



## Circular business paradigm in innovative solutions of industrial ecosystems of regions

### Paradigma de negocio circular en soluciones innovadoras de ecosistemas industriales de regiones

Saida Kazbekovna Kuizheva<sup>1</sup>, Ludmila Grigorievna Matveeva<sup>2</sup>, Tatiana Anatolievna Ovsyannikova<sup>1</sup>, Vladimir Ivanovich Zarubin<sup>1,\*</sup>, Anastasiy Valerievna Kaplina<sup>3</sup>

<sup>1</sup> Maikop State Technological University. Maikop, Russia.

<sup>2</sup> Russian information, analytical and research water management center (FSBI RosINIVHC). Rostov-on-Don, Russia

<sup>3</sup> Rostov State University of Economics (RINH). Rostov-on-Don, Russia

\*Corresponding author E-mail: [zarubin.vi18@yandex.ru](mailto:zarubin.vi18@yandex.ru)

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#### ABSTRACT

In the conditions of the continuing crisis, determined both by external sanctions against Russia from several Western states, and the ongoing coronavirus pandemic, it is the industrial ecosystems of the country's regions that form innovative solutions with subjects of other industries and spheres of activity and are the main rational consumers of regional resources that combine the potential of innovative speed, high quality, adaptation to changing consumer demands, etc. This article examines the scientific and practical problem of the formation and functioning of innovation-oriented industrial solvates, the solution of which is in line with the new approach proposed by the authors to identify, determine the sources and rank the effects of innovative solutions in the regional industry. This approach is built on the concept of a circular economy, which is based on the assumption of the most rational organization and use of all types of resources of integrated industrial enterprises and related industries (spheres of activity), including through the use of end-to-end digital technologies. It has been proved that in various phases of the economic cycle, effective resource provision of solvation processes in the system of industrial innovations is of decisive importance, which means not only the rational distribution of limited resources between the participants of innovative solutions but also their lean and waste-free use in the production process.

**Keywords:** Circular economy, economic cycles, end-to-end digital technologies, industrial ecosystems of the region, innovative solutions.

#### RESUMEN

En las condiciones de la crisis continua, determinada tanto por las sanciones externas contra Rusia por parte de varios estados occidentales, como por la pandemia de coronavirus en curso, son los ecosistemas industriales de las regiones del país los que forman soluciones innovadoras con sujetos de otras industrias y esferas de actividad y son los principales consumidores racionales de recursos regionales que combinan el potencial de velocidad innovadora, alta calidad, adaptación a las demandas cambiantes de los consumidores, etc. Este artículo examina el problema científico y práctico de la formación y funcionamiento de solvatos industriales orientados a la innovación, cuya solución está en línea con el nuevo enfoque propuesto por los autores para identificar, determinar las fuentes y clasificar los efectos de las soluciones innovadoras en la industria regional. Este enfoque

se basa en el concepto de economía circular, que se basa en el supuesto de la organización y el uso más racionales de todos los tipos de recursos de las empresas industriales integradas y las industrias relacionadas (esferas de actividad), incluso mediante el uso de productos finales. tecnologías digitales de punta. Se ha demostrado que en varias fases del ciclo económico, la provisión efectiva de recursos de los procesos de solvatación en el sistema de innovaciones industriales es de importancia decisiva, lo que significa no solo la distribución racional de los recursos limitados entre los participantes de las soluciones innovadoras sino también su magro y uso sin residuos en el proceso de producción.

**Palabras claves:** economía circular, ciclos económicos, tecnologías digitales de extremo a extremo, ecosistemas industriales de la región, soluciones innovadoras.

## 1. INTRODUCTION

In the context of sanctions restrictions and the unprecedented impact of external factors on the Russian economy, which are amplified by economic losses from the coronavirus pandemic, studies of the sustainability of the industry as a fundamental component of the country's economy that ensures the formation of an import-substituting circuit are being updated. This trend was demonstrated in the healthcare sector by the production of Russian coronavirus vaccines, which have already proven their effectiveness (which confirms the demand for Russian vaccines from more than 60 countries of the world), as well as the launch of a unique drug for coronavirus infection of different strains.

The Russian industry faced several serious challenges already during the first wave of the pandemic, but quickly reacted, mobilized resources, and increased the production of medicines, ventilators, personal protective equipment, etc., including within the framework of the import substitution paradigm.

