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Alexander Burnasov

Ural Federal University named after
the first President of Russia Boris Yeltsin
Department of International Relations
burnasov@mail.ru

Maria Ilyushkina

Ural Federal University named after
the first President of Russia Boris Yeltsin
Department of Linguistics and Professional
Communication in Foreign Languages
ilyushkina_maria@mail.ru

Yury Kovalev

Ural Federal University named after
the first President of Russia Boris Yeltsin
Department of International Relations
yykowaljow@gmail.com

Anatoly Stepanov

Ural Federal University named after the first
President of Russia Boris Yeltsin
Chair of Economics and Law
anatoly_stepanow@mail.ru

RESEARCH AND DEVELOPMENT OF INNOVATIVE SYSTEMS IN BRICS COUNTRIES

Summary: This article analyzes the research perspectives of innovative systems in BRICS countries and the typical features of their development. The current status and the peculiarities of the formation process of such systems are characterized in the article. The main innovation indicators in these countries and the factors influencing innovative development are represented in the article. The importance of TNCs in the transfer of new knowledge and technologies is also taken into consideration. Additionally, the article attempts to characterize the main directions of scientific-technological policy in BRICS countries.

Keywords: innovation, research, high technologies, BRICS countries, government support.

JEL Classification: O10, O32.

Introduction

An article will be a descriptive analysis with use of tables which is due to lack of historic sources and researches in terms of political and economic relations in BRICS countries. Brazil, Russia, India, China and South Africa (BRICS) are major universally recognized national economies with some unique economic, social and political features. The BRICS members are all developing and newly industrialized countries, distinguished by their large, fast-growing economies and significant influence on regional and global affairs. Each year they become more influential on the world arena not only as producers of standardized goods, raw materials and provision suppliers on the market, but also as the developers of new technologies, creative decision-makers and innovation founders. Significant government support plays an important role in the formation of innovation systems in these countries, and bilateral relations among BRICS nations have mainly been conducted on the basis of non-interference, equality, and mutual benefit.

Along with the differences and similarities in social and economic activities, BRICS countries possess many common features in the advancement of science and technology. They are considered to be the world leaders and they are approaching to the level of developed countries according to growth indicators of students in the institutions of higher education, researchers involved in scientific studies and development projects, publications and patents.

BRICS countries enjoy great potential for future world leading positions in the spheres of high technology production and intensive knowledge service[1], and already occupy leading positions in some high-tech industries. Some are space and nuclear powers and are also among first-rate automobile and aircraft world producers, with obvious progress in the sphere of high-technologies. Each year China, India and South Africa reinforce their positions in information and telecommunication markets and in the production of electronics and pharmaceutics. Brazil and Russia are developing their information sectors intensively resulting in the export of software and other costly services. A transition period is typical of the industrial and power-energy sectors of BRICS countries, characterized by demand in hi-tech services, green technologies and alternative energy. BRICS countries are now attractive for foreign venture capital, with new transnational high-tech players appearing in these countries.

A further common trait is seen in the dualistic research-and-production system characterized by sector and regional disparities. In the economies of BRICS countries we can look to two sectors of economy, one is modern (innovative, post Fordist) and the other, traditional (capital-intensive, Fordist).

The modern sector includes export-oriented, competitive manufacturing industries and service industries. Science and production are closely interconnected

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[1] The industry is considered to be science intensive if its expenditures on production from the capital turnover of industrial enterprises exceed the average indicators in other industries (4%). Knowledge intensive services include service spheres where the proportion of people with higher education exceeds average indicators in other services [Kämpf, 2008, p. 270].

with this sector. Industrial competitiveness depends on the level of cooperation and interaction between study groups and manufacturers.

The traditional sector is characterized by weak innovation activity, and a low level of science and production integration. It includes low-tech branches of the mining industry and traditional agriculture. Dualistic features of business structures are revealed in the developing countries, however, in BRICS countries, the polarization of traditional and modern sectors is extremely high. In the above-mentioned countries the contrast is striking. For example, in the Indian techno polis of Bangalore we can observe the juxtaposition of a clean high-tech sector alongside the abject poverty and unsanitary conditions of the informal sector.

Dualism in development is a typical feature not only of the research-and-production systems of these countries, but also their social and regional structures, and substantial differences in population's incomes and people's life levels in BRICS countries are evident.

