska and van den Bergh, 2010) and the business models standardization continues within the cluster. The inertia in cluster development also increases when entering foreign markets (Kallis and Norgaard, 2010). Inertia (as opposed to innovation) is understood as the absence of qualitative changes in the products and technologies of the cluster, the innovation occurrence attenuation, the decrease in the synergistic effect of cooperation and the drop in efficiency up to the collapse of cluster interaction. As noted in Perkins (2003), an increase in the intensity of cooperative ties over a certain level will impede the introduction of new technologies. The mechanism of technological blocking of production diversification takes place as well (Luhas et al., 2019; Perkins, 2003).

In the course of studying the clusters development (Vasilieva et al., 2017; Kozhukhov et al., 2017; Mantsaeva and Delikova, 2016; Rezanov, 2016; Smorodinskaya, 2014; Balland et al., 2018; Ketels et al., 2012; Luhas et al., 2019; Østergaard and Park, 2015), a conclusion was drawn regarding the sectoral focus of cooperative ties. If the cluster is formed by enterprises of related industries, then it stimulates innovation at the cluster enterprises and productivity growth in the region, while in the case of narrow industry specialization, productivity at cluster enterprises increases, but innovation is blocked (Aarstad et al., 2016). A number of other studies (Cooke, 2012a; 2012b; European Commission, 2014) confirm the fact that "specialization works against innovation". It is noted that the content of cooperative interactions should include, to one degree or another, the exchange of knowledge (Li, 2018) between cluster participants and external stakeholders.

As the case analysis showed, the practical interest in clusters is due to both the expansion of their support from national and regional authorities, and their economic role as drivers of competitiveness, innovation, and economic growth (Haviernikova et al., 2016; Păuna, 2015). The cluster's main features, along with the concentration of operations in a limited area and innovative activity, are recognized as the existence of stable ties between participants in cooperative interactions. Achieving the goal of updating the territorial and sectoral structure of the timber industry complex, introducing new resource-saving technologies and recycling technologies (Mokhirev et al., 2015) requires the develop-

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ment of cooperation in related industries, thus leading to the growth of the importance of cooperation relations that are external to the cluster. Cross-sectoral knowledge transfusion and knowledge cooperation are needed.

Another landmark of the projected cluster for the waste processing should be the formation of a quad-spiral interaction between society, state, science and business. A round table held in Krasnoyarsk in July 2019 confirmed this, as issues related to the processing of forest resources and their wastes were discussed. The participants were representatives of all quad-helix actors, including the government representatives of the Krasnoyarsk Territory, such as Ministry of Economic Development, Ministry of Ecology, and Ministry of Forest, public organizations (i.e. four environmental and professional organizations), thirty-six legal business entities, and three higher education institutions. Five questions were discussed publicly and fourteen questions were included in the questionnaire that was issued to each participant in the round table. For the participants of this event, the most interesting issues are joint projects to enter the world market and receive state support; the need for interaction and product innovation is recognized as well. Due to the awareness of the participants regarding the significant accumulated volumes of forest complex waste, the possibility of introducing circular supply models (Accenture, 2014) and restoring resources, using the potential of forests subjected to fires and pests, is being examined.

Regardless of the cluster structure, the flow of knowledge and information is an essential element in the cooperation of cluster structures and cluster elements. The information factor is understood quite widely, including informal communication between cluster members (Vatne, 2011). The degree of cluster members' connectedness and the level of external cooperative ties are estimated by the number of contacts per year (Balland et al., 2018). The frequency of cluster managers contacting in Europe with other people in various sectors decreases in the following order: other cluster members, government agencies, research institutes, educational organizations, other clusters, international markets, and financial institutions.

The results of the survey of potential participants of the waste recycling cluster showed a different picture. They displayed the greater importance of contacts with financial institutions and foreign companies, and the lower importance of contacts with educational and scientific organizations and other clusters. An assessment of informal contacts frequency within a cluster (once every two or three months) is of particular value at the stage of cluster formation and can be an indicator of the cluster members' motivation. As for the interaction between enterprises, the preference is given to property relations and technological considerations, rather than to relational arrangements. There is also the lack of understanding of the importance of contacts with educational and scientific organizations, with other clusters and the public. Even less valuable are the relationships with society.

Also during the survey, 87 managers/chief specialists of enterprises were surveyed and a list of cooperation obstacles was revealed. Based on the list, obstacles were ranked using pairwise comparisons; the results are presented in Table 1. Pairwise comparisons of cooperation obstacles were carried out on a 5-point scale, where 5 (1/5) points are respectively the highest (least) significance of the obstacle, 4 (1/4) points have a significantly different meaning of obstacles, 3 (1/3) points have an accordingly high (low) significance of an obstacle, 2 (1/2) points have an insignificantly different significance of obstacles, and 1 point, in which the significance of two obstacles is equal. Next, the matrix was transformed into a normalized one, row-average matrices were determined for each obstacle, summed up by estimates of 10 experts, and the ranks were determined on this basis.

