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RESEARCH AND DEVELOPMENT INTERNATIONALIZATION: WORLD EXPERIENCE AND RUSSIA

Summary: In a comprehensive analysis of the development of national systems of innovation in the context of globalization and the activities of TNCs and the implementation of research and development peculiarities of the global innovation system and the benefits of internationalization of research and innovation, as well as the recommendations for enhancing the participation of Russia in this process with the purpose of embedding the economy in the contours of the global high-tech world economic space.

Keywords: R&D, innovation, world industry, manufacturing, spatial structure, regional shifts.

Introduction

Relevance of the study is determined by speed, volume, scale development of innovative processes in the modern world. With the globalization of the world economy, the role of the internationalization of R&D activities, which becomes the foundation for accelerating the development of many modern states.

The subject of the study: a set of economic relations in the development of national systems of innovation and internationalization of research activities in the globalized world. The purpose of the study: to describe the process of innovation development in the countries of the world and the direction of internationalization of research activities.

Research hypothesis is based on the belief that the state of the national innovation systems of the world depends on the global trends in the global com-

munity, such as: globalization, trends towards a society based on knowledge, structural changes in the world economy in the direction of increasing the value of high-tech industries and production, the process of internationalization of research and innovation, the formation of the global innovation system, etc.

1. The spatial organization of R&D and scientific-industrial activity in the world

To proceed to the analysis of the situation in the global manufacturing sector, it is necessary to trace the dynamics of the process and describe the current state of the scientific landscape of the world. The countries' positions in the world economy depend on the way they use the advantages of R&D. From how to use the advantages of the state R & D depends on their position in the world economy. Now, knowledge-based industries play a vanguard role in the development of economy and social sphere.

On a highly competitive global market, the producers of developed countries are forced to invent more and more competitive products and services. It is associated with the growth of science- and technology-intensive production processes, i.e. with an increase in R&D costs. Therefore, for developed countries, it is more profitable to produce and sell expensive products.

Developed and leading in the technological development economies are gradually moving their production to less developed countries. And those, in turn, as their technological capacity grows and the cost of the labor force rises, take some of their production out to other countries, which are below by level of technical and economic development. This is a mechanism of technological innovation diffusion (in the broadest sense of the word). The question is: are there any opportunities for the global periphery countries to perceive and develop technologies that can be transferred there from advanced countries? Therefore, developing countries participate in the redistribution of the world product – some of them to a greater extent, the other – to a lesser [Rodionova, 2009].

Determinants of innovative growth and development in the world show that the spatial disparities of the socio-economic development of the countries have led to polarization of the R&D and, on the whole, changed the picture of the modern world "scientific landscape".

Undoubtedly, the development of world economy is based on the widespread investment increase in R&D. According to the report "2012 Global R&D Funding Forecast", global R&D investment will increase to US$1.5 trillion in

2013 (in 2008 – US$1.15 trillion) (2012 Global R&D Funding Forecast). Wherein, the share of developed countries still accounts for over 70% of the world total. The group of developed countries also concentrates more than 60% of the global number of researchers in R&D, and about 70% of scientific publications. In other words, through the "North – South" (developed – developing countries), the contrasts retain.

Three main areas of research were formed: North American, European, East Asian, besides the transformation of a three-dimensional space of R&D (USA – EU – Japan) to a four-dimensional (USA – EU – China – Japan) was fixed. The most rapidly evolving research and scientific-industrial activities are noted in Asia and especially in China [Galkin, 2013].

According to UNESCO, in 2012, the share of the USA in global spending on R&D was about 36%, the share of Europe – over 24%. The share of Asia increased to 37%. The share of R&D spending in GDP ranged from 0.4% in Africa to 2.1% in the European region (in the U.S. – about 2%). The share of expenditure on R&D in the structure of world GDP is 2.15%, with a double gap index between the economically developed and developing countries (2012 Global R&D Funding Forecast). The situation with the change of R&D expenditure in the leading countries is illustrated by the table's data (Table 1).

