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Ecosystems and Their Digital Models as Factors of Algocognitive Culture and Transition to New Technological Order

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Abstract: In the paradigm of dissipative structures based on theories of economic and regional development, business networks, and the theory of algocognitive culture, the authors studied the processes of the formation of ecosystem formats for business development in the region as the core of a new technological paradigm. The research aimed to identify the relationship between current development formats in digital transformation with the basic foundations of business ecosystems and the possibility and willingness to use ESG principles and network practices to replicate cognitive forms of human brain hypernetworks. In this research, the authors used the methods of systemic and comparative analysis, grouping, and generalization including the authors' practices of functional environmental analysis. As a result, the primary trends showed cooperative-network multi-level formats of interaction between business partners in the space of value formation, the development of the business ecosystem environment of the regional economy, and guidelines for the development of service practices. The new ecosystem formats implemented in the economy are considered as a manifestation of the patterns of dissipative structures and new realities of algocognitive culture including the formation of algorithmic thinking of a contemporary person. The compliance of the development of mass businesses in the region with the primary basic characteristics of ecosystems and their active use of basic digital technologies in business processes is shown. The authors revealed the readiness and need for the development of the economy of the region in the formats of ecosystems and a sufficient degree of development of this kind of format by various businesses of the territory. The possibility and necessity of using digital models of business ecosystems were established and the primary hypothesis of the research was confirmed, which forms the assumption about the active development of modern formats of interactions in the environment of small and medium-sized businesses and their cooperative associations. It provides a basis for the proposal and development of digital models of such interactions, which should significantly increase the effectiveness and speed of qualitative changes in the transition to a new technological way of life.

Keywords: ecosystems; cooperative network interactions; digital models of business ecosystems; hypernetwork; algocognitive culture

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1. Introduction

In present theories, economic development is seen as a conscious activity of a person and communities of people, aimed at ensuring life by creating goods and services. In the theories of choice or maximum utility, the primary postulates are the rational activity of a person and firms aimed at obtaining the maximum profit. For the buyer, it is the utility of the purchased product (service) (Ricardo 1955; Schumpeter 2008; Smith 2007). In the theories of contracts, the mutual benefit from the voluntary exchange is considered including various

approaches to equalizing the incentives of the contract participants, contract performance, theories of firm organization, etc. (Fehr et al. 2011; Hart 1995; Thaler and Sunstein 2008). These theories and their separate directions as well as the contradictions that arise in economic practice provide a constant impetus to new research and the development of systematic approaches on new foundations. As described by J. W. Forrester (1965), the "profit centers" in large corporations have become the starting point of many studies including those who studied new organizational "matrix" structures of firms (Forrester 1965). In their studies, R. Miles and C. Snow showed that each company is searching for the optimal structures to implement its tasks (Mckinsey Global Institute 2019).

The studies of subsequent periods demonstrated that the primary qualitative change was the active use by firms in their interests not only of their internal, but also of the external resources formed in a partner environment. Exploring these processes, J. Lipnack and J. Stamps identified the following five primary principles, based on which such entrepreneurial networking occurs: (1) a single goal; (2) independence of participants; (3) voluntary connection to achieve goals; (4) the presence of several leaders (Lipnack and Stamps 2009). At the turn of the 20th and 21st centuries, the research of the authors formed the results that made it possible to supplement the mentioned principles (Kuimov 2019).

Further studies of business practices and theoretical generalizations in this area led many authors to the conclusion that the logic of the current economy is built on the formats of the "network revolution." A new business develops relations with business partners on qualitatively new foundations: (1) the integration of individual resources; (2) broad cooperation (including outsourcing); (3) the formation of joint resources of a single information and marketing space; (4) cooperation with competitors in certain areas of activity, etc. (Castells 2000; Parker et al. 2016; Weber 1926).

