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Issues Relating to the Hi-Tech Industry in the Eurasian Economic Union

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Abstract. The research of the hi-tech industry development is one of the tools necessary to solve the priority strategic task of a scientific and technological breakthrough that is determined by the challenges of the sixth technology revolution which is characterised by the convergence of bio-, nano- and cogno-technologies. It is essential to attain the international level to effectively achieve this ambitious goal and develop the hi-tech industry, this is why the Eurasian economic union in partnership with other stakeholders can become an integration platform to address these challenges. This research is based on the convergence (integration) of bio- and nano-technologies that form a promising hi-tech bionano-industry. The paper addresses its main characteristics and issues associated with its development; the industry's current state and future trends of the development of the market and industries where such technologies are used are analysed; essential methodologies that need to be improved as well as the solutions to the identified problems are developed. Creation of innovative international bionano-clusters with foresight centers to support convergence of technologies, foresight research, bionano-technology foresight projects is a methodological solution to organizational problems of the bionano-industry. To establish the aforementioned clusters it is essential to further study the ways to improve the cluster policy with a view to develop hi-tech complexes; scientific justification of the organizational model of innovative international bionano-technological clusters; the development of their engineering infrastructure, including the establishment of engineering centers there to provide various engineering services to small and medium innovative businesses participating in the cluster; joint research and development; acceleration of technology introduction into mass production; capacity development.

1. Introduction

The Russian Federation and the Eurasian Economic Union face a priority strategic task determined by the sixth technological revolution of the development of a hi-tech industry based on the convergence of various technologies. A new technological revolution is based on the convergence of bio-, nano-, and cogno-technologies. This research studies the case of the integration of the bio- and nano-technologies. The boundaries between them are blurring more and more, and ever more pronounced convergence is taking place. They form the so-called bionano-industry, which, if developed, can produce a major scientific effect, a system of new manufacturing technologies, they can also design and produce innovative products on the basis of bionano-technologies. This is why the goal of the present research is to identify the main problems of the development of a hi-tech industry and solutions using the case of the bionano-industry as a result of the convergence (integration) of bio- and nano-technologies in the Eurasian Economic Union. The conducted research resulted in the formulation of

the major issues associated with the development of bionano-technologies, bionano-industry and possible solutions. Every group of issues, the corresponding solutions and prospects of the development of the essential methodologies are the topics to be considered in future scientific studies and papers. The hypothesis of the study is that the main tools for the development of the hi-tech bionano-industry is a coordinated industry and investment policy of the states of the Eurasian Economic Union that is aimed at the integration of the markets and industry complexes; international industry partnership and scientific and industry partnership; establishment of innovative international industry clusters, including the creation and maintenance of the relevant engineering infrastructure. The article has the following sections: introduction; pertinence, scientific value with a brief reference overview; the goal setting; theory; practical value, the produced scientific results and propositions regarding further research, conclusion.

2. Pertinence, scientific value with a brief reference overview

The sixth technological revolution puts the hi-tech market in contrast to the markets of raw materials and semi-manufactured products, into the lead in today's global market economy, and it becomes clear that Russia needs to abandon the export-oriented resource-based development, as it becomes more unattractive. In Russia, innovations are not developed and introduced into the hi-tech industries fast enough, despite the decisions made on the state level that have been aimed at ensuring innovative development and making the hi-tech business economy more attractive for investors and more competitive. In our opinion, it is difficult for one country to make such a scientific and technological breakthrough, and international cooperation and collaboration as well as joint efforts on the international level are essential. The existing integration group of countries, the Eurasian Economic Union (EEU) can become such a platform. This is why the development of a hi-tech industry cannot be ensured without international industrial cooperation, scientific and industrial partnership, coordinated industrial and investment policy of the EEU member states, creation of innovative international industrial clusters.

Issues and problems of the development of the hi-tech industry, economic innovative capacity building, development of knowledge-intensive industrial complexes are considered in pertinent scientific quoted publications by various researchers and experts. We must point out the main characteristic of the solution to this issue, namely the international level necessary to achieve this goal: integration of states and international industrial cooperation [4, 18, 19], international industrial cooperation [16, 11], integration of markets [5] and industrial complexes of different states. The main condition for raising the innovative and technological level of the industry and move to the next technological stage is to use the cluster approach to the organization of industrial complexes: to create industrial clusters [1, 2, 8, 12] based on innovative technologies; to use the synergetic effect of the cooperation between stakeholders from various areas; unification of scientific, technological, engineering and industrial infrastructure as well as financial, investment, scientific and personnel potential of the private and public sectors. One of the factors that contributes to the acceleration of the innovative (hi-tech) product design is the so-called technology transfer network based on the network cooperation principle with various stakeholders in the process of scientific research and development (scientific and technological projects), including the organization of virtual scientific groups in the form of a syndicate [14]. Such a technology transfer is a stage in building interstate unified cooperation and technological chains with a view to create breakthrough hi-tech (knowledge-intensive) products [6].

