

# Sustainable Development of the Innovation System in the Context of the Sixth Technological Paradigm

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**Keywords:** Innovative Development, Digital Economy, Technological Priorities Of The Sixth Technological Paradigm, Sustainability Of Enterprises, Innovation Infrastructure, Innovation Activity, Innovative Territorial And Spatial Formations.

**Abstract:** As a result of the desire to ensure high consumer characteristics of products and reduce individual production costs below the socially required ones, technological changes occur over time, which are prerequisites for the transition to a new technological mode. Priority preparation for a new technological mode becomes one of the important tools of state policy to consistently ensure the economy's sustainability through the innovative trend of development of the national economy as a whole and of the enterprises that make up its foundation. However, this can only be realized through a shift in innovation priorities, radical transformation, and investment in new technologies and areas of activity. The article considers several problematic issues related to the transition of the economy to the sixth technological paradigm, the presence of which is due to the peculiarities of territorial and spatial formations, heterogeneity of their resource potential, different innovation activity of economic systems, as well as the need to identify effective principles and management mechanisms, the choice of transformation models and formation of innovation infrastructure in conditions of existence of multimodality of the Russian economy.

## 1 INTRODUCTION

In modern conditions of transition to technologies of the sixth technological mode and digitalization of the economy, it is the level of development of innovation systems that largely predetermines the horizons of national economic growth. In developed countries, as a rule, the fourth and fifth technological modes prevail. In the domestic economy, in addition to the fourth and fifth patterns, there is the third one.

With significant improvement of the institutional and infrastructural innovation environment in the domestic economy, the methods and tools of innovative activity of economic entities are insufficiently implemented, which has a weak impact on the development of innovation potential.

This leads to a significant lagging of the Russian economy in the field of high technology. The

countries with the highest volume of high-tech exports (\$ billion) in 2019 were distributed as follows: China, 715,843; Hong Kong, 322,038; Germany, 208,677; US, 156,074; South Korea, 153,561; Russia, 10,864. Russia's high-tech exports account for 1.5% of Chinese exports and 6.9% of US exports (World Bank Group, 2021).

In this regard, the formation of a truly innovation-active economy in the near future requires, firstly, a clearly defined economic strategy in accordance with the technological priorities of the sixth technological mode, and secondly, the solution to the problem of forming a system of innovation activity management at all levels of the national economy.

Given the technological priorities of the sixth technological mode, it is necessary to develop a comprehensive approach to the transformation of innovation infrastructure capable of ensuring

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sustainable economic development and competitiveness of the national economy in high-tech markets.

## 2 RESEARCH METHODS

The study of the above problems is based on methodological tools, ensuring the comprehensiveness and objectivity of their study, in particular, the dialectical methods of knowledge. We are talking about the application of such general scientific methods of knowledge, as analysis and synthesis of theoretical material, generalization, classification, grouping. This allows us to substantiate approaches to the formation of the logical structure of innovation activity management and the organizational mechanism of functioning of the system of innovation activity of enterprises and the region in the context of the new technological mode. The evidentiary basis of the hypothesis justification is based on the method of comparative analysis, which allowed us to compare different approaches to the transformation of the innovative structure of the national economy and the construction of infrastructure adequate to the technological challenges of the 4th industrial revolution. In order to substantiate the author's position on the indicated problems on the basis of general scientific methods of abstraction and generalization, the theoretical analysis of different points of view and scientific views set out in the publications of academic economists, as well as the synthesis of the materials obtained. In addition, the experience of the authors of this article as experts is involved.

As part of the ongoing research to conclude on the feasibility of joint use in the study of systemic and synergetic approaches, which allowed a constructive approach to solving the problematic issues of research and description of innovative activities and activities of economic entities of different levels, capable of self-development and changes in the system properties that arise during technological leaps. This is due to the duality of the manifestation of innovation activity. In one case, the system through innovation moves to a higher qualitative level, and in the other case, through perturbing influences leads to a violation of the stability of the system's functioning.