South Africa is the world leader in this sphere. In Brazil, 20% of the population hold 75% of the national wealth of the whole country. At the same time 20% of the impoverished make 2.3%. In China, Russia and India these correlations are not as clear cut. [Russoft, 2015, p. 38; Freedman, 2006, p. 102]. It is evident that 50% of the world's poor are concentrated in these countries. Furthermore, a huge gap in the standards of life exists between regions within these countries. As a rule, living standards in the centre are higher than in the periphery.

Disparities are typical of the territorial high-tech production distribution of BRICS countries. The high concentration of innovative resources such as high technological enterprises and the number of patents registered every year are reported to exist only in specialized areas of these countries. 50% of funds concentrated in the whole of Brazil are located in Sao Paolo. Moscow and St. Petersburg bring together 33% of national organizations dealing with scientific and engineering development. Beijing and Shanghai produce 60% of all innovative goods in China, while three Indian states (Maharashtra, Gujarat and Tamil Nadu) make 50% of all registered inventions in the country [IST, 2007]. Peripheral territories find themselves all but excluded from national innovation process.

The governments of these countries adopt a high-technological policy aimed at overcoming technological lag from industrially developed countries and transferring into endogenous innovative development, as indicated in new programs of innovation development. However, the implementation of scientific and technological policies has been implemented at different times in these countries, influencing the levels of innovation development between them. Within a short period of time, China managed to diversify to some extent its agricultural structure as well as carry out reforms in education and science. In the 1980s-1990s China introduced programs for high-technological development (program 863 (1986), Torch program (1988), program 973 (1997) which affected the development of high-tech industries.

The country has enormously increased its expenditure on supporting priority industries in education and science and innovative enterprises. The Chinese Academy of Science has set up many science intensive enterprises including the internationally famous company Lenovo. This policy success is reflected in growth indicators of scientific potential, patent activity and in the contribution of high-tech industries to China's export structure.

In Brazil the conception of a high-technological policy of innovative development started to dominate at the end of 1990s, in Russia and South Africa from the beginning of 2000s. Moreover, these countries have elaborated their programs for the development of innovative economy by pointing out priority development industries for the new economy including information technologies, nanotechnologies and biotechnologies, new material production, the creation of new energy sources and new technologies for environmental protection.

Within education and science we have witnessed impressive changes. In Brazil, the portion of high-tech production in the export structure runs at 19%, while in Russia, according to statistics, it does not exceed 0.5%. Starting in the 1970s, Brazil has been experiencing export growth of mechanical engineering products and reduction of raw material industries.

However, this development is not linear, but cyclic. It is defined by the world market situation [Russoft, 2015]. The export of raw materials and products with a low science intensive extent are still dominating in Russia and South Africa. Backtracking from a raw material oriented economy in Russia is one of the acute problems facing national economic policy. The transition to an innovative economy in these countries is possible by means of intensifying the innovative system in the country (both the national system and the regional one) and with the help of special programs in the development of education, science, entrepreneurship and interaction between them with simultaneous integration into the world innovation system, attracting high-tech companies which can transfer knowledge to the Russian enterprises and provide access to emerging world markets.

1. Innovations and innovative systems

Innovativeness and innovative systems have many various contexts in literature. In terms of methodology used in this paper which is basing on very changeous global conditions innovativeness must be understood as untypical political and economic system between countries with various territory, culture and wealth. The concept of innovative development occupies the central position in theories of regional development. Regional growth is stimulated by territorial capital increase. Such capital increase is formed with the help of competitive advantages in trade. The innovation constituent of goods and services is considered to be the key factor influencing monopolization of some market sectors by the producer leading to profit gain (the concept of innovation rent). Upon the expiration of the period rivals start producing the same products to make the competition intense. This process activates new innovations. The concept of 'innovation rent' explains why some particular regions and large companies refuse their own production, but concentrate on the services of high-valued industries such as scientific and construction engineering, design and logistics. It is becoming easy to reach rapid competitive advantages in these spheres.

According to the definition given by K. Koshatsky, innovation discoveries represent the evolutionary, cumulative, interactive and integrated process of transferring information and knowledge into know-how of a technical, social and organizational character [Kämpf, 2008, p. 62]. This process is rather risky as it assumes information search, its coding and decoding and training. The innovation process develops a systemic nature and is based on the interaction of innovative actors. Nowadays, innovation production appears impossible within a single specific enterprise. Cooperation and actors' interaction are necessary for innovation creation. Groups of various integrated innovative actors on the same territory form the regional innovation system (RIS).