The import substitution imperative, which is reinforced by the situation of the coronacrisis, is now operating in almost all spheres of the Russian economy. It is of particular importance in industry, which significantly determines the share of products that can replace imported analogs in almost all other industries that use industrial products (Zarubin et al., 2017).

In this context, the value of the industrial sector is increasing, which is developing in line with the new industrial revolution (Industry 4.0) (Aurik, Leurent, 2018). The innovative interaction of the production sector with other industries contributes not only to resisting external negative influences but also to the gradual recovery of the Russian economy from the crisis phase of the economic cycle. This relatively new industrial model is gradually becoming the basic code for the development of the national economy, actualizing the problem of rational use of the resource potential of participants uniting in innovative alliances (Aurik, Leurent, 2018; Simachev et al., 2016).

That is, this refers to the formation of so-called innovative solvations (interactions) of an intersectoral, industrial, and social nature, within the framework of which a real retorsion to external negative factors is carried out. Therewith, the concept of rational use of limited resources of the region is being implemented and a platform for stable and sustainable development of the regional and national economy is being formed according to an innovative scenario. Drivers of innovative solvates (for example, innovation and production regional clusters), which set the vector and pace of innovation processes in the region, can be both "customers" of industrial innovations and their industrial partners.

## 2. METHODS

*The Current State and Degree of Study of the Problem of the Formation of Innovative Solvates in the Industrial Ecosystem of the Region*

The economic management system tries to prevent, with the help of adaptive changes in the institutional field of industrial ecosystems, an objective reduction in the rate of economic growth caused by the influence of external

factors and confirmed by real practice. All modern institutional modernisms implemented at the regional and national levels are aimed at reaching the trajectory of sustainable industrial and overall economic growth as soon as possible. This is confirmed by the three-stage plan proposed by the Russian government to overcome the crisis, the implementation of which is impossible without breakthrough successes in the field of innovation, which involves the use of new, adaptive business models of innovative interactions (solvations) of economic entities.

According to the authors of the "Ecosystems in the space of the new economy" monograph, "the current conditions provoked by the complex sanitary and epidemiological situation further emphasized the importance of modernization transformations of the technological structure of the production sector, the development of progressive business models, the formation of a digital environment of intersectoral cluster interactions based on:

- implementation of digital technologies, including mechanisms of interaction "customer-supplier", which allows assessing the demand for the introduction of information technologies, digital platforms, and databases that can work in real-time, collect and present extensive analytics to build predictive data;

- creation of unified digital business ecosystems, which represent modular management of the value chain based on universal platform solutions, taking into account the profitability assessment;

- integration of all links of production chains within the framework of a single scientific and technological chain of the production system of the region" (Borovskaya et al., 2002, p. 168).

Thus, business models that implement the concept of a circular economy allow the most rational allocation and efficient use of limited resources that are scarce for the regions.

The industrial ecosystem is a complex structured relatively isolated open emergent system formed by economic agents focused on creating an industrial product. This system not only has all the characteristics of a classical system but also has strong connections with the external environment and has a significant influence on it.

To study the circular business paradigm as a priority for innovative alliances in the industrial ecosystem of the region, it seems appropriate to assume that there is a certain autarchy (isolation) of this ecosystem. Such an assumption contributes to a more complete analysis and assessment of the real resource potential of solvation, allows it to be reasonably focused on solving priority problems determined taking into account the determinants of the federal center and the peculiarities of the region.

Following the key provisions of the theory of systems, the following main characteristics of the industrial ecosystem can be distinguished: goal orientation, integrity, openness, strong impact on the external environment, relative isolation, multilevel, self-organization and self-regulation, self-development, a clear hierarchy of interrelations of elements, subordination of their local goals to the goals of the system.

The theory of solvation was first proposed simultaneously and independently by scholars I.A. Kablukov and V.A. Kistyakovskii in 1881-1891 to study the interactions of molecules, some of which are dominant (leading), and the other is driven (Kablukov, 1935). According to these scholars, solvation is the interaction of solvent molecules with solute molecules. As a result of this interaction, solvate complexes are formed, in which a synergistic effect is produced.

This interpretation of the "solvation" concept served as a reason for the authors of this article to adapt this model of interaction concerning innovative alliances in the industrial sphere of the region.

