



## The Methods of National Innovation Systems Assessing

Svetlana S. Kudryavtseva<sup>1\*</sup>, Alexey I. Shinkevich<sup>2</sup>, Sofia Sh. Ostanina<sup>3</sup>, Ekaterina L. Vodolazhskaya<sup>4</sup>,  
Natalia M. Chikisheva<sup>5</sup>, Irina V. Lushchik<sup>6</sup>, Lidiya V. Shirokova<sup>7</sup>, Elmira R. Khairullina<sup>8</sup>

<sup>1</sup>Kazan National Research Technological University, Kazan, Russia, <sup>2</sup>Kazan National Research Technological University, Kazan, Russia, <sup>3</sup>Kazan National Research Technological University, Kazan, Russia, <sup>4</sup>Kazan National Research Technological University, Kazan, Russia, <sup>5</sup>Tyumen State University of Architecture and Construction, Tyumen, Russia, <sup>6</sup>Russian Foreign Trade Academy, Moscow, Russia, <sup>7</sup>Moscow State University of Mechanical Engineering, Moscow, Russia, <sup>8</sup>Kazan National Research Technological University, Kazan, Russia. \*Email: [dlogscm@kstu.ru](mailto:dlogscm@kstu.ru)

### ABSTRACT

The relevance of this problem is reasoned by the fact that the rapid acceleration of changes in the existing economic and institutional environment confronting business entities with new challenges that require new approaches and solutions which in future will also speed up innovation and modernization transformation. The purpose of the article is to develop a comparative assessment of the level of innovative development of the EU countries and Russia with the European innovation scoreboard technique. The leading approach to the study of this problem is the modeling method, allowing the level's evaluation of national innovation systems' innovative development with the help of qualitative and quantitative indicators. This paper proposes a method of matrix ranking of national innovation systems based on integral indices of expenses and benefits of innovation activity. Article submissions are of theoretical and practical significance for the development of models of innovation management, and strategy development of the state innovation policy.

**Keywords:** National Innovation System, Index of Global Competitiveness, Global Innovation Index, Intellectual Capital, Economic Growth

**JEL Classifications:** C15, F15, H43

## 1. INTRODUCTION

### 1.1. The Relevance of the Study

The main direction in implementation and support of innovation activity in the economics knowledge becomes the formation of a national innovation system, which is to carry out innovative development through the intellectual resources' and innovative competences' strengthening, creation of innovation infrastructure and their subsequent use in the production of innovative goods.

The issues of national innovation systems have been studied by many scientists: Kingston (1984), Patel and Pavitt (1994), Metcalfe (1995), Yakovec (2004), Lundvall et al. (2006). Kingston noted that innovation - "Is the process of a new idea or invention converting into socially significant products that have

fundamentally new technical and economic parameters or the transformation of ideas into concrete objects" (Kingston, 1984).

From the point of view Lundvall "national innovation system is formed by elements and relations within the boundaries of the state that provides interaction in the creation, diffusion and application of new and creative knowledge" (Lundvall et al., 2006).

Patel and Pavitt define the national innovation system as "a system of incentives and competences of national institutions on the basis of which the main trajectories of technological learning in a country are defined" (Patel and Pavitt, 1994).

Institutional approach to the definition of the national innovation system can be traced by the S. Metcalfe - "The set of institutions that contribute to the creation and use of new technologies and

creating the conventional boundaries in which the authorities implement national science, technology and innovation policy” (Metcalfe, 1995).

Kuzyk indicates the unity of the hierarchical, functional and support structures in the national innovation system. To the hierarchical structure, the researcher refers the levels of innovative activity - From local to global; to functional subsystems - Forecasting and selection of priorities, strategic planning and programming, evaluation and selection of innovative ideas and inventions, innovative transformation of inter-branch complexes and territories, the integration of innovative projects; to provision subsystems - Legal, financial, human resources, information technology, management and organizational structure (Yakovec, 2004).

According to Yakovec definition, innovation - “Is the introduction into various types of human activity of new elements that increase the effectiveness of this activity.” It is noted that the concept of innovation is multifaceted and its understanding is not so easy as it seems. The author highlights the “edges” or hypostasis of innovations (Yakovec, 2004).

