UDC 330.341.1:339.972

Methodology and key determinants of building an efficient national innovation system of a country

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ABSTRACT. The paper represents a research of theoretical principles for determining national innovation systems, as well as analyzes performance results displayed by national innovation systems of the leading countries in the global innovation space, while also describing characteristic features thereof and formulating recommendations for NIS build-up based on the same, implementation of which should serve as the basis of the national innovation system effective performance. It has been determined that at the current stage of global economy development such factors as science, technology and innovation play an important role in formation of a competitive economy. It has been established that the overall funding level with respect to science proves one of the key characteristics of an innovative country, and therefore NIS performance analysis was carried out based on the national expenditure indicator regarding research and development as well as on the country's position in the Global Innovation Index. The analysis carried out showed that the NISs of certain countries were more efficient than those of the others due to peculiarities of the innovative system elements that can be further referred to as determinants of building an effective national innovation system of a country.
KEYWORDS. National innovation system, innovation, innovation policy, scientific and technical activities, competitiveness, efficient operation, R&D.

Introduction

At the current stage of the global economy development the innovative development has become a priority in terms of economic policy pursued by many countries. This trend can be traced back to the early 1990s, whereas ever more countries recognize expediency and necessity of transiting to such a development path on account of facing increasingly toughening competition between states in the international markets. The main condition for achieving long-term positive economic growth rate of both national economy as a whole and individual businesses implies active innovation and investment activities. As globalization processes develop, position of a country on the global stage is ever more often determined by its general competitiveness, which in turn depends on the national innovation system structure and efficiency. Exactly the innovation system enables a state to occupy a certain niche in the

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IEP, № 23, (2015) pp. 138—158

ISSN 1811-9832/2015/№ 2 (23)

international labour division system as well as gain weight and status in terms of international relationship.

Building an efficient innovation model of economic development proves only possible in case of mutually beneficial partnership between the state and businesses, combining national and corporate interests and providing for a business environment conducive to innovation. Support and promotion of processes aimed at creation and commercialization of new technologies are officially recognized in most countries as the basis of national competitiveness strategies and imply a priority for the national economics policy[2].

Modern geo-economical, technical and technological changes produce a significant impact on the internationalization processes in terms of establishing a global innovation environment implying uniform conditions for development of national and international innovation systems directly influencing the principles, methods and features of developing and implementing the innovative strategies of corporations, states and integration associations.

The issue of forming an efficient national innovation system is the subject of studies carried out by the leading foreign scientists, such as: B. Lundvall[3], S. Metcalfe[4], R. Nelson[5], D. North[6], P. Romer[7], C. Freeman[8], J. Schumpeter[9], Yu.Yakovets[10] and others. In turn, the leading national scholars such as L. Antoniuk[11], Yu.Bazhal[12], V. Heyets[13],

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[2] *Fedirko O.* National innovation system as state innovation policy subject [Electronic resource]. — Access mode: http://www.iepjournal.com/journals/6/2007_03_Fedirko.pdf. [In Ukrainian].

[3] *Lundvall B-A.* National Innovation Systems: Towards a Theory of Innovation and Interactive Learning/ B-A. Lundvall.- London, Printer, 1992. — 317 p.

[4] *Metcalfe S.* The Economic Foundations of Technology Policy: Equilibrium and Evolutionary Perspectives / S. Metcalfe// Handbook of the Economics of Innovation and Technological Change. — Oxford (UK)/Cambridge (US): Blackwell Publishers, 1995. — P. 409-512

[5] *Nelson R.* National Innovation Systems. A Comparative Analysis/ R. Nelson.- New York/Oxford, Oxford University Press, 1993. — 560 p.

[6] *North D.* Institutions, Institutional Change and Economic Performance / D. North; / Translated from English by A. N. Nesterenko; preface and editing by B.Z. Milner. — M.: Economic Book Fund *Nachala*, 1997. — 180 p. [In Russian].

[7] *Romer P.M.* Endogenous technological change / P.M.Romer // Journal of Political Economy. 1990, October. V. 98. № 5. P. 71-102.

[8] *Freeman C.* The National System of Innovation in Historical Perspective // Cambridge Journal of Economics. — 1995. — № 19 (1), February. — P. 5-24.

[9] *Schumpeter J. A.* The Theory of Economic Development. An Inquiry into Profits, Capital, Credit, Interest, and the Business Cycle / J. A. Schumpeter; translated from English by V. Stark. — K.: Kyiv-Mohyla Academy, 2011. — 242 p. [In Ukrainian].

[10] *Yakovets Y.V.* Epochal innovations of the XXI century / Y.V. Yakovets; P. Sorokin-N.Kondratieva International Institute —M.: Economics, 2004. — 444 p. [In Ukrainian].

[11] *Antoniuk L.L., Poruchnyk A.M., Savchuk V.S.* Innovations: theory, mechanism of development and commercialization: Monograph. — K.: KNEU, 2003. — 394 p. [In Ukrainian].

[12] *Bazhal Y.* Development of the national innovation system as a part of Ukrainian information society [Electronic resource]. — Access mode: http://www.ekmair.ukma.kiev.ua/bitstream/123456789/412/1/Bazhal_Rozvytok_natsionalnoi.pdf. [In Ukrainian].

[13] *Heyets V.M.* Innovative prospects for Ukraine / V.M. Heyets, V.P. Semynozhenko. — Kharkiv: Constanta, 2006. — 272 p.

Yu. Makohon[14], A. Poruchnyk[15], L. Fedulova[16] and others are engaged in studying foreign experience in formation and operation of the national innovation systems with the purpose of applying the same while building the NIS in Ukraine.

