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Development of National Innovation Systems in Developed Countries

O. Karasev[1], A. Beloshitsky[2], S. Trostyansky[3], A. Krivtsova[4], V.N. Valerievna[5]

Abstract:

The article presents the results of the analysis of existing models of innovative development, features of the scientific, technological and innovation policies of the leading countries in the formation and development of their own national innovation systems. The leading countries are Great Britain, Germany, USA, Canada, Japan, France and Italy.

The study shows that the innovation systems of each of these states have common features that reflect the main directions of development of science and technology, as well as certain specific features. Such features depend on what models of innovation policy the countries belong to - the "Euro-Atlantic policy", "East Asian policy" and "triple helix policy".

The article presents the innovations that are offered to be included in the innovation system of Russia with regards to the development of the new State Program, and suggests recommendations for further development of the Russian national innovation system.

Keywords: *Innovations, Science and Technology, National Innovation System, Innovational Development Model, Developed Countries.*

JEL code: *O30, O38*

[1]*Lomonosov Moscow State University, Russian Federation, oikarasev@econ.msu.ru*
[2]*Lomonosov Moscow State University, Russian Federation, alexei_bel@hotmail.com*
[3]*Lomonosov Moscow State University, Russian Federation, strostiansky@yandex.ru*
[4]*Lomonosov Moscow State University, Russian Federation, annakriwz@gmail.com*
[5]*Military Educational and Scientific Center of the Air Force N.E. Zhukovsky and Y.A.Gagarin" (Voronezh) of the Ministry of Defence of the Russian Federation, volynkina_n@mail.ru*

1. Introduction

Creation of an effective national innovation system (NIS) is the most important task of the scientific, technological and innovation policies of each state. The national innovation system is defined as a set of interacting institutions of public and private sectors in creation, registration, storage, transfer, modification, distribution and transformation of new knowledge into technologies, goods and services consumed by society (Lundvall, 1992; Freeman, 1995; Nelson, 1993; Metcalfe, 1995; OECD, 1997).

In the first part of this study, theoretical concepts of NIS are highlighted. The second part of the article presents results of the analysis of the world practice of NIS development using the example of leading countries of innovative development: Great Britain, Germany, USA, Canada, Japan, France and Italy. Particular attention is paid to the innovation development model a country belongs to: The Euro-Atlantic, East Asian and "triple helix" one. The final part of the work presents comparative studies of the innovation systems of selected countries, as well as analysis of the current and prospects for the future development of innovation system in Russia.

2. Literature Review and Methodology

The concept of national innovation systems was developed in parallel in Europe and the United States in the 1980-1990s. Great contribution to this process was made by the English economist Freeman (1995), the Danish scientist Lundvall (1985) and the American researcher Nelson (1993). In recent years, the NIS concept has become more popular, and new directions that emphasize the system characteristics of innovation, but focus not on the state (national) level, but on other levels of economy, have been emerging (Lundvall, 2007; Ivanova *et al.*, 2017a; 2017b).

Lundvall (1992) formulated the notion of a national innovation system as follows: *"These are relationships and elements that interact in production, dissemination and use of new and economically useful knowledge ... and are located within the boundaries of the state"*. The main elements of NIS are economic entities that, under the existing institutional conditions, based on their interaction on creation, storage, transfer, modification, dissemination and transformation of new economically useful knowledge into technologies, products and services consumed by society, ensure the growth of competitiveness of the national economy.

Models of innovative development: The NIS of the leading innovative countries have three basic models of innovative development: "Euro-Atlantic", "East Asian" and "triple helix".

- *The Euro-Atlantic model* is aimed at supporting a full innovative cycle that lasts from the moment of the emergence of an innovative idea to the mass production of a finished product (Sergeev *et al.,* 2008). Full innovation cycle is determined as consistent transformation of the idea into a product, passing the stages of fundamental,

applied research, design development, marketing, production, sale, which eventually creates conditions for widespread goods consumption. Innovation systems of this type have both developed fundamental science, and applied developments based on its achievements, close to production processes, as well as engineering.