## 3 RESULTS OF RESEARCH

As we know, the functioning of economic entities is based on such basic laws as development, self-preservation, and synergy. According to the first law, business entities are motivated to innovate in an environment with factors of uncertainty and competition. The development of innovation activity in the system of economic and scientific and technical relations of economic entities, as a rule, creates synergetic effects. From the position of the state's interests regarding changes in economic and innovation priorities and values of market relations, it is fundamental to ensure consistency of actions of all participants of the innovation system (Shinkevich et al., 2016), (Gusev et al., 2017), (Rodionova, 2016), (Rodionova, 2015). The dual nature of innovation should be taken into account. On the one hand, innovation is one of the main sources of profit growth, development of enterprises and territories, and on the other hand, it is a possible source of risk and loss of sustainability of enterprises.

As the research shows, the external environment factors are becoming increasingly dynamic of change, especially in the context of digitalization of the economy and the 6th technological mode (Kaminsky et al., 2019), (Gusev et al., 2016), (Golichenko, 2011), (Kaminsky et al., 2019), (Sviridova et al., 2019), (Digital Russia, 2019).

The first group of factors is manifested in relation to the impact on socio-economic development (including institutional environment factors). The second - in connection with the impact on the state of innovation potential of an economic entity. The third group of factors directly influences innovation performance and development (innovation activity, innovation receptivity, etc.).

Low dynamics of the introduction of innovations at the enterprises of spatial-territorial formations is caused by the manifestation of factors of a negative character. First, the risk of investing in new innovative projects under conditions of instability of both national and global economies. Secondly, limited opportunities for investment in large innovative projects that have a long payback period. Thirdly, imperfection of the legal support of innovation activities.

Low innovation activity is often related to internal factors. An example could be large enterprises whose degree of innovation activity is related to their monopolistic position and to the rare application of anti-monopoly legislation to them.

Thus, the development of innovation infrastructure in different territorial-spatial

formations occurs unevenly, affecting, ultimately, the state of the innovation environment of the national economy.

Given the technological priorities of the new technological paradigm, it is necessary to take adequate measures to transform the national innovation system (NIS) and adapt the national economy to the new realities under the control of government agencies with the ability to optimize the emerging situation.

Of course, the development trajectory of economic entities and territorial and spatial formations should be sustainable. In this regard, two problems become very urgent for economic entities and territorial and spatial formations:

- transformation of the national innovation system and ensuring the management of innovation activity for its own development in the transition to the 6th technological mode (Gusev et al., 2017), (Kaminsky et al., 2019);

- ensuring at the same time the sustainability of the national economy as a whole and individual economic entities (Shinkevich et al., 2016), (Gusev et al., 2016).

At the same time, based on the ideas about the essence of innovation, it follows that their real implementation and materialization take place largely at the level of economic entities (enterprises), which represent a system that has an integral characteristic of abilities (competencies) and readiness to implement innovations to obtain a specific target result.

In this case, the enterprises - leaders perform the function of poles of attraction for innovation and development of production (in accordance with the model of "growth poles" by F. Perroux). Later on, due to economic growth, an increase of financial resources, and infrastructure development there is a gradual spread of positive trends and an increase of efficient use of resources of spatial formations to the whole economy.

At the same time, as research and scientific publications show, megacities and clusters have a significant impact on the formation of the innovation environment in addition to enterprises. This is ensured by a high degree of concentration of scientific and technical resources and production capacity. "Concentrating resources on key areas of innovation ensures that it is scaled up in current and strategic ways. This is especially true for breakthrough technologies, the dependence of which on the scale of funding is evident" (Gusev et al., 2017). This conclusion finds support in publications on this problem, e.g. (Shinkevich et al., 2016).

Currently, the "environment" cluster concept, which is based on the approach to justify the interaction between cluster participants (Rudskaia et al., 2015), as well as the concept of forming network mechanisms of relations between economic entities, has been widely spread (Rodionova, 2016), (Rodionova, 2015), (Vodolazhskaya et al., 2017), (Petrikov, 2019).

The clusters created in regions and industries are an example of the development of innovative activity and the formation of a community of innovation process participants (Petrikov, 2019).

For example, the share of Moscow in the structure of gross value added of Russian regions in 2019 was 20.8% (Rudskaia et al., 2014). The clusters located in the Moscow metropolitan area are focused on such innovative areas of specialization as microelectronics and instrumentation; industrial biotechnology; medical industry; pharmaceuticals; new materials; nuclear and radiation technologies. Quite large clusters are developing in the megalopolis of St. Petersburg and a number of other regions.