The research on the interactions of market entities actively using digital technologies allowed the authors to generalize the new processes and define them as "the economy of cooperative network interactions." The characteristic features of such an economy are an active stigmergic reaction to the actions of partners in the space of value creation, cooperation of resources or their parts, multi-level integration, maintaining the independence and initiative of the participants, and the desire to build relationships on a long-term basis by considering the development of markets and projects of the government and communities (Kuimov 2019).

The presented generalized conclusions give grounds to believe that economic processes in their development are increasingly being built as nature-like ecosystems. Based on the research of I. Prigogine, the authors assumed that economic interactions are based on dissipative principles. Inside business structures, the energy of actions, forces, and information of market entities and their employees is transformed into goods and services, and this labor energy is transmitted and transferred to the external environment. This practice of dissipation implies absorption and dispersion, which is typical for business structures. Under certain conditions, such systems pass into a more stable state and form fractals (Prigogine 1997, 2003).

The basis of the "dissipative force" in society is the actions of millions of individuals and business structures that can plan their behavior and adjust it based on experience, adapting to the conditions. Therefore, they interact like a hypernetwork.

In dissipative structures, with significant deviations from equilibrium, ordered states arise, which are the fractals (from Latin *fractus*—"fractional, indented") (Prigogine and Stengers 1984). Such basic structures in the economies of various historical periods were family and subsistence farming, family business, partnerships, joint-stock, and cooperative businesses. In the context of digitalization, computer systems ensure the growth in the speed and volume of information and data exchange, where such basic structures become cooperative networks (business networks) and business ecosystems.

New formats of the economy are emerging based on the breakthrough combinations of "available resources" obtained through innovative and breakthrough combinations (Schumpeter 2008). The authors' research confirms that along with the classical ones

(land, capital, and labor), new resources (knowledge, information, technologies, value propositions [brand, idea, etc.]) interacting in the digital environment create qualitatively new conditions for development. Multiple combinations of resources become possible through the analysis of the practices and mental activity of a person or group of people. Therefore, the transformations of forms of business systems are directly related to human cognitive activity.

According to the interdisciplinary theory of M. Donald, in the course of the evolution of people, nature has developed a completely new cognitive strategy. Humans stood out from the animal world due to their developed abilities to imitate and actively interact with their relatives and special skills to adapt to changing conditions. These three factors led to the active development of the human brain as hypernetworks, making it possible to develop counting, writing, science, new technologies, and industries (Donald 1991, 1992).

The activity of people in the economy, as one of the components of human culture, is a "cooperative cognitive work" and leads to the emergence of a unique quality: emergence. It manifests itself as a network effect of interaction. In economic practice, the activity communications of participants are through the exchange of appropriate signals, both declared and based on stigmergy, which is read by other participants. Therefore, it can be argued that it is economic activity, as a method of understanding the world, and activity that acts as an important link in human culture, in which there is an active development of mental activity based on the increasingly complete development of the human brain as a complex multi-level hypernet (Friston 2009, 2016).

The active use of digital technologies in both the economic and social practices of a person and business is built on the application of appropriate algorithms and networks to obtain the result. The human brain, as a hypernetwork, broadcasts itself in the same forms in social and economic networks.

It is important to identify the basic characteristics of business ecosystems and their presence in regional business systems to analyze the compliance and readiness for development in business ecosystem formats. The authors rely on the practices of leading international consulting and digital platform companies and their early personal research.

Different researchers have revealed different aspects of business ecosystems. They have shown that " ... the digital ecosystem connects specific stakeholders who are connected through the sharing of resources and experience to collectively provide products ... " (Ivanov and Shustova 2020). Others have argued that " ... they are breaking down industry barriers, opening opportunities for cross-functional products and services, and blending previously segregated markets. They are transforming not only their sectors but also broad areas of the economy" (Zakharov et al. 2019).

