The Innovation Development of the BRICS Countries: Preconditions and Prospects for Cooperation[1]

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Abstract

The most important factor in the development of the global economy is the intensification of international innovation processes. The degree of state involvement in the international innovation market determines the overall level of national economic competitiveness. However, the pace and scale of innovation in the Russian economy are insufficient. At the same time, innovation processes are closely linked to integration processes. Currently, the role of international integration associations is increasing; as significant subjects of the global economy, they directly interact with other associations, states, transnational corporations and international institutions. In this context, this article analyzes the development of innovation in the BRICS grouping of Brazil, Russia, India, China and South Africa, identifying and describing the preconditions and prospects for cooperation in this field. In this regard, first, the article investigates the development of innovation in the BRICS countries by analyzing the statistical data and the indices to determine the key achievements and problems of countries in this field. Second, it identifies the preconditions and prospects for innovation cooperation among the BRICS countries. This article demonstrates that, despite the obvious leadership of China, all BRICS countries have advantages of development. It also shows that in different years joint research projects of the BRICS countries have been successfully implemented. However, active cooperation began in 2015. The main international agreements are the Memorandum of Understanding on Cooperation in Science, Technology and Innovation, the Strategy for BRICS Economic Partnership and the BRICS Science, Technology and Innovation Work Plan 2015–2018. This article concludes by identifying a number of measures aimed at stimulating further innovation development of the BRICS countries. This article extends the knowledge about the innovation development and cooperation of the BRICS countries.

Key words: innovation development of the BRICS countries; Global Innovation Index; Knowledge Economy Index; World Modernization Index; innovation cooperation of the BRICS countries

For citation: Sidorova E. (2018) The Innovation Development of the BRICS Countries: Preconditions and Prospects for Cooperation. International Organisations Research Journal, vol. 13, no 1, pp. 34–50. (In Russian and English.) DOI: 10.17323/1996-7845-2018-01-02

Introduction

At present, the innovation development of many countries, and of developing and emerging economies in particular, is not sufficient to achieve the structural and institutional modernization of their economies. It should be noted that international eco-

[1] The editorial board received the article in February 2017.

The article was written as a part of project № 15-32-01043, supported by the Russian Foundation for Basic Research.

nomic integration has a positive impact on the economies of the BRICS grouping of Brazil, Russia, India, China and South Africa, including on their innovation development. A key principle of the integration process is accelerated economic development of the system and its components through the implementation of integration potential, which is the managed part of the external relations of the system. These external relations can be represented in the form of a united integration potential with the external environment or can be divided in accordance with particular integration associations or coalitions [Betilgiriev, 2004]. At the same time, it is possible to state that while innovation potential is a component of integration potential, innovation processes also change the association's integration potential by influencing the development and deepening of integration processes. Owing to the introduction of uniform developments in the BRICS member countries there is an expansion of space for innovation, coordination of research programmes, growth of financial opportunities of researchers and the creation of an interconnected economic system at the same technological order. Thus, for the creation and implementation of integration potential it is the "purely" integrative processes (that is, the aspiration of national economies and their structural elements to rapprochement and merger) to join with innovation tendencies of development in a single integration and innovation stream that are key.

The creation of the BRICS reflects the objective rise of new world actors – the emerging and developing countries. Neither the absence of a common border nor the different levels of development among member countries are a barrier to integration. The great importance of BRICS for Russia was confirmed with the adoption of the Concept of Participation of the Russian Federation in BRICS by President V.V. Putin in 2013. However, the export structure of the BRICS is dominated by the fifth technological order as compared to that of the Group of 7 (G7) in which the sixth technological order prevails [Sadovnichiy, Yakovets, Nikonov, Akayev, 2014, p. 378]. In this connection, BRICS countries should intensify their innovation development efforts in the education and science sectors to accelerate their transition to new technological order.

Literature Overview

There is a growing body of research on economic cooperation among the BRICS economies. Among foreign researchers, the work of Jim O'Neill, John Kirton and Caroline Bracht is noteworthy. Investigations in this field have also been conducted by Russian researchers including B.A. KHeifitz, S.P. Glinkina, O.V. Klimovets, G.D. Toloraya, I.S. Troekurova, M.E. Trigubenko and K.A. Pelevina. Particularly worth mentioning is the "Prospects and Strategic Priorities for the Rise of the BRICS: A Scientific Report to the 7th BRICS Summit" edited by V.A. Sadovnichiy, Yu.V. Yakovets, V.A. Nikonov and A.A. Akayev.