In the innovation sphere of the industrial ecosystem of the region, solvation is the interaction of drivers of innovation activity and other participants in interactions (including suppliers of resources and consumers of products), forming a model of a circular economy. This model is formed in the industrial sector of the region, including through the initiation and introduction of innovations at all stages of a closed technological cycle, focused on the production of high-quality import-substituting products.

In addition (and this is also fundamentally important for innovative solutions in the industry), from the position of a circular economy, as an alternative to the classical linear economy, consumption and production occur in a closed-loop cycle with three conditions (Pudovkina, 2019):

- 1) resources are used as much as possible – efficient resource consumption;
- 2) waste does not accumulate – rational use of resources at all stages of the technological chain (waste-free production);
- 3) there is no negative impact on nature – the solution of environmental problems of the industrial ecosystem of the region and the region as a whole as a supersystem.

At the same time, it is important to take into account the dual nature of solution effects in the conditions of digitalization, which consists in the fact that "the increase in the production capabilities of solvates as a result of digitalization can lead, on the one hand, to greater consumption of resources due to an increase in production volumes, on the other hand, to the more rational use of them" (Khachemizov, Zarubin, 2018, p. 266; Kosolapova et al., 2021).

The implementation of digitalization strategies that contribute to "both productivity growth and sustainable development" (Shklyar, n.d.) is not only a priority of modern scientific research but also a target and an object of regulation of already existing supranational and national policies (Kosolapova et al., 2021).

The concept of business ecosystems was formulated by G. Moore, who actively used biological metaphors to study the principles of the development of economic communities. In the article "Predators and Prey: A New Ecology of Competition" G. Moore (1993, p. 76) draws attention to the fact that "the economic community in its development should be in mutually beneficial (symbiotic) relations with consumers, competitors, suppliers", thereby focusing attention on the fact that "the connections that permeate the economic system are not static in nature, but changeable, and their effectiveness largely determines the functioning of the system as a whole". S.V. Doroshenko and A.G. Shelomentsev (2017, p. 212) complement this idea, emphasizing that "the entrepreneurial ecosystem is an open system of dynamic interaction", contributing to the sustainable socio-economic development of the region.

The concept of sustainable development, based on the idea of achieving a balance between solving socio-economic problems and preserving the environment, which is the basis for the creation and functioning of innovative solvates in industry, has been gaining increasing recognition in academic and expert circles in recent years (Closed-cycle economics: reuse and recycling, 2020; Silvestre, Țîrcă, 2019). Therewith, "adaptation and change of products, processes, management approaches are required to increase the efficiency of sustainable development (the industrial ecosystem of the region), and therefore, innovations are a necessary prerequisite for sustainable development" (Silvestre, 2015, p. 156) not only for industry but also for the region as a whole as a supersystem.

The innovative resonance in the solutions of the industrial ecosystem is formed as a result of the synchronicity and consistency of the internal dynamics of development processes implemented by its participants, as well as the management actions carried out. The synchronicity of the processes occurring in them, the strengthening of the connectivity of the constituent elements of economic potential "are fundamentally important for the emergence and practical implementation of resonant effects in innovative solvates of regional industry" (Skiba, 2011, p. 65).

Depending on the level of synchronization, individual processes occurring in ecosystems may have an advanced, delayed, or coordinated nature. Both the advanced and delayed nature of the development of processes lead to a violation of the balance of innovative development of individual solution participants, weakening the connectivity of the components of the entire industrial ecosystem.

This thesis is confirmed by the fact that the rapid and large-scale introduction of information and digital technologies, including end-to-end technologies, into all spheres of life (Doroshenko, Shelomentsev, 2017; Nikitaeva, 2018), as well as the high potential of the circular business model of the economy have fundamentally changed the principles of interaction of participants in innovative processes in the industry. Moreover, “digital technologies are changing the very approaches to the organization of activities and business models of industrial enterprises since flexible connections between market participants are currently being activated, digital value chains are being formed and dynamically developing, cyber-physical systems are being established” (National project "Digital economy" for the period 2019-2024, 2019).

Following this, the current structure of the development of digital platforms within the framework of the circular economy is of interest (Figure 1).