The issues of the state and development of the hi-tech business and complexes, including bionano-industry that is studied in this paper, are considered by Russian researchers, in particular by N.V. Zinkovskaya and M.A.Tolstopyatenko [9, 10, 7] who have contributed to the study of this problem. The authors identified and analysed a number of problems associated with the development of hi-tech industries, industrial complexes, and proposed key areas of hi-tech industrial modernisation, factors in the creation of an innovative hi-tech industry development model [9, p. 36-38]; they also offered a programme and goal approach to the creation and development of hi-tech industrial complexes, including state innovation policy, cooperation between industries and the Russian Academy of Science,

network centers for industrial excellency, scientific and manufacturing centers of the new formation, open innovation centers and industrial clusters [10, p.42-47].

3. The goal setting

The goal setting process is determined by the goal of the research and envisages the following:

- to conduct a brief analysis of the Russian and global bio-technology and nano-technology markets, and to justify why the bio-industry is a separate line of activity, and to identify the aspects of its development within the EEU;
- to establish the main challenges to the development of bionano-technologies, bionano-industry and suggest possible solutions to be implemented in the EEU;
- to identify the areas for further scientific research.

4. Theory

This scientific research and the produced results are based on the following methods of scientific analysis: systemic analysis, comparison and contrasting the analysed phenomena and processes, synthesis, generalization and economic analysis of the data. The research studied bionano-industry as one of the hi-tech industries. The hypothesis of the study is the assumption that the main tools for the development of the hi-tech bionano-industry are a coordinated industry and investment policy of the states of the Eurasian Economic Union that is aimed at the integration of the markets and industry complexes; international industry partnership and scientific and industry partnership; establishment of innovative international industry clusters, including the creation and maintenance of the relevant engineering infrastructure.

5. Practical value, the produced scientific results and propositions regarding further research

The practical value of the conducted research concerns the possibility to use the produced scientific results in:

- researching the trends in the innovative development of hi-tech industries, hi-tech industrial complexes;
- improving the cluster policy of the state;
- developing a coordinated industrial and investment policy of the EEU member states.

The development level of an economy, its place among the developed economies is determined in large part by the development level of its industrial complex. It is the industry that brings together the majority of the scientific and technical innovations; it is the driver of the innovative development of the national economy, the source of the creation and development of a hi-tech business of the new generation [10].

This research says that Russia can achieve the goal of innovative development of its economy and ensure the development of the hi-tech industry by territorial and institutional integration of national markets, including the markets of the EEU member states. "The integration of markets means that national markets get closer and more interconnected on the international scale" [5, p.2].

In this research by the integration of markets we mean the creation of integrated industrial markets, integrated industrial complexes of Russia, Belorus, Kazakhstan, Armenia and Kyrgyzstan that are member states of the Eurasian Economic Union. Integration processes within the EEU help to fulfil the following tasks:

- more sustainable and competitive economies in the member states;
- new additional drivers of economic development;
- less exceptions, limitations and barriers for the free movement of goods, services, capitals and labour;
- strengthened positions of member states in the third countries' markets and in international organizations [19].

Consequently, this calls for the development and implementation of a coordinated, harmonized policy in various industries, the development and implementation of a coordinated industrial policy in

order to give a new impetus to the industrial cooperation and development, to introduce innovative technologies, enhance the competitiveness of the industry, of various industrial complexes, and innovative activities of the member states (see Figure 1).

The sixth technological revolution envisages the convergence of bio-, nano-, info-, and cognotechnologies (see Figure 2), with a view to fulfil the ambitious strategic task of the development of the hi-tech industry on the basis of the convergence of various technologies (NBIC convergence), which calls for an international integration-driven approach [20]. As we can see from Figure 1, "The main areas of industrial cooperation in the Eurasian Economic Union" is the essential document necessary to develop the cooperation, integration of industrial markets and industrial complexes; it lists the priority economic activities, including biotechnologies and nano-industry; the key cooperation areas in terms of integration of industrial markets, development of hi-tech manufacturing businesses, including bio- and nano-technologies. The boundaries between them are more and more blurred, they are getting closer than ever.