Scholars from the Massachusetts Institute of Technology (Boston, MA, USA) pointed out that " ... an ecosystem ... provides customers with more choice, offers the best price, and accelerates innovation" (Weill and Woerner 2018). The Mckinsey Global Institute defines an ecosystem as " ... an interconnected set of services that enable users to meet different needs in one integrated experience," highlighting their defining characteristics of reducing friction, generating network effects, and integrating data that enable companies to achieve strategic benefits, both in terms of the products and in working with partners and customer experience (Mckinsey Global Institute 2019).

In the studies of the BCG Henderson Institute (USA), business ecosystems are understood as " ... a dynamic group ... independent players who create products or services to solve a single problem." The ecosystem here is characterized by " ... a value proposition and ... a group of actors with different roles." The company classifies such interactions as business ecosystems, " ... which, within the framework of one task, bring together several narrowly focused manufacturers, various offers that combine the services of different suppliers, wholesale and logistics centers, payment systems, and so on" (Lang and von Szczepanski 2020).

The research hypothesis is that the presence and compliance of groups of industrial and territorial businesses in the region with these basic characteristics determines the

degree of their readiness for development in new ecosystem formats and the transition to a new technological order.

According to the hypothesis, the presence and accordance of the region's businesses with the above basic characteristics reflect their preparedness to establish new business ecosystem formats and the degree to which they master the new technological order.

The research novelty lies in identifying the compliance of regional industry and territorial business groups with the basic characteristics of business ecosystems (i.e., their readiness to work in new formats and a new technological order). At the same time, both the forms and structures of business interaction are built on the principles of dissipative structures, and under the influence of the human hypernet brain, combine the algorithms of digital technologies and the algocognitive culture that reproduces similar structures—business ecosystems.

Methodologically, the studies have been built on general scientific methods of the synthesis of the evolutionary, systemic, and functional-environmental approaches and statistical and expert assessments.

Advanced corporations in the current economy broadcast similar approaches to the definition of business ecosystems. Therefore, Alibaba (PRC) defines the format of its business model as " ... a business ecosystem with millions of players, from sellers to software solution providers and logistics partners", which " ... uses technology solutions to implement and coordinate the efforts of thousands of companies, creating a unique virtual business ecosystem (functioning and managed online) that is faster, smarter, and more efficient than traditional business infrastructure" (Miles and Snow 1992; Ming 2019).

"The research corresponds to the economics of cooperative-network interactions; for it, the processes of interpenetration and harmonization are typical due to the simultaneous platform interaction of producers, consumers, and partners in the forms of hierarchies, the market, and networks as a whole based on (1) recognition of common goals and values, (2) cooperation of their resources or their parts, (3) active use of external resources and opportunities based on outsourcing, (4) while maintaining the independence of participants and their leadership, (5) the compliance to voluntary connection, (6) with possible interaction with government and public structures using new information technologies and communications" (Kuimov 2019).

The main studies are focused on the region's businesses of various formats and industries including vertically integrated enterprises and social institutions. The authors limited the distribution of the research results to the activities of non-profit organizations, associations, and religious and political structures. At the same time, general trends in ecosystem development are actively manifested in industries, regions, and separate territories.

2. Materials and Methods

The research aimed to analyze trends toward the ecosystem sustainable development of individual industries and businesses in Krasnoyarsk Krai (Russia) in the context of digital transformation. The primary tasks are to identify the practices of ESG approaches and substantiate the presence of network interactions and their compliance with ecosystem practices. The authors' method of functional-environmental analysis was used, which makes it possible to identify the features and qualities of business activities, their strengths and weaknesses, and most importantly, promptly make the necessary adjustments to existing practices (Kuimov 2019).

The authors built the analysis of the regional component of development based on the classical theories of development and the distribution of productive forces and competition by A. Smith (2007) and D. Ricardo (1955), the theory of new development by J. Schumpeter (2008), placement optimization theory by J. H. von Tyunen (1926) and A. Weber (1926), economic zoning by G. Krzhizhanovskiy (Krzhizhanovsky 1989), the spatial organization of the French economists by F. Perroux and J. Boudeville (Perroux 2007), interregional integration by M. Porter (2005) and A. Granberg (Granberg and Suslov 2010) as well as based on studies by other scholars from the USSR and Siberia.