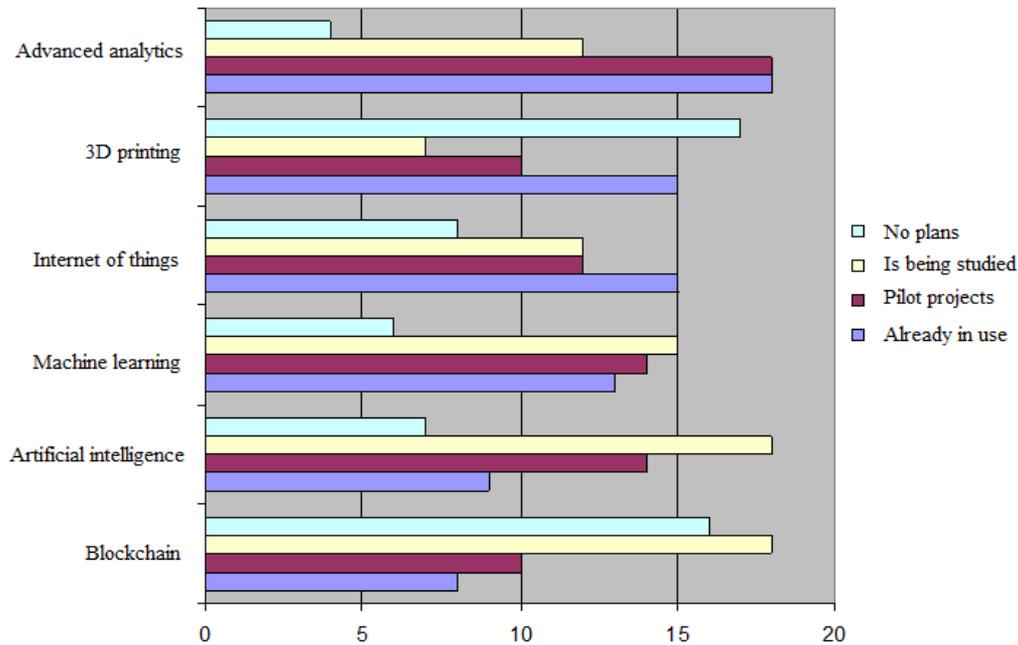


Figure 1. The structure of the development of digital platforms in the circular economy

We believe that the approach to the study of the circular business paradigm in digital coordinates is a priority for innovative solutions in the industrial ecosystem of the region (especially in crisis conditions). Therewith, it is necessary to place additional emphasis on the importance of supporting and stimulating the production of import-substituting products. This theoretical message is confirmed by the real state of affairs in the field of import substitution. Despite the difference of views on the nature and scale of import substitution, it is unconditionally considered by leading scholars as to the most important and necessary condition for the growth of the competitiveness of the national economy, which is convincingly proved by the success of Russia, for example, in pharmaceuticals.

However, despite these important achievements, it takes time to “increase the technological potential of our enterprises for the production of the vaccine itself. Nothing prevents the production of the vaccine components themselves at the sites of foreign countries, which will have to invest their money in the expansion of these industries and the purchase of appropriate equipment” (Results of the press conference of Putin and the direct line, 2020).

In addition, the domestic pharmaceutical and medical industries belong to the category of those industries that are "maximally import-dependent" (Sagieva, 2020) due to the absence of some domestic analogs of medical products on the market, as well as the higher cost and insufficiently high quality of Russian analogs. This fact is confirmed

by the results of the analysis of indicators of international trade in manufacturing technologies (Figure 2), as well as the dynamics of the claimed patents for innovative technologies in medicine and the pharmaceutical industry (Figure 3).

The export of Russian technologies is traditionally aimed at the markets of the OECD countries and since 2013 has averaged 60-70% of the total export structure, including 66.7% in 2019. The largest foreign currency receipts to the Russian budget are made from Germany, the United States, Great Britain, and Switzerland. Technological exports to the CIS countries in 2019 amounted to 4% (Belarus, Kazakhstan), 29.3% – to the countries of the Asian region (China and India), which in financial equivalent amounted to 517.6 US Dollars Million. The share of OECD countries was 81.3 %, CIS countries – 1.2%, other countries, including the countries of the Asian region (China, Korea) – 17.6%. The largest financial flows were sent from Russia to the Czech Republic, Germany, the USA, China, France, the Netherlands, and Switzerland.