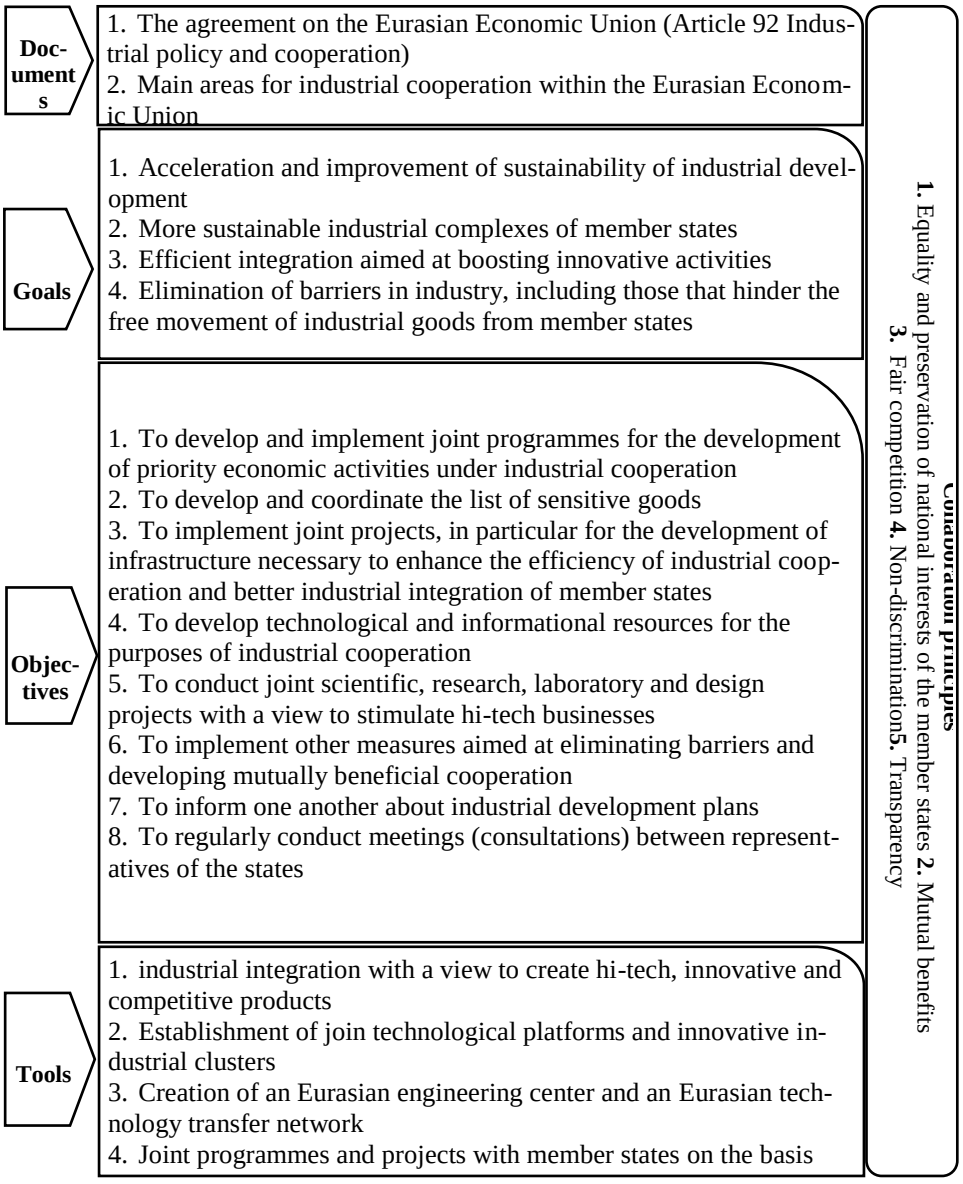

Figure 1. Goals, tasks and tools of industrial cooperation of the EEU member states.

Compiled by the authors on the basis of [4, 18]

They form the so-called bionano-industry, which, if developed, can produce a major scientific effect, a system of new manufacturing technologies, they can also design and produce innovative products on the basis of bionano-technologies.