In accordance with the main propositions of RIS theory, a regional innovation system is represented as territorial companies' net including research, administrative and specialized organizations, which interact with each other in terms of innovation process [Kobayashi-Hillary (ed.), 2008, p. 213]. It consists of two sub-systems; the first sub-system is production and knowledge transfer with its research and administrative organizations, and the second sub-system is adaptation and knowledge transfer, making this knowledge a commercial product (industrial enterprises, service companies and so on).

As a rule, there is a huge difference between regional innovative systems of developing and developed countries. In many developing countries central elements (organizations) of innovation system are absent or have a rudimental representation. In most countries only universities producing new knowledge without their future commercialization, can be named among the structural elements of the system. Sub-systems of knowledge implementation into commercial trends represented in developed countries by technological enterprises are developed on a lower level. The same problem is typical of innovation systems of South Africa, Russia, Brazil, India and China.

The number of enterprises which can manufacture innovative goods is almost half that in developed countries (on average, 23% in industrial production while in the European Union this figure equals 40%). The development of the subsystem in the sphere of knowledge implementation should be prioritized in order to achieve efficiency growth in the regional innovation system. Regional innovative systems have the following characteristics.

Evolution. Obviously, any innovative system does not appear within a day; its evolutionary development is a result of a nations' historical development, which can arise as the product of centuries-long evolution of culture, economy and science and the results of their influence and interconnection.

Special features in historical development of the above-mentioned spheres have influence on modern structures in the regions. For instance, the modern Stuttgart region is impossible to imagine without the inventions which have been used here since the 19th century when R. Bosch and G. Daimler founded the automobile industry paving the way for the biggest automobile cluster in Europe. Technological regional development follows the exact path which was set out with the help of previous historical events. Moreover, existing technologies and regional specialization further determine regional development by implementing innovations in existing industries.

It is not only technologies that are subjected to evolutionary development, but also various regional institutions that can influence the conditions for innovation formation. First of all, regional political structures need to adapt conditions necessary for innovation development.

A high technology policy together with robust industrial and commercial policies can help develop innovations as well as impede these processes. The interdependence of innovative processes and evolutionary territorial development together with knowledge accumulation leads to their spatial differentiation. From a geographical perspective, it results in the existence of some regions with developed innovative systems although it may also lead to regions without innovative structures.

In Russia, the development of the knowledge production system has a 280-year history. In 1725, according to a Decree issued by Peter the Great, the Academy of Science was established together with other European Academies (Berlin in 1700, and Swedish in 1739). Over the course of Russian history science has been characterized by different research perspectives, internal resource allocation and efficiency. It has contributed greatly to the development of world science and the generation of new ideas and knowledge. Nevertheless, economic indicators of the received knowledge and the practical implementation of such knowledge are still considered to be the weak point in the country's innovation system. Total government control over innovation processes, the system of planned economy and the lack of rivalry existed in the USSR, preventing it from developing the innovation potential of the country.

Many technological inventions and discoveries were not introduced into everyday life, ultimately resulting in the technological lag behind developed countries and incompatibility of industrial products of the civil sector of the USSR and, later, Russia.

Innovation discrepancies are obvious up to the modern period of industrial development. Russia's proportion of highly industrialized enterprises in the economic structure equals 11.4% while its market share of high technologies is small (0, 5 %) [Kohlhep, 2003, p. 266].

The modern scientific systems of Brazil, India, China and South Africa are rather young from the perspective of evolutionary development of national science (the Academy of Science was established in South Africa only in 1996) [Koschatzky, 2001, p. 464], and according to the number of scientific schools which is less than in European countries and Russia.

China formed its science system according to the Soviet model with a large number of scientific schools and institutions, while India carries out research both in special institutions and universities. In Brazil and South Africa, however, research is concentrated in the universities [Kovalev, 2002, p. 156].

Despite the historical gap in the development of high technologies between developed and developing countries, since the 1990s these countries (particularly China and India) have introduced the concept of the 'innovation lap' (or leapfrogging) which confirms the ability of transition towards a new technological paradigm without evolutionary development. The concept is based on the idea that technological progress is possible at the expense of revolutionary transformation of all inner structures within a country.

Technologically backward countries do not need a long evolutionary path to develop, and can instead borrow advanced technologies from Western countries and develop their economies on that basis. Moreover, they can economize money and time in order to expand their own technologies as in the case with global mobile installation in the countries of the Third World lacking the previous development of an expensive stationary telephone network.

Interaction. Division of labor in innovative processes and cooperation between its actors is a critical moment in its organization. Taking into consideration the complexity of the innovation process, many organizations with different functions take part in this process. Collaboration may follow both the vertical line of innovation process and its horizontal line of innovative and educational activities. Under vertical collaboration, interaction between actors is organized within the innovative chain. Fundamental research is carried out by state research institutions and universities, which in turn share the research results with commercial enterprises to implement new ideas in new products and produce them for the consumers.

