GLOBAL AND REGIONAL PROJECTS

CHANGING OF GLOBAL KNOWLEDGE NETWORKS IN THE WORLD SYSTEM RECONFIGURATION: THE CASE OF RUSSIAN AND BRICS+ RESEARCH WITH INTERNATIONAL CO-AUTHORSHIP

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Global networks of knowledge diffusion are both among the major products of globalization and its strongest factors, contributing significantly to its further development. However, in the course of the ongoing reconfiguration of the World System, which is likely to intensify in the coming decades, global knowledge networks, as well as international cooperation in science and research in general, are bound to experience profound structural changes. The paper examines Russia's current position in these networks and the recent dynamic changes in this position and in the structure of Russian researchers' international collaborations by focusing on the networks of international research co-authorship. At the first glance, the ongoing re-structuring of the system of Russian academic links with foreign countries could be attributed to the impact of sanctions, but this viewpoint fails to take into account the dynamics of the global academic co-authorship network and Russia's position within it over the past decades, which has been defined by the post-Soviet legacy and the abovementioned reconfiguration of the World System. Increasing investment in the domestic R&D, improving research infrastructure, and enhancing the quality of research can all make the World-System semi-peripheral and peripheral countries increasingly attractive R&D partners for each other. This factor is likely to contribute to the growth of the share of research collaborations between the countries outside the World-System core.

Keywords: *international cooperation in science and technology, World System reconfiguration, Russian science, international research co-authorship, knowledge diffusion, global networks.*

Introduction

Globalization is a powerful force shifting the current global economic-political balance (Grinin 2021; Grinin, Korotayev 2014). Among the numerous approaches to the study of globalization, some of the most notable insights are provided by the network ap-

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proach through its focus on the structure (and substructures), topological properties, and dynamic changes of global networks of various kinds (Shulgin *et al.* 2019; Zinkina *et al.* 2013, 2019). Thus, the global trade network has been studied to reveal waves and patterns of globalization and de-globalization (Chase-Dunn *et al.* 2000; Li *et al.* 2021), globalization and regionalization (Kim and Shin 2002), and structural changes in the global economy (Smith and White 1992; Vidya and Prabheesh 2020; Antonietti *et al.* 2022; de Soyres and Gaillard 2022) including periods of its integration and disintegration (Kali and Reyes 2002). Another example would be international networks of capital flows – in the form of FDI, first and foremost (Bolivar *et al.* 2019; Li *et al.* 2019), but also in other forms, such as the network of bilateral investment treaties (Bandelj, Mahutga 2013). The late twentieth and the first decades of the twenty-first century have seen a growing interest in global networks that transfer non-material objects, such as knowledge, across national borders – the so-called *R&D spillover* effect (see, *e.g.*, Coe and Helpman 1995; Engelbrecht 1997; Coe *et al.* 2009; Maxwell and Stone 2004; Zhu and Jeon 2007). Such networks can be simultaneously viewed as drivers of globalization and its results, stemming from the emergence and vigorous development of international research and production teams, cross-border production chains, etc. The impact of R&D spillovers on the recipient countries is closely related to some profound changes in the global trends. Most importantly, these changes include the departure of the World System from the Great Divergence between the developed and the developing countries (which lasted for about 170 years) to the Great Convergence between these economies. Indeed, starting from the 1970s, developing economies began catching up with their developed counterparts, thanks to increased rates of economic growth in the former (Grinin and Korotayev 2015).

International cooperation in science and technology is a companion of globalization (often in parallel with economic integration) and one of its strongest facilitators. It is often referred to as 'science diplomacy' as a field of interaction between science and technology, on the one hand, and foreign affairs and international relations, on the other (Ruffini 2020). This sphere can traditionally be divided into 'diplomacy for science,' 'science for diplomacy' and 'science in diplomacy' (see, *e.g.*, Berkman 2019; Krasnyak and Ruffini 2020).

However, even given the increasingly globalized environment, the development and successful cross-border spillover of science, technology, and innovation (STI) is not guaranteed *per se*. UNCTAD, for instance, specifies three major pre-requisites for the successful adoption and implementation of foreign STI at the national level, including a robust digital infrastructure, the improvement of human capital, and the channeling of development assistance towards STI. Teams from various UN agencies emphasize the necessity to focus the activities of various stakeholders on maximizing the level of STI development for reaching the Sustainable Development Goals (SDGs) globally (UNCTAD 2023).