Setting objectives

Despite high degree of studying the issue, not all of its scientific aspects have been sufficiently covered in the modern scientific literature. In particular, the problem of selecting the national innovation system building model is rather urgent both in terms of methodology and applicability. In the context of Ukraine, whose economy requires coordinated state policy in the field of innovation, quite important is to conduct analysis of the experience and performance of national innovation systems applied by the leading countries in the global world scientific and technological space. The objective of this research is to analyze performance results displayed by national innovation systems of the leading countries in the global innovation space aimed at describing characteristic features thereof and formulating recommendations for NIS build-up in Ukraine.

Main part

The objective of innovation activities carried out by a state (in the field of education, research and development, design, production, technical and technological, foreign economic relations etc) is a continual structural upgrade of the economic system along with upholding national interests by consolidating the efforts of enterprises, industries and regions for effective implementation of the scientific and technical progress achievements in both domestic and foreign markets. It is the state that contributes to improving national competitiveness, the modern management concept for which is based on the effective business functioning principles, flexibility of state regulation thereof and excellence of infrastructure.

In developed countries an innovative model of economic development has been formed based on intensive production and use of new

[14] *Makohon Y.V.* Prospects for regulation of innovation activity in Ukraine / Y.V. Makohon // Problems and prospects of innovation activity development in Ukraine: Materials from the 5th International Business Forum (Kyiv, March 22, 2012) / editor-in-chief A.A. Mazaraki — K. : Kyiv. Nat. univ. of trade and econ., 2012. — 297. (p. 170-172). [In Ukrainian].

[15] *Antoniuk L.L., A.M. Poruchnyk, V.S. Savchuk.* Innovations: theory, mechanism of development and commercialization: Monograph. — K.: KNEU, 2003. — 394 c. [In Ukrainian].

[16] *Fedulova L.* Development of the national innovation system / L. Fedulova, M.Pashuta // Ekonomika Ukrayiny. — 2005. — No.4. — p. 35-47. [In Ukrainian].

knowledge due to implementation of which in such spheres as education, technology and production growth of GDP from 70% to 85% is currently achieved. The positive impact of innovation on the competitiveness of the economy is manifested by growth of productivity and added value as well as by structural upgrading of the economy, increasing the share of high-tech and knowledge-intensive industries in the structure of production and export, while also by product quality improvement and hence expansion of markets.

After the financial crisis, the science, technology and innovation (STI) make a vital contribution to sustainable and durable economic recovery process as well as to forming long-term prospects for economic growth in all countries of the world. Science, technology and innovation can open up new ways of solving certain major problems the society is facing: demographic change, global healthcare issues and climatic changes. To meet these objectives, it is vital that countries maintain productive investments in knowledge. STI have never played a more important role. Another important role in the integration of science, technology and innovation and their impact on economic development is vested in the model of the national innovation system existing in the country.

Theoretical principles for national innovation system determination

The concept underlying the theory of national innovation systems is based on the pre-requisite that understanding ties and relationships between participants in an innovation process is the key to development of 'innovative production'. Innovation and technological progress are spawned by a complex set of relations and interactions between the innovation process participants, which produce, distribute and make use of the new knowledge. Innovative development of a country depends largely on how effectively these participants interact as elements of a collective system of knowledge creation and use thereof for the purpose of ensuring technological progress and competitiveness.

The NIS formation theory founders are C. Freeman[17] (the Science Policy Research Unit of the University of Sussex, Great Britain), B.-A. Lundvall[18] (Uppsala University, Sweden) and R. Nelson[19] (Columbia

[17] *Freeman C.* The National System of Innovation in Historical Perspective // Cambridge Journal of Economics. — 1995. — № 19 (1), February. — P. 5-24.
[18] *Lundvall B-A.* National Innovation Systems: Towards a Theory of Innovation and Interactive Learning/ B-A. Lundvall.- London, Printer, 1992. — 317 p.
[19] *Nelson R.* National Innovation Systems. A Comparative Analysis/ R. Nelson.- New York/Oxford, Oxford University Press, 1993. — 560 p.

University, USA), who have analyzed development of innovation activity in different countries and based on that offered a definition of the NIS.

At that, the research was based on the results previously obtained by J. Schumpeter[20] (Theory of Economic Dynamics), F. Hayek[21] (concept of dispersed knowledge), D.North[22] (institutional theory), R. Solow[23] (scientific and technical progress role in economic growth), P. Romer[24] and R. Lukas (new growth theory). Each of the above authors offered his own definition of the NIS focusing on its individual elements and relationships.

The central role in J. Schumpeter theory was vested in the innovation. He would describe it «as a new production function»[25]. This could imply manufacture of a new product, implementation of new organization forms, merger, discovery of a new market etc. Innovation differs from discovery (novelty), which precedes innovation. All cycles are generated by innovation (innovative discoveries) being the final results of implementing the innovation aimed at changing the object of management and generating economic, social, technological, environmental or other effect.

A great influence on formation of the innovation systems theory was produced by works of F. Hayek, who had formulated the concept of dispersed knowledge. At the core of the latter is understanding of the market as a special kind of informational device using prices to detect, use and coordinate knowledge possessed by millions of independent people. J. Schumpeter and F. Hayek laid the foundations of the attitude to innovation as to a source of economic growth. However, while actively working both scientists did not represent the mainstream of economic theory[26].

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[20] *Schumpeter J. A.* The Theory of Economic Development. An Inquiry into Profits, Capital, Credit, Interest, and the Business Cycle / J. A. Schumpeter; translated from English by V. Stark. — K.: Kyiv-Mohyla Academy, 2011. — 242 p. [In Ukrainian].