Consumers are one active group of actors in the innovation process. A consumer can give impulses for the manufacturers. Horizontal interactions include collaboration between the same functional innovative structures in order to combine the resources and exchange their experience and ideas.

Cooperation between companies makes gathering new knowledge and information from other firms conditional. The educational process aimed at adapting internal and external knowledge goes together with the innovation process which is defined as the process of production of new goods. The process of education addresses innovative activities and our environment. All enterprises in the region, including joint ventures and foreign companies, can serve as knowledge resources, where knowledge is the precondition for innovations and innovations are the results of educational processes. In this sense interaction between innovations and new knowledge is worth pointing out.

Interaction between innovative actors becomes stronger if they are in close proximity to each other. Under this condition, the diffusion of so called not decoded knowledge presupposes personal contact between the actors, and is why innovation regions include cities with a large number of enterprises involved in innovation process. To intensify innovative cooperation many governmental organizations including those in Russia, Brazil, South Africa, India and China follow the policy of creating 'technological parks', clusters and zones of high technologies on their territories. These zones are reported to have the most intensive cooperation between different actors in the innovation process. Furthermore, within these parks, new enterprises obtain support from governmental structures in the form of funding, information and knowledge. Among the most successful projects in these countries we should name the Zhongguancun Park in Beijing, Electronic City in Bangalore (India) and Campinas in Brazil.

2. Innovative systems in BRICS countries

The development level of the innovative system of a particular country or region is reflected in its ability to generate innovative ideas and attract talented employees from all over the world (creative class). Such countries (regions) show good indicators in inventive activities, a high proportion of skilled personnel and the existence of hi-tech companies in the industrial sector as well as in the service sphere. Regions with high standards of innovative activities are named innovation regions.

When we estimate the innovative potential of regions, we should use the indicators evaluating financial support, personnel qualifications as well as the results of innovation activities.

Material costs are included in expenditures on construction activities. Specialists involved in research are estimated in absolute and relative indicators. The number of patents is the indicator for evaluating the results of innovation activities. For this purpose we can use both the absolute data and the number of patents in proportion to the population of the country or the region. With the patent, the inventor obtains the right to the monopoly use of the innovative product and receive rent from his invention. Although all the indicators measuring innovation activities have their drawbacks, in general they give statistical data about the level of innovation concentration on a particular territory and the level of development of the regional innovation system.

2.1. Innovation resources of BRICS countries

In the sphere of resources BRICS countries were not unique in the 1990s: absolute expenditure on scientific constructing fluctuated from 1 billion dollars in South Africa to 10, 4 billion dollars in China [Liefner, 2006, p. 232]. However, over the next 20 years, the situation has changed completely. In 2013 China occupied second place according to the absolute indicators of investment in the research sphere. The costs in 2013 exceeded 6 times the costs in India (42,8 billion dollars), 9 times more than in Brazil, 11 times more than in Russia (31,3 and 24 billion dollars) and 70 times more than in South Africa.

Investment in research in China (290 billion dollars) is second after the USA (396 billion dollars) and twice as much as that in leading technological empires such as Japan (140 billion dollars) [Maksakovsky, 2011, p. 18]. In 2013 BRICS countries had 26.6% of all world expenditures on research construction activities. China is one of the leading countries in the proportion of expenditure on research from GNP of the country. In this country the indicators in 2013 were at 2,08% higher, that is 3 times more, than in developing countries and higher than that of developed countries such as the Netherlands, Italy and Spain. The growth of these indicators in China is also impressive. Comparing the results shows that in 1995 expenditures from GNP were equal to 0,5%, but in 2000 –

0.9%, in 2003 this rose to 1,2%, in 2007 – 1,4%, 2013 – 2,08% (though in many developed countries these indicators were on the same level and have not changed). The Chinese 'leap' into the innovation economy based on the science sector and new technologies with gigantic volumes of investment and qualified personnel increase is quite obvious.

Other BRICS countries have been reported to have minor investment in research from GNP. In Russia it has grown from 0,85% to 1,12%, in Brazil – from 0,7% to 1,15%, in India – from 0,7% to 0,82% [Kohlhep, 2003, p. 266].