Moreover, the World System is currently experiencing profound transformations of its structure, and some of the countries previously subsumed under the label of 'developing economies' are at the epicenter of this structural re-shuffling – first of all, the BRICS (Grinin, Grinin, and Korotayev 2024), especially China and Russia. In order to

gain a holistic understanding of the ongoing transformations, the network approach could once again be relied upon, as the changes in the structure of the World System are highly likely to be reflected in the structure of global networks. Both material and non-material trans-border flows can be investigated in terms of such changes, but we expect the non-material flows (related to culture, information, knowledge etc.) to respond more deeply and rapidly to the changing global environment. We seek to contribute to the understanding of the dynamic changes in the structure of global knowledge networks by focusing on the networks of research co-authorship.

Methods

In order to study the global knowledge networks, we have chosen to focus on one particular aspect, namely the generation of knowledge by international teams of researchers and scientists. In the light of what has been said above, it is important to make international cooperation in STI a measurable category, so that one can trace changes in its volume and structure, as well as its effects. This is where the question of choosing the most feasible indicators arises, as there are many – ranging from availability of foreign funding and modern scientific equipment to easy access to exchange of ideas with peers all over the world, from the number of potential customers for R&D results to the possibility of high-quality independent assessment of research results.

Today, the legal regulation of international scientific and technological cooperation is often declarative in nature and does not contain universally accepted approaches to individual aspects of such cooperation.[*] Russia is no exception to this problem. This situation limits science to the territory of a particular nation-state and does not provide an opportunity to view the situation at a higher level of international research and technological collaboration. Meanwhile, such collaborations and partnerships are developing rapidly in the world as a whole and in Russia in particular. Their great potential makes it highly relevant to study their goal setting, principles, features, sources, and content.

Of particular interest for us is Russia's changing position in such global networks. So we focus on one indicator of such cooperation, namely international co-authorship of research articles published in academic journals. To achieve the goal of this work, we use the methods of bibliometric analysis. The Scopus and Web of Science databases have search engines that allow obtaining information on the level of international co-authorship in publications, both counted as a whole and/or categorized according to particular research areas.

Results

Figure 1 shows the results of the author's calculations of the annual number of research papers published by Russian scholars in Scopus-indexed journals in co-authorship with their foreign colleagues during the period 1990–2021.

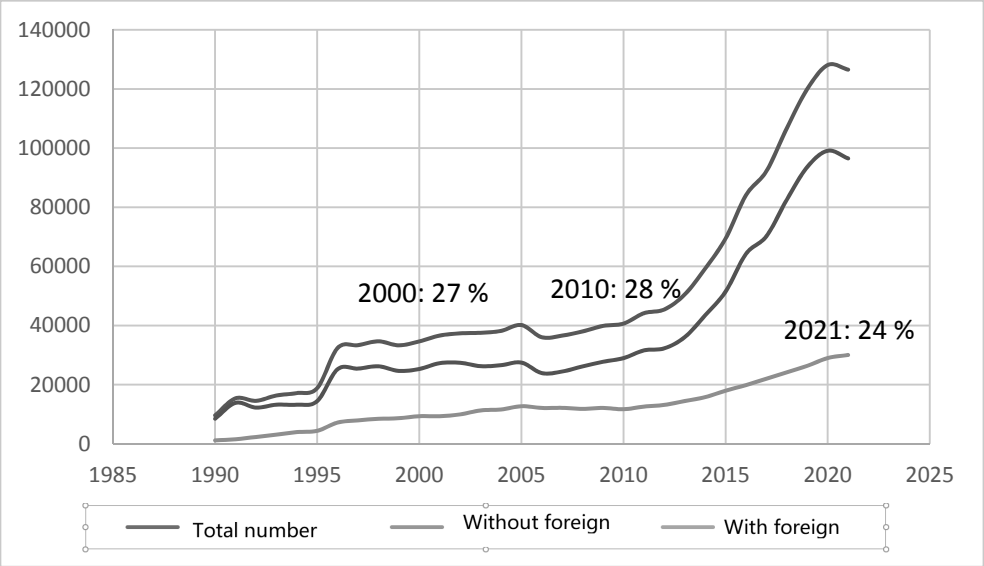

Fig. 1. Research papers published by Russian scholars in Scopus-indexed journals, 1990–2021 (total number; co-authored with foreign colleagues; not co-authored with foreign colleagues). Calculations were conducted on June 1, 2022