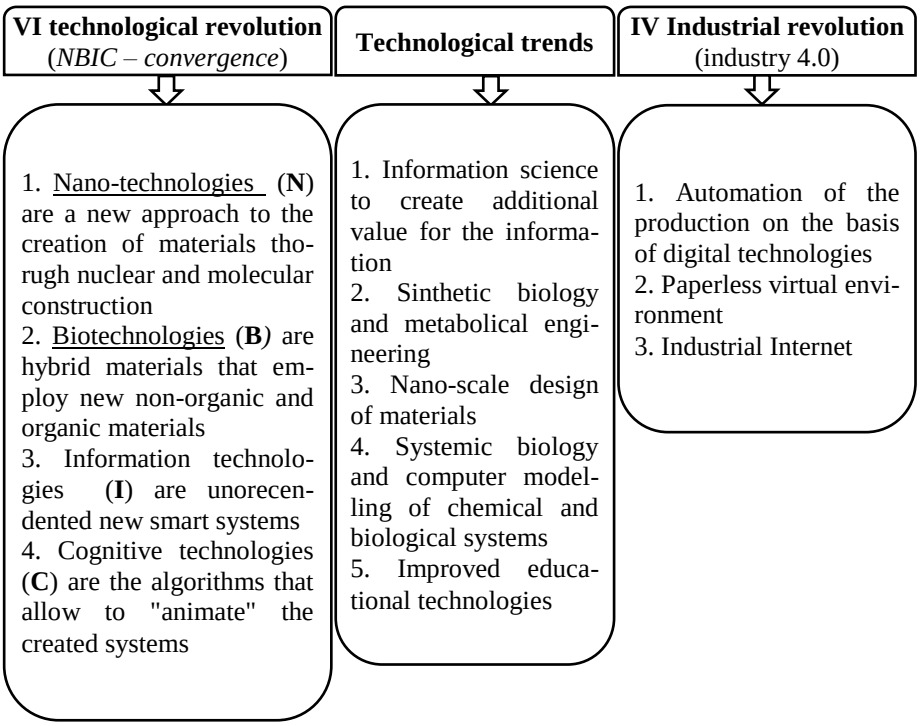

Figure 2. Global technology development trends Compiled by the authors.

The introduction of nano- and bio-technologies for general use and advantages of NBIC convergence creates a methodological basis for the design of nano- and bio-industrialization processes as a stage in the establishment of a technological mode of operation with mass production of goods with nano- and bio-parameters.

To do this, we recommend that integration links aimed at the creation of integrated industrial markets should be based on systemic and long-term basis. The goal is to reduce the share of imported industrial products (intermediate consumption products) and enlarge the share their export, and to do that, there is a need for an import phase out of imported industrial products by products manufactured within the integration union. The implementation of import phasing out strategy in terms of industrial products is more efficient, if it is based on joint production, international industrial cooperation [16, 11] and scientific and industrial partnership. The types of scientific and industrial partnerships of the EEU member states are shown in Figure 3. Moreover, the jointly manufactured industrial producrs can be promoted in the markets of third countries by interstate efforts.

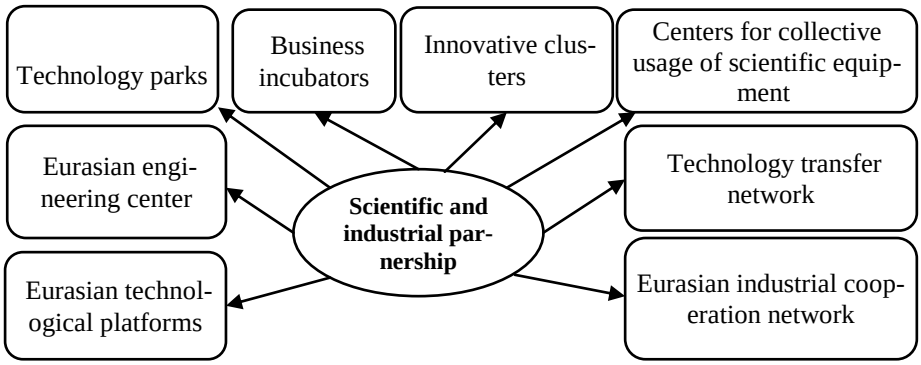

Figure 3. Types of scientific and industrial partnerships of the EEU member states. [Compiled by the authors]

An important condition to ensure advanced technological level of the national industrial complexes and their transition to the next technological era, the development of bionano-technologies, and bionano-industry as a whole is the creation of the following:

– innovative international industrial clusters [8, 12, 2];

– creation of joint technological platforms and technology transfer networks;

– implementation of joint programmes and projects in priority areas of the scientific and technological development (international industrial cooperation and scientific and industrial partnership).

It is essential to analyse the accumulated potential and the existing designs of every member state that supplements one another's scientific and technical research with a view to accelerate the process of designing new (innovative) products on the basis of the convergence of bio- and nano-technologies, to exclude the potential duplication and reduce the costs of R&D of the states.