1. The incentives to innovations. Yakovec notes that it is not necessary to refer everything only to the enterprising nature of man, the desire to disrupt the established routine. According to the author, the main motivation for innovation is increasing human needs and the competition for their best satisfaction. Yakovec concludes that innovation - “Is a general sociological pattern, the engine and the force motive of the society progress in all diversity.”
2. The sources and initiators of innovations. The initiators include:
  - Scientists, revealing new laws of nature, society and technology development, as well as proposing ways of new knowledge use
  - Inventors, offering innovations, methods to use it at practice and protecting their intellectual property through patents
  - Entrepreneurs, managers, investors, bankers, developing new forms of company management or investing in the implementation of innovations
  - Representatives of creative professions, developing the spiritual sphere of society: Musicians, writers, filmmakers, educators, etc.
  - Political and public figures, creating new forms of political life organization, political parties, legal norms, intergovernmental relations
  - Commanders, offering more efficient ways of warfare, using weapons.
3. The level of novelty of innovations. In general, the term “innovation” means phenomena of very different nature, the level of novelty and the scale of their introduction consequences: The epochal, basic, improving, micro-innovations, pseudo-innovations, anti-innovations.
4. The types of innovations. According the sphere of their usage the classification is proposed: Technological, environmental, economic, socio-political, state-legal, innovations in the

spiritual sphere, military and in law sphere.

5. Spatial sphere of innovations. Depending on the level of novelty the innovations have different spatial distribution. Epochal and basic innovations, spreading from the epicenter, gradually cover the whole territory inhabited by people. The action field of improving innovations may be restricted by the territory of the region, city. Micro-innovations (the author uses here the term “dot”) are limited by the enterprise, group of people (Yakovec, 2004).

## 2. METHODOLOGICAL FRAMEWORK

### 2.1. Methods of Study

During research following methods were used: Analysis, synthesis, system analysis, systematization and generalization of facts, modeling, positioning, cluster analysis, comparison, description, analogies.

### 2.2. Theoretical Base of the Study

The theoretical basis of the study is formed of basic and applied work of foreign and domestic scientists, exploring innovative development of economic systems involved in the development of management tools of innovation and modernization of the economy.

### 2.3. Stages of the Study

The study was conducted in three stages:

- At the first (preparatory) phase, the current state of the studied problem in the theory and practice of innovation management was analyzed; the program of research methodology was developed.
- At the second stage - The main stage - On the basis of statistical data the analysis of countries by global competitiveness index and global innovation index was carried out; the technique of national innovation systems’ positioning by integral indices of costs and benefits of innovation activity through European innovation scoreboard (EIS) was presented.
- At the third stage - The final stage - The systematization, interpretation and synthesis of the research results was carried out; theoretical conclusions were refined; the obtained results were processed and their registration was fulfilled.

## 3. RESULTS

### 3.1. International Comparisons of National Systems’ Innovation Development

The statistics of innovations is based on the following global principles:

- Consistent coverage by statistical observation of different economic activities and types of innovation.
- The development and use of a unified conceptual apparatus, the provision of the innovation activity indicators’ relationship and continuity.
- The complexity of the innovation process in the study, implying the inclusion of all its units: Research and development conducting, the introduction of innovations into practice, the yield of the products on the markets and obtaining of economic benefits.

- Provision of comparability with international standards (Oslo Manual, Unified Survey Program - EU CIS).

International comparisons of national innovation systems on the aggregate level of innovation activity of organizations has shown that in Russia this figure is below the level of Germany in 6.6 times, Sweden - 5.5 times, Japan - in 4.8 times. The intensity of expenditure on technological innovation (the share of expenditure on technological innovation in the overall volume of shipped goods, works, services) at the end of 2013 was 2.9, having increased in comparison with 2011 by 0.7 percentage points. By the intensity of expenditure on technological innovation Russia is ahead than Germany (2.12%), Belgium (1.9%), Austria (1.74%).

The share of Russian organizations that received funding from the budget for the implementation of technological innovations, following the results of 2013 was 22.9% (2011: 20.6%), which corresponds to the level of Germany - 23.7%, Poland - 23.2%, Italy 22% (Federal State of Statistics Service). However, for economic science to assess the national innovation systems it is mostly interesting to have not certain indicators of innovation, but integral variables.