The most evident trend, clearly visible in Figure 1, is the very fast growth in the total number of research papers published by Russian scholars in Scopus-indexed journals since 2010; more than tripling in the decade between 2010 and 2020. At the same time, the intensity of international cooperation in science and technology (as measured by the number of Scopus-indexed papers by Russian researchers with international co-authorship) has remained more or less stable and has been subject only to a rather slight decline when measured as a percentage of the total number of Scopus-indexed publications by Russian researchers. At the same time, it has grown considerably in absolute terms, by 2.6 times since 2010. This means that the intensity of international cooperation in science and technology has grown more slowly than the Russian research publication activity in general. The former increased by 18 thousand research publications per year in the period 2010–2021. This means that the contribution of the intensity of international cooperation in science and technology to Russian research publication activity was no more than 20 % of the observed growth of the latter. In general, this was a period when Russian scholars greatly increased their publication activity in the Scopus-indexed journals, and a number of Russian journals began to be indexed by Scopus as well. Nevertheless, international collaborations contributed to this growth, although their role was probably not decisive. However, this role may vary considerably from one country to another, so it is necessary to investigate the dynamics international co-authorships by Russian researchers by partner country (see Figures 2 and 3).

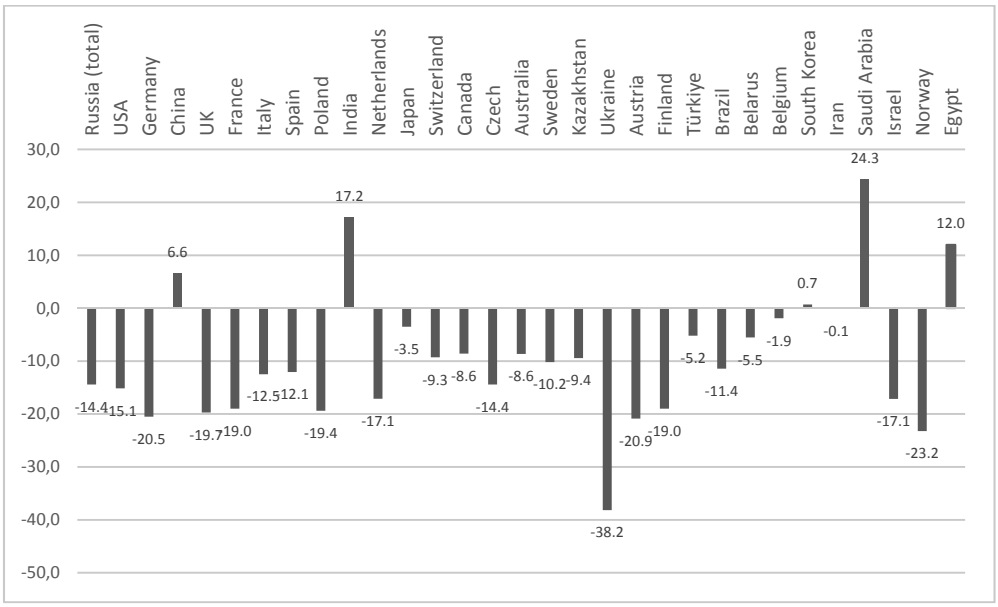

Fig. 2. The change between the share of internationally co-authored research papers published by Russian researchers in Scopus-indexed journals, 2022–2023

Source: author's calculations based on search results across the Scopus database obtained on October 1st, 2023.

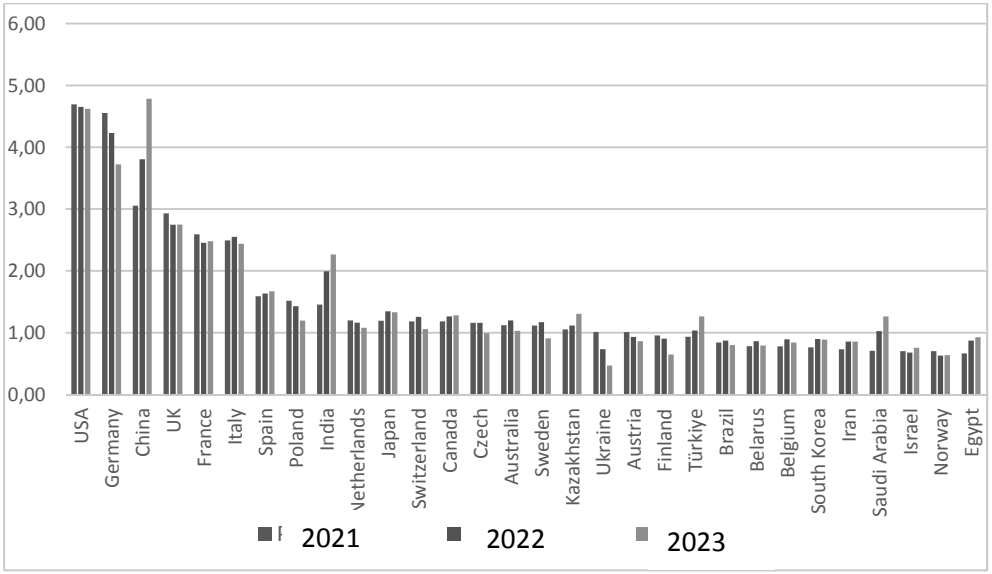

Fig. 3. Share of co-authorships with researchers from particular countries in the total number of international co-authored papers published by Russian researchers in Scopus-indexed journals in 2021, 2022, and 2023