Thus, we can have the so-called technology transfer based on the remote collaboration of participants, designers and stakeholders, partners in the joint R&D work, including the creation of virtual scientific teams in the form of a syndicate [14]. This principle should result in a deep-level cooperation between expert designers of innovative technologies and potential and existing partners. It is crucial to develop together business offers on various projects on creating unified cooperation and technological chains for manufacturing innovative products, transferring innovative ideas and technical solutions [6].

Besides the above-mentioned measures, the joint technological platforms that are being created contribute to the development of the hi-tech industry, for example, the Eurasian Engineering Center, the Eurasian Digital Development Platform for the EEU member states, and the Eurasian Development Bank.

There is no one correct scientific definition of the term "biotechnology". The 2020 Comprehensive biotechnology development programme of the Russian Federation defines a biotechnology as:

1) a discipline that studies the opportunities to use living organisms, their systems or waste products as solutions to technological problems, and a possibility to create living organisms with necessary qualities through gene engineering;

2) using biological structures in manufacture to produce foods and industrial goods and to achieve the target transformation [13].

Biotechnologies are divided into 9 industries: biopharmacy, biomedicine, industrial biotechnology, bioenergy, agricultural biotechnology, food biotechnology, forest biotechnology, environmental biotechnology, sea biotechnology.

The further development of biotechnologies and bioindustry is associated with biotechnologies based on the systemic biology technologies and other disciplines and is strictly a cross-cutting issue (bio-, nano-, and informational technologies).

According to forecasts, in 2020 the global biotechnology market will grow by 2 times in comparison with 2015 and achieve about $600 billion [17]. Industrial biotechnologies ("white" biotechnolo-

gies) and bioenergy as well as biopharmacy ("red" biotechnologies) and biohealthcare account for the major share of the biotechnology market.

The results of the conducted research show that the Russian biotechnology market lags behind the biotechnological leaders in terms of production output, growth rate and higher demand from consumers for biotechnology products. Moreover, Russia is an import-dependent country in terms of the basic biotechnological products, in particular medicines and animal feed supplements.

There is no accurate universally accepted by the scientists definition of the term "nanotechnology". Generally, nano-technologies are various operations with objects of the nano-world (molecules and atoms) and include images, measures, modelling and manipulations with these objects [1]. Nanotechnologies are cross-cutting and include science, engineering, design and the technologies themselves.

The nano-industry is a large-scale supra-sectoral form of mass production and bringing goods and services to the market using nano-technologies and nano-materials. The nano-product market is a system of economic relations for exchanging goods produced with the help of nano-technologies and/or including nano-components that have previously unattainable advantages in terms of benefits, costs and efficiency. There are 4 categories of nano-products: 1) initial nano-products (can be used for manufacturing other types of nano-products); 2) nano-containing products; 3) goods without nano-components – goods manufactured with the help of nano-technologies; 4) special nano-technology equipment.

Nano-technology as a revolutionary (atom and molecular) methods for building materials will ensure products with qualitatively new, unique or improved characteristics and functions that are in great demand in various industries. This will establish the foundation for all the economic sectors.

The 2020 forecast says that the global revenues from selling nano-products will be distributed in the following way: nano-electronics – 73%, nano-materials – 10%, nano-healthcare and pharmaceuticals – 6% [22].

Every year the ever-growing demand for nano-technologies in various industries gives a significant boost to the production output and revenues from nano-products on both the international and Russian markets. The volume of the global nano-technology market in 2015 was more $1.6 trillion [23]; that shows how promising it is for Russia and the EEU as a whole. The production of carbon nano-tubes and composite materials on their basis, nano-structural surfaces to improve durability of materials and surfaces, high-sensitive radiation-resistant nano-structural sensors, nano-membrane water treatment and fine purification systems, high-durability low-action radiation-resistant materials for electrotechnical cords is energetically developing in Russia.

In Russia "in 2016 547 businesses and organizations (323 manufacturing businesses and 224 scientific and production companies) carried out activities associated with the production of nano-containing products" [3, p.20]. However, according to the results of the nano-bibliometrical research conducted by A.Terekhov, after all, Russia is not in the top ten manufacturing countries in terms of nano-research and development [21, p.2].

We must say that "the correlation between bio- and nano-technologies is fundamental and is determined by a number of similarities: technologies operate molecular structures and substances; are the result of fundamental research that reached the level of real-life applications; every such technology has a network structure that ensures the optimal balance between the rate of capacity building in fundamental and applied science, experimental and manufacturing technologies [7, p.172].

