

Method for Assessing of the Level of National Innovation Systems Openness from the Institutional Approach Perspective

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ABSTRACT

The relevance of the presented problem is conditioned by the fact that the rapid acceleration of changes in existing economic and institutional environment raises the need to develop new theoretical-methodological and practical approaches to solve problems to achieve sustainable economic growth. The purpose of the paper is to develop methods for the assessment of open national innovation systems based on the use of the institutional approach. The paper suggests methodology to estimate the level of openness of national innovation systems (NIS) based on formal and informal institutions of innovative development. The ranking is built of EU countries and Russia under the integrated indicator of the openness of the NIS. Main characteristics of NIS from the perspective of the institutional approach are allocated. The paper presents the theoretical and practical significance for the development of models to manage open innovations, and for the development of strategy of the state innovative policy.

KEYWORDS

National innovation system, open innovations, assessment of the level of the NIS openness, institutional approach, formal and informal institutions, innovative development

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Introduction

The relevance of the study

Tendencies in socio-economic and innovative development of world economies in the last decade show that in the conditions when processes of competition and globalization are strengthening, the most promising form for

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cooperation between business entities is the transition to models of open innovation. The paradigm of open innovations determines the possibility and necessity to use external ideas and knowledge along with internal sources of innovation by companies. Open innovation combines internal and external ideas into architecture and certain systems and means that companies use external ideas and technologies, and their own unused ideas provide to other companies. This requires that each company would do open its business model, thereby organizing bilateral flows of knowledge, information, ideas and innovations: from the external environment into the company and from the internal environment to the outside (Shurkina et al., 2015). Thus, the open innovation is a known information from a variety of public sources about the essence and application of innovations.

The main direction of innovative activities' implementation and support in the knowledge economy is the formation of the national innovation system, which must implement innovative development through increasing of the intellectual resources and innovative competences, creation of innovative infrastructure and their subsequent use in the manufacture of innovative goods.

The issues of national innovation systems were studied by many scientists: W. Kingston (1984), P. Patel & K. Pavitt (1994), S. Metcalfe (1995), Y.V. Yakovec (2004), B.A. Lundvall, P. Intaracumnerd & J. Vang (2006), P. Romer (1992).

W. Kingston (1984) notes that innovation "is the process of new ideas' or inventions' converting into socially significant products with fundamentally new technical and economic parameters or ideas' transforming into concrete objects".

According to point of view of B.A. Lundvall, P. Intaracumnerd & J. Vang (2006), "national innovation system is formed of elements and relations within the state's borders that enable collaboration in the creation, diffusion and application of new and creative knowledge".

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

Institutional approach to the definition of the national innovative system can be traced in S. Metcalfe (1995) – "it is a set of institutions that contribute to the creation and use of new technologies and create conventional boundaries in which the state authorities carry out national scientific-technical and innovative policy".

B. Kuzyk indicates the unity of the hierarchical, functional and providing structure in the national innovation system. To the hierarchical structure the researcher refers the levels of innovative activities – 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 integrative innovative projects; to providing subsystems – legal, financial, personnel, information support, management and organizational structures (Yakovec, 2004).

According to the definition of Y.V. Yakovec (2004), innovation "is the introduction to a variety of human activities of new elements that enhance the performance of these activities." It is noted that the concept of innovation is

multifaceted and its understanding it is not as easy as it seems. The author points out "faces" or manifestations of innovations.

To issues of theory and methodology of open innovations the works are devoted of: H. Chesbrough (2007), M. Vanhaverbeke, M. Torkkeli & A. Trifilova (2010), J. West & S. Gallagher (2006), K. Kristensen & E. Skott (2008), M. Torkkeli, K. Kok & I. Savickaya (2009), D.S. Medovnikov & S.D. Rozmirovich (2011), S. Kudryavtseva et al. (2015),

S. Kudryavtseva et al. (2016a), S. Kudryavtseva et al. (2016b), T. Malysheva et al. (2016).

The theory of open innovation is based on the following fundamental principles:

- use along with internal ideas and developments of external knowledge;
- diversification of channels to the market of a new product through its own network and through the distribution system of external partners;
- the projecting of the model of "learning organization";
- the formation of a system of crowdsourcing;
- consideration of innovations as a factor of competitive advantage of national, regional economic systems, as well as individual businesses;
- support of innovation development on the basis of network cooperation and collaboration;
- achieving of high innovative activity of economic systems;
- the predominance of integrated systems of technological development ("global-linked").