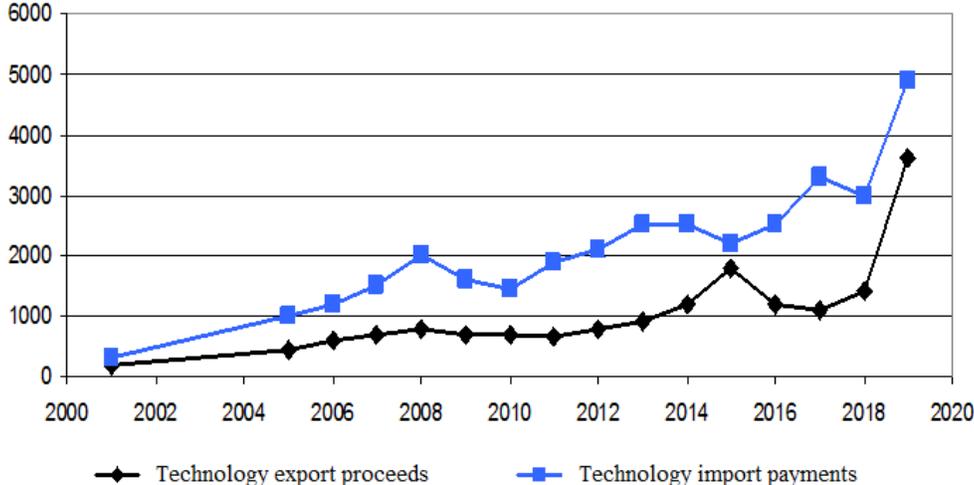


Figure 2. Dynamics of technology exports and imports in Russia (us dollars million) (Evtushenko, Streltsova, 2020)

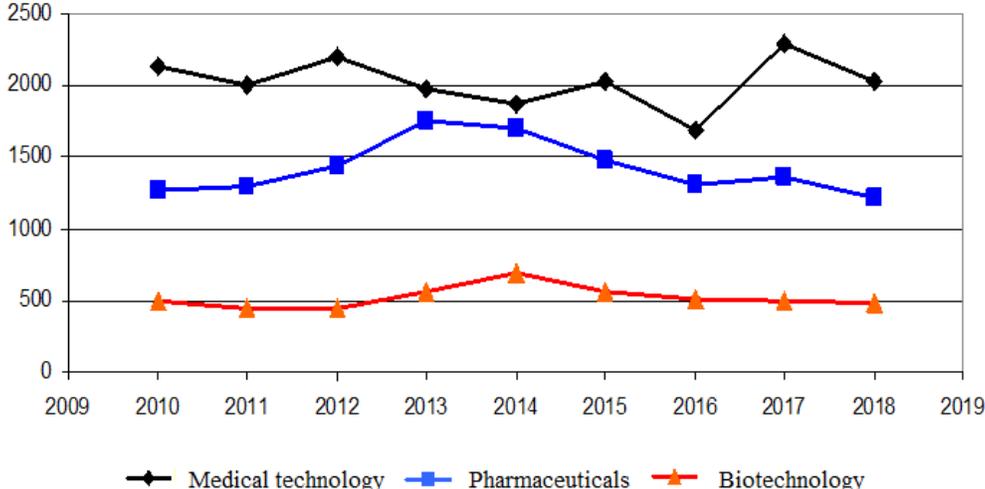


Figure 3. The number of patent applications for inventions filed by Russian applicants (units) (Evtushenko, Streltsova, 2020)

The above statistics on the import and export of technologies in Russia in recent years once again confirm the need to increase the technological potential of the industry and symmetrically reduce dependence on imported technologies.

In this context, a great scientific interest was aroused by the consideration from a new perspective of the circular economy model in the innovative solvates of the industrial ecosystem of the region, which, as noted, by definition are focused on the production of import-substituting products based on the introduction of innovations in the concept of rational resource consumption technologies.

*The Business Paradigm of the Circular Economy in Industrial Innovative Solvations: Sources and Hierarchy of Effects*

In the context of the above-mentioned special importance of the consistent transition of Russian industry to new digital platforms, it is necessary to quote the statement of A.Y. Nikitaeva, who notes that at present, the effectiveness of the development of the industrial sphere directly depends on how successfully the technologies of the new industrialization (neo-industrialization) and the fourth industrial revolution (Industry 4.0) will be integrated into the traditional and new industrial segments of the domestic economy (Nikitaeva, Serdyukov, 2020).