In addition to clusters, incubators and business angels, university complexes and research centers, venture capital funds, enterprises and organizations - producers of products (services), as well as consumers of products (services) are the basic elements of a complete and functioning infrastructure. The totality of such actors is the basis of the architecture of interconnected and interdependent processes of production, distribution, exchange and consumption.

Infrastructure has a special place among the elements of the innovation system, which plays a crucial role in ensuring the coherence of all actors in the economic process. The main provisions of organizing the functioning of innovation infrastructure are outlined in the works of many researchers (Vodolazhskaya et al., 2014), (Gusev et al., 2017).

The vector of infrastructural development of the national economy during the transition to the 6th technological mode should become new innovation and technological trends, which determine the points of growth, both at the level of enterprises and territorial-spatial formations (Kalashnikov et al., 2018), (Mudrak et al., 2019), (Sviridova et al., 2019), (Utepbergenov et al., 2018).

It seems that the priorities of innovation infrastructure entities should be primarily determined based not on the development of technologies and processes of the new technological paradigm that need to be implemented, but on the orientation towards markets for products (services) produced on

the basis of new paradigm technologies (for example, intelligent urban mobility and telematic transportation systems; neuroassistants, neuroeducation, neuromedtech, and pharma; Big Data and IIoT robotics; "smart" agriculture, etc.). This is mainly due to the fact that specific technologies only contribute to the creation of market-demanded use value.

The state occupies a special place in the innovation infrastructure, which performs, in our opinion, four main forms of interaction with economic entities and other structures of the national innovation system.

First, the state structures form the institutional environment and innovation climate for innovation activity based on the state strategy with the focus on the leadership in science and reliance on the scientific and innovation potential of defense enterprises (the state as an innovation customer), and act as a regulator of innovation activity and transformation of innovation into a market product.

Especially noteworthy in the context of transition to the 6th technological mode is the importance of forming an innovation strategy, transition of all structural elements of the innovation environment to a different qualitative state through the acquisition of new properties. In addition, the state is a key enabler of innovation.

Secondly, state structures carry out the development of the innovation infrastructure stimulating innovations.

The state creates special structures (networks of innovation diffusion centers, advisory centers, foundations for the financing of fundamental or applied research; technoparks, incubators, and other institutions providing services to innovative companies; institutions promoting cooperation between science and industry, etc.) that implement innovation policy, ensure the receptiveness of business entities to global scientific and technological advances and coordinate their actions in the innovation sphere.

Thirdly, state structures control the implementation of national projects and also create new competencies (professional retraining systems and providing opportunities for workers to acquire new skills that are in demand on the market throughout their careers).

Fourthly, state structures act as a source of funding for major projects, investing in selected priority areas, innovative national projects, fundamental or applied research.

The outlined functionality of state structures is represented in Figure 1 in the form of a rhombus.

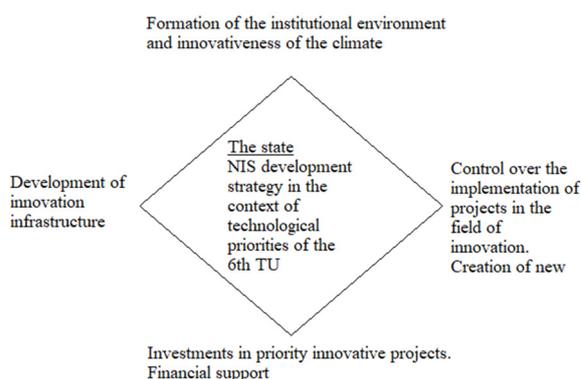


Figure 1: "State Functional Rhombus" in the national innovation system.

The complexity and multidimensionality of the structure and tasks of the national innovation system make it necessary to form an effective mechanism for coordination of interaction between the main subjects of innovation activities and support of innovation activities adequate to the challenges of the 6th technological mode.

Figure 2 presents the conceptual scheme of formation of the organizational mechanism of functioning of the management system of the national innovation system.