Expenditures on science construction in different sectors are spread unevenly. In Brazil, Russia and China, the main investment was directed to the entrepreneurial sphere. China spends only 76% of all money on research, Russia – 58,7%, South Africa – 43%, Brazil – 40,2% and India – 35% [Maksakovsky, 2011, p. 20].

The entrepreneurial sector is considered to be the most important innovation producer. It transforms ideas into real commercial products. Therefore, the more funds invested in research, the more innovative the national economy becomes. Comparing with the leading industrially developed countries, BRICS countries (excluding China) still lose their positions in the entrepreneurial sector within the research construction sphere, but surpass the majority of developing countries and even several developed countries.

Taking a more precise look at the financing structure of the research sphere and its sources, we can observe the distinct divergences. In Russia, money for financial support of research organizations and entrepreneurial structures is taken from the Russian Federation state budget. The state provides 56,7% of all research finance. The entrepreneurial sector takes 16,8% of all research money in the country (one of the lowest indicators in Europe) or summarily 3,8 billion dollars which is higher than in any country of the Eastern Europe [Kohlhep, 2003, p. 266].

There is a world trend in cutting investment from the state into the research sector, while simultaneously raising the entrepreneurial sector. The same trend is typical of BRICS countries.

Since the 1990s Russia, India, Brazil and China have experienced growth in their entrepreneurial sectors. For instance, China in 2012 had 21,7% of state financial support (in 2006 – 24,9%) and large amounts of money were invested in fundamental science. The Chinese government provided 50% of financial support to large and medium-sized companies in the 1980s, in 1990s – 25%, by the beginning of the 2000s – 10% [Kämpf, 2008, p. 270]. Much money is spent on research and investigations of state enterprises. Small businesses feel the lack of capital and, therefore, try to place themselves in the zones of high technologies where they can get regional support.

The state in China is moving away from the practice of direct sponsorship of research activities, but supporting innovation activities of companies by means of tax relief, mutual project financing, risk insurance for industrial enterprises and stimulation of technological transfers.

At the beginning of the 21st century China had 10,400 highly technological firms with capital turnover exceeding 5 million Yuan per year. 70% of these companies carried out their own research [Kämpf, 2008, p. 270]. Among BRICS countries Russia has fewer enterprises producing innovative products. In 2010, only 11,4% of industrial enterprises in Russia dealt with innovations (in Brazil – 35,9%, in China – 29%, in India – 18,5%, in South Africa – 21%).

The low innovation level of Russian enterprises is connected with the disinterest of enterprises in their own innovations, high risks and weak support from the government. Carrying out research in a company is essential not only for creating innovative products but also for implementing foreign technologies into the production process. Without financial support it will be dependent on foreign companies and suppliers of not only equipment, but also service backup. Moreover, innovation departments serve as generators of education procedures which will make the enterprise evolve and make the products more innovative. Therefore, the reduction of the number of research departments in the structure of a company will lead to regression and compatibility loss.

India and Brazil are now experiencing growth of high-tech production with increasing financing of research. Due to multiple advantages of having qualified, but cheap labor, and good infrastructure in some regions, these countries have become attractive for the transfer of some science-intensive types of activities from developed countries to developing ones. This transfer has resulted in a real boom in the high technology sector. Separate innovation regions specializing in the development of high technologies were formed in India; in Bangalore there are more than 250 thousand computer operators – many more than in the Silicon Valley in the USA. Alongside foreign companies, Indian giants of the world information industry such as Infosys exist (the number of employees grew more than 7 times during the period of 2001-2007 (from 9,8 to 70 thousand people). Other companies include Wipro (which grew from 9,9 to 66 thousand people), Tata Consultancy Service with 84 thousand employees (in 2001 it had only 13 thousand people. Special attention should be drawn to the Brazilian company Embraer which is the biggest high-tech exporter in the country.

Human resources are important as a key factor of innovative development of the country and its regions. Without skilled and talented workers innovative economy is impossible. This statement explains why there is a serious rivalry between the world regions for global intellectual capital (specialist, scientists and engineers), which leads to the internationalization of innovation regions and stimulate migration. Such countries as Singapore and Ireland which do not have their own resources are purposefully looking for talents in the world to involve those people into their innovation structures.

BRICS countries own human resources which are able to develop innovation economy. In 2013 they consisted of almost 30% of world research personnel. China had 65,2% of people from BRICS countries in the research sphere (1484 thousand people), Russia – 19,3% (440 thousand people), Brazil – 6% (138 thousand people), India – 8,4% (192 thousand people), South Africa – 0,9% (21,4 thousand people) [Maksakovsky, 2011, p. 20].