The key place among such technologies is occupied by artificial intelligence (AI), since the creation of "smart enterprises", "smart industries", "smart products" based on the use of AI allows increasing the level of competitiveness of industrial systems by reducing the innovation cycle, saving costs for the development, production, and operation of products, improving the quality of managerial decision-making, etc. This actualizes the study of the possibilities and directions of the introduction of artificial intelligence in the industrial sphere (Nikitaeva, 2018).

An example of innovative interactions of industrial enterprises within the framework of the circular business paradigm, based on the widespread use of end-to-end digital technologies, is shown in Figure 4.

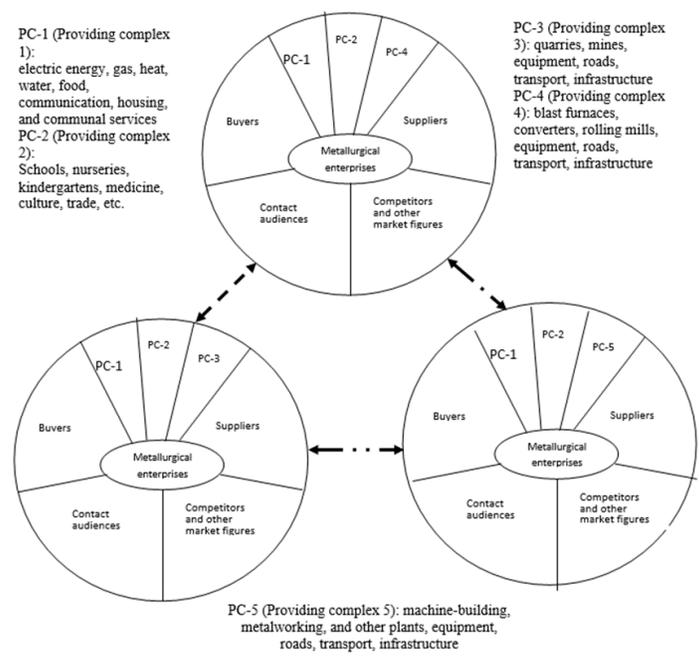


Figure 4. An example of innovative solvation of industrial enterprises in the framework of the circular business paradigm

In this context, it seems practically significant to investigate the significance of relevant institutional changes as an important factor and determinant of innovative and economic processes. Taking into account that "information is the main resource of institutional changes in the digital economy" (Matveeva, Nikitaeva, Chernova, 2018, p. 135), it is necessary to assess the effects of the balanced provision of necessary resources, including information, to the subjects of innovative solvation in the industrial sphere of the region.

According to its content, the business paradigm of the circular economy in innovative solvations in the innovative solvates of the industrial ecosystem of the region (Figure 5) contributes to the formation of a solvate shell. This shell accumulates not only the resources and energy of the participants but also the facilitating potential for obtaining a synergistic effect from their interaction at different levels, as well as a set of institutional rules (institutional matrix) for the functioning of solvates.

