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PROSPECTS FOR BRICS SCIENCE AND TECHNOLOGY COOPERATION IN THE CONTEXT OF DIGITAL TRANSFORMATION

Abstract:

Today in the changing global geopolitical context we can record the increasing role of the growing impact of scientific and technological progress on international economic relations.
Geopolitical tensions, objectively determined by structural shifts accompanying the ongoing change of technological modes, are a catalyst for the search for new scenarios focused on scientific and technological cooperation between countries.
New institutional structures, such as the BRICS group of countries, play an important role in today's global economy. In recent years, cooperation with the BRICS countries has increasingly become a priority in a variety of areas, especially in science, technology and innovation.
Effective use of scientific and technological potential by the countries is a fundamental factor of their stable economic development, improvement of competitiveness in the world global market, formation and development of national innovation systems. Emerging international science and technology relations (ISRT) are becoming a new systemic structure of international economic relations of the BRICS countries. In this regard, the issues of digital transformation of the countries are becoming increasingly important. In this paradigm, the experience of developing countries and regional associations, such as BRICS, is of interest, and has not been sufficiently studied so far.
The BRICS digital transformation scenario as an imperative to transition to Industry 4.0 entails not only technological and economic changes, but also institutional ones. This factor may be a strength of BRICS, because since 2011, all the adopted documents in the field of digital transformation of the member countries of the interstate association are characterized by a high level of implementation.

Keywords:

BRICS, digital transormation, science, technology

JEL Classification: O19

Introduction

Issues of scientific and technological development are currently of particular relevance due to the need for a breakthrough in the digital transformation of the economy and the transition to a new technological stage, that is, the fourth industrial revolution.

In recent years, cooperation with the BRICS countries has increasingly become a priority in a variety of fields, including science and technology. Among the generally recognized tools aimed at implementing such a development model are international scientific and technological cooperation and international integration in the field of research and development, organization of effective partnerships with foreign research centers, agreement with them on the priorities of scientific and technological cooperation (BRICS 2014-2021).

Accordingly, identifying S&T priorities shared by BRICS economies becomes increasingly relevant for planning their cooperation (Kahn, 2015; Kotsemir et al., 2017).

In addition, one of the priorities of BRICS cooperation is to strengthen innovative cooperation between the countries on enhancing sustainable growth in Industry 4.0 (the fourth industrial revolution) with a focus on the digitalization of technology. The BRICS partnership on the new technological paradigm was initiated at the Johannesburg summit in 2018 (Johannesburg Declaration of the BRICS, 2018). Digitalization is now a global, universal trend, transforming methods and means of management, approaches to managerial decision-making, and the economy as a whole. Knowledge is becoming a major factor - not only as an intellectual resource, but also as an information base, information about a system of relationships.

The new, fourth industrial revolution logically follows the third, the digital revolution, which emerged in the mid-20th century. It is characterized by a combination of technologies that blurs the boundaries between the physical, digital and biological spheres of society. Its speed, scale and impact on the world around it are unprecedented in history, as Industry 4.0 is evolving exponentially rather than linearly. Advances in fields such as artificial intelligence, robotics, autonomous vehicles, 3D printing, nanotechnology and biotechnology, combined with the unlimited access of millions of people to mobile devices with unprecedented computing power, are taking the fourth industrial revolution to a whole new level of development (Noga, 2021).

In this paradigm, the experience of developing countries and regional associations, such as the BRICS, is of interest, but has not been sufficiently studied so far.

Undoubtedly, the new geopolitical realities associated with the COVID-19 pandemic make the issue of intensifying digital transformation and increasing the interaction of countries in this vector particularly acute. The "digital boom" - the explosive demand for digital services and services in the context of the pandemic - has illustrated an important trend in both economic and social development of countries.

In this connection, research aimed at substantiating the priority tracks of BRICS cooperation in the digital transformation of the economy and at monitoring the digital profile of the BRICS countries become relevant. At the current stage, this is an important theoretical and applied task.