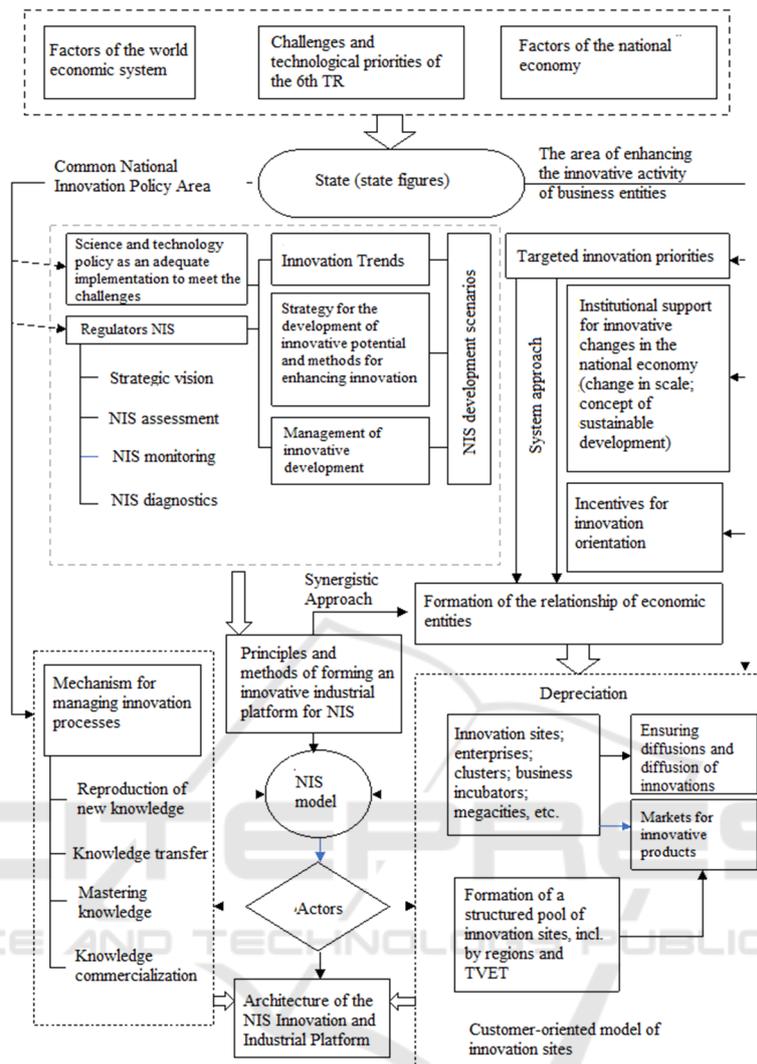


Figure 2: Formation of the organizational mechanism of the national innovation system management system.

## 4 RESULTS AND DISCUSSION

Both domestic and foreign specialists are engaged in the research of issues in the field of innovation theory, innovation management, and innovative development of organizations.

The points of view of domestic and foreign scientists on the problems under consideration are presented in Table 1.

Table 1: List of authors on the issues under study.

Issues under investigation	Domestic and foreign scientists
Development of theoretical and methodological approaches to the management of innovation activity and innovation activity of business entities. Interrelation of innovation activity and its activity with parameters of economic growth of economic entities.	Borisova E.Y., Vasilieva Z.A., Golichenko O.G., Grechenyuk A.V., Zeldner A.G., Izmailkova S.A., Korepanov E.N., Korolev D.V., Krotov M.I., Kurnysheva I.R., Lavrova N.A., Nizhegorodtsev R.M., Nikitin S.A., Sadkov V.G., Filimonenko I.V. et al.
Study of theoretical aspects of innovation activities	Drucker P, Castells M., Mensch G, Santo B., Twiss B., Schumpeter J., Anchishkin A.I., Blyakhman L.S., Valdaitsev S.N., Kondratyev N.D., Kokurin D.I., et al.
Development of innovation management tools and mechanisms	Glazyev S.Y., Grinberg R.S., Golichenko O.G., Gokhberg L.M., Gutman G.V., Zavlin P.N., Kazantsev A.K., Kovalev G.D., Mindeli L., Fatkhutdinov R.A., Yuryev V.M. et al.
Study of innovation processes in territorial spatial formations	Asaul A.N., Bakhtizin A.R., Bogdan N.I., Bodrunov S.D., Bortnik I.M., Glazyev S.Y., Glisin F.F., Golichenko O.G., Gokhberg L.M., Ivanova N.I., Ivanter V.V., Kuznetsov S.V., Lundvall B., Malinin A. M., Mensch G., Nelson R., Perani J., Razumovsky V.M., Santo B., Twiss B., Freeman K., Schumpeter J.A., Edquist C., et al.
Factors of innovative development of economic systems	Goldobina M.V., Esina O.I., Kantserov R.A., Mitrofanov M.Y., Monastyrsky V.V., Moskvina O.S., Olovyannikov A.A., Razumovsky V.M., Sukhovey A.F., Freimovich D.Y., Yuryev V.N., etc.