- *The East Asian type* is characterized by the absence of stages of formation of fundamental ideas at the early stages of the innovation cycle (Sergeev *et al.,* 2008). The increase in the export of high-tech products in such countries was expected due to active borrowing of technologies abroad, from the countries-representatives of the "Euro-Atlantic" model and the "triple-helix" model.
- *The "triple-helix" model* (Etzkowitz and Leydesdorff, 2000) assumes that the three elements - the state, science and entrepreneurship - must be in continuous interaction, often adopting each other's functions. This can be partly seen on the example of expanding the functions of universities, initially focused primarily on education, but over time, scientific research was also added to functions, and recently - commercialization of research and development results.

3. Results and Discussion

3.1 Comparative analysis of national innovation systems of the BRICS countries

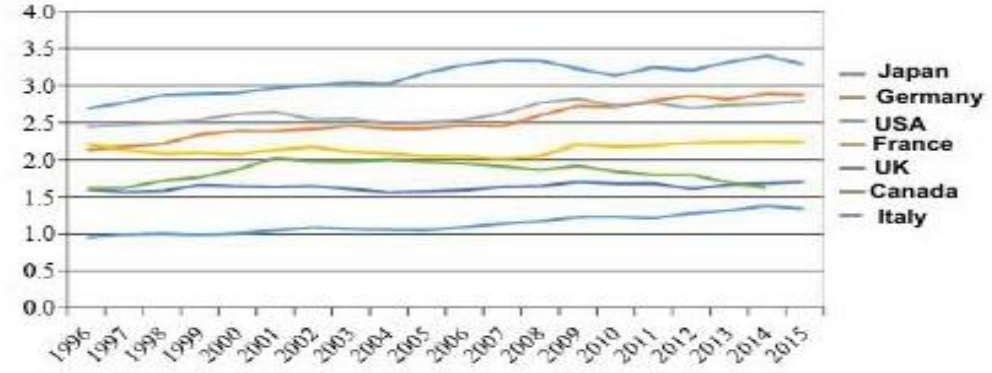
Today, all the countries of the Group of Seven (G-7), actively cooperate in the field of research and development. Differences among these countries' policies are in their belonging to different models of the innovation system. For countries such as the UK, Germany, Italy and France, typical is the Euro-Atlantic model of innovative development, assuming that all elements of the innovation cycle exist: research and development, development of prototypes and launch of mass production. Innovation systems of the developed countries of the American continent, in particular Canada and the United States, are characterized by the "triple helix" model. This model is of great importance for the development of the economy, because it is based on the generation of knowledge through active cooperation of universities and business with substantial state support. The East Asian model of innovative development is typical for the countries of the East Asian region. Japan is considered a classic example of the East Asian model, where the latest technologies are not only developed in the country itself, but are also borrowed from other countries.

Among the G-7 countries, two vectors can be distinguished, depending on which research is given more attention: fundamental or applied. The UK and France are betting on fundamental research, the rest of the countries are for the applied research. Unlike other G-7 countries, in Japan, the Government determines the priority areas for the development of science, technology and innovation, and then actively finances projects implemented within the framework of established directions. Most of the state funding goes to state laboratories and research centers. Thus, Japan has a model of an innovation system in which the state plays a central role. In the US, many elements of the private model are used, and market incentives for the development of science and

technology are stronger than in many other states. In other countries, these principles are used in combination.

One of the indicators of innovative development of countries is used as the expenditure on science and technology as percent of GDP. Japan was the leader in this indicator in 1994-2016 - the share of such expenditure in its GDP in 2016 was 3.14% (Figure 1). The second place in the last six years was taken by Germany (2.94% in 2016), the third by the USA (2.74% in 2016). The lowest share of science and technology in GDP in the period 1994-2016 was for Italy (1.29% in 2016). It is noteworthy that a high share of expenditures on science is simultaneously observed in countries with different models of NIS.