There is a growing body of research on S&T cooperation among the BRICS countries. Among foreign researchers, the works of John Kirton, Jim O'Neill, and Caroline Bracht should be noted. Research in this area has also been conducted by Russian scientists. The works of A.V.

Biryukov, S.A. Gusarova, E.A. Degtereva, I.V. Danilin, L.N. Krasavina, M.V. Larionova, A.V. Malgin, Y.N. Moseikin, A.G. Pikalova, G.D. Toloraya, B.A. Kheifets are of interest.

Research Materials and Methods

The key method of this study is a content analysis of open sources of information, such as the BRICS strategic documents on the digital economy, the BRICS joint documents on digital partnership, in particular, the 2018 Johannesburg Declaration of the BRICS countries and the approved BRICS Economic Partnership Strategy until 2025. In addition, the method of comparative analysis is actively used. The methodological basis of the research is international ratings of the OECD, the World Bank Group, the International Telecommunication Union (ITU) and the International Institute for Management Development. The information base of the study is the scientific works of foreign and domestic authors in the field of digital transformation and cooperation of the BRICS countries.

Results

Over the past five years, science, technology and innovation cooperation (hereinafter - STI) within the interstate association BRICS has developed exponentially and reached a fundamentally new level.

The cooperation of the five countries in the field of science, technology and innovation can be rightly recognized as one of the drivers of cooperation within the framework of the interstate association. The successful implementation of STI initiatives is carried out with the consistent and effective fulfillment of commitments enshrined in such fundamental documents as:

- Memorandum of Cooperation in Science, Technology and Innovation (Brasilia, Brazil, March 18, 2015). The year 2020 was the five-year anniversary of the signing of the document;

- BRICS Economic Partnership Strategy (Ufa, Russia, July 9, 2015, as well as paragraph 62 of the Ufa Declaration adopted at the end of the seventh BRICS Summit (Ufa, Russia, July 9, 2015);

- annual declarations consolidating the progress achieved and defining further vectors of development. On September 20, 2019, the seventh meeting of BRICS science, technology and innovation ministers was held in the city of Campinas, Brazil. At the end of the meeting, the ministers adopted the Campinas Declaration and signed a calendar of STI BRICS events for 2020;

- BRICS Working Plan for Science, Technology and Innovation 2019-2022 [1].

Tools for the implementation of BRICS STI cooperation include regular meetings of ministers and senior officials, working groups, joint research projects, forums for young scientists, the BRICS Global Research Infrastructure Network, etc.

Under Russia's second BRICS presidency in October 2015, the Ministers of Education and Science of Brazil, Russia, India, China and South Africa signed the Moscow Declaration, which supported the establishment of working groups on large research infrastructures, financing multilateral research projects, technology commercialization and innovation. The list of areas of cooperation among the BRICS member states was expanded with the following priorities:

[1] BRICS: Russian Chairmanship 2020 Electronic resource, access mode: https://brics-russia2020.ru/images/39/55/395526.pdf (accessed 28 July 2022)

Establishment of the BRICS Young Scientists Forum (coordinated by India);

- biotechnology and biomedicine, including human health and neurosciences (coordinators - Russia and Brazil);
- Information technology and high-performance computing (coordinated by China and South Africa);
- ocean research, polar research and technology (coordinators - Russia and Brazil);
- materials science, including nanotechnologies (coordinators - Russia and India);
- photonics (coordinators Russia and India).

The Jaipur (India) Declaration and Work Plan on BRICS Cooperation in Science, Technology and Innovation, signed by BRICS ministers in October 2016, expanded the prospects for cooperation by establishing the BRICS Network on Global Research Infrastructures to support initiatives for sharing and developing mega-sciences and the Innovation Network Platform as a mechanism to coordinate and engage business and academia, transfer of technology, involvement in innovative.

The discussion of innovation as a tool for BRICS cooperation and a critical driver of sustainable economic development was the main topic of the Seventh Meeting of BRICS Senior Officials and the Fifth Meeting of BRICS Science, Technology and Innovation Ministers in Hangzhou (PRC) in 2017.