Table 1. The cooperation obstacles ranking in a cluster (data from 10 experts[a])

Rank	Cooperation obstacles	Rank	Cooperation obstacles
1	lack of experience	8	lack of linking institutions
2	high coordination costs	9	discrepancies in determining the parameters of the interaction project
3	technological mismatch of potential partners	10	information difficulties in finding partners
4	lack of adequate infrastructure	11	lack of interest in cooperation
5	financial constraints	12	significant distances
6	competitive relationship	13	possible reputational risks
7	know-how disclosure risks	14	synchronization problems

[a] Scientists and teachers of Krasnoyarsk universities were involved as experts

In conclusion, the quad-spirals of innovative interaction are not formed yet. While comparing the results of the cluster participants' questionnaire, the public survey and the expert community, it can be argued that pair interactions are debugged only in pairs such as "society and state", "state and education", and "municipality, as the representative of the local community interest in business". The ideas of business, government, science and the public regarding the directions of development of forest waste processing may differ significantly. This increases the importance of managing cooperation in the cluster, which can be carried out based on assessing the cluster cooperation intensity.

In practice, a cooperation coefficient is used in order to assess cooperative interactions in a cluster. It shows the volume of semi-finished products, components, etc., received from the outside, to the total costs of the enterprise for the manufacture of marketable products. However, for a more accurate assessment of the situation in the cluster, it is proposed to use the integral indicator of cooperation (Ki.i.c), combining several cooperation criteria, including a share of the output cost, costs share, jobs share, intellectual property share, and share of fixed capital investments used in the framework of the cluster. The list of indicators is determined by the need to harmonize the interests of participants in external and internal cooperation for the cluster and reflects the need for circular supplies (indicators # 1 and 2), increased employment sustainability (# 3), diffusion of knowledge (# 4), and accumulation of investment resources within the cluster (# 5). Weights will reflect the specifics of the targets / obstacles to the development of the cluster, which may change over time. Since the targets are blurred at the stage of creating the cluster, the level of weighting coefficients was determined based on previously obtained points of obstacles significance as criteria, with the involvement of the same experts. The total data for calculating the integral indicator is presented in Table 2.

The cooperation indicator calculation is worked out by multiplying the specific gravity of the corresponding indicator and its individual value for enterprises with their subsequent addition (equation 1):

$$\text{Ki. i. c} = \sum_{t=1}^{5} W_i \times K_i \qquad (1)$$

where W_i – indicator weight;

K_i – *i*- indicator used in calculations.

The presented indicators do not contradict the updated requirements of the legislation of the Russian Federation (The Government of the Russian Federation, 2016b). They have been established in order to provide state support to clusters, while allowing us to evaluate not only the industrial, but also the innovative knowledge-based cooperation. The calculation of indicators 1 and 2 is not carried out for all participants in the cooperation, but taking into account the participant's position in the value chain (i.e. the choice and weight of indicators 1 and 2).

4. DISCUSSIONS

Summarizing the features of cluster policy that allow stimulating innovation and region renewal (Njøs and Jakobsen, 2016), it is noted that it should support the development of external and internal cooperation of the cluster, the influx of new knowledge, the provision of specialized business services and the creation of infrastructure for collective innovation, as well as regional localization value chains (Fløysand et al., 2012). There is an opinion that the assessment of cluster connectivity is necessary at its local (as opposed to global) scale (Rezanov, 2016). In our opinion, the need to assess the level of cooperation is inherent in any type of cluster; the differences are in the approaches used and the information available.

The normative level of the cooperation indicator may vary depending on the target orientation and development strategy of the cluster. The value of the indicator 0.4-0.6 corresponds to the strategy of specialization, a situation where the main goal is to tap into economies of scale and reduce production costs for a limited range of products. In the cluster evolution process, goals will change; product diversification through innovation will be a priority. In this case, the level of cooperation should be 0.2–0.4, and its actual level should be calculated according to the methodological recommendations (Abashkin et al., 2017). On the share of cluster members mutual supplies in the formed forest clusters, the averages are 0.15–0.2 (The Government of the Russian Federation, 2016a) in the Tomsk region - 0.26 (Kozhukhov et al., 2017). Thus, the prevailing conditions for the interaction of forest cluster participants support a diversification strategy, fragmentation of goods supply and the introduction of new technologies.

The study analyzed the activities of 87 timber enterprises of the Yenisei Siberia, which could potentially form the basis of clusters in the timber industry. The calculation of the proposed integral cooperation indicator has been worked out, its level equal to 0.23 supports the formation of the cluster.

Of course, the need for analytical tools is not limited to assessing the level of cooperation. Therefore, in Mantsaeva and Delikova (2016), a system of indicators has been proposed for assessing the prospects of cluster formation in the region, with a division into quantitative and qualitative. The set of indicators is determined by the properties of cluster structures and allows not only assessing the possibility of cluster formation, but also "monitoring the state of the cluster at a certain stage of development" (Mantsaeva and Delikova, 2016).