In spite of less significant human potential, these countries have various trends in future development.

More and more research specialists and engineers are appearing in India, Brazil and China. During the period of 2002-2013 the number of these specialists doubled (from 750 thousand to 1484 thousand people), in Brazil 70 thousand more specialists have appeared, 39 thousand have been added in China [Maksakovsky, 2011, p. 21]. In Russia during the same period of time the number of personnel reduced by 40 thousand people. Since the collapse of the Soviet Union more than half million of people have left research posts. Such a global scale of ‘destruction’ of one of the most important spheres of culture does not have any analogs in history. The main reason for this the social and economic shock seen in the 1990s. Deteriorating economic conditions for scientists and engineers caused mass migration to other sectors of economy and abroad. Between 1991-1997, more than 70 thousand specialists left the country [Kovalev, 2002, p. 154]. From 1990 to 2006, 1047 research organizations were disbanded, with employees dismissed or forced to change department [IST, 2015]. Currently, we can see mass decline in jobs, but not on a global scale.

2.2. Innovation activity results: Patents and export

The indicator of patent activity of regional actors and foreign companies clarifies the situation with the efficiency of national and regional innovative systems and shows the real number of all declared patents.

Despite the fact that this indicator is used by national and international statistical departments, it has some disadvantages. For instance, not all regional and national enterprises have the opportunity to apply for patents due to high costs and bureaucracy involved. One more factor is that not all applications show the results of innovation activities, many of them just imitate existing products or are the results of industrial espionage. In spite of these drawbacks, data about national and regional patent activity can help evaluate the technological level of development.

Table 1. Invention patenting in BRICS countries in 1995 and 2012

Country	Patent applications received (thousand)		Including patents from national applicants (thousand)	
	1995	2012	1995	2012
Russia (data of the year 2013)	22,2	44,9	17,5	28,7
India	6,5	43,9	1,5	9,5
China	18,6	652,7	10,0	535,8
Brazil	7,4	30,4	2,7	4,7
South Africa	–	–	0,883	0,608

Source: *Russia in Figures 2008* [2014].

Analysis of Table 1 puts China in the absolute leading position according to the number of patent applications received. In 2012, China occupied first place leaving behind such technological giants as the USA (542 thousand) and Japan (342 thousand patent applications).

China's patent growth is impressive. The number of patent applications in China is 10 times bigger than in other BRICS countries on average, placing China in the leading position in this sphere. During the period of 1995-2006 the number of applications increased 11 times (from 18 to 210 thousand). During 2006-2012 it increased a further 3 times. If this growth rate continues, China can expect to become the biggest technological power in the world.

At the same time other BRICS countries were marked by the growth of national patent activity, although not as rapid as in China. In India the patent number increased to 8 thousand, in Brazil – to 2 thousand, in Russia – to 11 thousand, although in South Africa the number of patent applicants decreased. The largest amount of applicants was in China – 74,9% and in Russia – 63.7%. In India and Brazil national inventors play a secondary role in the technological development of the country. Their patent applications make 15,4% in Brazil and 21,6% in India. More applications in these two countries were received from huge foreign corporations which are located on these territories.

Russia occupies second place among BRICS countries according to the number of patent applications. It surpasses many European countries such as Great Britain (23,2 thousand), France (16.6%), but gives way to Germany (61,3 thousand applications) [Kohlhep, 2003, p. 260].

A positive trend in the research sphere of the country is the application growth and high proportion of national applicants, which indicates the increase in innovation activity of Russian enterprises.

On the other hand, the insignificant role of foreign inventors proves that the number of high-tech complexes on the Russian market is limited and that our national resources are not attractive.

Patent activity is closely connected with the trade of high-tech products within the export structure of the country. The number of patent applications is correlated with the position of the country in the structure of world high-tech products export. Such world powers as China, the USA, Japan, Korea and Germany are patent leaders according to their role in the world export.

BRICS countries are characterized by a large proportion in the structure of world export of goods. In 2013 this proportion was equal to 30% which was higher than the proportion of such regional groups as NAFTA 9%-11%) and ASEAN (14%) [*Russia in Figures 2008*, 2014].

In all BRICS countries high-tech export during the period from 1990-2013 increased. As it appeared the Chinese economy is a locomotive for growth dynamics in BRICS countries. Its share in the world export of ready-made goods has increased from 1,9% to 27,3%, in India – from 0,5% to 0,8%. The position of Brazil and Russia has remained the same since 1996, although according to absolute and relative indicators high-tech export has increased. Some changes can be observed on the world high-tech markets (Table 2).