The BRICS organizations that finance research and innovation agreed on the BRICS Framework Program for Science, Technology, and Innovation Cooperation in 2016 and began to implement it. The program provides for the allocation of funds to joint research and innovation projects (one project must involve at least three partners from three different BRICS countries) selected on the basis of competitive bidding.

The recently created mechanism for the management and coordination of BRICS STI cooperation deserves special attention. According to the BRICS New Science, Technology and Innovation Architecture concept proposed by Brazil in 2019, the governance model is structured around four areas of collaboration:

- Scientific collaboration carried out by BRICS Working Groups (hereafter, WGs) (WGs in a wide range of thematic areas: astronomy; biotechnology and biomedicine, including human health and neuroscience; photonics; materials science and nanotechnology; geospatial technologies and applications; natural disaster management; information and communications technology (ICT) and high performance computing systems; oceanic and polar research cooperation; LED light sources;

- research infrastructure cooperation (BRICS Global Research Infrastructure Network (BRICS GRAIN);

- cooperation in the field of innovation (BRICS Innovation Cooperation Action Plan 2017-2020, the BRICS Innovation Network (iBRICS), technology transfer centers of the BRICS countries);

- development of the sphere of long-term cooperation (holding the BRICS Young Scientists Forum, meetings of representatives of BRICS Academies of Sciences and conferences on technological foresight and STI policy). In order to implement the New BRICS Architecture initiatives, Russia has developed and agreed with its BRICS partners a mechanism in the format of the Steering Committee to ensure full-fledged management and coordination of STI activities of the BRICS countries.

The BRICS Young Scientists Forum has been held annually in different BRICS countries since 2016. The international forum provides the potential for creating a powerful networking platform for the interaction of young scientists and entrepreneurs of the BRICS countries and has become an important arena for the promotion of new scientific ideas and the training of young specialists. Every year the country presiding over the BRICS interstate association hosts the BRICS Young Scientists Forum. It promotes communication and cooperation between young scientists from the BRICS countries.

The priority research and development areas of individual BRICS countries are: Brazil - agricultural, biological and medical sciences; Russia - physics and astronomy, engineering, mathematics, materials science, Earth and planetary sciences; India - mechanical engineering, medicine, computer science, chemistry, physics and astronomy; China - mechanical engineering, materials science, computer science; South Africa - medicine, social sciences, agricultural and biological sciences (Kotsemir,2017).

At this time, BRICS cooperation is concentrated in areas such as physics and astronomy, Earth sciences and, to a lesser extent, medicine.

The following subject areas are particularly important for several BRICS countries at once: agricultural and biological sciences; biochemistry, genetics and molecular biology; chemistry; computer science; Earth and planetary sciences; energy; environmental sciences; engineering and materials science. Thus, these areas represent priorities for multilateral cooperation.

Meanwhile, there is no data on S&T cooperation with the simultaneous participation of all BRICS countries in the framework of single projects. However, it is possible to identify several promising areas of BRICS cooperation (Table 1). These are the fight against cyber threats, the safe development of nuclear energy, the peaceful exploration of space, and the use of high technology in logistics, including the use of radio-frequency identification.

Characteristically, the proposed areas (with the exception of logistics) coincide with the technological and sectoral priorities in all BRICS countries.

Table 1: Possible directions for multilateral cooperation among the BRICS countries

Technology	Subject matter	Partner countries
Space Technologies	Joint orbit monitoring, tracking of scientific satellites in deep space and to expand the coverage and accuracy of the GLONASS system	Russia, South Africa, Brazil, India
Internet Technology	Development of transcontinental ICT infrastructure to improve the sustainability and reliability of telecommunications between the BRICS countries, including the implementation of a transcontinental undersea Internet cable directly connecting all BRICS countries	All BRICS countries
Nuclear power	Development of scientific cooperation at the level of scientific and expert cooperation	Russia, China, India

High-tech in logistics	Development of a common radio frequency identification standard that could be adopted as a global standard	All BRICS countries
Biotechnology & Pharma	Research and development of new vaccines and pharmaceuticals	All BRICS countries

Source: compiled by the author

The BRICS countries' positions in the rankings concerning digitalization and digital transformation are of particular relevance within the framework of the topic under consideration.