Research Purpose

This research analyzes the innovation development of the BRICS countries based on statistical data and the index method to reveal and describe the preconditions and prospects for their cooperation in this field. Specifically, a rating assessment is made based on the Global Innovation Index, the Knowledge Economy Index and the World Modernization Index. Further, statistical data is compared to the actual state of innovation development in each country. This analysis reveals preconditions and prospects for innovation cooperation among the BRICS countries by considering the experience and current interactions involving the development and implementation of joint research and educational projects, and also by reviewing the main international agreements governing these relations.

Innovation Development of the BRICS Countries

The Analysis of Selected World Indices

The Global Innovation Index (GII) is an annual cross-country performance assessment intended to update and improve the way innovation is measured. The GII was established in 2007 and is copublished by Cornell University, INSEAD and the World Intellectual Property Organization (WIPO). In 2016 it was a key source of detailed metrics for 128 economies, representing 92.8% of the world's population and 97.9% of the world's gross domestic product (GDP).The overall GII score is the simple average of the input and output subindex scores. The innovation input subindex is comprised of five input pillars that capture elements of the national economy which enable innovation activities: institutions, human capital and research, infrastructure, market sophistication and business sophistication. The innovation output subindex provides information about outputs which result from innovation activities within the economy. There are two output pillars: knowledge and technology outputs and creative outputs. Each pillar is divided into three subpillars and each subpillar is composed of individual indicators, for a total of 82 indicators in 2016 [Cornell University, INSEAD and WIPO, 2016]. Table 1 presents the GII scores, the input and output subindex scores, the input and output pillars scores for the top three economies and the BRICS countries in 2016.

Table 1 shows that Switzerland, Sweden and the United Kingdom have remained in the top three places over the last few years. Among the BRICS countries China has the best GII score, placing 25th overall. Russia moved up to 43th place in 2016, with South Africa improving by six places, India by 15 places and Brazil by one. Brazil has the lowest GII among BRICS countries, coming in at 69th place.

The analysis of the input and output pillar scores of the BRICS countries points to a number of interesting conclusions. For the first pillar – institutions – South Africa has the best result among the BRICS countries (46th place). Russia takes second place among the BRICS countries; while this observation seems to contradict the results of

Table 1. The Global Innovation Index

Rank in 2016 (Rank in 2015)	Country	The Global Innovation Index	The Innovation Input Subindex					The Innovation Output Subindex	
			Institutions	Human Capital and Research	Infrastructure	Market Sophistication	Business Sophistication	Knowledge and Technology Outputs	Creative Outputs
1 (1)	Switzerland	66.3	90.3	63.3	61.0	69.8	57.6	67.0	61.4
2 (3)	Sweden	63.6	88.3	64.8	66.3	66.2	56.8	63.9	53.4
3 (2)	United Kingdom	61.9	87.6	62.6	66.4	71.6	49.2	50.2	62.5
25 (29)	China	50.6	55.2	48.1	52.0	56.6	53.8	53.3	42.7
43 (48)	Russia	38.5	57.9	50.4	44.5	43.1	37.5	31.9	28.7
54 (60)	South Africa	35.8	69.1	33.1	37.4	58.7	32.2	24.7	26.5
66 (81)	India	33.6	50.7	32.2	37.0	50.3	32.2	31.0	22.5
69 (70)	Brazil	33.2	55.3	32.5	44.9	43.9	37.0	23.7	23.6

Source: [Cornell University, INSEAD and WIPO, 2016, pp. 191, 199, 225, 273, 281, 284, 285, 296].

the Knowledge Economy Index (see below), this result can be attributed to the effective development of the business environment which the GII includes as an indicator whereas the Knowledge Economy Index does not. China is in second-last place among the BRICS countries. For the second pillar – human capital and research – Russia has the best result among the BRICS countries (23th place).The scores related to the third pillar – infrastructure – for the BRICS countries vary from 52.0 points (China) to 37.0 points (India); Russia and South Africa have scores for this pillar that are below their group averages. Regarding the fourth pillar – market sophistication – South Africa has the highest ranking among the BRICS countries (17th place) while Russia takes the last place. In the innovation input subindex, South Africa and Brazil have higher rankings than in the overall GII. For the sixth pillar – knowledge and technology outputs – China shows particular strengths and takes sixth place, ahead of the United Kingdom. For the seventh pillar —creative outputs – all BRICS countries have rather low scores, and on the innovation output subindex China and India have higher rankings than in the overall GII.