Table 1. R & D expenditure in relation to GDP in the leading countries of the world economy (2002-2012)

№	Country	R&D expenditure (Billion $)			R&D expenditure and GDP 2012		
		2002	2007	2009	GDP PPP, trillion $	R&D expenditure/ GDP, %	R&D expenditur, billion $
1	USA	277.1	373.2	398.2	15.305	2.85	436.0
2	China	39.2	102.4	154.1	12.434	1.60	198.9
3	Japan	108.2	147.8	137.1	4.530	3.48	157.6
4	Germany	56.7	74.1	84.0	3.158	2.87	90.6
5	Republic of Korea	22.5	40.7	43.9	1.634	3.45	56.4
…							
11	Russia	14.6	26.6	33.5	2.491	1.08	26.9

Sources: [UNESCO Science Report, 2010; Global R&D Funding Forecast, 2012].

In terms of R&D expenditures, in 2012, the following countries were the leaders: the USA (31% of global spending – US $436 billion), China (14% – about US $200 billion), Japan (about US $160 billion), and Germany (over US $90 billion). The eighth, ninth and twelfth positions are occupied by India, Brazil and Taiwan. Only on the 11th place is Russia (1% of the country's GDP in

PPP terms, about US $27 billion). India, Brazil, Taiwan have the eighth, ninth and twelfth place. Russia is just on the eleventh position (1% of total countries' GDP (PPP) or US $27 billion).

Research investment has demonstrated a rapid growth in emerging economies. In addition to the rapid development of R&D in China, South Korea, Taiwan, such representatives of the developing world as Malaysia, Indonesia and Saudi Arabia, started with a relatively small investment in R&D (less than 1% of GDP), but they intend to increase it during next few years for consolidation the status of the states with an innovation-oriented economy (2012 Global R&D Funding Forecast).

To characterize the impact of R&D and information technology development on global economic growth, the correlation coefficients have been calculated and direct dependence between the numerical values of the indices of about 80 countries in the international rankings of innovative development and some selected indicators of economic development in 2012: 1) GDP per capita (the correlation value is in the range of 0.86-0.92); 2) value added of high-technology manufacturing industries per capita, by countries (in the range of 0,52-0,70); 3) value added of ICT industries (of goods and services production in ICT sector) per capita, by countries (in the range of 0.79-0.88) and 4) expenditure of R&D per capita (in the range of 0,81-0,91). The following conclusions had been made: foremost, at present, countries with the highest level of socio-economic development are ready for knowledge-based economy and widespread ICP usage [Galkin, 2013]. The leaders in manufacturing of high-tech products are those countries, which have put the knowledge and ICTs at the service of the economy, so that they occupy the leading positions in the world economy.

2. Regional shifts in the world manufacturing industry

The statistical analysis shows that the share of developing countries in global industrial production has increased significantly over the past decade, including the growth in the manufacturing sector (more than 35% in 2010) [United Nations Industrial Development Organization, 2011]. This trend is retained till now – 35% in 2012 [United Nations Industrial Development Organization, 2013].

From 1990 to 2010, production in the manufacturing industry grew at a rate of about 3% per year, and increased from US$4290 to US$7390 billion (Table 2).

Table 2. Manufacturing value added (MVA), by region (US$, billions)

Region	2005	2008	2009	2010	Share of world MVA, 2010 (%)
World	6570	7350	7020	7390	100.0
Developed economies	4710	5010	4600	4760	64.4
Developing economies	1870	2340	2410	2630	35.6
Region/country					
East Asia and Pacific (incl. China)	966	1290	1390	1540	20.8
China	646	920	1015	1134	15.3
Europe (incl. Russia)	148	176	164	169	2.3
Russia	67	71	63	64	0.9
Latin America and the Caribbean (incl. Brazil)	373	423	397	423	5.7
Brazil	111	121	116	129	1.7
Middle East and North Africa	183	217	216	229	3.1
South and Central Asia (incl. India)	149	185	194	210	2.8
India	91	113	119	131	1.8
Sub-Saharan Africa (incl. South Africa)	47	53	52	54	0.7
South Africa	27	30	28	28	0.4
Least developed countries	24	30	32	34	0.5

Source: Calculated by: [United Nations Industrial Development Organization, 2011, p. 16].