[21] *Hayek F.A.* The Use Knowledge in Society [Electronic resource] / F.A. Hayek // American Economic Review. — 1945. — V. 35, no 4. — Access mode: http://www.econlib.org/library/Essays/hykKnw1.html.

[22] *North D.* Institutions, Institutional Change and Economic Performance / D. North; / Translated from English by A. N. Nesterenko; preface and editing by B.Z. Milner. — M.: Economic Book Fund *Nachala*, 1997. — 180 p. [In Russian].

[23] *Solow R. M.* The Economics of Resources or the Resources of Economics / Robert M. Solow. // The American Economic Review, Papers and Proceedings of the Eighty-sixth Annual Meeting of the American Economic Association. — 1974. — C. 1–14.

[24] *Romer P.M.* Endogenous technological change / P.M.Romer // Journal of Political Economy. 1990, October. V. 98. № 5. P. 71-102.

[25] *Schumpeter J. A.* The Theory of Economic Development. An Inquiry into Profits, Capital, Credit, Interest, and the Business Cycle / J. A. Schumpeter; translated from English by V. Stark. — K.: Kyiv-Mohyla Academy, 2011. — 242 p. [In Ukrainian].

[26] *Hayek F.A.* The Use Knowledge in Society [Electronic resource] / F.A. Hayek // American Economic Review. — 1945. — V. 35, no 4. — Access mode: http://www.econlib.org/library/Essays/hykKnw1.html.

Works by D. North[27] laid the foundation of the national innovation systems theory. His specialty is economic history, while his distinguishing feature implies paying special attention to the interaction of institutional structures and technologies as well as to their joint role in economic and social development. D. North based his conclusions coming from the fact that the institutions set a system of incentives (both positive and negative), thus directing activities of people in a certain way. Therefore, institutions reduce the uncertainty of economic development, making actions of the agents more predictable and performing its primary function — reducing the transactional costs.

Considering the fact that researchers of transactional costs usually come from the fact that institutions define only transaction costs, while the technologies define only transformation costs (i.e. those borne due to 'transformation' of resources vested in land, labour and capital into goods and services, i.e. production costs), D. North develops the idea that institutions also influence the technologies, while also showing examples of complex relationship between transactional and transformational costs.

Technology, in his view, sets only the upper limit of attainable economic growth. In the context of institutional theory, this implies that with zero transactional costs increase of knowledge volume and application thereof should be the key to potential prosperity. Thus, the main aspect missed by neoclassical analysts is the answer to the question why scientific and technological potential in fact accessible to everyone, is not fully implemented, and why such a huge gap between rich and poor countries has been formed[28].

In the 1980s, P. Romer[29] developed a 'new growth theory' putting technological development at the forefront. According to this theory, the increase of knowledge is endogenous in nature while also linked to economic factors such as improving opportunities for profit growth or education. Thus, the rate of technological change is not stable at all with their velocity largely dependent on the activity carried out by the state and individual companies. Based on the constructed model, P. Romer concludes that countries with a larger amount of accumulated human capital will have higher growth rates. That implies, the scientist researched innovation as a product manufactured by a particular sector

[27] *North D.* Institutions, Institutional Change and Economic Performance / D. North; / Translated from English by A. N. Nesterenko; preface and editing by B.Z. Milner. — M.: Economic Book Fund Nachala, 1997. — 180 p. [In Russian].

[28] *North D.* Institutions, Institutional Change and Economic Performance / D. North; / Translated from English by A. N. Nesterenko; preface and editing by B.Z. Milner. — M.: Economic Book Fund Nachala, 1997. — 180 p. [In Russian].

[29] *Romer P.M.* Endogenous technological change / P.M.Romer // Journal of Political Economy. 1990, October. V. 98. № 5. P. 71-102.

of the economy, i.e. directly by the scientific research and development process.

The basis of the national innovation systems theory was formed by works of the aforementioned authors, whereas the concept of an innovation system was first used in 1987 by C. Freeman[30] in his study of technology policy in Japan. C. Freeman described the most important elements of the Japanese innovation system, which provided for the economic success of this country during the post-war period. Today, this scientist is considered the founder of the modern innovation theory, since he was the first to introduce consideration of innovation as an interactive process (a process of interaction) as well as the first to introduce the concept of the national innovation system (NIS) in 1987 as «the combination of private and public sector institutes interacting and initiating, creating and promoting diffusion of new technologies»[31]. However, the first serious work dedicated to the innovation system is considered to be the book *National Innovation Systems*, edited by BA Lundvall and published in 1992. The approach to studying technological development in certain countries derived from this concept proved quite attractive on the account of the following:

- the innovation system concept embodies the most advanced understanding of the innovation process;
- the concept reflects important changes both in terms and contents of innovation activity occurring in the last decade;
- researches based on the innovation system concept create a promising basis for developing technological and industrial policy.

We consider it necessary to note that despite the fact that the concept of a national innovation system has for decades been actively used by many countries in the development of strategies and programs, yet there is no single approach to defining the essence of the 'national innovation system' concept. Even the founders of the national innovation systems theory used different approaches to interpreting the essence of this concept, which is mainly caused by different approaches, views and research objectives. Thus, R. Nelson concentrated attention on technological innovation, B.-A. Lundvall and C. Freeman also studied institutional, social, educational innovations and organizational changes. For R. Nelson central problems implied those of state scientific and technological policies, opportunities and limitations thereof as well as those of contemporary NIS in countries with different levels of development. R. Nelson demonstrated that comparing experience of different countries in

[30] *Freeman C.* The National System of Innovation in Historical Perspective // Cambridge Journal of Economics. — 1995. — № 19 (1), February. — P. 5-24.