Source: author's calculations based on search results across the Scopus database obtained on October 1st, 2023.

From Figure 3 we can infer that the steepest decline in the proportion of co-authored papers was observed between Russian and German researchers both in 2022 to 2021 and 2023 to 2022. Quite surprisingly, the proportion of research papers co-authored by Russian and US researchers has remained nearly stable – but this does not mean that it stayed intact in terms of absolute numbers, but rather that it declined at the same rate that the number of internationally co-authored papers by Russian researchers did. The most pronounced increase, meanwhile, was observed between Russian and Chinese scholars, with somewhat smaller increases in the cooperation of Russian scientists with their colleagues from India, Kazakhstan, Turkey, and Saudi Arabia.

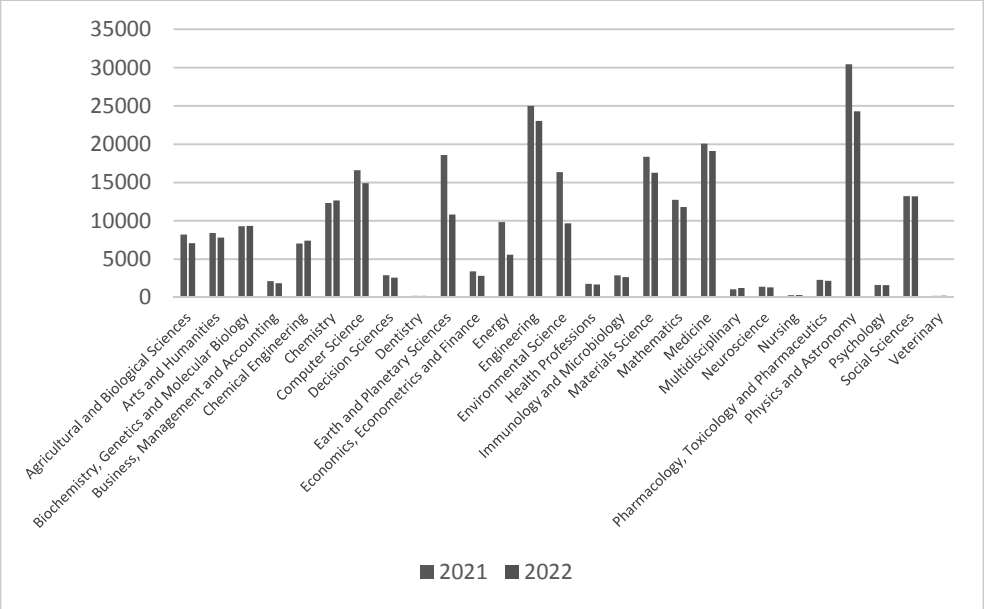

Fig. 4. Number of publications by Russian scientists in 2021–2022 by field of science

According to the data as of April 2024, using not the Scimago resource, but the direct search in Scopus (the final data may differ in different portals), 6,000 fewer Russian publications were published in Scopus-indexed journals in 2023 than in 2022, with only 20 % of them being written by international teams of authors. Thus, the level of international cooperation of Russian researchers on international scientific publishing platforms has decreased as compared to the previous period. The largest shares of international co-authorship were observed with China (3.7 % of joint publications by scientists from these two countries of the total number of Russian publications), the USA – 3.5 %, Germany – 2.9 %, the UK – 2.1 %, France – 1.9 %, Italy – 1.9 %, India – 1.8 %, Spain – 1.3 %, and Kazakhstan – 1.2 %.

Against the background of sanctions and intense geopolitical turbulence, it is reasonable to study the strengthening of cooperation between Russia and friendly countries in the sphere of science and research. For this purpose, let us consider the changes in the publication activity of Russian scientists together with their counterparts from the BRICS countries, including the new countries of the association (that joined it in 2024),

as well as with the United States. To this end, we will consider and compare the indicators for 2021 and 2023. First of all, it is necessary to find out the general change in the publication activity of these countries (Figure 5).