### 3.2. The Global Competitiveness Index

Currently in the international community to assess the economic entities' innovative activity a variety of indicators is used. The most common of them is the global competitiveness index, global innovation index and EIS can be considered (Shurkina et al., 2015). The global competitiveness index is calculated on the base of 113 indicators reflecting the competitiveness of national economies. 70% of the variables included in the index represent qualitative data obtained from the results of a global survey of companies' top management in various sectors of the economy, while 30% - This is quantitative, formed on the basis of official statistical reports and the results of research carried out by international institutions. The variables are aggregated into 12 integrated indicators characterizing competitiveness of national economies. Among them:

- The quality of institutions
- Infrastructure
- Macroeconomic stability
- Health and primary education
- Higher education and vocational training
- Market efficiency of goods and services
- The efficiency of the labor market
- Developed financial markets
- The level of technological development
- The size of the domestic market
- Competitiveness of companies
- Innovative potential.

When creating the index on the basis of expert estimates the fact is taken into account that the states' economic development is characterized by heterogeneity that is largely determined by institutional conditions and other factors.

By the end of 2014 the leading position in the global competitiveness index were occupied by Switzerland (5.7), Singapore (5.6) and

the United States (5.54). Russia was located at the 53<sup>rd</sup> place with Index value of 4.4, which was similar to the metric value of Italy, Kazakhstan, Costa Rica, Philippines, Bulgaria and South Africa. At the same time over the past year Russia's position in the ranking has grown from 67<sup>th</sup> place in 2012 and 64<sup>th</sup> - in 2013 till 53<sup>rd</sup> place in 2014. Totally 144 countries participated in the ranking (Table 1) (The Global Competitiveness Index).

### 3.3. The Global Innovation Index

The global innovation index is compiled by International business school INSEAD in cooperation with the world intellectual property organization on the basis of 80 indicators characterizing the level of innovative activity in national economies. When calculating the index, special attention is paid to innovative capabilities and institutional conditions for its implementation, contributing to the transformation of resources into capital. The index is calculated as the scores' weighted sum of the two groups of indicators:

- Available resources and institutional conditions for innovation activity implementation (Innovation Input)

**Table 1: The ranking of countries according to the global competitiveness index**

Rating	Country	The index value
1	Switzerland	5.7
2	Singapore	5.6
3	USA	5.5
4	Finland	5.5
5	Germany	5.5
6	Japan	5.5
7	Hong Kong	5.5
8	Netherlands	5.5
9	United Kingdom	5.4
10	Sweden	5.4
51	Costa Rica	4.4
52	Philippines	4.4
53	Russia	4.4
54	Bulgaria	4.4
59	Romania	4.3
71	India	4.2
77	Croatia	4.1
144	Guinea	2.8

**Table 2: The ranking of countries on global innovation index**

Rating	Country	The value of index
1	Switzerland	64.8
2	United Kingdom	62.4
3	Sweden	62.3
4	Finland	60.7
5	Netherlands	60.6
6	USA	60.1
7	Singapore	59.2
8	Denmark	57.5
9	Luxembourg	56.9
10	Hong Kong	56.8
29	China	46.6
47	Qatar	40.3
48	Thailand	39.3
49	Russia	39.1
50	Greece	38.9
54	Turkey	38.2
128	Uzbekistan	25.2
143	Sudan	12.7

- The results obtained of innovation activity (innovation output)
- Thus, the Index allows estimate the ratio of costs and results, reflecting the efficiency of measures to foster innovation in national economies. In 2014, the Index calculation was carried out based on data for 143 countries.

According to the index of innovations as three leading countries were accounted for (Table 2) Switzerland (64.8), the UK (62.4) and Sweden (62.3). Russia in the overall ranking took the 49<sup>th</sup> place (39.1) between Thailand (48<sup>th</sup> place, 39.3) and Greece (50<sup>th</sup> place, 38.9), rising up in comparison with 2013 to 13<sup>th</sup> position. Among the BRICS, Russia takes the second position after China (the 29<sup>th</sup> place, while China's rating is now comparable with the rating of many countries with high income levels), being ahead of South Africa (57), Brazil (61) and India (76).