Methodological Framework

Research methods

During research the following methods were used: analysis, synthesis, systems analysis, systematization and generalization of facts, simulation, comparison, description, analogies, factor and component analysis.

Theoretical base of research

The theoretical basis of the research constitute the fundamental and applied works of foreign and domestic scientists who study the innovative development of economic systems, open innovations; dealing with the modeling of regularities in the development of economic systems at the micro, mezzo and macro levels, the development of managerial tools of innovative modernization development of economics.

The stages of the research

The study was conducted in three stages:

— In the first phase – the preparatory phase, the modern condition of the problem under study was analyzed in the theory and practice of managing of open innovations; the program of the study methodology was developed;

— at the second stage – the main stage – calculation of the integral indicator of the openness of national innovation systems was carried out with the help of the author's methodology taking into account formal and informal institutions, the

characteristics of national innovation systems was presented from the perspective of the institutional approach;

— At the third stage – the final stage – systematization, interpretation and generalization of the research results were carried out; theoretical insights were refined; the processing and clearance of received research results were carried out.

Results

A synthesis of indicators for the calculation of the integral indicator of the level of national innovation systems' openness

Currently, in the world economy remains a controversial issue of the evaluation of the level of national innovation systems' openness. At this stage there is no single universal methodic. In this regard, it is proposed to use an integral indicator of the level of national innovation systems' openness consisting of the following indices:

1. The number of international scientific publications per 1 million inhabitants;
2. The share of scientific publications of the highest international level in the total volume of scientific publications in the country;
3. The proportion of doctoral students, who are not natives of the country in the total number of doctoral students in the country;
4. Medium - and high-tech exports, in % of total exports.
5. Exports of knowledge-intensive services, in % of total exports of services;
6. "New for market" and "new for firms" products (sales), in % to the total turnover;
7. Revenues from licenses and patents from abroad, in % to GDP;
8. The index of institutional regime;
9. Characteristics of the organizational culture of NIS by G. Hofstede (2008).

Components of the integral indicator of NIS openness are the indicators of the global indices of innovative development, which, in our opinion, to a greater extent in quantitative and qualitative terms characterize the level of openness of the innovation system. Thus, in the integral indicator of NIS openness the indicators of European innovation scoreboard (p. 1-7), of the Index of the knowledge economy (p. 8) and the characteristics of organizational culture by G. Hofstede (2008) are presented. Description of the methods of the European innovation scoreboard and the calculation of the Index of the knowledge economy, as well as their results are considered in the authors' works (Shinkevich & Kudryavtseva, 2014). In our opinion, the calculation of the integral indicator of NIS openness should include the cultural characteristics of States, since quality levels of organizational and national culture can be seen as informal institutions that influence innovative activity.

In the work of G. Hofstede (2008), published in 2010, data for 93 countries are given. The proposed model of organizational culture includes the following dimensions: power distancing, individualism, masculinity, avoidance of uncertainty, dynamism, and indulgence versus restraint.

However, from the presented characteristics of national culture to the level of NIS openness can be referred: power distancing, avoidance of uncertainty, dynamism, and indulgence versus restraint.

Power distancing – perceptions of power, the degree with which members of a society, institution or organization who are endowed with a relatively less power expect and accept the unequal distribution of power; cultures with great distancing from the government (Arab countries, Latin America, Southeast Asia, Russia) are characterized by the perception of power as the most important part of life, reverence for superiors; cultures with a small distancing from the government (Austria, Denmark, USA, Germany) are characterized by relations based on equality, respect for the individual.