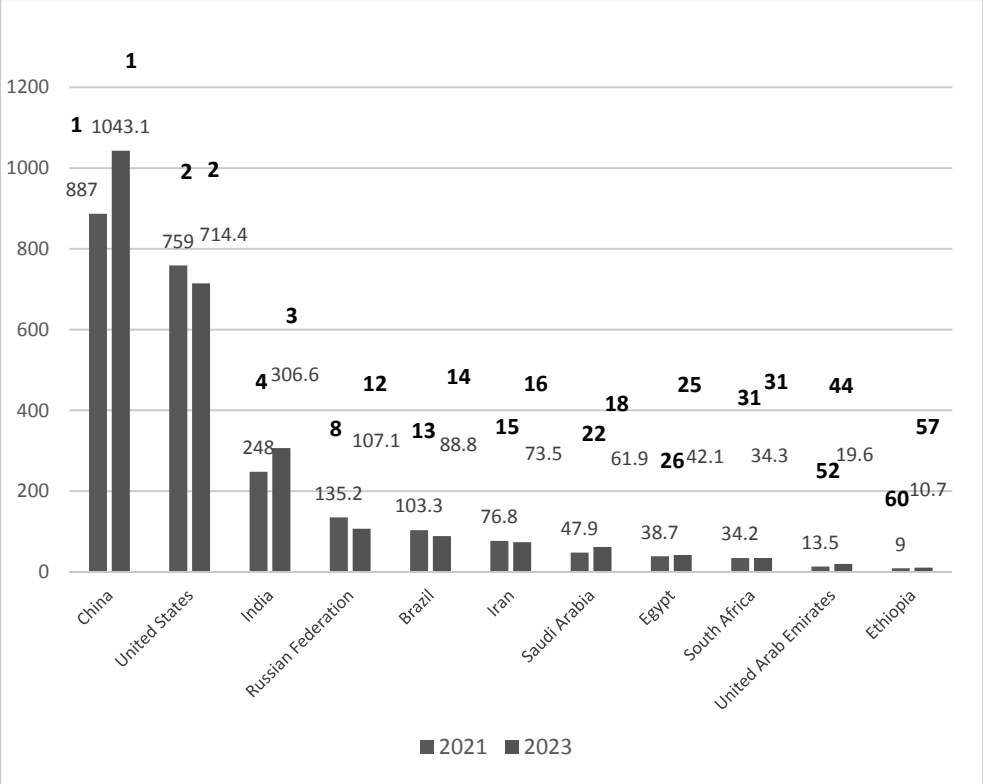

Fig. 5. Number of publications in Scopus (in thousand units) in the BRICS countries, including those that joined the association in 2024, and in the USA (for comparison) (2021 and 2023). The position of these countries in the ranking by the number of publications for each year is shown (highlighted in bold)

As can be seen from the data in the figure, the United States, Russia, Brazil and Iran show a slight decrease in the number of publications, while other countries, especially China, India, Saudi Arabia and the United Arab Emirates, show a significant increase in the annual number of publications from 2021 to 2023. In 2023, six BRICS countries are already among the top-20 countries in the world in terms of the number of scientific publications. Publication activity can grow both through purely domestic efforts and through their combination with active engagement in international research collaborations. In this respect, we consider the shares of publications written in international collaborations for these countries in 2021 and 2023 (data obtained by the author through the analytical module of the Scopus search engine on September 1, 2024) – Figure 6.