According to the report, the advantages of Russia's Global Innovation Index are determined by the quality of human capital (30<sup>th</sup> place), business development, knowledge and technology (43<sup>rd</sup> and 34<sup>th</sup>, respectively). Indicators of infrastructure remain at an average level (51). Factors that prevent to enhance innovation are imperfect institutions (88<sup>th</sup>), low results of creative activity (72<sup>nd</sup>) and the development of the internal market (111<sup>th</sup>) (Research INSEAD).

### 3.4. The Methods of National Innovation Systems' Assessing using Integral Indices of Innovation Activities' Expenses and Benefits

To date, the EU assesses the level of innovative development of national economies on the methodology of the EIS, according to which the indicators are grouped in three units:

- The unit of "Innovation potential" is characterized by the "drivers" of innovation development and includes three sub-units - the "human resources," "public research system" and "financing and state support," consisting of 8 indicators.
- Unit "activities of companies" includes a selection of three subunits ("Investment of Companies," "Cooperation and Entrepreneurship," "Intellectual Assets"), covering 9 indicators.
- The unit Benefits (the results) reflects the results of innovative activities of businesses' entities and integrates eight indicators in the two sub-units: "Innovators" (the number of organizations using the technology, marketing and organizational innovations) and "economic effects" (the level of employment in the innovation sector, exports and sale of innovative goods and services) (Innovation Union Scoreboard).

To evaluate the efficiency of innovations according the ratio of expenses and benefits of innovative activity seems feasible by using matrix of national economies' positioning (on the example of EU countries and Russia) according to the principle "expenses - benefits." The Russian economy can be described by all the indicators of the EIS based on official statistical data. In this case, the integral index of the innovation activities' expenses will be shown in the performance units "Innovative capacity" and "Activity of companies" and the integral index of the innovation activities' benefits - by indicators of the block "benefits (results)."

To convert the innovation activities' expenses and benefits indicators into a single integral value it is proposed to use the regression model, where the exogenous variable would be the volume index of gross domestic product (GDP), and endogenous variables - Indicators on the block "expenses" and "benefits," respectively. When modeling the dependence of the physical volume's index of the country's GDP from the innovative activities' expenses and benefits, from the beginning partial correlation coefficients and their significance level for units have been calculated: "human resources," "public research systems," "financing and state support," "investment of companies," "cooperation and entrepreneurship," "intellectual assets," "innovators," "economic effects." The results of the correlation analysis has allowed to establish that in the unit "innovators" there is a high direct correlation between indicators of "organizations engaged in technological innovations - organizations engaged in organizational and marketing innovations" and a statistically significant coefficient of pair correlation is 0.8. In order to avoid the effect of multicollinearity the index "organizations engaged in organizational and marketing innovation" was excluded from the model, which is less linked to an exogenous variable (coefficient of pair correlation with the index of physical volume of GDP amounted to 0.11) (Kudryavtseva et al., 2015; Sabirov et al., 2015).

Further on the basis of regression models indicators' weights values were calculated in units "expenses" and "benefits" of innovation activity, which formed the basis of positioning matrix of national economies. With integral evaluation of the expenses and benefits of innovative activity in the national economic system, countries' matrix ranking can be constructed in which the integral index of the expenses and the integral index of the benefits of innovation activities are located, respectively, on the axes of abscissa and ordinate. The distribution series medians of integral estimations of the expenses and benefits of innovative activity divide the matrix positioning into four quadrants (Kudryavtseva and Shinkevich, 2015).

The first quadrant includes states in which the expenses and benefits of innovative activity are characterized by high indicators, exceeding the median value (Germany, Austria, Sweden, Switzerland and others). A characteristic feature of these countries is the matching of financial, informational, intellectual, material resources, and created innovative products, technologies, services.