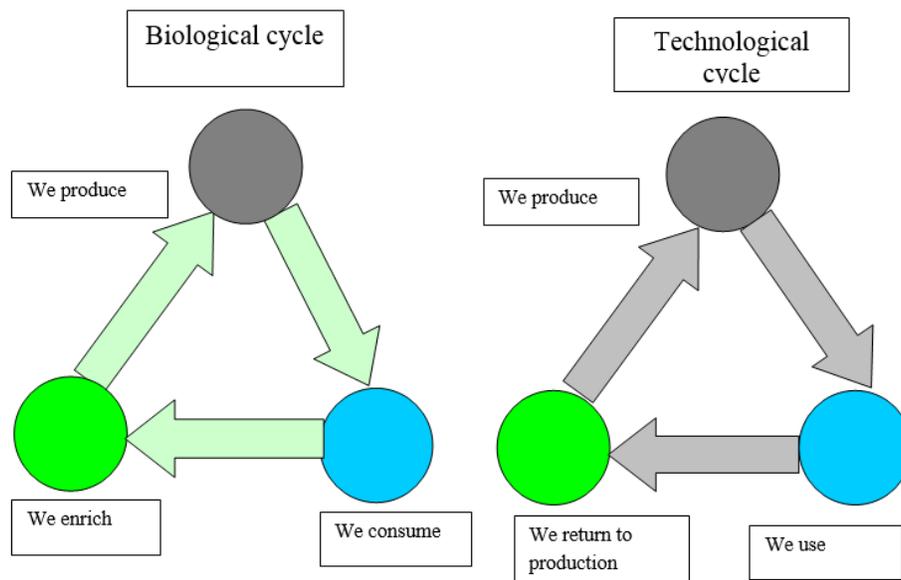


Figure 5. The business paradigm of a cyclical economy in innovative solvation

### 3. RESULTS AND DISCUSSION

Cyclical nature in innovative solvations is manifested in economical use of resources involved in innovative projects and the implementation of the "smart production" model in practice; synchronization and balancing of multidirectional interests of participants in innovative alliances; achieving innovative harmonization in the subsystems of the industrial ecosystem; significantly reducing the negative impact on the external environment at each stage of the innovation and production process and the process of selling products to end consumers or to the initial participant of the circular model.

In this context, it seems practically significant to investigate the significance of relevant institutional changes as an important factor and determinant of innovative and economic processes. Taking into account that "information is the main resource of institutional changes in the digital economy" (Matveeva, Nikitaeva, Chernova, 2018, p. 136), it is necessary to assess the effects of the balanced provision of necessary resources to the subjects of innovative solvation in the industrial sphere of the region.

In addition, the business model of innovative solvate proposed assumes synchronization of technological and biological cycles, as well as rational and waste-free use of resources. Following this, the formation and functioning of innovative solvates in the industrial ecosystem of the region actualizes the problem of

not only sufficiency but also harmonization of the resource provision of participants of such alliances (including temporary, consortium nature) as a necessary condition:

*firstly*, achieving the goals of interaction (both in the whole integration system and each of its participants - initiators, producers, and consumers of industrial innovations; donors and acceptors);

*secondly*, maintaining circularity (closure of the business model);

*thirdly*, preserving the stability and integrity of innovation alliances, which produce a synergistic and multiplicative effect, manifested at different levels of the state, economic, political, organizational hierarchy, as well as at the level of individual consumers of industrial innovative products;

*fourthly*, creating effective information and digital space of the industrial ecosystem, incorporated into the structure of the unified information space of the region.

Thus, the formation of "healthy" innovative solvates in the industrial ecosystem of the region is a harmonious and balanced development of institutes of science, technology, innovation, supporting innovative solvations in the industrial sector, the participants of which are characterized by mutually beneficial (symbiotic) relations between themselves and with the environment, resulting in the manifestation of innovative resonances in the associated ecosystems (meso, macro, micro). Innovation resonance is a spatial-temporal balance of proportions, scales, and directions of innovation activity in the subsystems of the industrial ecosystem concerning the general range of innovative development of the region's economy as a supersystem.

The hierarchical nesting of the resource "response" of the economic system, in particular, the industrial ecosystem, to external disturbances, as well as the hierarchy of the processes of manifestation of solvation effects in the innovative alliances of the region's industry are shown in Figure 6.

Achieving an innovative resonance in the industrial ecosystem will contribute to the generation of socio-economic effects, both in the industrial ecosystem and in the environment.

Therefore, it is so important to determine the forces and conditions that cause the resonance effect and the appearance of an innovative "response" in the subsystems of regional industry. Thus, it should be taken into account that the achievement of innovative resonances in the industrial ecosystem is ensured by an effective resource exchange between its subsystems and with the environment at each stage of the value chain. Including the exchange of information as "the main resource of institutional changes in the digital economy" (Matveeva, Nikitaeva, Chernova, 2018, p. 135) and a factor of balanced provision of other resources to the subjects of innovative solvation in the industrial sphere of the region.