Therefore, the BRICS countries have high hopes for the strengthening and development of the digital economy. This direction is a priority within national programs, and each country has allocated for it enormous resources - Russia plans to increase costs for the development of the digital economy by three times (Digital Economy of the Russian Federation), the Indian government together with individual investors has invested more than 300 million dollars in the project Digital India, China has access to investments exceeding the mark of 25 billion dollars (Digital China, Made in China 2025). Since 2017, Brazil has launched "The Brazilian Digital Strategy," which aims to provide 30% of the population without Internet access with the necessary resources to do so, which should contribute to the introduction of digital technology in all areas of society. Since 2013, South Africa has been integrating modern Internet technologies in remote areas of the country as part of the "Electronic Communications Act: South Africa Connect: Creating opportunities, ensuring inclusion South Africa. Broadband Policy".

In addition, the BRICS countries have adopted a number of joint documents on the topic of digital transformation. In 2016, during the Indian BRICS presidency, the BRICS ICT Development Agenda and Action Plan was approved. In 2017, under the presidency of China, the E-Port Network model was approved. The main focus of the summit in Johannesburg, South Africa, in 2018 was the fourth industrial revolution. E-commerce and the functioning of the Internet were touched upon. BRICS leaders agreed that Industry 4.0 would serve as a great stimulus for economic growth and strengthen the potential of industrial production, and the creation of business incubators and a network of science parks could help.

It should be noted that currently there is no single methodology that would fully assess the level of development of the BRICS countries' digital economy, but the methodological approaches of the OECD, the World Economic Forum, the World Bank Group, WIPO, the INSEAD International Business School, the UN International Telecommunication Union and other organizations are mostly used.

As A.A. Ignatov rightly pointed out, if we put the above approaches under a common denominator, we can distinguish the following categories: 1) tools to assess the development of the digital economy by specific parameters; 2) evaluation systems whose criteria are based on technical statistics; 3) integrated approaches that combine both evaluation indicators and statistical data (Ignatov, 2020).

The limiting factor is the incompleteness and insufficiency of national statistical data to obtain a complete picture of the state of the innovation and institutional environment in the BRICS countries.

In this regard, of particular interest is the Networked Readiness Index (NRI), which is calculated on the basis of 60 indicators in four areas ("technology", "governance", "people" and "influence"). It is designed to assess not so much the infrastructure of digital transformation, but the overall factors of national policies and institutions, which, in turn, enable countries to use ICTs more effectively for sustainable growth and competitiveness. According to the NRI index, the BRICS countries are characterized by varying degrees of network readiness of national economies.

Table 2: BRICS countries in the Network Readiness Index

Country	Score	Rank	Technology	People	Governance	Impact
Russia	57,74	43	53,71	58,80	59,97	58,49
China	65,62	29	57,27	66,48	63,98	74,77
South Africa	48,88	70	45,59	46,42	61,25	42,25
Brazil	55,86	52	49,08	57,35	62,89	54,12
India	49,74	67	49,24	45,96	48,71	55,07

Source: compiled by the author on the basis of data from the Portulans Institute

As can be seen from the table, the BRICS countries are in the middle of the ranking for all its components. Based on the positions of the BRICS countries in individual sub-indices, the main competitive advantages of China are: a developed regulatory function in the field of legislation, in particular in the field of Internet commerce; the prevalence of broadband Internet access; and the high share of business in the financing of research and development. China's weakness, in addition to the incredibly high level of air pollution and the population's disdain for the available "clean" technology, is its regulatory function in the field of ICT.