Agreeing with the need to study the evolution of the cluster, it is believed that the list of quantitative indicators, along with territorial proximity, industry efficiency for the regional economy, innovative activity, and export opportunities, should also include a quantitative measure of the cooperative ties intensity. As noted in Vasilieva et al. (2017), "intercompany cooperation (...) develops along the entire value chain based on competitive forms, rather than integration within the framework of a single property, and is accom-

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Table 2. Indicators for calculating the intensity of cluster cooperation

Indicators	The indicator calculating formula	Weights
1. The production share indicator ($К_{product.}$)[a]	$К_{product.} = V_{fc.\ product.} / V_{total}$ product. $V_{fc.\ product.}$ – the volume of industrial products, raw materials, materials and components, work and services of a production nature, produced / performed by members of the industrial cluster and used by other participants; V_{total} product. – total volume of marketable products and services of cluster members.	0.30
2. Cost share indicator ($К_{costs}$)[b]	$К_{costs} = V_{fc.\ costs} / V_{total\ costs}$, $V_{fc.\ costs}$ – cost volume for industrial products, raw materials, materials and components, work and services of a production nature, purchased from cluster members; $V_{total\ costs}$ – total cost of cluster members.	0.25
3. Jobs share ($К_{workplaces}$)	$К_{workplaces} = N_{fc.\ workplaces} / N_{total.\ workplaces}$, $N_{fc.\ workplaces}$ – the number of workplaces in the framework of industrial cluster; $N_{total.\ workplaces}$ – total number of jobs in the cluster enterprises.	0.20
4. Intellectual property ($К_{intellect.\ property}$)	$К_{intellect.\ property} = N_{fc.\ intellect.\ property} / N_{total\ intellect.\ property}$, $N_{fc.\ intellect.\ property}$ – the number of patents and certificates for intellectual property used by participants in the framework of the industrial cluster; $N_{fc.\ intellect.\ property}$ – total number of patents and certificates for intellectual property used by cluster members.	0.15
5. investment proportion ($К_{invest}$)	$К_{invest} = V_{fc.\ invest} / V_{total\ invest,}$ $V_{fc.\ invest}$ – investments volume in fixed assets in the framework of industrial cluster; $V_{total\ invest}$ – total investment in fixed assets of cluster enterprises	0.10

[a] For participants who do not carry out final production of industrial products.

[b] For participants engaged in the final production of industrial products (The Government of the Russian Federation, 2016a; 2016b).

panied by "blurring" the firms' boundaries", which, in turn, complicate the study of the phenomenon of cooperative connections.

The perception of risks accompanies cluster cooperation and in many respects depreciates cluster initiatives in the eyes of potential participants. An understanding in terms of the crisis phenomena causes in clusters is necessary. Thus, Østergaard C. R. and Park E. see the reasons for the clusters decline in technological lag and the exit of key firms from the cluster (Østergaard and Park, 2015). Technological blocking (Perkins, 2003) often occurs with an excessively high level of cooperation, which remains to be assessed, and the output of anchor companies in the cluster is often due to a low level of cooperation. Understanding the degree of cluster members' co-dependence through a cooperation level assessment will allow us to predict a decline, and even prevent it with an increase in the intensity and diversity of cooperation.

In general, the results of this study are confirmed by the work carried out by the Ministry of Economic Development of the Russian Federation, the Russian Venture Company and the Higher School of Economics on cluster policy issues. These development institutions have concluded that when evaluating the activity of clusters, it is necessary to use quantitative indicators of cooperative ties (Abashkin et al., 2017).

5. CONCLUSION

The proposed methodology for assessing the development level of cooperation mechanisms in a forest waste recycling cluster allows a specialized cluster organization to make informed management decisions to increase the cluster effectiveness, i.e. the participants' set formation around the product and select carriers of the raw material resource. The methodology makes it possible not only to manage the cluster's activities based on the obtained analytical data, but also to formulate a forecast for its development, as well as to assess the possibility of "bottlenecks" in the cluster's technological chain.

To maintain a balance between innovativeness and sustainability of cluster interaction, built-in mechanisms are needed to increase innovation activity, which one way or another are determined by the level of cooperation. A low level of cooperation limits the feasibility of innovative ideas, which is too high, and creates the effect of technological blocking. Note that, in the absence of a type of "knowledge" of cooperation among cluster members, the most likely scenario for the development of the Yenisei Siberian forestry complex is associated with catching up modernization and reproduction of the industry's technological backwardness, which will not allow for solving environmental and social problems specific to the cluster.

The use of the proposed integral indicator for assessing the intensity of cooperative ties has certain limitations associated with the justification of weight coefficients. In this work, the rationale is based on criteria to overcome obstacles for the cooperation development; for formed clusters, expert estimates of weight coefficients should be based on the criteria of the cluster interaction goals.

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