Table 2 presents not only the dynamics of the volume of manufacturing output in the world and separate developing and developed regions, but also shows the share of leading countries in the global industry.

According to the data for 2012, volume growth of the world industrial production declined in 2009 as a result of the global financial crisis, but in 2012, the growth rate was 2.2% [United Nations Industrial Development Organization, 2011; 2013].

Meanwhile, China, the Asian NIEs and some other countries (with the priority for the development of manufacturing industries) have significantly strengthened their positions in the global economy. The volume of industrial output grew due to the fact that it relocated from advanced to emerging countries, such as China, India, Taiwan, Mexico, Brazil and other countries, which rapidly developed the industrial sector of their economy. In 1990, the share of developed countries was 79.3% of global manufacturing output (in terms of value added), in 2005 – 72.7%, and by 2010 their share had fallen to 64.4 %. In other words, the share of developing countries was constantly rising. At the same time (as it had been already mentioned) the number of highly economically developed countries enlarged from 33 to 57 since 2000 and replenished with such countries as South Korea, Malaysia, Singapore, etc. [United Nations Industrial Development Organization, 2011]. The share of emerging countries is much higher (if the geographical typology is used, i.e. the division of countries into developed and developing countries). Onward we use the countries' classification, adopted by UNIDO.

The level of industrial development can be evaluated by the index of per capita production output (Table 3).

Table 3. Per-capita MVA at constant (2000) US$

Regions	1990	1995	2000	2005	2010
World	827	848	948	1036	1052
Developed economies	3575	3722	4239	4548	4267
Developing economies	171	211	254	321	430
Regions					
Latin America and the Caribbean	591	608	656	680	711
Asia	130	159	177	221	270
China	100	199	303	480	820
Middle East and North Africa	157	163	193	206	242
Sub-Saharan Africa	30	26	28	30	35
CIS	397	200	232	330	358
Russia	520	322	345	461	504

Sources: [United Nations Industrial Development Organization, 2012].

According to this indicator, UNIDO experts noticed some significant disparities in countries and regions of the world.

Thus, the U.S., China, Japan, Germany, South Korea, United Kingdom, France and Italy are the leaders of the global industry. China and South Korea firmly settled on the top lines of the rating, ahead of almost all advanced countries of Europe. Then, India, Taiwan, Brazil, Mexico and Turkey go further in the list of the leaders by manufacturing output. Russia accounts for only about 1%.

3. Features of the development of national innovation systems and TNCs

Identified features of the development of national innovation systems (for example, the United States, Japan, India, China, Germany, Russia). It is shown that each country and its national innovation system is unique (Table 4). They all have different effects on the formation of a global innovation system and the internationalization of innovation in the context of globalization.

Table 4. Indicators of national innovation systems

Indicators	USA	EU	Japan	China
1	2	3	4	5
R&D expenditure (GERD) , billion (2012)	436.0	330.0	157.6	198.9
% world GERD (2012)	31.1	24.1	11.2	14.2
GERD as % of GDP (2012)	2.85	2.1	3.48	1.6
GERD per capita, in PPP $ (2012)	1377	670	1238	147
The number of researchers in R&D, thousands (2009)	1426	1525	655	1423

Table 4 cont.