Table 2. BRICS share in the world export of ready-made goods and high-tech products and knowledge intensive services in 2014

Country	Industrial goods (%)	Computer and office equipment (%)	Telecommunication equipment (%)	Integral schemes and electronic components (%)	Computer, informational and telecommunication services
Russia	2,6	0,1	0,1	0,07	1,1
China	12,3	40,9	39,5	17,2	4,5
India	1,7	0,09	0,2	0,06	13,8
Brazil	1,2	0,04	0,06	0,03	0,8
South Africa	0,5	0,07	0,1	0,01	·

Source: *Russia in Figures 2008* [2014].

The analysis of Table 2 displays the Chinese presence on the world markets of high technologies, especially in computer production and exports, and telecommunications, including mobile phones. China is also in a leading position in the world export of electronics and pharmaceuticals. For the last 5-7 years China managed to increase its market share 5-6 times, and the price of exported goods rose 10 times. Data visible in table shows significant differences between goods exported from BRICS countries. It implies some effects that may occur in relations between the BRICS states. Comparative analysis performed below explains what is the essence of these relations, but analyzing the chances and perspectives of development of BRICS group would require to use the methods of analyzing used for example for analyzing influence of various quantities, for example income per capita on ‘willingness’ of ethnically various states to incorporate [Alesina, Perotti, and Spolaore, 1995, p. 753].

In comparison with China, Russia, India, Brazil and South Africa have lower indicators on the world high-tech markets. India is one of the top ten pharmaceutical export countries (2,4% of world export), with its rapid development of biotechnologies, aircraft equipment and computer software. High-tech production share in the structure of industrial export in the country has increased from 3,9% to 8% during 1990-2013. Brazil is focusing mainly on aircraft industry and such not technological branches as food industry and mechanical engineering.

It is worth mentioning that, within a short period of time, India and Brazil managed to transform their export structure and increase the production of manufacturing industries with a reduction of raw materials used. For example, in Brazil in 1970 the share of food supply (coffee, sugar and fruit) in the export structure was 58%, but in 2001 it reduced to 17%. However, with growing demand for Brazilian products in the world, it increased to 35% by the year 2013.

In 2000 India exported business consultant services and computer services. During the period 2006-2014 the export of these types of services increased more than twofold (from 21,4 billion dollars to 55,6 billion dollars). India is second place in the world according to its export indicators [IST, 2007, 2015].

Millions of people are employed in the field of information technologies [SIPRI Yearbook, 2015].

One of the reasons for growth in this industry is the integration of India into the international system of labor division. India has a cheap, but highly-qualified labor force and can attract many high-tech foreign companies to the country. A lot of transnational corporations have opened production centres in India. 92% of IT-companies in India belong to foreign investors, and 100 research centres of foreign transnational corporations are located in India [SIPRI Yearbook, 2015].

The Russian share in the structure of world export is little. Russia is at the bottom of the list when considering the export of computer, electronics and telecommunication equipment. The main reasons for this are the under-development of the high-tech sector and the low activity of high-tech transnational corporations.

According to statistics, only 11,4% of all Russian enterprises are innovative. Most of these are in the military field, petro-chemicals and aircraft equipment.

Raw materials are extremely important in the export structure.

Gas and oil products make 69% of all exports from the country. Among other products from the manufacturing sector metals make up 11,5% and a further 4,4% are taken from the chemical industry. High-tech products make up only 10% of the country's exports [Stamm, Altenburg, and Ankerländer, 2007, p. 13]. At the same time Russia is the main exporter of ammunition on the world market (27%). From the 1990s onwards, growth trends can be observed in the information and bio-technology sectors. Innovation clusters started their formation on the territory of Russia (technopolis Skolkovo, Kazan). However, the indicators of information technologies sectors plummeted and by 2015 this sector showed only 0,65% of GNP of the country. Research centres were opened by foreign hi-tech companies, such as Intel, Motorola, Siemens, Alcatel, Borland, Sun Microsystems, Dell, IBM, offering employment to Russian specialists. In 2015, 5,082 IT-companies were operating in Russia in the off-shore service sphere (in 2009 there were only 365 companies) [UNESCO Science Report, 2015]. Russian computer exports in 2014 equaled 4,4 billion dollars (up from 2, 6 billion dollars in 2008). According to export indicators in the IT sector Russia occupies 8th place worldwide.