Figure 1. *Share of GDP in countries attributable to science and technology, %*



Let's consider the structure of expenditure on R&D according to sources of financing (Table 1). Most of the funding for research and development in the G-7 countries comes from the private business sector. In Japan, business plays the most significant role in financing R&D among all analyzed countries, about 78% (Eurostat) fall on it. A relatively high level of state activity is typical for Italy, where the state's contribution is 38% of the total expenditure on R&D (Eurostat). Also noteworthy are significant shares of the private non-profit sector (4.9%) and foreign funds (17.1%) in expenditures on research and developments in the UK, offsetting relatively small business contribution (Eurostat). In Canada, unlike in other countries, a significant portion of expenditures on R & D is provided by educational institutions (10.3%) (Eurostat).

Table 1. *Comparative analysis of the structure of R&D financing in the G-7 countries*

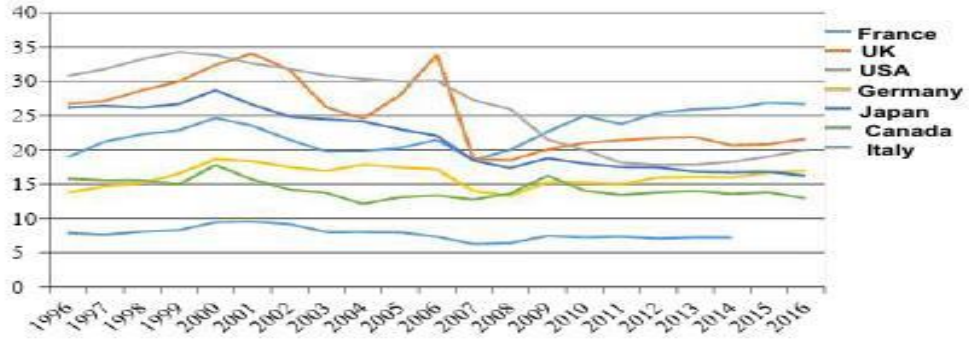
#	Feature	UK	Germany	France	Italy	Canada	USA	Japan
1	**NIS model**	"Euro-Atlantic"				"Triple Helix"		"East Asian"
2	Level of state activity in financing R&D	■■□	■■□	■■■	■■■	■■■	■■□	■□□
3	Level of entrepreneurial activity in financing R&D	■□□	■■□	■□□	■□□	■□□	■■□	■■■

4	Level of activity of the education sector in financing R&D	■□□	□□□	■□□	■□□	■■■	■□□	■■□
5	Level of activity of the private non-profit sector in financing R&D	■■■	■□□	■□□	■■□	■■■	■■■	■□□
6	The degree of participation of foreign sources in financing R&D	■■■	■■□	■■□	■■□	■■□	■□□	■□□

Note: *The table uses the following conventional symbols: □□□ — no feature; ■□□ — relatively low degree of feature manifestation; ■■□ — average degree of feature manifestation; ■■■ — relatively high degree of feature manifestation.*

France was the leader in the share of high-tech products in the total volume of exports in 2016. The smallest share is in Italy (Figure 2), which is explained by the relatively higher level of development of such sectors of economy of this country as light industry and agriculture. Over the past twenty years, there has been a decline in the share of high-tech exports in the US, Great Britain, Japan, Canada and Italy, while in France and Germany this indicator has been growing.

Figure 2. *Share of high-tech products in the country's exports, %*



Since 2001, the largest share of payments from GDP among countries falls on Canada, the least amount of payments in relative terms in recent years is carried out by the United States (Figures 3- 4). Japan got the maximum amount of money for the use of intellectual property among the G-7 countries since 2014, from 2006 to 2013, the leader in this indicator was the United States. The least activity in this market is typical for Italy.