1	2	3	4	5
The share of researchers in the world, %	20.0	21.8	9.4	16.5
Researchers per million inhabitants (2009)	4673	2934	5409	1071
GERD per researcher, thousands PPP $ (2009)	244	197	209	134
Number of publications, thousands of articles (2009)	273	360	75	105
% world publications	27.7	36.5	7.6	10.6
Exports of high-technology goods, millions of current dollars (2010)	325	810	140	662

Sources: [World Development Indicators, 2012; UNESCO Science Report, 2010; Science and Engineering Indicators, 2012; Global R&D Funding Forecast, 2012].

The authors formulated the idea, now that the global innovation system is still developing. In the most heavily affected by the formation of the largest national innovation systems – the U.S., Japan, China and the EU-27. However, an increasingly important role in the internationalization of R&D has played not individual states, and transnational corporations (TNCs). They are active in research, as well as creating innovative centers for the production and application of the knowledge and technology around the world to expand the areas of sales, expanding the boundaries of their influence. TNK form an extensive network of international production, ”destroy” the boundaries between national markets of goods, capital, labor, at the expense of information, technological, industrial ties between enterprises in different countries of the world. This causes the effect of the internationalization of the economy. At the enterprises of foreign affiliates of TNCs employ about 70 million people, sales totaled $28 trillion and the gross production exceeded $7 trillion [World Investment Report, 2012]. The data on the activities of TNCs reflect the main trends in the international production of goods and services.

We characterize the activities of the world’s largest TNCs in terms of their R&D expenditure. Among the leaders in 2011 were corporations such as Toyota, Novartis, Roche Holding, Pfizer, Microsoft (9-10 billion dollars), Samsung, Merck, Intel, General Motors Nokia (8-9 billion). In this case, a total of only 20 major corporations accounted for nearly 154 billion dollars (more than 12% of global R&D expenditures). Among the first twenty TNK – more than 40% are American companies [*The budgets in R&D*..., 2013]. It is important to emphasize that the costs for R&D of large TNCs exceed the expenditure for R&D in many countries. In the list of leaders in expenditure on research are many pharmaceutical companies. Costs of these TNCs are concentrated in the areas of research in the classic sense of the word (labs, study drugs, animal testing and clinical trials). The largest TNCs are active not only in the expansion of FDI and

its production facilities overseas, but also the transfer of a number of R & D in the home countries of foreign branches and subsidiaries. This increases the importance of return on investment in R & D and scientific interactions. There is an exchange of innovation, technology, information, knowledge, research staff. It creates a network of research units stationed in the affiliates of TNCs worldwide.

4. Features of the development of the process of internationalization of research activities

It should highlight the following features of the development of the process of internationalization of research activities: the formation of innovation infrastructure (the transfer of knowledge and technology at the global level, the ability to access information from the centers of knowledge); growth and diversity of research activities; development programs and international cooperation in research and development; the formation of the national innovation systems of the world and their participation in the process of establishing a global innovation system; the availability of highly skilled human capital, capable of leading an active international research activities; the interest of big business (TNCs) in the internationalization of research and innovation. It has been shown that the globalization is accompanied by the formation of an economy based on knowledge ("knowledge based economy"), the development of networks, including the Internet, etc., which creates opportunities for the development of R&D internationalization. Knowledge, information becomes increasingly accessible, there is a rapid exchange of technology. Governments of different countries come to life innovative programs of economic development and international projects.

Analysis of the information shows that the internationalization of research is becoming one of the key areas of modern development. Currently, there is an exchange of innovation, technology, information, knowledge, scientists between countries. Many processes are particularly intensively occur within TNCs, and at the creation of innovation centers, technology platforms, within the framework of international agreements and scientific programs. Is not only an adaptation of technology to the specific conditions of a country. The process encompasses a growing number of countries. In the highly competitive internationalization of R&D includes a wide variety of research activities. The process of internationalization of research is characterized by the following features:

– difficulties and lack of opportunities for scientific research only within a country without the use of overseas development, international technology experience;

- increase access to knowledge, information, technology in the modern world;
- variety of research activities through joint efforts of scientists around the world;
- competition for the "best" brains (the problem of "brain drain");
- the formation of co-operation within the framework of the global innovation system.