Qualitatively, new aspects of territorial development make it possible to identify concepts including territory marketing, development of the creative class R. Florida (2007), the dominance of the service approach by Lusch and Vargo (2006), and vertically integrated and network approaches by Shchedrovskiy and Knyaginin (2004). New approaches to development are defined within the "Industry 4.0" theories or business ecosystem formats. The conclusions of the theory of "dominance of services" are taken into consideration, which considers intangible resources as basic exchanges (Schwab 2017). Services, especially in the social sphere (education, healthcare, social protection, culture, sports, etc.), along with infrastructure (roads, communications, Internet, logistics, etc.) form the most important service component of the region and act as a significant component in the research and design of activities.

For further analysis of the readiness of businesses and governments of the region and territories to work in new ecosystem digital formats, the authors studied (1) the involvement of mass businesses in the main industries in ESG practices, vertically integrated formats, and networking, and (2) the formation of the service component of the region and the compliance of the most massive business groups with the basic characteristics of business ecosystems. According to the research hypothesis, these characteristics revealed the readiness of businesses to cooperate in ecosystem formats.

The number of enterprises and organizations in each group was determined based on a sample of regional statistics, a unified register of small- and medium-sized businesses, and data from municipalities.

3. Results

To achieve the goals set based on primary information and content analysis, three blocks of studies and generalizations were carried out including the following:

- Analysis of the involvement of municipal districts and cities in the implementation of sustainable development programs and ESG principles, as the authors assumed that their mass use characterizes a higher degree of readiness of businesses and authorities to work in a new technological order;
- Inclusion of enterprises of various industries in vertically integrated corporations, networking, and the formation of the service component of the region, which, according to the research hypothesis, shows the level of readiness of businesses for new formats of interaction;
- Correspondence of the interactions of the most massive businesses and organizations in the region with the basic characteristics of ecosystems and the trinity of sustainable development, which makes it possible to focus on their readiness to enter (join) various ecosystem forms (strategic alliances, clusters, platform business ecosystems, etc.).

The goal-setting procedure was confirmed by the analysis of strategic documents (Strategies for the Development of Municipalities) adopted by the administrations of districts, cities, and rural councils of Krasnoyarsk Krai for the presence of landmarks that coincided with the program of Sustainable Development Goals (SDG) (UN General Assembly 2015; Vazhenina and Vazhenin 2020).

In the territory of the largest in the Siberian Federal District of Krasnoyarsk Krai, as of 1 January 2021, in 544 municipalities including 17 urban districts, 41 municipal districts, three municipal districts, 26 urban, and 457 rural settlements have 2866.3 thousand inhabitants. The gross regional product of Krasnoyarsk Krai in 2020 amounted to RUB 2280 billion (USD 35 billion). To assess the implementation of the primary guidelines for sustainable development, the "development strategies" of the local municipalities of Krasnoyarsk Krai were analyzed (in total, 61 strategic documents were adopted by local authorities). The research data are summarized in Figure 1.