Over the past twenty years, the largest number of patents per capita has been registered in Japan (Figure 5). Nevertheless, in recent decades there has been a negative dynamics of patent activity in Japan. The US ranks second in this indicator, the least active positions are taken by Italy and France.

In the period 2003-2016, the articles were most actively published by residents of Canada, the United Kingdom and the United States take the second and third places in this indicator, Japan is significantly behind other countries and takes the last place (Figure 6).

Figure 3. *The volume of funds paid by residents of the country to non-residents for the use of intellectual property in % of GDP*

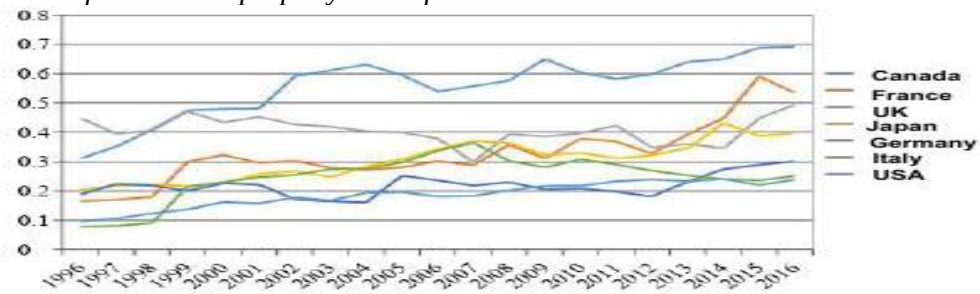


Figure 4. *The volume of funds received by residents of the country from non-residents for the use of intellectual property in % of GDP*

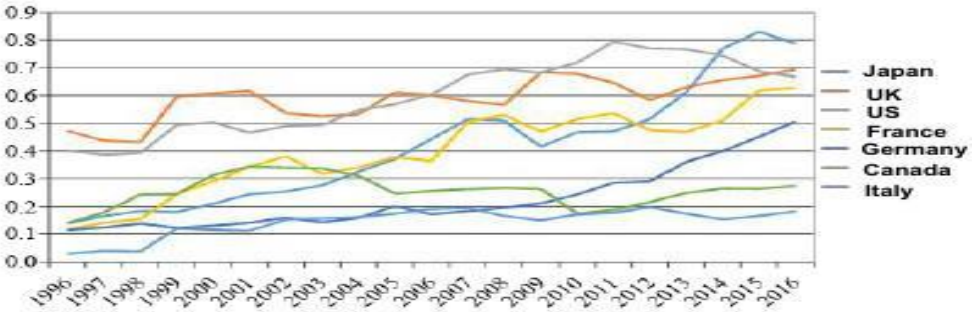


Figure 5. *Number of applications for registration of patents per year, units per 1 thousand people of the population*

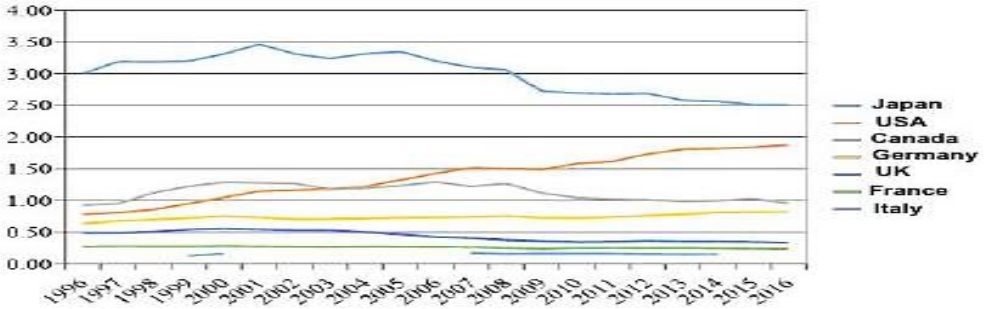
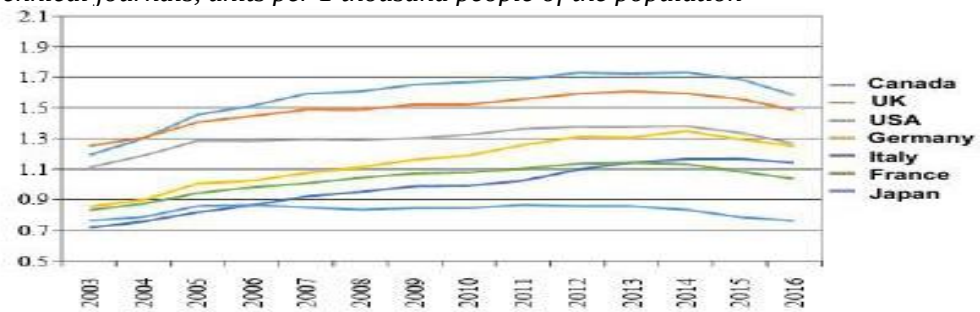