Separateness (individualism) - as opposed to unity (collectivism) – the tendency towards personal goals, awareness of the self as "I", protection of private interests, relations between individuals, not burdened with strong commitments to act together (USA); collectivist culture (Latin America) is characterized by group purposes, awareness of themselves as "we", maintaining of relationships, norms.

Masculinity is the focus on achieving results at any cost; countries with a high value of this indicator can be referred to the "male type" (Japan, Italy, Austria, Mexico, the Philippines), they are characterized by qualities such as ambition, confidence, dedication, commitment to material values; countries with a low value (Denmark, Norway, Sweden) – to the "female type" and they are characterized by the veneration of relationships, cultural values, care about quality of life.

The avoidance of uncertainty (uncertainty avoidance) – the degree of perception and response to unfamiliar situation; for countries with a high index of uncertainty avoidance is typical to avoid uncertain, ambiguous situations, the desire to establish clear rules of behavior, trust for customs and traditions, the tendency to intra-group harmony, tolerance for people with different lifestyle and mindset; countries with low uncertainty avoidance are characterized by the manifestation of personal initiative, the acceptability of risk, calmly accepting of differences, other points of view.

Dynamism (short-term or long-term orientation for the future) – focus on the solution of strategic, long-term goals, the desire to look into the future; cultures with large values of this parameter (Southeast Asia) is characterized by thrift, perseverance to achieve goals, vitality, cultures with small value (Europe) – commitment to tradition, and fulfilling of social obligations.

Indulgence versus restraint characterizes the ability of culture to meet immediate needs and personal desires of members of society. In societies where moderation is a value, strict societal rules and norms dominate within which satisfaction of personal desires are constrained and are not encouraged.

Componential and factor analysis of indicators of integral indicator of national innovation systems' openness

In the first stage of analysis based on componential and factor analysis weights coefficients for indices and indicators included in the integral indicator of NIS openness were calculated (table 1 and 2).



Table 1. The results of highlighted main components of the integral indicator of NIS openness

	Eigenvalues	The percentage of the total variance	The accumulated eigenvalues	The accumulated percentage of the total variance
1	5,610625	46,75520	5,61062	46,7552
2	1,837219	15,31016	7,44784	62,0654
3	1,257834	10,48195	8,70568	72,5473
4	0,826890	6,89075	9,53257	79,4381
5	0,757371	6,31143	10,28994	85,7495
6	0,572106	4,76755	10,86205	90,5170
7	0,326355	2,71963	11,18840	93,2367
8	0,259565	2,16304	11,44797	95,3997
9	0,215127	1,79273	11,66309	97,1924
10	0,173687	1,44739	11,83678	98,6398
11	0,122416	1,02013	11,95920	99,6600
12	0,040804	0,34004	12,00000	100,0000

Table 2. The results of factor analysis using the principal components method for the integral indicator of the NIS openness

	Factor 1	Factor 2	Factor 3	Weight
The number of international scientific publications per 1 million inhabitants;	0,9164	-0,1504	-0,0630	3
The share of scientific publications of the highest international level in the total volume of scientific publications in the country;	0,8672	-0,1785	-0,1066	3
The proportion of doctoral students, who are not natives of the country in the total number of doctoral students in the country;	0,7326	-0,2456	0,1309	3
Medium - and high-tech exports, in % of total exports.	-0,1159	-0,7128	0,4259	2
Exports of knowledge-intensive services, in % of total exports of services;	0,6754	0,3841	0,2352	3
"New for market" and "new for firms" products (sales), in % to the total turnover;	-0,2792	-0,7918	-0,3193	2
Revenues from licenses and patents from abroad, in % to GDP;	0,7694	-0,3933	0,0877	3
The index of institutional regime;	0,8225	0,0490	0,2956	3
Power distancing	-0,6665	-0,1887	0,2398	3
The desire to avoid uncertainty	-0,7182	-0,3423	-0,2153	3
Dynamism	-0,3215	-0,1594	0,7901	1
Indulgence versus restraint	0,7763	-0,3235	-0,2521	3
The total variance	5,6106	1,8372	1,2578	
The proportion of the total variance	0,4676	0,1531	0,1048	