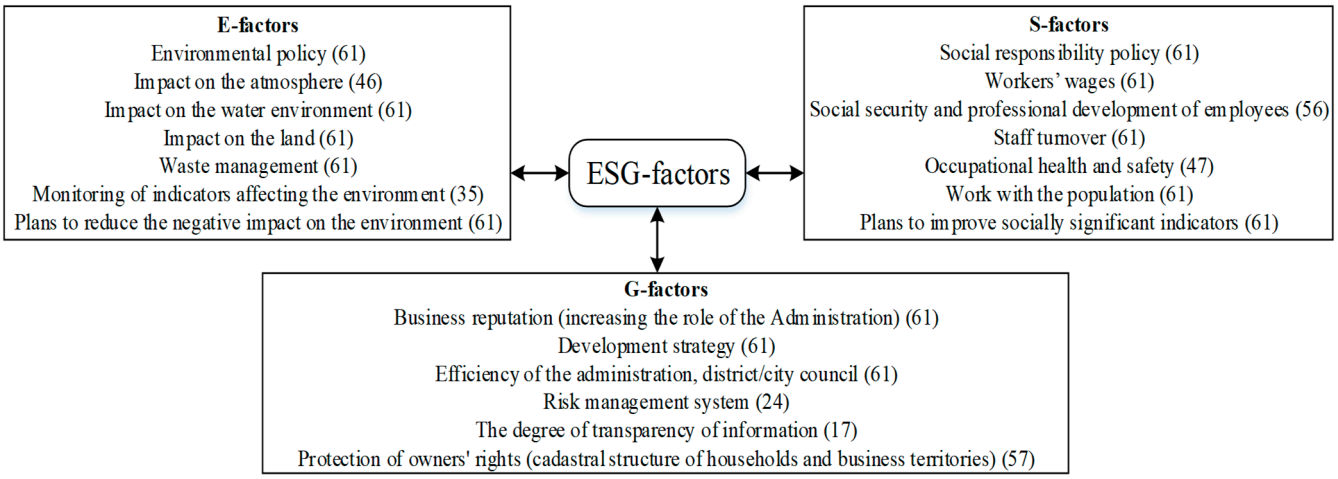

Figure 1. Implementation of separate principles for sustainable development.

In this paper, the authors continued their long-term research conducted from 2010 to 2023, which determined the volume of the sample set of objects of the empirical research. About 25,000 enterprises representing the main industries and social spheres of Krasnoyarsk Krai serve as an empirical base. The authors asserted that the entire sample population (80% of those operating in Krasnoyarsk Krai), to a certain degree, participated in ecosystem interactions that were assessed in accordance with the hypothesis and are further detailed in Table 1.

Table 1. Correspondence of interactions and compositions of the social infrastructure organizations, agribusiness, forestry, and construction complexes as well as industrial infrastructure with the basic characteristics of the business ecosystems of the region and the trinity of sustainable development.

Key Characteristics of Business Ecosystems [1]		Conformity of the Interactions and Compositions of Businesses at the Regional Food Market to the Characteristics of Business Ecosystems:			
		Township	**District/City**	**Consolidated Area**	**Region**
Dynamic group of largely independent players		Full	Full	Full	Full
Creates products or services to solve a single problem		Full	Full	Full	Full
Management model that helps solve business problems		Full	Full	Full	Full
Forms a holistic value offer		Full	Full	Full	Full
Geographical diversity		Full	Full	Full	Full
Inter-industry focus		Full	Full	Full	Full
Short and flexible transaction structures		Full	Full	Full	Full
Hierarchical supply chain		Partial	Partial	Partial	Full
Continuous value creation		Full	Full	Full	Full
Coordination in the online network of functions of producers, processors, sellers, service providers, logistics companies		Within individual businesses	Within individual businesses and companies	Within and between individual companies, business systems	Between individual companies, business ecosystems
Simultaneous platform interaction of manufacturers, consumers, and intermediaries		Inside branches of individual businesses	Inside branches of individual businesses and companies	Between individual businesses, business systems, companies	Between individual companies, business ecosystems
Trinity of sustainable development	Economic	Full	Full	Full	Full
	Social	Full	Sufficient	Limited	Limited
	Environmental	Full	Full	Sufficient	Sufficient

Note: [1] In the index, please indicate the following: Key characteristics are identified by McKinsey and BCG international consulting companies.

The conducted studies allowed the authors to conclude that according to the absolute majority of ESG indicators, the territories in the region have plans for the development and achievement of qualitative improvements that are substantiated in strategic documents. However, the depth of the involvement of municipal territories in the implementation of sustainable development tasks is different. The studies provide a reason to believe that the parameters of sustainable development can find a practical solution in specific areas and are provided for by strategic documents. The concept of sustainable development has been adopted and included in the practice of managing the development of the relevant territories of Krasnoyarsk Krai.