Figure 6. *Number of articles published by residents of the country in scientific and technical journals, units per 1 thousand people of the population*



One of the key tasks of the innovation system is formation of human capital (Figures 7-8). The lowest number of researchers in 1996-2015 was registered in Italy. Germany has a high share of technical specialists.

Figure 7. *Number of researchers in the field of R&D, per 1 million people of population*

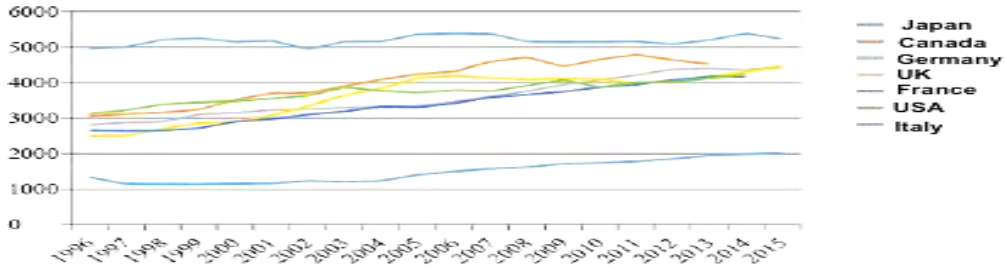
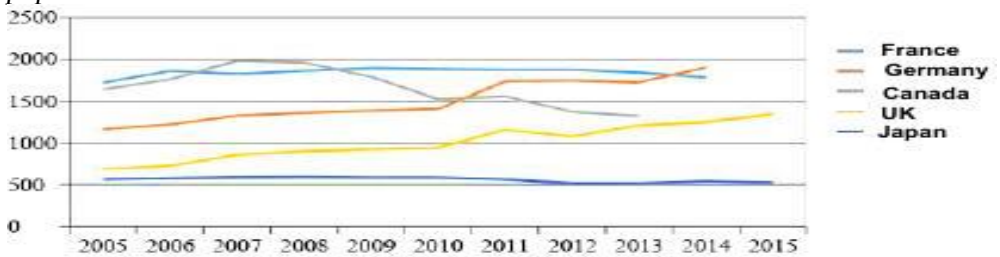


Figure 8. *Number of technical specialists in the field of R&D, per 1 million people of population*



The results of the analysis of statistical data characterizing the level of development of the innovation systems of the G-7 countries do not allow us to single out an unambiguous leader in the innovation sphere. Differences in the countries' achievements in indicators are determined by the model of innovative development.

Japan invests the largest amount of funds in relative terms in the sphere of science and technology. It is in this country that the business sector plays the most significant role in financing R&D. The interest of Japanese business in R & D, in particular in applied research, contributes to the orientation of NIS of this country mainly to applied and experimental research and development, which, in its turn, explains the leadership in the level of patent activity. The demand for the latest developments also provided Japan with the largest amount of money received from the G-7 countries for the use of intellectual property. At the same time, the level of fundamental research in the country is relatively less developed than applied science. In spite of the highest level of provision of research personnel among the countries, Japan has the smallest number of articles published per capita in the country. This is due to the specifics of innovation system of Japan and its belonging to the East Asian type of NIS.