Thus, 12 baselines were distributed in the 3 integral factors that allowed us to assign weight to each indicator when calculating the integral indicator of NIS openness. The greatest weight – 3 was assigned to the indicators forming the

first group of factors explaining 46.8% of the variance of sign change, weight 2 – to the second group of factors explaining 15,3% of the variance in sign change and weight 1- to the third group of factors explaining 10.5% of the variance of sign change.

For calculation of integral indicator of NIS openness the formula of the weighted average arithmetic was used.

The integrated indicator of NIS openness (IIO NIS) $_i = \frac{\sum Xi}{32}$, where

X_i –indicator of local index for i-th NIS.

Interpretation of the integral indicator of national innovation systems' openness

Leading position by the integral indicator of NIS openness belongs to Switzerland that is provided by high values for all considered parameters in comparison with the European average level, with the exception of exports of knowledge-intensive services, in % to total services exports – 31% versus 48.1% in EU countries. The number of international scientific publications per 1 million population exceeded the European average 7.7 times; revenues from licenses and patents from abroad, in % of GDP -3.4 times; the proportion of doctoral students, who are not immigrants from the European Union in the total number of doctoral students in the country -2.4 times. In addition, there is a low value of power distancing – 34 points out of 100 and high dynamism of development – 74 points.

The second place in the ranking belongs to Iceland, that is provided primarily by indicators such as "Number of international scientific publications per 1 million people" – exceeding the European average 7.7 times; "Income from licenses and patents from abroad, in % to GDP" – exceeding 2.3 times; low power distancing – 30 points out of 100.

The three leaders by the transparency level of the NIS are closed by Denmark. A significant contribution to the formation of an integral indicator of the NIS openness was made by: "the Number of international scientific publications per 1 million people" – exceeding the European average 5.1 times; "Exports of knowledge-intensive services in % to total exports of services " – 1.3 times; low power distancing – 18 points out of 100 and a desire to avoid uncertainty – 23 points. Russia in this rating is located on the penultimate 34th place, leaving behind Turkey. The most significant influence on the decrease in the integral indicator of NIS openness is made by, "the Export of knowledge-intensive services, in % to total exports of services", accounting for 15% of the European average indicators; "New for market" and "new for firms" products (sales), in % to the total turnover" – 19%; "the Proportion of scientific publications of the highest international level in the total volume of scientific publications in the country" – 23%, the low value of the index of institutional regime –2.23 against 6,95 in Europe countries; high power distancing is 93 points out of 100 and a desire to avoid uncertainty – 97 points.

Descriptive statistics for integral indicator of NIS openness is presented in Table 3.

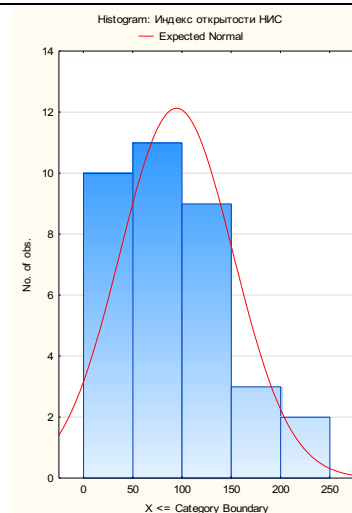
Table 3. Descriptive statistics of the Integral indicator of NIS openness

The integral indicator	A histogram of the distribution
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of the openness of the
NIS

Value N	35
The average value	94,5
geometric mean	78,9
harmonic mean	65,8
The median	81,5
Mode	-
Minimum	23
Maximum	247
The scope	224
Variance	3315,7
The standard deviation	57,6
The coefficient of variation	60,9
Asymmetry	1,0
Excess	0,7



The results of descriptive analysis show that the distribution of the Index is close to the normal distribution of variables (asymmetry and kurtosis are weakly expressed). A number of distributions are characterized by slight right-sided asymmetry. About the closeness to a normal distribution of the analyzed Index also from the histogram of the distribution is seen.