The research also included monitoring the readiness of businesses and governments in the region and its territories to work in new ecosystem digital formats, an analysis of the inclusion of mass businesses of the primary industries of Krasnoyarsk Krai in vertically integrated forms of interaction, networking, and the formation of the service component of the region.

Summarizing the results of scientific work, the authors note that in the region, mass business and state-municipal organizations of social infrastructure show a certain willingness and understanding of the relevance of the formation of modern integration and networking practices to achieve high-quality results in their activities. There is a significant potential for a transition to new formats of interaction and obtain high-quality results on this basis.

Another area of research for a complete understanding of the readiness of the region's businesses to master new ecosystem formats of new development was the analysis of signs of their compliance with the primary characteristics of business ecosystems (Table 1).

According to the research hypothesis, the authors noted that the levels of compliance of readiness for ecosystem development formats should be analyzed under the basic characteristics of business ecosystems. Agro-industrial complexes and social infrastructure enterprises showed the greatest readiness for ecosystem interaction, while vertically integrated companies in the region showed the least readiness.

These basic characteristics of business ecosystems, highlighted by leading consulting and digital companies (Mckinsey Global Institute, BCG, Alibaba), will be used as criteria when analyzing the compliance and readiness of the region's businesses to develop in new ecosystem digital formats.

The data obtained fully show that state and municipal organizations and businesses in the region have experience and involvement in the implementation of the strategic directions of the present development. The territories have defined strategic practices for the implementation of some of the Sustainable Development Goals. The largest Russian corporations with offices in Krasnoyarsk Krai (MMC Norilsk Nickel PJSC, RUSAL United Company, NK Rosneft PJSC, SUEK JSC, and gold mining company Polyus PJSC) have defined their programs for the implementation of the UN Sustainable Development Goals and included the integral rating of the independent credit rating agency RAEX-Europe. The other 145 Russian companies were assigned an ESG rating (RAEX Europe n.d.).

The municipal and regional authorities of Krasnoyarsk Krai have approved and are implementing the guidelines of the Russian Federal Government on sustainable development as one of the components of the transition to a new technological order, as evidenced. In the region, there is a sufficient degree of the integration of industry businesses to achieve high-quality results, which should be considered as a certain degree of readiness for the transition to ecosystem-based and digitally-based interaction formats.

To varying degrees, the enterprises and organizations of Krasnoyarsk Krai correspond or partially correspond to the primary postulated characteristics of business ecosystems. These factors confirm the research hypothesis that regional and sectoral organizations and businesses in their practice are mastering new formats of current economic and social development and are moving to business–ecosystem interaction.

At the same time, the analysis showed that the pace of transition to new formats in businesses of different industries differed significantly. In large retail chains, banks,

insurance companies, other enterprises of the federal level, and in state-municipal organizations with a high level of digitalization of business and technological processes, the results achieved meet the present world standards and were even higher. At the same time, small- and medium-sized enterprises, primarily agro-industrial, timber industry, construction complexes, and several industrial infrastructure enterprises, do not use digital technologies enough.

During the research, the authors studied the possibilities of implementing current development tasks based on digital models. The results showed that a new business ecosystem development in territories and industries is possible based on digital models that implement individual functions of collecting data from participants in networks, taking into account the behavior and preferences of the customers, making decisions on purchase and sale transactions, ordering, logistics, settlements, payment taxes, insurance, etc. The solution can be achieved based on multi-level systems. The first level is digital platform production and marketing systems, based on which the entire production and marketing process for enterprises is built upon according to the principles of marketplaces. Large businesses organize their own or cooperative systems. The second level consolidates the flows of goods and services and develops wholesale markets on interregional, intercountry, and global scales.

A digital model based on neural network functional-environmental analysis, like a human brain, can analyze processes in a business ecosystem in real-time and give signals for their improvement. Such artificial intelligence forms the possibility of a constant reaction to changes, replication, and self-regulation. Development based on ecosystem formats, digital technologies, and digital models creates qualitatively new conditions for businesses and consumers and is increasingly being transformed into nature-like systems built on the principles of a hypernet.