The United States has a significant share of the world's intellectual property, which is why the country is among the leaders in the rating on the level of received payments from non-residents for the use of these assets, while paying a relatively small amount of funds to non-residents. The United States takes the second place in terms of the level of patent activity, and there is a positive dynamics of the country in this indicator. There is also an active process of publishing research results (3rd place).

France became the leader of the rating on the share of high-tech products in the country's exports. The most dynamically developing branches of France are automobile industry, pharmaceutical industry, production of telecommunications equipment and aerospace sector, and main share of French exports (about 39% in 2016 (Trend Economy 2018) fall on products and services of these industries.

Canada leads by a number of indicators:

– the number of trademarks registered in the country;
– the number of articles published by residents of the country in scientific and technical journals per capita;
– a high indicator of the availability of research personnel in the field of R&D, which confirms the fact that a significant share of employment in the country is concentrated in the scientific, technological and innovation spheres. Back in the 1940s, at the initial stage of NIS formation, a developed system of higher education was created in the country, where scientific research was carried out simultaneously with the educational process.

Italy in recent years has been losing to other countries of G-7 in most of the indicators of innovative development. The development of NIS in Italy is hampered by such factors:

– a relatively low starting level of development of the innovative part of the economy;
– insufficient inflow of qualified personnel (the country takes the last place in terms of the number of R&D researchers per capita);
– a relatively small share of usage of high technology in industry (among the countries analyzed, Italy has the smallest relative number of patents and trademarks registered, high-tech products take up the smallest share of exports);
– a volume reduction of the main funding source for R&D - government funding (Italy spends the smallest share of GDP from R&D).

Table 2 shows the latest published values of several of the best-known indices that characterize the level of innovative development for the countries analyzed.

Table 2. *Position of the G-7 countries in the world innovative development ratings*

Human Development Index	**Global Innovation Index**	**H-Index**	**Bloomberg Innovation Index**

Country	Place, the value of index in 2016	Country	Place, the value of index in 2017	Country	Place, the value of index in 2016	Country	Place in 2015
Germany	(4, 0.926)	USA	(4, 61.4)	USA	(1, 1965)	Japan	2
Canada	(10, 0.920)	UK	(5, 60.9)	UK	(2, 1213)	Germany	3
USA	(10, 0.920)	Germany	(9, 58.4)	Germany	(3, 1059)	USA	6
UK	(16, 0.909)	Japan	(14, 54.7)	France	(4, 966)	France	9
Japan	(17, 0.903)	France	(15, 54.2)	Canada	(5, 963)	UK	10
France	(21, 0.897)	Canada	(18, 53.7)	Japan	(6, 871)	Canada	12
Italy	(26, 0.887)	Italy	(29, 47.0)	Italy	(7, 839)	Italy	24

None of the existing NIS models of foreign countries can be fully applied when forming and developing Russia's innovative system, but experience of the use of separate measures to support innovation activities deserves attention, such as:

– support for priority research areas (fundamental and, in particular, applied) - most typical for countries in which the Euro-Atlantic model of innovative development and the "triple helix" model are implemented;
– improvement of legal support is a process actively pursued in a number of countries implementing the Euro-Atlantic model;
– tax incentives, widely used to support innovation in Germany, Italy and the United States;
– development of measures in the field of migration policy is a characteristic feature of - creation and development of innovative infrastructure (technology parks, business incubators, technology innovative zones, clusters). The developed innovative structure is a characteristic feature of the state, oriented towards the "triple helix" model;
– financing (venture funds, loans, innovative vouchers, public funding) is an active measure of US innovation policy.