[31] *Fagerberg, J.* Innovation: A Guide to the Literature / J. Fagerberg // The Oxford handbook of innovation / ed.: J. Fagerberg, D.C. Mowery, R.R. Nelson. — Oxford: Oxford Univ. Press, 2006. — P. 1—26.

terms of historically long periods proved to have yielded the most spectacular results. The founders of the concept agreed to consider a national innovation system as a process and a result of integrating structures diverse in terms of their goals and objectives. Subsequently, the concept has evolved due to the efforts of a large number of researchers[32].

For example, the famous British economist S. Metcalfe while trying to give the most exhaustive definition of a NIS, suggested to consider it as a set of different institutions that both individually and jointly contribute to the development and provide boundaries for a public policy having impact on the innovation processes. Thus, S. Metcalfe came to a conclusion that NIS should be regarded as a system of diverse institutions that produce, store and transfer knowledge, skills and man-made products used in the development of new technologies[33].

One should also bear in mind definition of a national innovation system formulated by the Organization for Economic Cooperation and Development (OECD): a set of private and public sector institutions that both individually and jointly ensure development and distribution of new technologies within a given state[34].

Ukrainian scientist Yu. Bazhal suggests considering the national innovation system as a set of institutional, legal and economic measures stimulating innovative technological changes in the country aimed at ensuring national strategic advantages and efficient international competitiveness both in the domestic and foreign markets. Today, introduction and spreading of information technologies are regarded as efficient innovative technological changes[35].

By systematizing the views of leading scientists on the definition of a «national innovation system», one could note variability of approaches taken to address the above issues. An overview of literature provided an opportunity to suggest a comparative description of the «national innovation system» definition (Table 1).

Despite the variety of approaches to defining the term, most scientists adhere to common methodological principles:

- a special role in economic development is vested in the knowledge;
- the main factor of economic dynamics is competition between businesses based on innovation;

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[32] *Yakovets Y.V.* Epochal innovations of the XXI century / Y.V. Yakovets; P. Sorokin-N.Kondratieva International Institute —M.: Economics, 2004. — 444 p. [In Russian].

[33] *Metcalfe S.* The Economic Foundations of Technology Policy: Equilibrium and Evolutionary Perspectives / S. Metcalfe// Handbook of the Economics of Innovation and Technological Change. — Oxford (UK)/Cambridge (US): Blackwell Publishers, 1995. — P. 409-512

[34] National Innovation Systems [Electronic resource] // Economic and Social Data Service International. — Access mode: http://www.oecd.org/science/inno/2101733.pdf

[35] *Bazhal Y.* Development of the national innovation system as a part of Ukrainian information society [Electronic resource]. — Access mode: http://www.ekmair.ukma.kiev.ua/bitstream/123456789/412/1/Bazhal_Rozvytok_natsionalnoi.pdf. [In Ukrainian].

- the institutional context of innovation directly influences content and structure thereof.

Table 1 **Comparative Characteristics of Definitions for the National Innovation System Concept**

Scientist	Definition of the 'national innovation system'
C. Freeman[36]	a system of institutions in the public and private sectors, activities and interaction between which are designed to initiate, import, modify and diffuse new technologies;
B.-A.Lundvall[37]	a set of elements and ties interacting in terms of production, distribution and use of new economically-efficient knowledge while either found in or originating from the territory of a national state;
R. Nelson[38]	a set of institutions whose interaction determines innovative performance (efficiency) of national firms;
L. Fedulova[39]	a set of interrelated organizations (bodies) involved in production and commercialization of scientific knowledge and technology within national boundaries, small and large companies, universities, laboratories, incubators and technology parks as a combination of legal, financial and social institutions, providing for innovative processes and being of national origin, while possessing traditions, political and cultural features;
O. Holichenko[40]	a set of national, state-owned, private and public organizations and mechanisms of their interaction, by virtue of which creation, preservation and dissemination of new knowledge and technologies are carried out;
N. Ivanova[41]	a set of interrelated organizations (bodies) involved in production and commercialization of scientific knowledge and technology within national boundaries (small and large companies, universities, laboratories, technology parks and incubators); a set of legal, financial and social institutions providing for innovative processes and being of national origin, while possessing traditions, political and cultural features

In national literature the following main characteristics of a national innovation system are distinguished:

1) systematic nature, i.e. a national innovation system is considered as a combination of elements interacting in a special manner;

2) the institutional aspect, i.e. effect of the existing formal and informal social institutions on the pace and scale of innovation development;

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[36] *Freeman C.* The National System of Innovation in Historical Perspective // Cambridge Journal of Economics. — 1995. — № 19 (1), February. — Pp. 5—24.

[37] *Lundvall B-A.* National Innovation Systems: Towards a Theory of Innovation and Interactive Learning/ B-A. Lundvall.- London, Printer, 1992. — 317 p.

[38] *Nelson R.* National Innovation Systems. A Comparative Analysis/ R. Nelson.- New York/Oxford, Oxford University Press, 1993. — 560 p.

[39] *Fedulova L.* Development of the national innovation system / L. Fedulova, M.Pashuta // Ekonomika Ukrayiny. — 2005. — No.4. — p. 35-47. [In Ukrainian].

[40] *Golichenko O.G.* The main factors of the national innovation system development: lessons for Russia / O.G. Golichenko; Central Economics and Mathematics Institute, RAS. — M. : Nauka, 2011. [In Russian].

[41] National innovation system in Russia and the EU. M.: Central Institute of Science Development Problems at RAS, 2006. Edited by: V.V. Ivanov (Russia), N.I. Ivanova (Russia), J. Roseboem (Netherlands), H. Hijsbers (Netherlands). [In Russian].