BRICS countries in general are characterized by average figures indicating the development level of innovation systems in comparison with other countries. The most important resources are concentrated in the subsystem of knowledge production. The state sector prevails in the financing of innovation activity in Russia, India and Brazil. The main problems of BRICS countries are the lack of the development of a subsystem in knowledge application (entrepreneurial sector) and dominating in innovation production in limited number of industries. The analysis of material costs, employment levels, export and patent activity confirms that there are obstacles on the way to transforming knowledge into technological advances and their further commercialization.

Conclusions

One of the key factors influencing the growth of innovation systems of BRICS countries is their research policy. Despite various discrepancies, it includes four directions for development. Firstly, the aims of technological and scientific development of the countries were identified and the industries with the best prospects were pointed out. This has allowed for the concentration of funds on key industries. In China electronics took the leading position, in India pharmaceutical and off-shore IT-services, while in Russia the priority spheres are nanotechnologies and the military sector. Brazil leads in aircraft building and information technologies, and finally, South Africa has developed its biotechnology and automobile industry.

Secondly, the volume of financial support to national systems of education, science and regional infrastructure was increased. In India, China, Russia, Brazil and South Africa the growth of state expenditure on science and education has become more obvious recently. GNP contributions are now substantial, and China and India have gone as far as introducing government programs for stimulating the return of scientists from the USA and the European Union. The opportunity to have qualified employees is one of the key factors of integration BRICS countries in the world production and innovation system. Innovation activity development is reflected in the location of technological parks, formation of innovation clusters, and improvements to transport and research infrastructure.

Thirdly, the ability to attract foreign investment in BRICS countries is more than just important. The formation of effective innovation systems is impossible without technological complexes within their structures.

Huge international corporations with developed logistics, access to the industrial market of developing countries, advanced knowledge and technological know-how influence regional development and integration of the regions in the world economy. All BRICS countries now have highly technological clusters, but their number is different in these countries.

Fourthly, stimulation of technological and scientific transfer between national and regional actors is worth paying attention to. Innovation development of the regions and the whole country is possible only by means of close cooperation and collaboration between different actors. Universities, research centres, ministries and various companies take part in the formation of regional innovation systems.

Knowledge transfer initiated by both private companies and the state intensifies the local innovation net, and creates innovation advantages of the territories which make the region attractive for other foreign actors.

By organizing meetings and negotiations with the representatives of business and science and involving the government, attracting funds for joint projects and conferences, the government encourages the processes of experience and knowledge exchange, providing the conditions for the growth of the territorial capital.

The innovation development of BRICS countries proves that this particular policy leads to the growth of innovative systems, but the consequences in BRICS countries are not unique. China and India have experienced innovation systems growth with the positive effect on economic development of these two countries. Moreover, China managed to become the most serious technological ‘player’ in the world and produce unique innovative products which are in high demand all over the world. Brazil is reported to have a constant growth of resources potential of innovation systems and technological inventions and production. Unfortunately, Brazil has not changed its position on the hi-tech world market due to its products with a low level of processing in the export structure.

South Africa and Russia are still dependent on their raw materials in the world economy. The indicator of hi-tech products in the export structure in South Africa is 5% while in Russia it is 10% [Stamm, Altenburg, and Ankerländer, 2007, p. 19]. On the one hand, Russia has not managed to make the innovation breakthrough, although on the other hand, the information service is developing in this country together with military expenditures based on world geopolitical conditions. The economic and political isolation of Russia from the USA and European countries might lead to the further reduction of innovation potential of the country. Even now we can observe capital outflow from the country and problems with human resources and Western partners. In this complex situation government support for innovation systems is essential. Furthermore, innovation development and cooperation with BRICS countries is necessary nowadays.

In conclusion, it is worth noting that cooperation in innovation activities can decrease intellectual dependence on developed countries, favorably influence economic and social development of these countries and strengthen their position on the world arena.

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BADANIA I ROZWÓJ SYSTEMÓW INNOWACYJNYCH W KRAJACH BRICS

Streszczenie: W artykule przeanalizowano perspektywy badawcze innowacyjnych systemów w krajach BRICS oraz typowe cechy ich rozwoju. Został opisany aktualny stan i osobliwości procesu formowania takich systemów, a także główne wskaźniki innowacji w tych krajach oraz czynniki wpływające na innowacyjny rozwój. Uwzględniono również znaczenie TNC w transferze nowej wiedzy i technologii. Ponadto artykuł próbuje scharakteryzować główne kierunki polityki naukowej oraz technologicznej w krajach BRICS.

Słowa kluczowe: innowacje, badania naukowe, technologie wysokiej technologii, kraje BRICS, wsparcie rządu.