Russia, ranking second among the BRICS countries, has advantages on the human capital subindex in terms of the quality of higher education, the literacy of the population, and the country's skilled workforce. However, Russia's greatest weaknesses in the NRI are in the regulatory environment in general and the regulatory environment in ICT, the use of virtual social networks, and affordable and clean energy.

Brazil is characterized in the ranking by: the highest score in legislative regulation in the field of e-commerce (8th place in the world); publication activity and use of open data; and e-participation. In contrast, Brazil's weaknesses are: regulatory environment scores; ease of doing business; and income differentiation.

South Africa's weaknesses in the index are: benefits of e-commerce legislation (1st place in the world); adoption and adaptation of new technologies; and use of electronic payments. Weaknesses of South Africa are: low qualification of human resources; low life expectancy; low level of transport security.

India lags far behind on the NRI index, primarily because of the low level of Internet connectivity, the sustainability of cities and communities, gender inequality, low satisfaction with the quality

of life and life expectancy. However, India also has a number of advantages, such as: high quality of government e-services and websites; investment in new technologies; publication activity; and the use of open data.

In the World Digital Competitiveness Ranking, the BRICS countries have shown variable positions over the past five years. China has shown strong growth on this indicator, moving from 35th position in 2016 to 15th position in 2021. Russia ranks 42rd in 2021, Brazil 51st, India 46th, and South Africa 60th.

Countries are ranked according to three main indices: "Knowledge", "Technology", " Future readiness". In turn, each index includes a number of sub-indices. The Knowledge index assesses talent, education and skills, and the level of scientific potential. The "Technology" index includes sub-indices such as "Regulatory Environment," "Capital and Technology Base." The Future readiness Index is assessed by the sub-indices Adaptive Approaches, Business Agility and ICT Implementation

Table 3: BRICS Countries in the International Digital Competitiveness Rating (WDCR)

Country	Position, 2016	Position, 2021	Knowledge	Technology	Future readiness
Brazil	54	51	51	55	45
Russia	40	42	24	48	47
India	53	46	41	44	50
China	35	15	6	20	17
South Africa	51	60	62	59	59

Source: World Digital Competitiveness Ranking, 2021

The world rankings show that the BRICS countries are not yet in the lead and generally lag significantly behind developed countries. The main reason for this lies in the availability and use of digital infrastructure for the countries' populations. The positions of the BRICS countries in most indices are quite close. However, it should be noted that the obvious leader among the BRICS countries is China. Russia's experience with digital infrastructure is also indicative, and it is currently comparable with the indicators of the world leaders. In terms of the Network Readiness Index, Russia's experience (along with that of China) is roughly on a par with them in terms of future production drivers. An important fact is that the BRICS countries are characterized by high rates of use of mobile digital devices and services.

The strength of the BRICS countries is the high level of readiness of educational systems to the challenges of the digital era, which is comparable to that of the world leaders, and this is particularly relevant in the transition to Industry 4.0. The digital transformation of the BRICS countries will boost economic growth, while enhancing the competitiveness of the BRICS members as they embark on the transition to the new industrial revolution.

Industry 4.0 certainly poses new tasks and challenges for the BRICS countries. First of all, the industrial revolution will increase the regional diversity and digital divide of the BRICS countries, which inevitably leads to the need for a complementary approach in the development of partnerships between the countries.

Another challenge posed by the transition to the fourth industrial revolution is the change in the factors of competitiveness and the redistribution of vectors of labor and capital flows of the BRICS countries. The introduction of 3D printing technologies and the automation of production, which are gaining momentum in developed countries, can significantly undermine the competitive advantage of developing countries, namely the low cost of labor.

In general, the BRICS digital agenda is characterized by a short period of autonomy and covers a limited number of areas. However, in this respect, it is worth noting the high level of implementation of the commitments made by the BRICS leaders on digital development.

From 2011 to 2019 (the period of active work of the BRICS countries on the digitalization of all spheres of society, and the economy in particular), more than 40 commitments and agreements aimed at developing the digital economy were announced, and most of them (in particular the 100% commitment on ICT) have been implemented.