In addition, it should be noted that the BRICS countries, and particularly China, improve their rankings on the combined innovation quality indicator:[2] Brazil, India, China and South Africa are among the top 10 middle-income economies in innova-

[2] To better measure the quality of innovation, three indicators were introduced into the GII in 2013: first, the quality of local universities (determined through indicator 2.3.4, QS university rankings average score of the top three universities); second, the internationalization of local inventions (indicator 5.2.5, patent families filed in three offices; this indicator was changed to patent families filed in two or more offices in the 2016 GII); and

tion quality. Specifically, China takes first place in innovation quality in the group of middle-income economies and 17th place in the overall quality of innovation; India takes second and 25thplaces respectively, Brazil takes third and 27th places respectively and South Africa takes fourth and 28th places respectively. The gap between China and the other BRICS countries is significant. Russia, now a high-income economy, has an overall score for this composite indicator that places it in the 26th spot among all other economies [Cornell University, INSEAD and WIPO, 2016, p. 19].

The Knowledge Economy Index (KEI) developed by the World Bank (WB) is an aggregate index representing a country's overall preparedness to compete in the knowledge economy. The KEI is based on a simple average of four subindices which represent the four pillars of the knowledge economy: the economic incentive regime index, the innovation index, the education index and the information and communication technology (ICT) index. At the same time a simple average of three subindices (the economic incentive regime index, the innovation index and the education index) is the knowledge index (KI). Each of these pillars is based on three indicators that serve as proxies for the performance of that pillar: the economic incentive regime index is based on tariff and nontariff barriers, regulatory quality and rule of law; the innovation index is based on royalty payments and receipts, patent applications and journal articles; the education index is based on average years of schooling, secondary enrollment and tertiary enrollment; the ICT index is based on telephones per 1000 people, computers per 1000 people and internet users per 1000 people. The value of each index falls in the range 10–0 and is an expression of the relative position of a country in comparison to all other countries whose index is calculated. According to the World Bank there is a correlation of 87% between the accumulated knowledge measured by means of the KEI and the level of economic development of the country. Calculations by the WB show that an increase in the KEI of one point increases the rate of economic growth by 0.49%. However, starting conditions must also be taken into account [Suslov, 2015, p. 64]. To date, the KEI and the KI have been calculated for 1995, 2000 and 2012. Table 2 presents the KEI, the KI and four subindices for the top three economies and the BRICS countries in 2012 (the most recent data available).

Table 2 shows that Sweden retained its position as the world's most advanced knowledge economy, with a KEI of 9.43 in 2012. Compared to 2000, Finland jumped six positions to second place while Denmark retained third place in 2012.Among the BRICS countries Russia has the best result in 2012, moving up from 64th to 55th place. China also improved its ranking on the KEI and rose seven positions to 84th place. The other BRICS countries moved down in the KEI in 2012: Brazil fell by one spot to 60th place, South Africa fell by 15 spots to 67th place and India fell by six spots to 109th place. India has the lowest score on the KEI.

As to four subindices, among the BRICS countries Russia takes the highest places in three of them: the innovation index, the education index and the ICT index. Notice-

third, the number of citations that local research documents receive abroad (indicator 6.1.5, citable documents H index) [Cornell University, INSEAD and WIPO, 2016, p. 18].

ably, Russia has the lowest score on the economic incentive regime index as compared with the other BRICS countries (117th place) while South Africa has the highest score. In addition, the innovation index is the best subindex for Brazil, India, China and South Africa. The ICT index is the best subindex for Russia.

Table 2. The Knowledge Economy Index

Rank in 2012 (Rank in 2000)	Country	The KEI	The KI	The Economic Incentive Regime Index	The Innovation Index	The Education Index	The ICT Index
1 (1)	Sweden	9.43	9.38	9.58	9.74	8.92	9.49
2 (8)	Finland	9.33	9.22	9.65	9.66	8.77	9.22
3 (3)	Denmark	9.16	9.00	9.63	9.49	8.63	8.88
55 (64)	Russia	5.78	6.96	2.23	6.93	6.79	7.16
60 (59)	Brazil	5.58	6.05	4.17	6.31	5.61	6.24
67 (52)	South Africa	5.21	5.11	5.49	6.89	4.87	4.58
84 (91)	China	4.37	4.57	3.79	5.99	3.93	3.79
109 (103)	India	3.06	2.89	3.57	4.50	2.26	1.90

Source: [Suslov, 2015, pp. 65–66].