The second quadrant is represented by countries in which prevail high expenses of innovation activity however the benefits obtained in the form of innovative goods are less than its average value in the European Union (Norway, Estonia and Iceland). Innovation systems of these countries are characterized by the accumulation of innovative resources without further transformation into an innovative capital. There is a discrepancy between the level of research and education and financial sectors of the economy to the level of innovative activity in industry and services. State scientific-technical and innovation policy of these countries is aimed at supporting knowledge-intensive, high-tech sectors of economy, however, the results of this work manifest themselves fragmentally. In the third quadrant there are countries with low integral indices of expenses and benefits of innovative activity:

Turkey, Bulgaria, Russia, Romania and others. Institute of innovative activity, innovative infrastructure, financial market development, high-tech sectors' development in industry and information economy in comparison with other European countries are in the early stages of the life cycle, which largely increases the gap in the innovation development between them and the leading countries in innovative development. In the fourth quadrant countries are united in which the integral indices of innovative activities' expenses and benefits with the median values, or with a slight excess of the integral index of the benefits: Czech Republic, Slovakia, Malta and others. The main task in the field of science, technology and innovation policies for national economies, included in the fourth quadrant, is the formation of triple helix model of innovations, and strengthening the integration between science, business and government. Intensification of the work in this direction will contribute to the movement of the fourth quadrant countries into the first one marked with leadership positions in the field of innovation development. The opposite option – when weak incentives to innovative entrepreneurship of the state will not enhance innovative capacity and its transformation into innovation capital, which, consequently, will lead to a reduction of expenses and benefits of innovative activity.

#### 4. DISCUSSIONS

At the final stage of the study it is expedient to carry out the grouping of countries by level of innovative development, using the technique of cluster analysis. For example, in terms of innovative development based on integrated indices of innovative activities' expenses and benefits Russia forms a cluster with Turkey, Croatia, Serbia, Bulgaria, Romania and Latvia. The method of cluster analysis in determining the strategic position of the national innovation system can be used to develop the state scientific-technical and innovation policy.

Thus, in the innovation economy, the main challenge is not so much in increasing of the intellectual, institutional, financial resources as their transformation into innovation capital, expressed in the growth of innovative products, technologies, services demanded by society. At the same time the dominant role in creating the appropriate institutional conditions for such transformations belong to the state, which through formal and informal mechanisms may affect the structural elements of the national innovation system, achieving sustainable innovative growth of the economy.

In the study of national innovation systems, identifying the position of the country is crucial. Using matrix ranking the countries' position by the innovative activities' expenses and benefits was determined as well as their consistency/discrepancy to each other. Definition of the strategic position of the country can serve as a basis for research and developments in the field of public innovation policy. Combining of national innovation systems in homogeneous groups lead to better understanding of the logic and their development trends, as well as to the effectiveness of the state innovation policy. This method is widely used for comparative analysis and preliminary assessment of the level of national innovation systems' development.

The previous researches, which were made by Kingston (1984), Patel and Pavitt (1994), Metcalfe (1995), Yakovec (2004), Gumerov et al. (2015, 2016a, 2016b), Kharisova et al. (2015), Malysheva et al. (2016) and others are devoted to the study of innovation systems.

However, the analysis of scientific research on the issue of integrated methods to assess the level of national innovation systems' development is not structured and has a debatable character.

#### 5. CONCLUSION

It is found that the comparative assessment of the level of innovative development of the European Union countries and Russia should be based on the methodology of the EIS. Indicators that reflect the level of development of innovative economy are combined into three units: The unit "innovative potential" describes the "drivers" of innovative development and includes three sub-units ("human resources," "public research systems" and "funding and state support," consisting of 8 indicators); unit "activities of companies" consists of three sub-units ("investment of companies," "cooperation and entrepreneurship," "intellectual assets," covering 9 indicators); unit "benefits (the results)" reflects the results of innovative activities of businesses and integrates eight indicators in the two sub-units ("innovators" [the number of organizations using the technology, marketing and organizational innovations] and "economic effects" [the level of employment in the innovation sector, exports and sale of innovative goods and services]). A method for matrix positioning of national innovation systems is proposed based on expenses and benefits integrated indices of innovation activity: 1<sup>st</sup> Quadrant - high values of the expenses on innovations correspond to a high benefits from innovation activity; quadrant 2<sup>nd</sup> - The high expenses on innovation and poor benefits; quadrant 3<sup>rd</sup> - low expenses and benefits on innovation; 4<sup>th</sup> quadrant - integral indices of expenses and benefits of innovative activity correspond to the median values, or have a slight excess of the integral index of the benefits.

Article submissions have theoretical and practical significance for the development of models of innovation management, and the development of strategy of the state innovation policy. Taking into account the obtained results of this study a number of research challenges and promising directions for further consideration can be identified: Deepening and extension of certain provisions contained in the article and related to the assessment of the level of national innovation systems' development.