4. Discussion

This research attempts to systematically integrate theories of economic development including regional, dissipative, and algocognitive approaches, theories of understanding other people's opinions, and the formation of business ecosystems and their digital models. The authors' primary message is that the evolution of a person and their brain, as hypernetworks, replicates nature-like economic and social dissipative systems in practice. This statement combines the theory by I. Prigogine (1997, 2003) on the dissipative structures that absorb and dissipate energy and, under certain conditions, form fractals (business ecosystems) and the theory of algocognitive culture as the interaction of the hypernetwork of the brain and culture, understanding the opinions of others (by M. Donald and K. Friston). At the same time, culture is also understood as economic activity, the most important direction in ensuring life. These statements are generally confirmed by the results of development studies in the region, but require further multilateral discussion since most of the studies use data from large corporations, and there are no data from small- and medium-sized businesses and regions. It was revealed that the research data analysis (Figure 1, Table 1) is somewhat at odds with the conclusions of A. L. Ivanov, I. S. Shustov, V. Ya Zakharov, and O. V. Trofimov that Russian business is lagging. The research showed that even prominent small- and medium-sized businesses of the agro-timber industry complexes showed readiness and tendencies for ecosystem development and actively used digital technologies (Porter 2005; Ricardo 1955).

These principles are the basis for the analytical activities of many companies, the digitalization of their business processes, the policy of promotion in social networks, etc. The principles act as drivers for the substantiation of digital models of business ecosystems, which will further support the production and marketing activities set by human communities in the formats of economic and social networks. Therefore, in the future, the authors see and anticipate the active interaction of digital platforms, constantly learning systems in the economic and social activities of communities and the individual to achieve its goals including the sustainable development of society. However, the authors

understand the conditionality and significant underdevelopment of this point of view but consider it necessary to put it forward for discussion.

5. Conclusions

The authors analyzed the development of certain areas and businesses in Krasnoyarsk Krai, the largest region of Russia by using the provisions of present theories of the economy, regions, people, and business ecosystems. The research showed the following:

- The territories of the region, their municipal districts, cities, and urban and rural settlements are focused on the Sustainable Development Goals defined by the UN, and most territories have strategic development programs considering SDG indicators;
- The analysis of development practices including integration and networking considered in the research as transitional to ecosystem ones confirms that most businesses and organizations are structured in the present formats and are in the process of continuous development (through the active use of digital technologies);
- The analysis, in accordance with the interactions and composition of the organizations of the region (social infrastructure, businesses of the agro-industrial, timber, and construction complexes, and industrial infrastructure), with the basic characteristics of business ecosystems and the trinity of sustainable development, showed that in these industries, development takes place based on the primary principles specific to the current stages of the development of business ecosystems in the context of digital transformation.

The development of new digital formats in the regional economy has yet to be sufficiently studied. The most widely described is the experience of the Baltic cluster, implemented by some countries of the European Union. A study of the practices for cluster formation in Russian regions including the work conducted by the authors, shows that this is only the initial stage of development; therefore, study should be continued. Further research should be focused on the analysis of the best practices for developing ecosystem formats, digital models of interactions in the regions of Siberia, and the features of their manifestation in different industries and business groups.

The research results confirm the primary hypothesis that in regions including the environment of small- and medium-sized businesses, their cooperative associations, and interactions, their present formats are actively developing, providing a basis for the proposal and development of digital models of such interactions, which should significantly increase the effectiveness and speed of qualitative changes. Simultaneously, the obtained results including the adaptation of the idea of the cognitive distributed networks in the economy encourage further research on the possibilities of using digital models based on neural network learning and optimizing business processes in working with the customer experience and content, the processes of accumulating and processing big data, and developing algorithms and solutions to the current and strategic tasks.

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