However, the analysis carried out by E.V. Balatskij and N.A. Ekimova shows that Russia's position in most of the western institutional ratings is underestimated – sometimes quite significantly. These ratings, as a rule, rely heavily on expert estimates which in most cases are subjective [Balatskij, Ekimova, 2016, p. 232]. Therefore the current analysis would be incomplete without inclusion of the Chinese rating based on the World Modernization Index. This index includes three subindices: the first modernization index, the second modernization index and the integrated modernization index. According to the developers, each subindex reflects the modernization level in economic, social, information and other sectors, but does not show the level of modernization in terms of policy. The first modernization index includes such indicators as gross national income (GNI) per capita, employment in agriculture, value added in agriculture, value added in services, urban population, physicians, infant mortality rate, average life expectancy, literacy rate and tertiary enrollment, and is suitable for developing countries. The second modernization index includes 16 indicators in the four categories of knowledge innovation, knowledge dissemination and knowledge application I and II (quality of life and economic quality), and is suitable for developed countries. The integrated modernization index includes 12 indicators in three categories – economy, society and knowledge. Integrated modernization is the coordinated development of the first and second modernizations [Balatskij, Ekimova, 2016, pp. 104–108]. To date, the World Modernization Index has been calculated only in 2006 and 2012. Table 3 presents this index and three subindices for the top three economies and the BRICS countries in 2012 (the most recent data available).

Table 3. The World Modernization Index

Ranking by the World Modernization Index 2012	Country	Ranking by the First Modernization Index*	Ranking by the Second Modernization Index	Ranking by the Integrated Modernization Index
1	Sweden	1	1	2
2	United States	1	2	9
3	Finland	1	4	4
26	Russia	1	31	38
58	Brazil	1	47	43
64	South Africa	66	58	72
73	China	58	56	62
97	India	91	96	100

* A single ranking is shared by all those scoring 100 on the first modernization index.

Source: [China Centre for Modernization Research, 2012].

Table 3 shows that among the BRICS countries Russia has the best result and was in 26th place in 2012. The other BRICS countries have lower rankings: Brazil – 58th place, South Africa – 64th place, China – 73rd place, India – 97th place. Only Russia and Brazil have completed the first modernization.

Moreover, for a more objective presentation of the data it is necessary to calculate the median or average global rating of the BRICS countries' innovation development. This model was taken from E.V. Balatskij and N.A. Ekimova [2011, p. 134] and was applied by them as the first step of research into the reliability of the comprehensive global university rankings. They state that the combination of various ratings "turns on" the law of large numbers. Therefore the average assessment received on the basis of various ratings can provide a reference point for the country's true ranking. At the same time, they emphasize that because the received median rating has some auxiliary value, it should be considered not as an independent indicator, but rather as a quasi-objective assessment of ratings.

$$z_j = \frac{1}{m}\sum_{i=1}^{m} x_{ij}, \quad (1)$$

where I is the rating index; j is the country index (j runs from 1 to N, where N is the number of all countries in the rating); m is the number of all ratings under study; x_{ij} is the rank (place) of the country j in the rating i; and z_j is the rank (place) of the country j in the median rating.

After applying this model, the BRICS countries are ranked as follows: in first place, Russia (41st place conditionally); in second, China (61st place conditionally); in third South Africa (62nd place conditionally); in fourth, Brazil (62nd place conditio-

nally); and in fifth, India (91st place conditionally). It should be noted that in this case Russia is the obvious leader while China, South Africa and Brazil share similar conditional rankings. Overall, South Africa and Brazil have scores that differ by less than one point. It is necessary to apply the results of calculations very carefully, but these results bring some clarity to a disposition of the countries from the point of view of the existing global ratings of countries' innovation development.

The Analysis of the Statistical Data

Table 4 presents some statistical science and technology indicators for the BRICS countries in 2015 (or the most recent data available) and shows the position of Russia among the member countries.

Table 4. Science and Technology Indicators for the BRICS Countries and Position of Russia

Indicator	The Absolute Value					The Relative Value (Russia —100%)				
	Brazil	Russia	India	China	South Africa	Brazil	Russia	India	China	South Africa
Researchers in R&D, Full-time Equivalent per Million	698	3073	157	1089	405	22.7	100	5.1	35.4	13.2
Scientific and Technical Journal Articles per 10,000*	2.38	2.48	0.73	2.96	1.82	95.9	100	29.4	119.4	73.4
Expenditures for R&D (% of GDP)	1.24	1.19	0.82	2.05	0.73	104.2	100	68.9	172.3	61.3
High-technology Exports (% of Manufactured Exports)	12.3	13.8	7.5	25.8	5.9	89.1	100	54.3	187	42.8
Intellectual Property Receipts ($ Millions)	581	726	467	1085	103	80	100	64.3	149.4	14.2
Intellectual Property Payments ($ Millions)	5250	5634	5009	22022	1708	93.2	100	88.9	390.9	30.3
Patent Applications of Residents per 10,000	0.22	2.05	0.1	7.06	0.16	10.7	100	4.9	344.4	7.8

* Data are available for 2013.