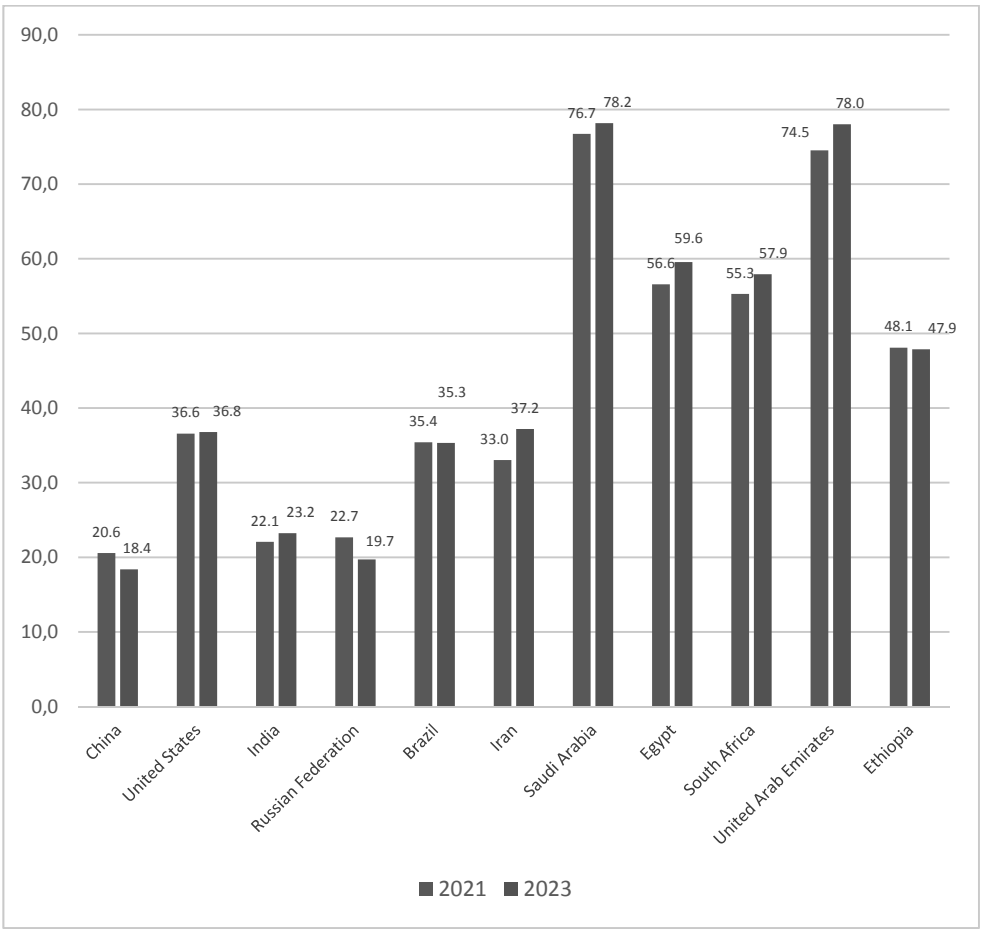

Fig. 6. Share of publications in 2021 and 2023 prepared in international collaboration, %

Data source: calculated by the author based on search conducted within the Scopus database – 09/01/2024.

Most of the BRICS countries and the United States have increased their level of international collaboration in research publications (even Iran, which is under heavy sanctions), but China and Russia, and to a lesser extent Brazil, have shown a fairly significant decrease in this level, especially Russia, where the total number of publications from 2021 to 2023 has decreased by 21 % due to the effects of sanctions pressure. However, there is no doubt that such pressure will cause a mutual desire to redirect international interaction towards friendly states in general and members of the BRICS and SCO in particular. In this regard, it is important to identify the 'fine structure' of the content of intercountry interaction in science as reflected in joint scientific publications. Table 1 presents the relevant data on international cooperation in research papers co-authored by the BRICS countries among themselves and by the United States in 2021 and 2023.

Table 1

Ranking and share of joint publications by researchers from BRICS countries with researchers from other BRICS countries, and publications co-authored with researchers from the USA in 2021 (A) and in 2023 (B)

A)

	Brazil	Egypt	India	Iran	China	UAE	Russia	Saudi Arabia	Ethiopia	South Africa	USA
Brazil		22–1.1	17–0.72	23–0.96	29–0.24	22–2.15	23–0.75	31–1.08	28–1.16	15–2.77	13–1.64
Egypt	45–0.42		16–0.7	27–0.81	25–0.3	5–8.4	37–0.47	1–20.1	31–0.99	45–1.02	34–0.45
India	15–1.7	5–4.6		9–2.02	15–0.6	3–10.4	10–1.1	2–13.9	1–12.5	6–4.98	11–1.8
Iran	30–0.72	18–1.6	21–0.63		23–0.32	24–2.1	34–0.51	22–1.67	24–1.3	26–2.65	23–0.7
China	10–2.05	3–6.9	4–2.2	3–3.73		6–7.6	3–2.7	5–9.4	4–4.5	8–4.7	1–8.07
UAE	54–0.28	8–2.9	26–0.57	44–0.37	44–0.1		63–0.16	13–2.8	41–0.81	48–0.95	43–0.28
Russia	21–1.1	12–2.3	15–0.78	13–1.3	20–0.46	19–2.4		20–1.96	39–0.84	18–2.22	19–0.82
Saudi Arabia	38–0.5	1–25.9	3–2.7	18–1.04	17–0.51	4–9.9	42–0.41		17–1.86	21–2.05	26–0.66
Ethiopia	83–0.1	80–0.23	30–0.46	69–0.16	60–0.05	66–0.55	87–0.04	62–0.35		46–1.0	61–0.12
South Africa	26–0.92	33–0.91	18–0.7	31–0.74	36–0.18	18–2.4	30–0.53	26–1.47	7–3.8		22–0.71
USA	1–12.1	2–8.95	1–5.5	1–6.96	1–6.9	1–15.8	1–4.4	4–10.4	2–10.1	1–15.9	