Moreover, in terms of international S&T cooperation (ISTC), in the era of the digital economy, it is not certain scientific fields that become a priority, but new digital platforms. For example, each BRICS country has previously attempted to create such CPs: Land2Land (Brazil), Beginning Space (China), iBESA (South Africa), CIIE IIMA (India).

Digital platforms create new opportunities for industries. They provide more open platforms for the interaction of counterparties, as well as a full range of information about industries (prices, products, vendors, intermediaries), thereby creating a new market. Existing markets are expanded, and more and more participants are involved, creating a "network effect" or "synergy effect. Another advantage of platforms is the ease of scaling. While market expansion for traditional businesses involves significant costs to build a distribution network and market products, the cost and value of a platform grows as the number of consumers grows.

The main changes in industries influenced by the spread of digital platforms are as follows: affordability provokes demand growth and market expansion; digital businesses capture market share by dramatically reducing prices; entire industries are gradually transformed into a platform; consumers move massively and quickly to a better offering; traditional forms of business lose efficiency and are forced to leave or integrate into the platform.

In order to intensify scientific and technological cooperation among the BRICS countries, it is proposed to create a unified digital platform for global scientific and technological cooperation, organization and conduct of joint research in remote access of the BRICS countries. This platform should provide users with a number of digital services, the main of which is the user's personal account, a digital profile of the organization, which is a set of functionalities that will allow the researcher to access existing or projected information systems, with which the information interface will be implemented.

This platform implies the approach of the Integrated vision concept as a new stage in the development of cooperation based on the polycentric model of interaction between national network platforms and technology transfer centers, in which each country can choose its own internal structure of the innovation ecosystem, which will interact with other BRICS countries through a coordination center.

The key purpose of the platform is to research and forecast the BRICS innovation market, opportunities for the formation and internationalization of innovation teams and companies, and to provide information and recommendations for placement in BRICS innovation structures, such as technology parks, clusters, incubators and gas pedals. The educational trajectory of

the project is supportive and aimed at organizing hackathons in order to establish informal connections, consultations with experienced partners and training programs on individual components of the innovation process. An important function of the platform is also the verification and updating of information about participants from a wide variety of sectors of science and innovation.

The main effects of the formation of a single digital platform for global scientific and scientific-technological cooperation of the BRICS countries should be:

- creation of links between academia, research institutes and entrepreneurs;
- activation of research and innovation activities between the countries;
- commercialization of the results of scientific activities;
- training under advanced training programs;
- assistance in developing globally competitive technologies with high commercial potential;
- access to accumulated knowledge and experience in the field of increasing the competitiveness of science, technology and innovation of countries in the world market, etc.
- gaining access to the main forms of state support of foreign investors.

Conclusion

Thus, the consistent efforts of the BRICS countries to harmonize STI cooperation can give new impetus to the development of integration processes. The intensification of scientific and technological cooperation in the era of digital transformation has become one of the main factors in the realization of BRICS economic, social and political potential and a condition for sustainable development.

The digital transformation of the BRICS economies, which has been identified as one of the key vectors of the Strategy for BRICS Economic Partnership until 2025, should include the accelerated development of the infrastructure ecosystem of the digital economy. The scenario of the BRICS countries' digital transformation as an imperative of transition to Industry 4.0 entails not only technological and economic transformation, but also changes of an institutional nature. Thus, the creation of an institutional ecosystem will allow the countries to adapt quickly during the transition to the new technological order.

The BRICS countries have great potential in terms of a collective approach to solving common problems in the field of digital information. Of course, the fact that at the moment there is a strong gap in the level of development of all five economies may make this cooperation a bit difficult, but in no way reduces the likelihood of future success.

However, it is worth considering the specifics of the association and its club character (without hierarchy), which illustrates a more "restrained" capacity to create, coordinate and unify the BRICS countries' approaches to the implementation of digital transformation.

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