#### REFERENCES

- Federal State of Statistics Service. Available from: <http://www.gks.ru>.  
 Gumerov, A.V., Pavlova, A.V., Kharisova, G.M., Abdullina, S.N., Matveeva, E.S., Vyukov, M.G. (2015), The role of the quality production process of the business entities in volatile environment. *Asian Social Science*, 7(1), 200-206.  
 Gumerov, A.V., Biktemirova, M.K., Babushkin, V.M., Nuryakhmetova, S.M., Moiseev, R.E., Nikolaeva, A.B., Kharisova, R.R., Rukomoinikova, V.P. (2016a), Quality functions

- modeling of industrial enterprises products. *International Review of Management and Marketing*, 6(1), 165-169.
- Gumerov, A.V., Ryabinina, E.N., Minsabirova, V.N., Temirbulatov, R.R., Mitrofanova, M.Y., Litvinova, E.M., Makhotkina, L.Y., Kharisova, G.M. (2016b), The analysis of regional development on the basis of corporate structures' activity. *International Review of Management and Marketing*, 6(1), 101-105.
- Innovation Union Scoreboard. Available from: <http://www.seuropa.eu>.
- Kingston, W. (1984), *The Political Economy of Innovation (Studies in Industrial Organization)*. New York: Springer. p272.
- Kharisova, R.R., Kiselev, S.V., Chikisheva, N.M., Rudenko, L.G., Astafyeva, I.A., Grankina, V.L., Khabibullina, L.V. (2015), Methodological approaches to assessing the regulatory impact of the state in the innovation development sphere of market services. *Journal of Sustainable Development*, 8(3), 194-202.
- Kudryavtseva, S.S., Shinkevich, A.I. (2015), An institutional approach to intellectual capital in public innovation systems. *Proceedings of the 3rd International Conference Innovation Management and Corporate Sustainability*. p142-150.
- Kudryavtseva, S.S., Shinkevich, A.I., Shvetsov, M.Y., Bordonskaya, L.A., Gorlachev, V.P., Persidskaya, A.E., Schepkina, N.K. (2015), National open innovation systems: An evaluation methodology. *Journal of Sustainable Development*, 8(6), 270-278.
- Lundvall, B.A., Intaracumnerd, P., Vang, J. (2006), *Asia's Innovation System in Transition*. USA: Edward Elgar.
- Malysheva, T.V., Shinkevich, A.I., Kharisova, G.M., Nuretdinova, Y.V., Khasyanov, O.R., Nuretdinov, I.G., Zaitseva, N.A., Kudryavtseva, S.S. (2016), The sustainable development of competitive enterprises through the implementation of innovative development strategy. *International Journal of Economics and Financial Issues*, 6(1), 185-191.
- Metcalfe, S. (1995), The economic foundations of technology policy: Equilibrium and evolutionary perspectives. In: Stoneman, P., editor. *Handbook of the Economics of Innovation and Technological Change*. Cambridge, USA, Blackwell Publishers.
- Patel, P., Pavitt, K. (1994), The nature and economic importance of national innovation systems. *STI Review*. Paris: OECD. p14.
- Research INSEAD. The Global Innovation Index. Available from: <http://www.gtmarket.ru/news/2014/07/18/6841>.
- Sabirov, I.T., Ponkratova, L.A., Gracheva, N.A., Kiselev, S.V., Fatikhova, L.E., Chudnovskiy, A.D. (2015), The formation and development trends of the consulting market in Russia. *Mediterranean Journal of Social Sciences*, 6(2S3), 188-195.
- Shurkina, E.Y., Petrova, E.V., Petrova, G.D., Shirokov, L.V., Astaf'eva, I.A., Gatsenbiller, N.Y., Kharisova, G.M., Masalimova, A.R. (2015), Designing a model of interaction of economic resources in the quantization conditions of economic area. *Mediterranean Journal of Social Sciences*, 6(2S3), 129-135.
- The Global Competitiveness Index. Available from: <http://www.gtmarket.ru/ratings/global-competitiveness-index/info>.
- Yakovec, Y.V. (2004), *Epochal Innovations of the XXI Century*. Moscow: Economics. p10.