Source: [World Bank, 2015; Cornell University, INSEAD and WIPO, 2016, pp. 191, 199, 225, 273, 281].

According to Table 4, among the BRICS countries most of the absolute and relative indicators are highest for China, followed by Russia. At the same time the indicator for "researchers in R&D, full-time equivalent per million" is the best for Russia as compared with other BRICS countries. This is because, while China and India produce large numbers of scientists and engineers, the general population grows at a faster rate resulting in lower per capita scores. However, the gap in almost all indicators between

the BRICS countries should not prevent the development of scientific cooperation. It is possible to note the following conditions that are favourable to the development of innovation cooperation among BRICS countries.

First, while there are development gaps between BRICS countries, they are not critical. Second, the advantages of China are not total, and Russia has the best result on a number of indicators among BRICS countries. It is the mobility of the innovation growth centres that is important for international integration processes and is locomotive of healthy competition. Third, indicators such as "expenditures for R&D" and "high-technology exports" are several times higher for China than for the other BRICS countries – India trails China with a significant gap between them. Russia's strengths lie in the development of human capital and research and the number of researchers in R&D per million. Brazil shows positive results on the knowledge economy development and the modernization implementation indicators, and is second among BRICS countries after Russia on the Knowledge Economy Index and the World Modernization Index. Despite obvious problems South Africa shows the best result among BRICS countries on institutional development as confirmed by the Global Innovation Index and the Knowledge Economy Index, and also on market sophistication.

At the same time the BRICS Think Tanks Council outlines the current challenges for the BRICS countries' innovation development (Fig. 1).

According to Figure 1, low levels of productivity compared to developed countries, the overall low impact of patents and publications and regional imbalances within the country are weaknesses shared by all BRICS countries. Innovation cooperation among the BRICS countries should promote the solution of these problems.

Innovation Cooperation of the BRICS Countries

Experience of Implementation of Joint Research and Educational Projects

BRICS countries have undertaken various successful joint research and educational projects which should be noted. Brazil, Russia, India, China and South Africa had significant cooperation within the European Union's Seventh Framework Programme for Research and Technological Development in 2007–2013 (Table 5).

Embrapa's virtual laboratories programme (Labex, Brazil) is a mechanism to foster international cooperation among developing and developed countries and promote agricultural research networks. There are Labex projects in Europe, the U.S., Korea and China. Labex China was established by the Chinese Academy of Agricultural Sciences. Brazil and China also cooperate on space technology. In 1988 a partnership involving Brazil's National Institute for Space Research and the Chinese Academy of Space Technology was signed to develop remote-sensing satellites. This partnership continues to date.

Brazil	Russia	India	China	South Africa
• Low levels of productivity compared to developed countries. • Low and stagnant level of patent applications. • Overall low impact of patents and publications. • Regional imbalances within the country. • Imbalances in education and qualification of the workforce. • Dependence on commodities and resource-based industries. • Overall weak innovation performance and demand for innovation from business sector, compared to developed countries	• Low levels of productivity compared to developed countries. • Overall low impact of patents and publications. • Regional imbalances within the country. • Dependence on commodities and resource-based industries. • Overall weak innovation performance and demand for innovation from business sector compared to developed countries	• Low levels of productivity compared to developed countries. • Overall low impact of patents and publications. • Regional imbalances within the country. • Imbalances in education and qualification of the workforce. • Overall weak innovation performance	• Low levels of productivity compared to developed countries. • Overall low impact of patents and publications. • Environmental imbalances within the country. • Regional imbalances. • Prevalence of "secondary innovations"	• Low levels of productivity compared to developed countries. • Overall low impact of patents and publications. • Regional imbalances within the country. • Imbalances in education and qualification of the workforce. • Dependence on commodities and resource-based industries. • Overall weak innovation performance and demand for innovation from business sector compared to developed countries

*Fig 1. C*urrent Challenges for the BRICS Countries' Innovation Development

Source: [Institute for Applied Economic Research, 2015, p. 154].

Table 5. The BRICS Countries in the European Union's Seventh Framework Programme for Research and Technological Development

Country	Number of Organizations	Number of Projects	Total Value of Financing, € Millions
Brazil	235	166	26.5
Russia	452	281	54.9
India	254	164	34.6
China	269	237	30.1
South Africa	195	158	27.5

Source: [Gromova, 2014, p. 57].