Biotechnologies have produced a number of instruments for building nano-structures, while nanotechnologies promoted nano-healthcare that is a complex of technologies that allow to manage biological processes on the molecular level. Similarities of and differences between bio- and nanotechnologies are shown in Figure 4.

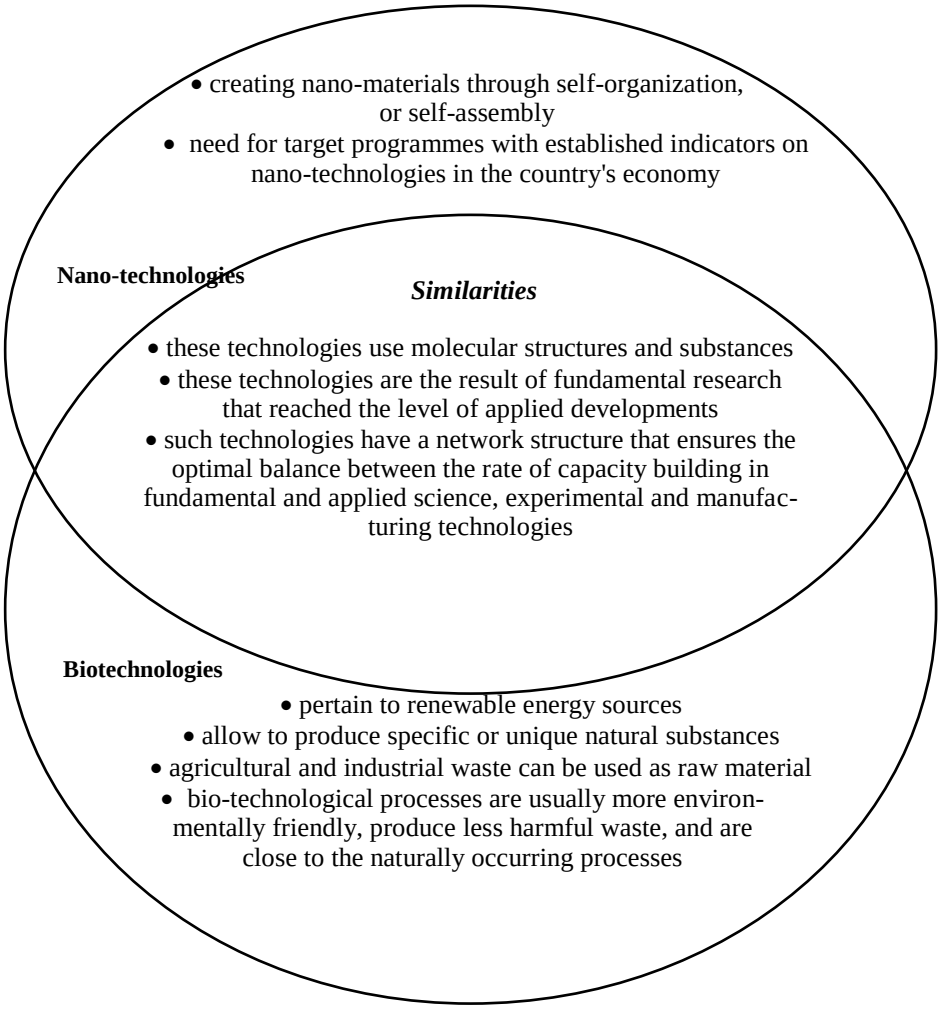

Figure 4. Similarities of and differences between bio- and nano-technologies [Compiled by the authors].

The evolution of these technologies leads to the creation of integration programmes of joint development of both technologies. For example, bionano-technologies have developed within the biotechnology system as a cross-cutting area of activities.

Bio-technologies is a cross-cutting scientific and technological area of knowledge that is based on the methods and means of bio-technologies and nano-technologies [15]. The goal of developing bionano-technologies is to design and produce products, technologies and processes that are beneficial for people.

This research defines a bionano-industry as a group of businesses and organizations that develop and manufacture products on the basis of bio-technological and nano-technological innovations.

The development of the bionano-industry is characterised by the following:

1) development of bionano-technologies is supported by the state from the stage of scientific development to the stage of introduction and implementation;
2) need for significant funds to support scientific research in the bionano-technological industry;
3) continuous development and introduction of revolutionary approaches to capacity building in bionano-technologies;
4) establishment and development of infrastructure to support fundamental research, find applications for the produced results, development of new bionano-technologies and their rapid commercialization;

5) rapid development of bionano-technology equipment manufacturing.