B)

	Brazil	Egypt	India	Iran	China	UAE	Russia	Saudi Arabia	Ethiopia	South Africa	USA
Brazil		28–1.1	24–0.6	21–0.91	33–0.2	27–2.2	27–0.6	38–0.98	31–0.95	15–3.1	14–1.58
Egypt	44–0.51		15–0.8	24–0.82	25–0.31	7–7.85	22–0.68	1–19.8	25–1.3	37–1.35	33–0.52
India	12–2.1	4–5.9		9–2.46	13–0.63	2–13.6	7–1.73	2–17.7	1–14.8	4–6.97	8–2.45
Iran	34–0.74	21–1.4	25–0.57		26–0.28	32–1.92	26–0.6	27–1.39	44–0.68	36– 1.39	21–0.77
China	10–2.4	3–7.6	4–2.1	2–4.04		5–8.6	1–3.6	4–10.5	6–3.9	8– 5.1	1–7.45
UAE	47–0.49	8–3.7	13–0.86	34–0.53	37–0.16		43–0.36	9–3.9	41–0.71	26–1.78	40–0.41
Russia	33–0.75	20–1.8	23–0.62	19–0.91	21–0.38	31–1.98		23–1.63	45–0.67	43–1.29	31–0.53
Saudi Arabia	38–0.67	1–28.8	2–3.5	16–0.17	14–0.61	4–11.96	13–0.9		8–3.2	18–2.4	19–0.86
Ethiopia	92–0.11	71–0.34	29–0.51	81–0.1	66–0.04	75–0.38	84–0.07	57–0.56		35–1.42	61–0.14
South Africa	22–1.2	24–1.1	18–0.77	31–0.67	36–0.17	19–3.1	37–0.4	28–1.35	4–4.6		20–0.78
USA	1–12.8	2–8.9	1–5.7	1–7.63	1–5.1	1–15.1	2–3.5	5–10.1	2–9.5	1–16.3	

Note: the first figure denotes the ranking in terms of the number of joint publications; the second number (separated by a dash) indicates the share of publications of scientists from the countries in the left column of the table in the total number of publications of the countries in the top row. A grey color indicates a decrease in the number of joint publications in a given pair of countries between 2021 and 2023.

Source: data obtained by the author through the search in the Scopus database (09/01/2024).

Discussion

At the first glance, the ongoing re-structuring of the system of Russian academic relations with foreign countries could be attributed to the impact of sanctions. However, when one considers the dynamics of the global academic co-authorship network and Russia's position in it over the past decades, this position seems to border on crude reductionism. Since the collapse of the USSR, significant changes have been observed in the Russian scientific infrastructure, which was largely inherited from the USSR. The intensity of collaboration between researchers from Russia and other post-Soviet countries declined sharply as all these countries went through an extremely turbulent period of social instability and severe economic crisis (Yegorov 2009). Other post-Soviet countries also experienced profound changes – for example, Eastern European countries of the former Warsaw Pact increased their scientific collaboration with Western countries more than among themselves during the 1990s (Kozak *et al.* 2015). Generally speaking, for a quarter of a century (1993–2018), the post-Soviet countries 'actively intensified scientific collaboration with other countries, eliminating the scientific isolation of Soviet science' (Matveeva *et al.* 2022: 1599), reaching higher indicators of collaboration than the average global values. At the same time, Russia (along with Lithuania) demonstrated the lowest share of international collaboration in its research sphere among all the post-Soviet countries, which could be a positive sign of the strengthening of national science. Thus, a part of the observed decline in the intensity of international co-authorship of research papers by Russian scientists could be attributed to the further development of Russian national science.