3) diffusion of new knowledge and technology as the primary function of a NIS.

Ukrainian scientists emphasize that the effectiveness of innovative processes results from the operation of national innovation systems, including those in the fields of: R&D, education and training, infrastructure; manufacture and institutions of legal, social and financial nature. The NISs provide mechanisms for relations between different companies as well as financing of their activities[42].

Efficiency of a national innovation system

Since the early 1990s the concept of national innovation systems tended to be used in studies conducted by international organizations, including OECD, as well as in terms of political programs within individual states. By now, the NIS concept has gained extensive spread in both domestic and foreign science relating to such spheres as: different approaches to defining and classifying innovation by types; researching development of national innovation systems, conceptual apparatus, state innovation policy; studying dynamics of innovation processes; analysis of innovations at the level of a company; development of scientific progress models and accounting for factors characterizing intellectual and innovation activity in development of macroeconomic production functions; developing economic growth models based on innovation; analysis and modelling diffusion of innovations; modelling behaviour in competitive markets with innovation; assessment of the role of regions in the economic development of innovation and innovation policy formation[43].

The degree of funding for science is considered one of the key characteristics of an innovative country and its preparedness to build a post-industrial society. Thus, under the Lisbon Strategy the European Union has set the goal to allocate gross expenditure on research and development (R&D) amounting to 3% of GDP, with the goal to be supported during the next decade as one of the five key objectives of the Europe 2020 Strategy.

According to OECD methodology, the R&D expenditure is considered in terms of funding sources as follows:

GERD — the country's internal gross expenditure on R&D;

BERD — the country's business sector expenditure on R&D;

GovERD — governmental expenditure on R&D;

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[42] *Antoniuk L.L., Poruchnyk A.M., Savchuk V.S.* Innovations: theory, mechanism of development and commercialization: Monograph. — K.: KNEU, 2003. — 394 p. [In Ukrainian].

[43] *Shepina I.N.* Innovation activities at the regional level: behaviours of regions and their stability. Publishing and printing center of Voronezh State University, 2012. [In Russian].

HERD — the country's higher education sector expenditure on R&D[44].

Among the EU member states only Finland with the expenditure level of 3.87% of GDP as well as Sweden (3.42%) and Denmark (3.06%) have exceeded the EU goal of 3% of GDP on R&D, while also proving more successful than the United States (2.81%). Another four EU countries, namely Germany (2.82%), Austria (2.76%), France (2.26%) and Slovenia (2.11%) showed higher rates than the average level of the EU-27, although failed to accomplish the 3% goal. In this coordinate system Ukraine reached the general expenditure level on R&D amounting to 0.75% of GDP, which is 2.4 times less than the average of the EU-27 (Fig. 1).

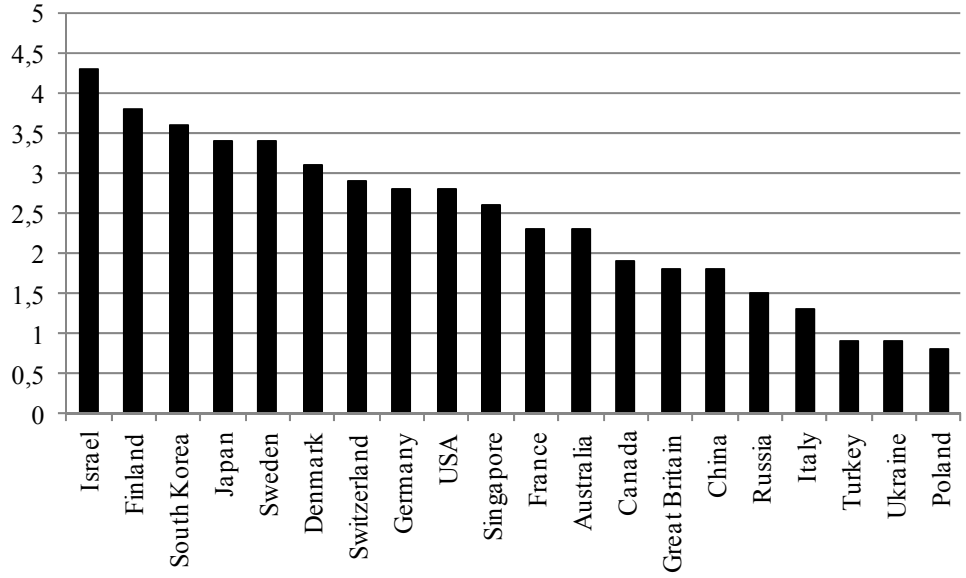

Fig. 1. GERD of countries in 2012, % of GDP[45].

Among OECD countries, the USA proved the major player with 42% of the GERD in OECD countries in 2012, followed by Japan (15%) and Germany (9%). Since 1999 real expenditure on R&D has been growing most rapidly in Estonia, Korea, Portugal and Turkey with the average annual growth rate of about 10%. Outside the OECD, the average an-

[44] Guide to OECD Main Science and Technology Statistics [Electronic resource] // Economic and Social Data Service International. — Access mode: http://www.esds.ac.uk/international/support/user_guides /oecd/sti.asp.

[45] OECD Factbook 2013 Economic, Environmental and Social Statistics [Electronic resource] // OECD iLibrary. — Access mode: http://www.oecd-ilibrary.org/economics/oecd-factbook-2013/expenditure-on-r-amp-d_factbook-2013-60-en

nual real growth of expenditure on R&D in China was approaching 20%. Consequently, China ranked second in terms of highest expenditure on R&D, ahead of Japan since 2009.[46]

In 2013, US expenditure on research and development increased by 1.2% as compared to 2012 (to USD 424 billion, representing 2.66% of GDP), of which budgetary allocations made USD 129 billion (by 1.4% more than in 2012), however the US federal budget draft for 2014 provided for an increase in R&D funding to USD 143 billion. China's expenditure on R&D amounted to USD 220 billion in 2013, which is by 11.6% higher than in 2012, while that of India was circa USD 45 billion, which was by 12% more than in 2012.