Source: compiled by the authors.

The review of the literature shows that the economic literature presents studies from the position in sufficient detail:

- adequate response of economic entities and the economy as a whole to changes in innovation and technology [Anchishkin A.I., Blyakhman L.S., Glazyev S.Y., Goldobina M.V., Zeldner A.G., Mensch T., Schumpeter J, Yuryev V.N. et al;]
- innovative and investment development, determined by strategic trends and priorities in the economy [Valdaitsev S.N. Drukker P., Clark K., Kondratyev N.D., Mitrofanov M.Y., Nizhegorodtsev R.M., Razumovsky V.M., Santo B. et al;]
- management of innovation potential and innovation activity of enterprises [Glazyev S.Y., Gokhberg L.M., Zavlin P.N., Kazantsev A.K., Kovalev G.D., Fatkhutdinov R.A., Yuryev V. M. et al;]
- The development of innovation activity and activity of economic entities in the system of cluster associations, megacities, and other territorial and spatial formations [Aleshin A.V, Alieva E.M., Asaul A.N., Gusev Y.V., Ivanter V.V., Isaeva E.M., Mensch G., Nikulina O.V., Nelson R., Perani J., Polovova T.A., Rodionova N.D., Skoch A.V., Trofimova

O.M., Chernikov E.A., Chernova O.A., Shevchenko I.K. Schumpeter, J.A. et al.].

At the same time, the analysis of publications of scientists-economists has shown that in the context of the theory of innovation systems it is necessary to further study the issues of transformation of the innovation system and its entire infrastructure in conditions of a radical change of technological priorities in connection with the new technological mode.

It seems that the creation of innovative infrastructure of the national economy can be implemented by changing the model of interaction between the state and economic entities and territorial spatial formations, including through the improvement of the investment mechanism as a national project.

For this purpose, an attempt has been made to substantiate the main provisions of the conceptual scheme of formation of the organizational mechanism of functioning of the management system of the national innovation system.

## 5 CONCLUSION

As a result of the study, the features of the current stage of development of the innovation economy, which intensify competition in the global market of high-tech products, were identified:

- The process of acceleration of scientific and technological development, which is a prerequisite for the transition of national economies to the sixth technological mode as a result of the fourth industrial revolution;
- Artificial intelligence production tools, digital technologies, nano- and biotechnologies, nanobiotechnologies, and other microelectronic components are predicted to form the technological basis of the new technological paradigm;
- Government agencies in many countries are taking a proactive stance with regard to stimulating R&D in priority areas with subsequent dissemination of science and technology achievements at the global market scale to ensure sustainable development of the economy.

Meanwhile, the national innovation system is characterized by dispersion of intellectual resources, selective financing of innovation projects, poor R&D and technology transfer results, and weak linkages in the "science-production-commerce" system.

As a result, the NIS of the domestic economy has a number of significant inconsistencies in the construction of the management system. The analysis of publications on this issue and our own research allowed us to substantiate and propose a conceptual scheme of formation of the organizational mechanism of functioning of the management system of the national innovation system. This approach can be used as the basis for the transformation and structural construction of the management system of NIS infrastructure of the national economy with new mechanisms and tools to generate innovation, technology transfer.

The results of the study of the formation of innovation environment in the transition period of the sixth technological mode allow us to further substantiate a number of provisions concerning the transformation of the complex of management tasks to enhance innovative development.

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