The main task of the bionano-technological sector development includes the advent of breakthrough innovative competitive products drawing on the bionano-resource potential.

The bionano-industry is one of the most knowledge-intensive industries that has created innovative technologies used in bionano-product mass production.

Potential applications of bionano-technology methods and bionano-industry products:

1) development of new healthcare and veterinary medicines, genetic engineering;
2) larger output of the agricultural production as a result of genetic engineering methods used in crop and animal farming;
3) development of non-ferrous metal deposits with the help of biotechnologies;
4) environmental protection.

Bionano-industrial markets are divided into two segments:

1) bionano-technologies that are investment bionano-products protected as intellectual property;
2) consumer bionano-products that are divided into bionano-goods market and bionano-services market.

In our opinion, there are the following main challenges to the creation and development of bionano-industry in the EEU:

1) inadequate level of innovative development of the EEU member states;
2) low level of innovation and technology trasfers;
3) lack of highly qualified experts in bionano-technologies;
4) need for substantial funds for R&D;
5) lack of scientifically justified organizational models of bionano-industrial clusters;
6) insufficient development level of bionano-industrial cluster infrastructure.

In our opinion, the prospects of scientific research in bionano-technologies without any doubt are associated with "full scale development of bionano- and environment-oriented technologies that ensure the creation of a new production capital and a new type of social relations that is expected following 2025-2030" [9, p.36].

Thus, the conducted research produced the results shown in Figure 5 with the major challenges to the development of bionano-technology, bionano-industry and what, in the authors's opinion, can become the possible solutions.

Every group of issues, corresponding solutions and development areas, relevant methodologies demonstrate potential for further research and publications.

Taking into account the aspects and issues of the bionano-industry development, the authors believe that the relevant modern methodological solutions can be associated with an innovative international industrial cluster with its own characteristics connected with the production raw material base, scientific development of technologies, manufacturing capacity, innovative potential of the industry and the relevance of manufactured products for the region and for the economy as a whole. The authors believe that further research can explore the development of cluster policy, scientific justification and creation of an organizational model for an innovative international bionano-technological cluster, including the creation of a foresight center to ensure the convergence of the scientific and technological process and technology, relevant foresight research and implementation of promising foresight bio- and nanotechnology projects.

Also, in the authors' opinion, further research can focus on the creation of engineering infrastructure in bionano-technological clusters, including the establishment of engineering centers there as providers of services for small and medium innovative businesses in the cluster, joint scientific and technical research and developments in bionano-technologies, their accelerated introduction into mass production, capacity building in bionano-oriented engineering.

6. Conclusion

The results of the research on hi-tech industry development allow the authors to say that in order to fulfil the set ambitious state task of making a scientific and technological breakthrough, the develop-

ment of a hi-tech industry, in particular bionano-technologies, is a relevant scientific issue and can be carried out on the basis of the integration of the EEU member states, including the integration of industrial markets and complexes, international industrial cooperation and scientific and industrial partnership, creation of innovative international bionano-technological clusters, and convergence of bio- and nano-technologies.