Apart from the development of Russian R&D *per se*, the global context of this development should be considered. The global World System is currently undergoing a major reconfiguration (including both structural and systemic changes) that is significantly weakening the World-System core countries. Leonid Grinin and Anton Grinin show that '[t]he main reason for this reconfiguration … is associated with a noticeable lag between the political component of globalization and its economic component' (Grinin and Grinin 2022: 263). As the gap between these two components cannot grow indefinitely, an intense catch-up of the political component is expected to take place in the coming decades, which will contribute significantly to the global geopolitical turbulence (Grinin 2022). Such a major reconfiguration is bound to influence the structure of all global networks, including the network of research collaborations. Indeed, the phenomenon of the Great Convergence mentioned in the Introduction implies that developing countries are catching up with economic frontier, which can only be paralleled by catching up with the knowledge frontier as well. Growing investment in the domestic R&D, improving research infrastructure, and enhancing the quality of research can all make the developing countries increasingly attractive R&D partners for each other, which is likely to contribute to the growth in the share of research collaborations between countries outside the World-System core.

The data presented in Table 1 show a general pattern that scientifically strong countries cooperate more actively with stronger countries, even despite political, economic, and other competition between them. Thus, China is the main partner of the US in terms of joint research publications, and both these countries lead the world in the number of publications. The US is the leading partner in joint research publications for 6 out of 10

BRICS countries, including even Iran, which is in a rather tough confrontation with the US. At the same time, however, the United States' position as a partner in joint research publications has slightly decreased for six out of ten BRICS countries in 2021–2023, which can only indirectly reflect the development of a network of scientific cooperation 'without America' within the world of developing countries as their economic and technological power increases. The relative decline in interaction with the United States particularly affects researchers from China and Russia (but not Iran). Russia's share in the number of publications of all the countries studied decreased between and 2023, but at the same time, Egypt, India, China, Ethiopia, Saudi Arabia and the UAE strengthened their positions in scientific co-authorship with Russia, and China generally took a leading position, displacing the United States. Similar, but somewhat less pronounced changes occurred in Iran.

These processes reflect a certain heterogeneity of the BRICS; the science and research sectors in some BRICS members have stronger ties to the US (and the West in general) than in others. The development of networks of international cooperation in science within the world of developing countries is moving towards the formation of closely related clusters that are only secondarily associated with the leading countries in world science. For example, Saudi Arabia is the most important science partner for Egypt and the second most important for India in 2023, while the role of cooperation with the United States has relatively decreased over two years. Within the BRICS, there are two strongly interconnected clusters: 1) India-Egypt-Saudi Arabia-UAE-Ethiopia, and 2) China-Russia-Iran, and interaction within them is clearly increasing. At the same time, the two clusters are closely interconnected. Brazil and South Africa tend to focus on traditional ties with Western science and are rather weakly interconnected in scientific terms.

Thus, scientific cooperation within BRICS is actively developing, while its 'non-American vector' is clearly strengthening, which undoubtedly contributes to Russia's efforts to preserve and use international scientific cooperation to develop its research in the context of Western sanctions pressure.

How should the sphere of Russian R&D be managed in the context of the ongoing reconfiguration of the World System and the accompanying global political turbulence it? A rather widespread view among Russian policymakers is to focus on the subordination of the R&D to solving the social and economic problems that need to be solved to maintain Russian national security. This is a pragmatic viewpoint that expects the R&D sphere to generate new knowledge and skills that are of high practical value.

However, this viewpoint suffers from some serious omissions in its perception of the potential of Russian science. First, applied research projects with the ultimate goal of maintaining national security and solving specific development problems can provide multi-use results that are of practical interest to other countries as well. This means that such projects can be supported through joint projects with foreign or transnational actors. In this case, knowledge and skills generated by such projects should also be of value to these actors.

Second, one of the main strengths of Russian science is the traditionally high level of fundamental researches, whose results are of global importance and can be applied in global development projects in order to meet the global challenges more efficiently.

Science has already achieved the ability to calculate certain scenarios of world development that are beneficial to humanity as a whole, using purely pragmatic approaches. Although the complexity of these calculations is such that it is still difficult to defend the value of their results at the level of universal human imperatives, nevertheless, world science has been following this path for more than 50 years and has been directly influencing the world agenda since the first reports to the Club of Rome.

Conclusion

International co-authorships of Russian research papers in particular and international cooperation of Russian researchers in general are important and can be considered within the framework of Russian approaches to maintaining international cooperation in the field of science and technology. It should be noted that international scientific and technical cooperation in itself is part of cooperation in the field of innovation. At the same time, it is necessary to understand the cross-border nature of knowledge generation in science in order to develop a strategy of international innovative cooperation, which is part of both economic cooperation and cooperation in the field of science and technology.

NOTE

[*] For a wide range of possible indicators please see: UNESCO Science Report: The Race against time for smarter development// UNESCO, 2021. 736 p. URL: https://unesdoc.unesco.org/ark:/48223/pf0000377433 (date of access: 1.01.2024).

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