The internationalization of research activities in the context of globalization is in the following areas: TNC investment, technology transfer, joint research activities (including the publication of scientific articles co-authored by scientists from different countries), the establishment of joint ventures; registering the results of research and development of international patent organizations, attracting scholars international class to work in different countries, innovation centers and universities, as well as in units of TNCs; foreign students at universities around the world, etc.

It is known that one of the important indicators of the effectiveness of the national innovation systems, and the fact of participation of countries in the process of internationalization of R&D is a publication activity. In the world was 986 thousand articles published, including in developed countries – 75.3%, in developing countries – 24.7% (2010). A distinctive feature of the process in the 2000-2010 period. is a two-fold increase in the number of articles in the developing world.

Europe is home to most of the publication activity – more than 40%, America occupies the second position (35%), Asia – a third (over 30%). One in five scientific paper published in the United States. Among European countries, the first position in the global market research publications occupy the United Kingdom, Germany and France. In Asia, Japan stands (7.6% of the world market). The group leaders broke China, where over the 2000-2010 period. the number of scientific papers has grown by 30%. [Antipova, 2012; Galkin, 2013]. China moved to the 1st place in the world in the number of applications for patents (2011). To authorize the marketing of the brand research and development in today's world emerged two centers with more than two-fold gap from other countries, China has taken the first position, the second center – the United States.

5. Recommendations to enhance the involvement of Russia in the global innovation system

The high level of education, the presence of the Soviet-era scientific bases – science cities, Scientific Schools (platforms for the creation and R&D) activities of the Russian Academy of Sciences and universities the opportunity to free

education in universities (along with the contract form of education), the access of talented young people from regions and different countries of the world in the prestigious Russian universities is an advantage the newly emerging Russian national innovation system. However, in the ranking of the Global Innovation Index for 2012, Russia has only 51 seats [The Global Innovation Index, 2012]. In the ranking of the Index of Knowledge Economy – 55th [Knowledge Economy Index, 2012]. The rating on the Global Competitiveness Index – Russia is on 67th place (for comparison: the U.S. ranks 7th, Japan – 10th place, China – 29th place, India – 59th) [The Global Competitiveness Index, 2012-2013].

Remains low proportion of higher education institutions that perform R&D, although the proportion of universities in the internal expenditures on research and development increased to 8.3% in 2010 (the scientific activities conducted 45% of Russian universities). It should be noted that while in Russia there is no significant improvement of conditions for talented young people, and maintain the prestige and pay an "aging" of a professional generation of scientists. Tax system is not encouraging R&D spending. And as a result: in developed countries the ratio of public spending and private sector R&D is 1:3 and 1:4, and in Russia there was the opposite situation – 2.5:1. China in terms of private sector spending on R&D per capita is 1.5 times faster than the Russian. Fixed low level of citation of works of Russian scientists. For the period 2006-2010 an average of one article published by Russian authors or with their participation, accounted for only 2.4 links from scientists all over the world, which once again confirms the lack of demand for works of Russian scientists the world scientific community (with half of all scientific articles of Russia in the database SCOPUS is in Moscow). Russian scientific system in a very small extent focused on the needs of the economy and society. The susceptibility of business to innovate and remain low, there is not a great demand for innovation.

But it should be noted the positive. In the period from 2002 to 2010 the number of young researchers (under 29 years) increased from 56.1 to 71.2 thousand. Their share in the number of researchers in the same period increased from 13.5% to 19.3%. In the period of 2005-2010 has created more than 140 technology innovation centers and technology parks [Galkin, 2013]. Implemented measures of state support for areas with a high scientific and technical potential, including the Russian science cities. However, experience has shown that not all the provisions of the concept of innovative development of Russia will be made in the near future. However, at present the country is implementing a number of innovative programs, research development for the period up to 2020. The main

purpose is to introduce common rules of innovation. Main line – the involvement of Russia in the global innovation system.