3.2 Development of the national innovation system of Russia

Today there is a significant gap between Russia and the G7 countries in terms of the level of innovative development. Thus, according to the calculations of the Innovative Development Index in 2017, Russia ranks 45th (Cornell University, INSEAD, and WIPO, 2017), in the countries' ranking of the Human Development Index in 2016 it takes 49th place (UNDP, 2016), by Hirsch Index in the same period – 22nd place (Scimago Journal & Country Rank). It determines the need to study and adapt the best foreign experience. However, some progress can be observed:

– the share of publications of Russian researchers in the scientific journals of the WEB of Science database exceeded the forecasted value and reached 2.5% by 2017 (Report…for 2013-2020, 2018);

– the proportion of young researchers under the age of 39 exceeded 41% (Report…for 2013-2020, 2018).

But increasing of investment attractiveness of scientific, scientific and technical and innovative activities, expressed in the growth of investments in R&D, have not yet been resolved. The total investment in research and development in the country in 2017 was about 1.1%. In accordance with the Strategy of scientific and technological development of the Russian Federation, it is expected that this indicator will reach 2% by 2035 (1.7% by 2030). In Russia, according to data for 2015, contribution to research and development was about 69.5% of the total amount of funds invested in R&D. The contribution of business is estimated as 26.5%, educational institutions - 1.2%, private non-profit organizations - 0.2%, 2.6% come from foreign countries (Eurostat). This structure of expenditures differs significantly from the practice of world leaders in innovative development, where business plays a significant role in financing R&D expenditures.

Currently, Russia is developing a new State program "Scientific and technological development of the Russian Federation", designed for the period until 2030. Implementation of the Program involves the following measures:

– allocation of additional funding for R&D;
– creation of new institutions engaged in research and development;
– provision of scientific and technological communication;
– creation of an advanced infrastructure of research and development, innovative activities (establishments of "megascience" class, collective use and unique scientific centers, experimental and small-scale production centers);
– creation of a network of world-class science centers;
– updating not less than 50% of the instrument base (Decree of the President of the Russian Federation No. 204 2018) and providing new institutions with equipment;
– support from manufacturers of high-tech products;
– creation of digital platforms for participants of scientific and technological development;
– creation and support of functioning of the National Technological Initiative centers;
– attraction of foreign leading scientists and young promising researchers, targeted improvement of working conditions for Russian leading scientists and young researchers (including programs to support targeted mobility and grant support).

4. Conclusion

Analysis of the experience of the G-7 countries has shown that the national innovative system of each state has features related to the specificity of its historical, geographical and socio-economic conditions. But the priorities are similar: the desire to form a

single scientific space, openness and flexibility. Besides, the importance of the influence of innovation policy on the socio-economic system as a whole is noted, primarily, on the increase of the level and quality of life of the population. World experience shows that regulation measures of the innovation system should be applied in a complex, cover all stages of the life cycle of innovative products, while each stage requires specific, adequate forms of support.

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References:

Benešová, D., Kubičková, V., Michálková, A., Krošláková, M. 2018. Innovation activities of gazelles in business services as a factor of sustainable growth in the Slovak Republic. Entrepreneurship and Sustainability Issues, 5(3), 452-466, https://doi.org/10.9770/jesi.2018.5.3(3)

Cornell University, INSEAD, & WIPO. 2017. The Global Innovation Index 2017: Innovation Feeding the World. Available at: https://www.globalinnovationindex.org/gii-2017-report.

Decree of the President of the Russian Federation No. 204. 2018. On national goals and strategic tasks for the development of the Russian Federation for the period until 2024, Available at: http://publication.pravo.gov.ru/Document/View/0001201805070038

Etzkowitz, H., Leydesdorff, L. 2000. The Dynamics of Innovation: From National Systems and "Mode 2" to a Triple Helix of University–Industry–Government Relations. Research Policy, 29(2), 109-123.

Eurostat. n./d. Science, Technology and Innovation Database. Available at: http://ec.europa.eu/eurostat/data/database.