Discussions

A characteristic feature of development of economy at the present stage is the formation of an innovative system based on the model of open innovations, providing competitive advantages of the highest order. Innovative activity, as one of the priority directions of state policy, requires the development and introduction of new approaches, forms and methods of restructuring management and evaluation of the innovation system. As a tool of scientific cognition to the category "open national innovation system" is proposed to use the institutional-cultural approach, which consists in identification of groups of institutions influencing the formation and development of the innovation system and the consideration of institutions in terms of culture – the basic beliefs, norms and patterns of behavior.

Institutional approach to the assessment of the NIS revealed the following characteristics:

- the formation of the open NIS starts at the first stage of reproduction of human and intellectual capital - in the family, because people with their skills, thinking and knowledge are the main entities of innovative activity;

- the innovative potential of open NIS cannot be formed by force, for its activation it is necessary to use motivational, and communication mechanisms aimed at stimulation of innovative activity of all economic agents;

- innovation potential of the NIS – decentralized category that determines the specificity of forms, methods and principles of state innovation policy;

- the innovative potential of firms, households and the regional innovation system as the structural elements of the NIS, on the basis of the principle of

subsidiarity constitute the innovative potential of the whole innovation system of the state;

— the state of the innovative environment is characterized by the level of development of groups of institutions in NIS, covering all spheres of life: social, economic and political-ideological.

In this regard, in our opinion, the issues of culture of innovations should be considered in the context of the formal institutions of innovative development, since culture is the most important system-forming factor of the environment of innovative activity.

The previous researches, which were made by J. West & S. Gallagher (2006), H. Chesbrough (2007), K. Kristensen & E. Skott (2008), M. Torkkeli, K. Kok & I. Savickaya (2009), M. Vanhaverbeke, M. Torkkeli & A. Trifilova (2010), D.S. Medovnikov & S.D. Rozmirovich (2011) are devoted to modelling of innovative systems.

However, the analysis of scientific works devoted to the problem of methodic for assessing the level of national innovation systems' openness and forecasting of innovative development is not structured and is only debatable.

Conclusion

Thus, when evaluating the level of NIS openness it is appropriate to take into account alongside the formal institutions of innovative development the informal institutions, because the most important role in achieving the effectiveness of innovative development and formation of open NIS belongs to the institutional structure of society, which is expressed in the relevant institutional matrix as a stable, historically formed system of basic economic, social, political-ideological and legal institutions. Thus, there is a need for institutional arrangements of the innovation system. Different types of institutionalization of the innovation system form the corresponding types of disequilibrium, which are characterized by complexity and dynamics of processes occurring in them. Open innovations is a natural phenomenon in the context of globalization and dynamic development of competitive markets for goods, services and technologies. The problems of generating of innovations go far beyond the process of new product development, expanding the focus on problems' solving such as business model, value chain, processes of patenting, marketing channels, service, brand, customer experience. Innovation activity is currently based on an integrated, multidisciplinary approach, where the introduction of technological innovations is accompanied by organizational, marketing, logistics, etc. innovations. Open innovations today cross the borders of individual companies, industries, countries and continents, presenting a cross-cultural process. Large-scale integration of Russian economy into the global innovation network involves the development of cross-cultural competences of Russian society.

The paper has theoretical and practical significance for the development of models for managing open innovations, and the development of strategy of the state innovative policy.

Taking into account the obtained results of this study one can highlight a number of research challenges and promising directions that require further consideration: deepening and extension of certain provisions contained in the paper related to the assessment of the level of development of open national

innovation systems and development on their basis of models for management of development of innovative economy.

Disclosure statement

No potential conflict of interest was reported by the authors.

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