The University of Shanghai Cooperation Organization is a network university which combines the educational potential of several universities from Kazakhstan, China, Kyrgyzstan, the Russian Federation and Tajikistan (79 universities in 2016). The education model is based on an academic exchange between students from joint cooperation programmes who must spend at least one semester in a partner university

in another country [Institute for Applied Economic Research, 2015]. M.V. Lomonosov Moscow State University and the Beijing Institute of Technology signed an agreement in 2014 to establish a Chinese-Russian University in Shenzen. It was opened in 2017.[3]

On18 November 2015 the BRICS ministries of education signed the Memorandum of Understanding on Establishment of the BRICS Network University in Moscow during Russia's presidency of the BRICS. This Memorandum is the key document for the establishment of the BRICS Network University aimed at developing, preferentially, bilateral and multilateral short-term joint training, masters and PhD programmes, along with joint research projects in various fields according to common standards and quality criteria, which are recognized for BRICS Network University participants as per national criteria. At the moment field priorities include energy, computer science and information security, BRICS studies, ecology and climate change, water resources and pollution treatment and economics.[4] In February 2016 the Ministry of Education and Science of the Russian Federation approved a list of 12 Russian universities which became part of the BRICS Network University, including MGIMO, M.V. Lomonosov Moscow State University, MIPT, National University of Science and Technology "MISiS," Tomsk Polytechnic University, Higher School of Economics, MPEI, Tomsk State University, Peoples' Friendship University of Russia, St. Petersburg State University, ITMO University and Ural Federal University.[5]

Current Science, Technology and Innovation Cooperation among BRICS Countries

BRICS countries stated their commitment to develop science and technology cooperation since 2009 at the first BRICS summit in Yekaterinburg. However, they have not taken active steps towards this goal until recently. Nevertheless, in March 2013 the BRICS Think Tanks Council was established to form a platform for the exchange of ideas among researchers, academia and think tanks, with responsibility for convening the BRICS Academic Forum. This Council comprises five research institutes representing each of the BRICS countries: the Institute for Applied Economic Research (Brazil), the National Committee for BRICS Research (Russia),[6] the Observer Research Foundation (India), the China Centre for Contemporary World Studies (China) and the Human Sciences Research Council (South Africa).

The BRICS countries took a major step toward the development of science, technology and innovation cooperation when the Memorandum of Understanding on Cooperation in Science, Technology and Innovation was signed at the II BRICS Science,

[3] Chinese-Russian University. Available at: http://msuinchina.org (accessed 20 April 2017).

[4] BRICS Network University. Available at: https://nu-brics.ru/universities/ (accessed 20 August 2017).

[5] The Ministry of Education and Science of the Russian Federation. Available at: https://минобрнауки.рф/новости/6841 (accessed 20 April 2017).

[6] In addition to the National Committee for BRICS Research, BRICS research in Russia is carried out by the Interfaculty Coordination Council of Lomonosov Moscow State University on BRICS Problems Research, the BRICS Centre at MGIMO, BRICS Studies Centre of Ural Federal University, and the BRICS Research Group of the International Organizations Research Institute at National Research University Higher School of Economics.

Technology and Innovation Ministerial Meeting in Brasília (Brazil) in March 2015. This document defines competent authorities, objectives, areas of cooperation, mechanisms and modalities of cooperation, governing structures, funding mechanisms and instruments and management of intellectual property rights. Also, in July 2015 the Strategy for BRICS Economic Partnership was adopted by the BRICS leaders in Ufa (Russia). The Strategy covers a wide range of issues including science, technology and innovation cooperation. Based on the Memorandum and Strategy documents, the BRICS Science, Technology and Innovation Work Plan 2015–2018 was developed and adopted in October 2015. This Work Plan focuses on the five thematic areas and defines contact institutions for collaboration: prevention and mitigation of natural disasters (Brazil); water resources and pollution treatment (Russia); geospatial technology and its application for development (India); new and renewable energy and energy efficiency (China); and astronomy (South Africa). Also, it provides new research and innovation initiatives. The Work Plan notes that "the coordination of the activities within the main areas of cooperation will be implemented by BRICS Research and Innovation Networking Platform (RINP) aimed at facilitation of research collaboration" [Official Website of Russia's Presidency in BRICS, 2015]. At the same time, to foster science, technology and innovation cooperation the BRICS Research and Innovation Initiative will be implemented providing the following mechanisms and levels of cooperation: first, promotion of the coordination within a large-scale research infrastructure to support initiatives leading to the efficient use and development of megascience projects; second, coordination of existing large-scale national programmes within the BRICS countries; promotion of research in the main areas of cooperation through the implementation of a BRICS Framework Programme for funding multilateral joint projects for research, technology commercialization and innovation; and establishment of the BRICS RINP to facilitate research collaboration, technology transfer, support of micro, small, and medium enterprises in technology and innovation activities, develop innovation and technology clusters, high-tech zones, science parks and incubators and create BRICS research and innovation centres [Official Website of Russia's Presidency in BRICS, 2015].