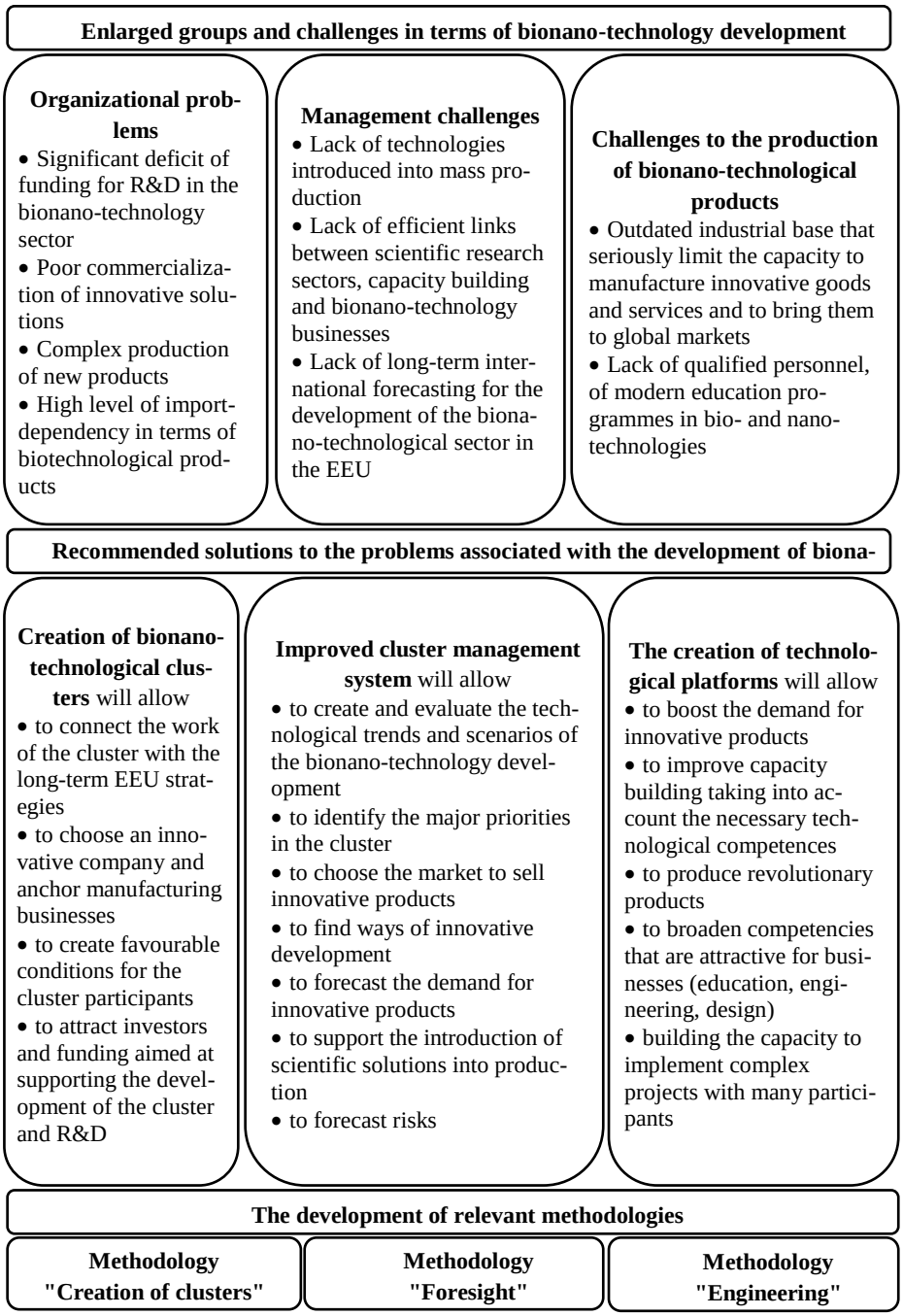

Figure 5. The major challenges to the development of biotechnologies, bionano-industry, possible solutions and necessary methodology development. [Compiled by the authors]

This conclusion is based on the results of the analysis of the bio- and nano-technology markets, including the issues of their integration, which form an independent hi-tech bionano-industry with high-

ly development prospects, both within the Eurasian Economic Union and on the global level. The identified characteristics of the development and the analysis of markets for the bionano-industry products and technologies allowed to formulate the solutions and show possible research areas that would boost the development and competitiveness of hi-tech sectors, industries and complexes on the national and international markets.

The main results of the research:

– Biotechnology sectors and Russian and international biotechnology markets are analysed;

– A brief analysis of the Russian and international nanotechnological markets, nanotechnology and nano-products applications was carried out;

– Similarities of and differences between bio- and nano-technologies are identified;

–Bio-industry as an independent area of activities was justified as a result of a fundamental interconnection and convergence of bio- and nano-technologies;

– various aspects of the bionano-industry have been identified;

– bionano-industry method application areas were found, and good prospects of scientific research of bionano-technologies;

– the main challenges to the development of bionano-technologies and bionano-industry are established, the solutions and essential methodologies are found that need to be further improved and refined;

– the authors suggest that the creation of innovative international bionano-technological clusters, with foresight centers to ensure the convergence of technologies, foresight research and foresight projects in the area of bio- and nanotechnologies are the methodological solutions to organizational problems associated with the development of bionanoindustry that were identified in the course of the research.

– With a view to create the aforementioned structures, the improvement of cluster policy for the purposes of the hi-tech complex development should be researched as well as the scientific basis for the organizational model for an innovative international bionano-technological cluster.

– the creation of engineering infrastructure in bionano-technological clusters with engineering centers as providers of various engineering services for small and medium innovative businesses in the cluster, joint scientific and technical research and development in bionano-technologies, their accelerated introduction into mass production, capacity building in bionano-oriented engineering.

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