Fomina, A.V., Berduygina, O.N., Shatsky, A.A. 2018. Industrial cooperation and its influence on sustainable economic growth, Entrepreneurship and Sustainability Issues, 5(3), 467-479, https://doi.org/10.9770/jesi.2018.5.3(4).

Freeman, C. 1995. The National System of Innovation in Historical Perspective. Cambridge Journal of Economics, 19(1), 5-24.

Hilkevics, S., Hilkevica, G. 2017. New information technologies use for Latvian stock companies financial health evaluation, Entrepreneurship and Sustainability Issues, 5(2), 178-189, https://doi.org/10.9770/jesi.2017.5.2(1).

Ivanova, B.O., Romanova, F.T., Kostoglodova, D.E and Romanov, G.D. 2017a. Strategic Directions of the Country's Ensuring Financial Security. European Research Studies Journal, 20(3B), 461-468.

Ivanova, A.E., Mackaev, M.M., Platonova, K.T., Elagina, V.N. 2017b. Theoretical Basis for Composition of Economic Strategy for Industry Development. European Research Studies Journal, 20(1), 246-256.

Kantemirova, M.A., Dzakoev, Z.L., Alikova, Z.R., Chedgemov, S.R., Soskieva, Z.V. 2018. Percolation approach to simulation of a sustainable network economy structure, Entrepreneurship and Sustainability Issues, 5(3), 502-513, https://doi.org/10.9770/jesi.2018.5.3(7)

Lundvall, B.A. 1985. Product Innovation and User-Producer Interaction. Aalborg, Aalborg University Press.

Lundvall, B.A. 1992. National Systems of Innovation. Towards a Theory of Innovation and Interactive Learning. London, Pinter Publishers.

Lundvall, B.A. 2007. National Innovation Systems: Analytical Concept and Development Tool. Industry and Innovation, 14(1), 95-119.

Metcalfe, S. 1995. The Economic Foundations of Technology Policy: Equilibrium and Evolutionary Perspectives, in Stoneman, P. (Ed.). Handbook of the Economics of Innovation and Technological Change. Cambridge, Blackwell Publishers, 409-512.

Nelson, R. 1993. National Innovation Systems: A Comparative Analysis. New York, Oxford University Press.

OECD. 1997. Diffusing Technology to Industry: Government Policies and Programms. Paris, OECD.

Ragulina, Y.V., Semenova, E.I., Zueva, I.A., Kletskova, E.V., Belkina, E.N. 2018. Perspectives of solving the problems of regional development with the help of new internet technologies, Entrepreneurship and Sustainability Issues, 5(4), 890-898, https://doi.org/10.9770/jesi.2018.5.4(13).

Report on the implementation and effectiveness evaluation in 2017 of the State Program of the Russian Federation "Development of Science and Technology" for 2013-2020. 2018. Available at: http://minsvyaz.ru/ru/documents/5135/

Scimago Journal & Country Rank. n./d. Available at: http://www.scimagojr.com/countryrank.php?order=h&ord=desc&year=2016

Sergeev,V., Alekseenkova, E., Nechaev, V. 2008. Paradigms of Social Development. The Journal of Political Theory, Political Philosophy and Sociology of Politics Politeia, 4(51), 6-22.

Trend Economy. 2018. International trade statistics. Available at: http://data.trendeconomy.ru/dataviewer/trade/statistics/h2?reporter=Sweden,France&trade_flow=Import,Export

UNDP. 2016. Human Development Report 2016. Human Development for Everyone. Available at: http://hdr.undp.org/sites/default/files/2016_human_development_report.pdf

Žižka, M., Valentová, V.H., Pelloneová, N., Štichhauerová, E. 2018. The effect of clusters on the innovation performance of enterprises: traditional vs new industries, Entrepreneurship and Sustainability, 5(4), 780-794, https://doi.org/10.9770/jesi.2018.5.4(6).