To achieve the stated aims of cooperation, a number of activities in science, technology and innovation areas within the BRICS countries were carried out in 2016–2017. In May 2016 a coordinated call for BRICS multilateral projects within the BRICS Science, Technology and Innovation Framework Programme was announced for the first time. The funding organizations from the BRICS countries were the National Council for Scientific and Technological Development (Brazil), the Foundation for Assistance to Small Innovative Enterprises (Russia), the Ministry of Education and Science (Russia), the Russian Foundation for Basic Research (Russia), the Department of Science and Technology (India), the Ministry of Science and Technology (China), the National Natural Science Foundation of China (China), the National Research Foundation (South Africa) and the Department of Science and Technology (South Africa). In Russia, the Russian Foundation for Basic Research supports basic research projects, the Ministry of Education and Science supports applied research projects and the Foundation for Assistance to Small Innovative Enterprises supports innovation research pro-

jects in the following thematic areas: prevention and monitoring of natural disasters, water resources and pollution treatment, geospatial technology and its applications, new and renewable energy, energy efficiency, astronomy, biotechnology and biomedicine including human health and neuroscience, information technologies and high-performance computing, ocean and polar science and technology, material science including nanotechnology, and photonics. The duration of a cooperative research project is up to three years. A total of 320 proposals have been submitted; 26 projects have been selected for support as an outcome of the call. At the same time Russian organizations take part in 22 projects. It should be noted that the Ministry of Education and Science supports seven research projects (the total budget for this call is up to 180 million roubles, up to 10 million roubles per project per year), the Russian Foundation for Basic Research supports 13 research projects (the total budget for this call is approximately 120 million roubles) and the Foundation for Assistance to Small Innovative Enterprises supports two research projects (the maximum amount per proposal is 15 million roubles).[7] In 2017 a second coordinated call for BRICS multilateral projects was announced.

Moreover, it is necessary to note the following actions. On 2 March 2016 a meeting of the BRICS Working Group on Geospatial Technology and Applications for Development was hosted in Noida, Uttar Pradesh, India. On 30 April – 3 May 2016 the BRICS First Conference on Photonics was held at the Skolkovo Institute of Science and Technology, Russia. On 5–7 September 2016 the BRICS Astronomy Workshop took place in Ekaterinburg, Russia. On 8 September 2016 the 2nd Meeting of the BRICS Astronomy Working Group took place also in Ekaterinburg, Russia. On 26–30 September 2016 the BRICS Young Scientists Conclave was heldin Bengaluru, India. On 29–30 September 2016 the international scientific and practical "BRICS Water Forum" was organized in Moscow, Russia with the support of the Ministry of Education and Science of the Russian Federation. On 16–18 February 2017 the BRICS Youth Forum was held at M.V. Lomonosov Moscow State University, Russia. On 15–16 May 2017 a two-day meeting of the BRICS Working Group on Research Infrastructure and Mega-Science Projects took place at the Joint Institute for Nuclear Research, Russia. On 1 June 2017a panel session entitled "BRICS: Boosting Economic Cooperation" took place within the St. Petersburg International Economic Forum 2017, Russia. On 11–15 July 2017 the Second Conclave of the BRICS Young Scientist Forum was organized in Hangzhou, China.[8] This list is not exhaustive, but shows the active development of science, technology and innovation cooperation among BRICS countries.

Based on this research, a number of measures can be proposed aimed at stimulating further innovation development of the BRICS countries:

1) open access to new research results in publications within the BRICS;

2) support of joint projects carried out by researchers and institutions from all BRICS countries;

[7] Foundation for Assistance to Small Innovative Enterprises. Available at: http://www.fasie.ru/upload/docs/Guide%20for%20Russian%20applicants%20BRICS%202016.pdf (accessed 26 June 2017); BRICS STI Framework Programme. Available at: http://www.brics-sti.org (accessed August 2017).

[8] National Committee for BRICS Research (Russia). Available at: http://nkibrics.ru/ (accessed 20 July 2017).