According to Fig. 1, the leading countries in terms of GERD in 2012 were Israel, Finland, South Korea, Sweden and Japan, proving that the above countries are willing to spend a significant share of GDP on innovation. However, the high cost of research and development cannot be seen as a guarantee of dynamic and effective development of economy, whereas great importance for that is vested in an efficient national innovation system. To assess the efficiency of national innovation systems, we offer a comparative analysis based on the 'Expenditure on research and development' index and the ranking of countries by the Global Innovation Index.

The Global Innovation Index has been computed since 2007 by INSEAD Business School in collaboration with Alcatel-Lucent, Booz company, Confederation of Indian Industry and the World Intellectual Property Organization. The feasibility of conducting such a specialized global research was grounded by recognizing the key role of innovation as a driving force of economic growth and prosperity. While computing this index a wide range of assessment indicators is used. The global innovation index was recognized as a valuable tool for facilitating public-private dialogue, in which politicians, business leaders and other interested parties can assess the status and progress in implementing innovation on a regular basis[47].

Based on the analysis results presented in Table 2 the following conclusions can be drawn.

Firstly, all countries ranking in the top 10 as regards expenditure on research and development are also leaders (included in the top 20) in terms of the Global Innovation Index, thus implying interrelation between the two indices.

[46] Ibid

[47] *Lihonenko L.* Assessing innovativeness of the economy of Ukraine in the international rankings / L. Lihonenko // Visnyk KNTEU. — 2012. — No.3. — p. 5-22. [In Ukraine].

Table 2 **Comparative Characteristics of Countries in Terms of Expenditure on Research and Development and Global Innovation Index Position**[48]

Country	GERD, % of GDP, 2012	Global Innovation Index position, 2014	
		Position [143]	Points [100]
Israel	4.3	15	55.46
Finland	3.8	4	60.67
South Korea	3.6	16	55.27
Japan	3.4	21	52.41
Sweden	3.4	3	62.29
Denmark	3.1	8	57.52
Switzerland	2.9	1	64.78
Germany	2.8	13	56.02
USA	2.8	6	60.09
Singapore	2.6	7	59.24

Determinants of development for national innovation systems in the leading countries of the global innovation space

Secondly, countries such as Great Britain, the Netherlands, Luxembourg and Hong Kong rank among the top 10 Global Innovation Index countries, while not being leaders in terms of expenditure on research and development. These results suggest that their innovative systems produce innovations at small expenditure on research and development, i.e. the innovation systems in these countries are the most efficient. In our opinion, this is possible due to the innovative features of the aforementioned countries. For example, the innovation system of Great Britain has the following features: operation of world-class universities (Oxford, Cambridge, University of London); developed venture capital; a high proportion of the population with higher education; developed 'university — industry' ties; proactive policy of attracting skilled personnel; favourable conditions for business in general. At that, certain shortcomings in the innovation system of the country can also be pointed out: lack of public and private expenditure on research and development and poor coordination between all links in the innovation system[49].

[48] The Global Innovation Index 2014 [Electronic resource]. — Access mode: https://www.globalinnovationindex.org/content.aspx?page=gii-full-report-2014; OECD Factbook 2013 Economic, Environmental and Social Statistics [Electronic resource] // OECD iLibrary. — Access mode: http://www.oecd-ilibrary.org/economics/oecd-factbook-2013/expenditure-on-r-amp-d_factbook-2013-60-en

[49] *Sharov V.F.* The experience of the European Union in creating conditions to increase competitiveness and efficiency of the national innovation systems / V. Sharov // The world economy and international economic relations. — 2012. — No.10 (95) — P. 205-212. [In Russian].

The innovation system of the Netherlands is quite similar to that of Great Britain: the world-famous Dutch universities ensure high level and quality of education, specializing in fundamental research in certain areas of scientific knowledge, such as physics and classical studies in Leiden University, economy and the energy issues in Groningen University, administration management and history of science in Amsterdam, etc. The key importance for development of fundamental science is vested in the Royal Netherlands Academy of Arts and Sciences and the Institute of Higher Studies in Wassenaar[50]. Applied research activities in the Netherlands are funded by grants and programs of Dutch multinational corporations such as Royal Dutch Shall, Unilever, and Phillips. The so-called public-private partnership is also actively developing as do high technology development projects, such as technology park at the University of Twente, the biotech park in Leiden, Brainport Technopark in Eindhoven, the centre for optimization in the oil and gas industry in Delft and the Energy Valley in Groningen, the primary purpose of which is to develop energy saving technologies and alternative fuel[51].

Formation of scientific, technology and innovation areas of Hong Kong began in the 1990s. The innovation system of this country is of export nature based on the combination of scientific and technological parks comprising five main clusters. The country's leaders work to create conditions for innovation. The related incentives include: availability of capital for companies engaged in innovation activities, developing programs to attract the best foreign scientists, formation of the legal framework in the field of innovation. The main problem of the NIS in Hong Kong might be low accessibility of venture financing[52].