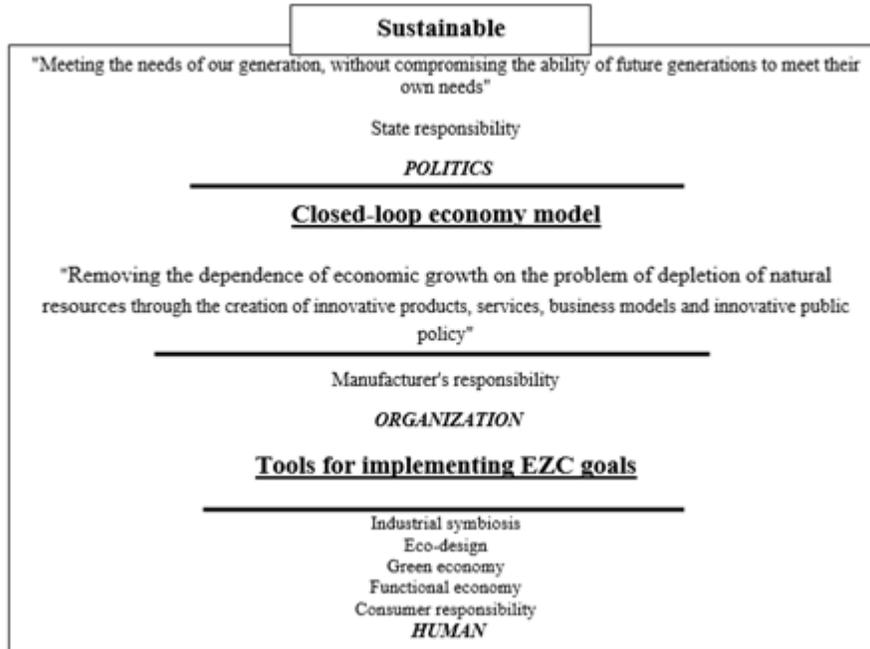


Figure 6. Subjects of innovative solvation in the industrial sphere of the region

Factors-conditions for the appearance of solvation effects in the innovative sphere of the industrial ecosystem of the region can be conditionally differentiated into the following groups.

1. Innovative solvation in the industrial ecosystem of the region is due to the formation of coordination links between the leader of innovation activity (the driver of industrial innovation in the region) and "gravitating" to it innovatively active enterprises and companies of different areas of activity (innovation production, production of innovative products, its sale), which allows forming the circular business models.
2. Institutional solvation – the formation of an institutional matrix, that is, a set of institutions supporting innovative solvation.
3. Resource solvation is a goal-oriented distribution of resources of all participants of innovative solvation and the achievement of a rational symbiosis between them within the framework of a circular business model (donor-acceptor interaction), built on the coordination of the interests of the parties (participants).
4. Information and digital solvation within the framework of single information and digital space of innovative interaction.

Following the ideas and considerations presented above, as already noted, an important aspect is the problem of harmonizing the resource supply of innovative solvation in the industrial ecosystem of the region as a factor of "successful" interaction of participants at all stages of the value chain. This applies to human, financial, and natural resources (in particular, water).

Thus, concerning water resources, this refers to the implementation of a policy of their rational distribution and consumption, since this is directly related to the strategy of general economic energy efficiency, which should also be guided in innovative alliances. Therewith, there is an obvious difference in approaches to solving this problem in different phases of the economic cycle. However, the problem of

using water resources is relevant for innovative industrial solvates created or operating in all regions without exception.

There may be sufficient or even complete resource provision for the cyclical business model of innovative interaction by the beginning of the crisis period, as at the beginning of any phase of the economic cycle. This is manifested in the absence of completely scarce resources in the industrial ecosystem of the region (for example, the possibility of full water supply of production processes), as well as in the presence of excess resources that can be exported. During the cycle periods, the problem of resource scarcity (for example, water – in dry periods) may become relevant, for which various methods and techniques are used to solve it. One way or another, it is important to eliminate the "bottlenecks" that limit the resources for innovative solvation to enter the trajectory of "healthy" growth to the Author Information section at the end of the paper.

#### **4. CONCLUSION**

The formation of the institute of import substitution in the industrial ecosystem of the region within the framework of the scientific and digital provisions formulated by us will contribute to the implementation of several consistent reforms within the framework of a systematic approach to using the resource and organizational potential of all participants in the circular business model of innovative solvation in industry. In this case, we propose to consider import substitution as a rational or effective phenomenon, taking into account several restrictions. Those industries and spheres of activity that either already produce products capable of replacing imported analogs, or have the corresponding potential, should switch to the import substitution model.

Those industrial ecosystems of regions where the policy of maximum orientation to the use of domestic resources with minimal dependence on imported import-substituting products is implemented will be more resistant to crisis factors and more successful in gradually overcoming the crisis.

As digital technologies are distributed to various industrial segments, the ways of purposefully using the resources available in innovative solvates will be significantly transformed.

New technological solutions based on the large-scale use of the advantages of information and end-to-end digital technologies allow monitoring the situation in the industrial ecosystem and the social sphere using the capabilities of artificial intelligence and new information processing tools. It is in the coordinates of information and digital determinants that it is possible to form an import-substituting contour of innovative alliances in industrial ecosystems.

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