3) establishment of innovation alliances between R&D institutes, universities and companies from the BRICS countries aimed at generation and implementation of joint projects;

4) stimulation of creation and development of innovation clusters which include R&D institutes and R&D-intensive companies from all BRICS countries in terms of using "open innovation" that can be described as combining internal and external ideas as well as internal and external paths to market to advance the development of new technologies;[9] these open innovations will be available to all participants of the cluster;

5) establishment of a BRICS institute of innovation and technology along the lines of that successfully developed in the European context – the European Institute of Innovation and Technology which integrates educational, research and innovation activities; and

6) development of mechanisms of interaction and hierarchy of national and international cooperation and activity coordination institutes; this mechanism must include the determination of the international institutes' priority and importance levels for national economies and vice versa, the development of a participation mechanism for the establishment of international institutes and their inclusion in the national economy, the introduction of dispute settlement procedures between international and national institutes, recognition of the validity of international obligations and national responsibility for meeting these obligations, and the use of international principles, norms, concepts and terms in national economy.

Conclusion

Based on the analysis in this paper, it can be stated that the transition from "purely" integrative processes to integration and innovation streams promotes the creation and implementation of integration potential. Within the BRICS there is an unevenness of development and a gap between member countries. Despite the obvious leadership of China, its advantages are not total. Russia has the best standing based on a number of indicators and takes the highest places on the Knowledge Economy Index and the World Modernization Index. Overall, all BRICS countries have advantages with respect to the development and implementation of their national economy's innovation potential. Despite obvious problems South Africa shows the best result among the BRICS countries related to institutions development and market sophistication, as confirmed by the Global Innovation Index and the Knowledge Economy Index.

Moreover, in different years joint research and educational projects among BRICS countries have been successfully implemented even while active cooperation began only in 2015. The main international agreements are the Memorandum of Understanding on Cooperation in Science, Technology and Innovation, the Strategy for BRICS Economic Partnership and the BRICS Science, Technology and Innovation Work Plan 2015–2018. To achieve the stated aims of cooperation, a number of activities in scientific, technology and innovation areas were carried out within the BRICS countries in

[9] Openinnovation.eu. Available at: http://www.openinnovation.eu/ (accessed 20 August 2017).

2016–2017.At the same time it is necessary to further stimulate the innovation development of the BRICS countries and then establish the Single Innovation Area.

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Инновационное развитие стран БРИКС, предпосылки и перспективы сотрудничества[1]

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Важнейшим фактором развития современной глобальной экономики является активизация международной инновационной деятельности. Степень включенности в международный рынок инноваций определяет общий уровень конкуренции экономики страны. Однако к настоящему времени темпы и масштабы развития инновационности российской экономики недостаточны. При этом инновационные процессы неразрывно связаны с интеграционными процессами. В настоящее время заметно возрастает роль интеграционных объединений, которые теперь являются полноправными субъектами мирового хозяйства, напрямую взаимодействующими с другими объединениями, государствами, транснациональными корпорациями, различными международными организациями. Поэтому целью исследования является анализ инновационного развития стран БРИКС, а также выявление и характеристика предпосылок и перспектив их сотрудничества в данной области. В связи с этим, во-первых, в статье в несколько этапов исследуется инновационное развитие БРИКС, включая анализ статистических данных и рейтинговых оценок на основе Глобального инновационного индекса, а также Индекса экономики знаний и Индекса всемирной модернизации; определяются ключевые достижения и проблемы стран в данной сфере. Во-вторых, раскрываются предпосылки и перспективы инновационного сотрудничества стран БРИКС. В ходе исследования выявлено, что все страны БРИКС имеют свои преимущества с точки зрения инновационного развития национальной экономики, несмотря на явное лидерство Китая. Также можно отметить, что в разные годы успешно реализовывались и реализуются совместные научно-исследовательские проекты стран БРИКС. Однако, несмотря на то, что приверженность стран БРИКС развитию научно-технологической кооперации утверждалась с самого первого саммита в 2009 г. в Екатеринбурге, активное сотрудничество началось с 2015 г. При этом основными международными соглашениями являются Меморандум о сотрудничестве в сфере науки, технологий и инноваций, Стратегия экономического партнерства БРИКС, Рабочий план БРИКС по науке, технологиям и инновациям на 2015–2018 гг. В результате исследования предложен ряд мероприятий, направленный на стимулирование дальнейшего инновационного развития стран объединения. Данная статья расширяет знания об инновационном развитии и сотрудничестве стран БРИКС.

Ключевые слова: инновационное развитие стран БРИКС; Глобальный инновационный индекс; Индекс экономики знаний; Индекс всемирной модернизации; инновационное сотрудничество стран БРИКС

Для цитирования: Сидорова Е.А. Инновационное развитие стран БРИКС, предпосылки и перспективы сотрудничества // Вестник международных организаций. 2018. Т. 13. № 1. С. 34–50. DOI: 10.17323/1996-7845-2018-01-02

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