Thirdly, we should point out the US, Singapore and the Nordic countries (Finland, Sweden, Denmark) occupying high positions in terms of both indices, which indicates efficiency of the innovation systems in these countries. Among the features of US innovation sphere development one should name emergence (virtually independent of the federal government) of the innovation sphere main institutions (such as parks and venture capital funds). Another feature of the US innovation sector is exceptionally high activity of small innovation companies. This is largely due to the existence of special government programs to support these companies, as well as sophistication and availability of venture capital

[50] Innovation policy: European experience and recommendations for Ukraine. — Volume 1. Key features of innovation policy as a basis for developing measures to promote innovation, guiding Ukraine to the knowledge-based competitive economy — a comparison of the situation in the EU and Ukraine. EU Project «Improvement Strategies, Policies and Regulation in Ukraine». — K.: Feniks, 2011.- 214 p. [In Ukrainian].

[51] *Roggema R., Dobbelsteen A. van den, Stegenga K.,* Pallet of Possibilities: Spatial Team, Grounds for Change, 150 p. (Province of Groningen, 2007).

[52] *Krasovskava O., Griga V.* Innovation in Eastern Europe and Central Asia — areas of cooperation. Part 1 // Problemy Nauki. — 2011. — No. 8. — P. 36–42. [In Russian].

being the main source of financial resources. In the US, the innovative cluster development is fully transferred to the level of the states and the federal government can not directly influence the decision-making process, although providing financial support and thus having certain influence on the situation in the regions. It should also be noted that over the last decade federal influence in the field of innovation has been growing[53].

The US universities have large land holdings as well as significant financial funds and receive funding for scientific research from the public sector. Besides, universities can implement technology transfer to industry by using venture capital. The important role is vested in the national laboratories, being large institutions engaged in various areas of applied science. There are also the so-called 'think tanks', i.e. research organizations involved in both fundamental and applied research, representing innovative clusters historically formed in the US during the past few decades, the main objective of which is to motivate universities, scientific and research centres as well as companies to create and commercialize innovative technologies.

Innovation systems of small European countries (Sweden, Netherlands, Denmark, Switzerland, Finland) are similar to Ukraine in terms of innovative development, where the emphasis is made on development of basic research. The difference is that in the Nordic countries this is performed by the leading universities, whereas in Ukraine an important place in the innovation system is occupied by research institutes of the National Academy of Sciences. In Sweden and in the Netherlands there are higher studies institutes, while applied researches in small European countries are funded primarily through grants and joint projects with large transnational corporations. However, active participation in the financing of research and development is shown also by the small and medium businesses. Of great importance are also regional projects in high technology, using the US Silicon Valley as a model[54].

The peculiarity of NIS formation in Finland is that it is a typical example of transition from an industrial resource-oriented industry to high technology and ICT. The world history has very few of such examples. At that, the origin of modern Finnish economy is based on 'user-producer' relationship between forestry companies as the first users of high technologies and the emerging engineering, electrical engineering and ICT sector companies.

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[53] At the dawn of the knowledge economy (world practices of scientific development and innovation)/ editor-in-chief A.A. Dynkin, A.A. Dagayev. M.: Institute of World Economy and International Relations of RAS, 2004. [In Russian].

[54] National innovation system in Russia and the EU. M.: Central Institute of Science Development Problems at RAS, 2006. Edited by: V.V. Ivanov (Russia), N.I. Ivanova (Russia), J. Roseboem (Netherlands), H. Hijsbers (Netherlands), p. 280. [In Russian].

Revival of the Finnish industry owes much to liberalization of trade and cancelling cash flow restrictions, which caused significant influx of investment in general and inflow of foreign capital in particular. Despite the fact that public funding of R&D has increased significantly over the past two decades, its relative share of all investments in R&D is gradually being reduced. A growing portion of funds for research and development comes from private foundations — today their share is 70%. The role of political institutions and organizations in the development of the Finnish knowledge economy is also quite important. Their main feature is clear distribution of functions performed by each of the organizations in the national innovation system[55]. At that, they listen keenly to the opinion of private initiatives aimed at strengthening cooperation between various innovative agents. This cooperation allowed to link basic research and applied R&D with business development and commercialization of innovations.

The Finnish innovation system comprises scientific research units of commercial firms, universities, research institutes, technology transfer centres, as well as governmental agencies involved in pursuing technology and innovation policy. In addition, the process of technological innovation implies interaction of companies with third parties for development and exchange of different information, knowledge and other resources. Examples of a third-party organization include professional and continued education institutions, investment banks and economic associations[56].

Fourthly, despite the high rates of expenditure on research and development such countries as Israel, South Korea and Japan are not included in the top 10 ranking of the Global Innovation Index, which may indicate lack of efficiency as regards NIS performance in these countries. That is, there are certain shortcomings restricting effective use of investments allocated for research and development. For example, in Japan the bulk of basic research is carried out in universities and governmental laboratories. However, the degree of implementation remains insufficient. A significant part of the applied scientific and technical projects is performed (with their outcomes remaining) in the laboratories of large industrial corporations, without providing the project outcomes to potential users within the industry. The required coordination between the public basic research and private sector's applied projects is not always ensured. The main share of expenditure on R&D in

[55] Finland as a knowledge economy. The elements of success and lessons for other countries / edited by Karl J. Dalman et al.; translated from English.; World Bank. — M.: Ves mir, 2009. — 170 p. [In Russian].

[56] At the dawn of the knowledge economy (world practices of scientific development and innovation)/ editor-in-chief A.A. Dynkin, A.A. Dagayev. M.: Institute of World Economy and International Relations of RAS, 2004. [In Russian].

Japan is vested in the private sector. This approach has provided for Japan's greatest success precisely in those areas of technological progress associated with production of mass demand consumer goods. In the field of basic research and non-mass production Japan notably lags behind other developed countries[57].