There are recommendations to strengthen the involvement of Russia in the process of internationalization in terms of research and innovation:

- Innovation policy and infrastructure should be formed by a single integrated development concept (which should be clearly defined mechanisms for its implementation).
- Should be at the state level to support and develop the competitiveness of research in universities and research centers associated with universities. At the universities of Russia (the experience of the U.S. and other countries) should be set up office management and technology transfer, in which the terms of reference will include: preparation of documents for the protection of intellectual property, financial support for the patenting process, strategic planning, product promotion, commercialization of technology, etc.
- Need to pay attention to the procedure commercialization of scientific results. The key point in this matter should be the relationship the researcher, the research institution and intermediary, introducing product on the market.
- Need to update legislation in the field of intellectual property, to reduce the taxation of the sector or type "tax holidays" for business opportunities, etc.
- Priority for the country should be the policy of support and preservation of highly qualified scientists and science in domestic market. You need to create a good environment for their work.
- Important to draw attention to the problem of patenting in Russia. Need to strengthen the system of protection of intellectual property rights. It is essential to well-known Russian scientific journals have received worldwide recognition (included in the SCOPUS database, etc.) is necessary to increase the level of international cooperation and innovative mobility of researchers.
- Public-private partnerships should be a key component of the new Russian innovation policy. The commercialization of new technologies should be demand-driven research and development by the private sector.
- There is a need to attract the largest Russian TNCs to engage in R&D, as well as the process of funding research in universities and other.

And, of course, it is necessary to restore the prestige and the role of the scientist. It is necessary to strengthen the relevance of the state of science, business, international partners, and society. In this case, the Russian Federation will be able to take a worthy place in the global innovation system. Russia should use a real chance that, given the global experience to go to the innovation.

Conclusions

The spatial non-uniformity of the socio-economic development of countries in the modern post-industrial stage of development has led to the polarization of research and development. Despite the high degree of concentration of R&D in the world, the scientific landscape has changed. The most significant change occurred in the early twenty-first century due to rapidly developing China.

Profound changes are taking place in all structures of the global industry. Its industrial structure is constantly diversifying under the influence of STP, the variety of public production organization forms is modifying, interdependence on the world markets of labor, capital, goods and technologies is increasing. At the same time, both at the country and at the regional and global level, there are shifts in the distribution of production capacity, i.e. the spatial structure of the global industry is changing.

Innovative development is the basis for leadership in the world economy and global industrial development (including in the production of high-tech goods). Leaders in the manufacture of high-tech products are the countries that have put the knowledge and information technology at the service of the economy, so that they now occupy a leading position in the innovation economy.

Based on the analysis of the situation in the Russian authors made recommendations to strengthen the involvement of Russia in the process of internationalization in terms of research and innovation. Russia should use a real chance that, given the global experience to go through innovation.

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ANALIZA MIĘDZYNARODOWYCH PROCESÓW INNOWACJI W ASPEKCIE RELACJI – ŚWIAT A ROSJA

Streszczenie: Artykuł zawiera rozważania z zakresu kompleksowej analizy rozwoju krajowych systemów innowacji z uwzględnieniem procesów globalizacyjnych i działalności korporacji transnarodowych. Rozważania szczegółowe dotyczą specyfiki badań i rozwoju globalnego systemu innowacji oraz korzyści płynących z jego umiędzynarodowienia. Sformułowano szereg zaleceń mających na celu zwiększenie udziału Rosji w tym procesie umożliwiających uzyskanie lepszej pozycji Rosji w zakresie światowej przestrzeni gospodarczej high-tech.

Słowa kluczowe: badania i rozwój, innowacje, przemysł na świecie, produkcja, struktura przestrzenna, zmiany regionalne.