In Israel, the innovation economy concept practically borders on the intellectual property, since there is no large-scale innovation business in the country. As one of the main tools of innovation policy Israel uses international funds for innovation support. A powerful tool for developing own profitable projects that is also used by Israel is the system of grants for R&D, in terms of which the state co-funds technology commercialization projects in different proportions depending on the stage of project development. One can distinguish between the following important features of this system: availability of grants and promptness of decision-making on financing.

The results of investment and innovation development of Ukraine for the last years imply enhanced role of targeted public policy focused on maintaining integrity of the innovation process — from scientific development to investment in mass production. This has contributed to improving Ukraine's position in the Global Innovation Index (GII) and the Global Competitiveness Index (GCI) ratings. At the international level, Ukraine ranked 63 among 141 countries in the GII 2012 rating compared to position 60 among 125 countries in 2011. The factors determining quality of innovation include the higher education development level and the research and development status:

- by the level of higher education development Ukraine ranked 34th in 2012 (39th in 2011), while particularly in terms of higher education coverage of population it ranked 8th, and in terms of the share of graduates majoring in science and engineering the country took position 19;
- assessment of the research and development sphere includes three indicators: the number of researchers per 1 million of population — Ukraine's position was 44; expenditure on R&D — position 37, and the quality of research institutes — Ukraine ranked 69;
- as regards productivity of scientific research, in 2012 Ukraine took position 30 (against 40 in 2011), including in terms of the following indicators: creation of new scientific knowledge characterized by the number of patents and scientific articles — Ukraine's position was 21; knowledge diffusion — position 55; impact of knowledge — position 66 (Fig. 2)[58].

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[57] *Avdokushin Y.F.* Japan's National Innovation System / Y.F. Avdokushin // Voprosy novoi ekonomiki. — 2010. — No. 4(16). — P. 39-53. [In Russian].

[58] Scientific and technological sphere of Ukraine [Electronic resource]. — K.: State Agency for Science, Innovation and Informatization of Ukraine, 2013. — 25 p. — Access mode: http://www.dknii.gov.ua/?q=system/files/buklet_2013.pdf. [In Ukrainian].

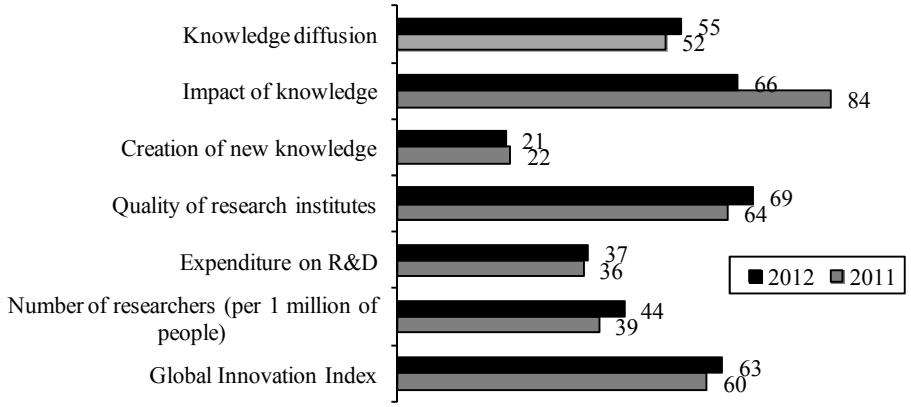

Fig. 2. Ukraine's rating by GII and sub-indices thereof in 2011 and 2012[59]

The significant shortcoming of the current innovation policy in Ukraine is the striving to pursue it aimed at covering a very broadly outlined innovation sphere. In fact, the state has no clear concept of the national innovative priorities. Often, the state budget envisages channelling funds to the sectors that ought to generate financial resources for innovative breakthroughs themselves, instead of being consumers of the finances. Also noteworthy is the absence of clear formulations as to development of priority technologies, including IT.

Conclusions

The study carried out shows that there is no unified optimal model for development and operation of a national innovation system for scientific research and innovation management. However, there is a set of practical solutions that can be more or less adapted for providing the overall satisfactory level of the national innovation system performance.

Thus, based on the study results and analyzing positioning of countries depending on the level of expenditure on research and development as well as positioning by the Global Innovation Index, the degree of NIS efficiency in the leading countries of the global innovation space was determined allowing to formulate their features being drivers of the active and effective performance of the innovation systems in the said countries.

In our opinion, Ukraine's priority in the national innovation system restructuring should be the re-orientation of information and knowledge flows from research centres to all other elements of the economic sys-

[59] The Global Innovation Index 2012 [Electronic resource]. — Access mode: http://www.globalinnovationindex.org/gii/main/fullreport/index.html

tem, since according to B.-A. Lundvall and S. Borras, the attention focus of the innovation policy, as opposed to scientific and technological ones, is moving from universities and technology industries toward all elements of the economic system, influencing the innovation process.[60]

Given the current state of the national innovation system, its development determinants could comprise the following:

- establishment of research centres at the leading universities;
- legislative parity as regards conditions of innovation performance for all agents — both private and public;
- establishing science and technology development priorities at the state-level;
- development of relationship between higher education institutions and industry;
- building effective mechanisms of cooperation between the state, science and business;
- transferring a portion of administrative functions in the field of innovation to the regional level aimed at decentralizing managerial network;
- building a network-based system of cooperation between the national innovation system elements on mutually beneficial, agreed and parity terms along with working out a common development strategy;
- intensification of inter-sectoral cooperation between the national innovation system agents;
- establishing regional higher educational institutions to enhance industrial development of regions;
- governmental support of targeted and grant funding for innovative projects.

For Ukraine, the use of these recommendations can become a basis of formation and development of an efficient national innovation system further acting as a driver for improving competitiveness of the national economy in the world.

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The article was received by the editorial board on 05.10.2015