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The Report on BRICS Science, Technology, and Innovation Cooperation

Center For Brics Studies, Fudan University

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CENTER FOR BRICS STUDIES, FUDAN UNIVERSITY

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Content

Introduction

At present, momentous changes unseen in a century are accelerating across the world, and the global governance system primarily shaped by the US and some Western countries is increasingly struggling to meet the needs of the times, and urgent solutions are needed for prominent issues such as imbalanced economic development, worsening climate and environmental conditions, the spread of biological risks, frequent regional conflicts, and intensified great power competition. As former proponents of economic globalization, some developed countries are increasingly demonstrating tendencies toward nationalism, protectionism, and unilateralism. Constrained by narrow domestic interests, they are acting against the major trends of the times and the theme of peaceful development. They continuously securitize, politicize, and ideologize economic and trade relations, building small yards with high fences, decoupling and severing supply chains, and misusing export controls, thereby shaking the foundations of international cooperation and undermining the development interests of the Global South. To address unprecedented global challenges, it is essential not only to establish a common understanding and stabilize North-South cooperation but also to advance the collective improvement, self-reliance, and win-win cooperation of the Global South.

China has consistently been an active advocate and firm defender of economic globalization. It has taken a clear stand against discriminatory regulations, called on all countries to jointly study and formulate guiding principles for the peaceful use of science and technology, and put forward concepts and initiatives that conform to the trends of the times and meet the urgent needs of all countries, such as the three major global initiatives, the Belt and Road Initiative, the Global AI Governance Initiative, and a Global Community of Shared Future, etc. These serve as both effective solutions for addressing common global challenges and concrete actions to advance world modernization.

In promoting the global governance system for the common good and the development of human society, China has consistently kept the Global South at its heart and rooted itself in it. It represents and actively safeguards the rights and interests of the majority of developing countries, serving not only as a backbone of the BRICS mechanism but also as a primary driving force for Global South cooperation. Significant achievements have been made in expanding economic, trade, scientific, and technological exchanges and cooperation among BRICS countries and in advancing the industrialization process of the Global South. President Xi Jinping has profoundly noted that it is for our shared pursuit and for the overarching trend of peace and development that the BRICS countries have come together. He has called on all countries to maintain the momentum of BRICS, consider and devise our strategy to address issues that have a global impact, determine our future direction, and possess strategic significance. The BRICS must set off a new era and forge ahead with one heart and one mind. The expansion of BRICS fully demonstrates the collective position and common aspirations of developing countries. It provides extensive opportunities for economic, trade, and technological development, a platform for voicing international concerns, and chances for practical cooperation and exchange for the Global South, positioning it as a vanguard in reforming the global governance order. Expanding and strengthening the BRICS mechanism is the only way to safeguard common global security, promote high-quality development of the international community, practice the concept of sustainable development, lead the reform of the global governance system, and forge a new realm of harmonious coexistence among all civilizations.

Over the years, BRICS have increasingly become a constructive force in promoting global economic growth, improving global governance, and advancing the democratization of international relations. The expansion of BRICS to 11 member states in 2024 marks a historic enlargement, which reflects the determination of BRICS to unite and cooperate with the broader developing world. This expansion is consistent with the common interests of emerging market and developing countries, and the expectations of the international community. The enlarged BRICS mechanism, which carries the shared vision and aspirations of emerging market countries, will further become a crucial pillar for promoting global cooperation and multilateralism, injecting greater certainty, stability, and positive energy into the world. Cooperation in scientific and technological innovation is a significant component of BRICS cooperation. In October 2024, *the Kazan Declaration* from the 16th BRICS Summit once again emphasized the importance of scientific and technological innovation cooperation, and outlined plans to strengthen cooperation in areas such as climate change, energy conservation and emission reduction, data governance, e-commerce, the digital economy, artificial intelligence, and cybersecurity etc.

The expansion of BRICS not only signifies a geographical extension of the BRICS cooperation mechanism, a further increase in its global influence, and an enhanced status within the global science and technology innovation governance system, but also provides a platform for member states to expand and deepen cooperation in areas such as resource complementarity, technology sharing, and market development. This presents significant opportunities for China to engage in international innovation cooperation. However, the expansion of BRICS also entails prominent challenges such as increased difficulty in coordinating collective action, intensified competition among different institutions, and the wavering positions of some member states. These issues bring notable negative effects for China's international science and technology innovation cooperation. At the same time, the trade wars and tech wars initiated by some leading powers have further exacerbated the processes of deglobalization, bloc formation, and fragmentation, damaging the already fragile global science and technology innovation ecosystem.

Therefore, this report aims to explore the current state of science and technology cooperation after the BRICS expansion, analyze the various opportunities and risks associated with such cooperation, and propose methods and pathways for promoting greater BRICS collaboration in science and technology. Based on respect for individual differences and the expansion of common interests, we should expand cooperation and leverage BRICS cooperation to break the center-peripheral system, turn crises into opportunities, and improve China's influence in BRICS scientific and technological innovation cooperation. This will help BRICS countries build a more open and free international scientific and technological cooperation ecosystem and play a positive role in the construction of a global scientific and technological community.

I. Foundation and Status Quo of BRICS Cooperation In International Science and Technology Innovation

(I). Foundation of BRICS Cooperation in International Science and Technology Innovation

The level of a national innovation system is a prerequisite for a country to engage in international science and technology innovation cooperation. It typically includes a measure of innovation capacity, which is composed of fundamental elements such as R&D expenditure, R&D personnel, and information and material technological infrastructure etc. *The Global Innovation Index 2024*, published by the World Intellectual Property Organization (WIPO), assessed the innovation performance of 133 economies worldwide using 80 indicators. Among the BRICS, China, the United Arab Emirates, India, Saudi Arabia, and Brazil ranked within the top fifty (Table 1). From the perspective of science and technology innovation input and output, the BRICS countries' R&D expenditures remain relatively low. China, the United Arab Emirates, and Brazil have a relatively high proportion of R&D expenditure to GDP, at 2.43%, 1.5%, and 1.15% respectively. Ethiopia and Indonesia have the lowest R&D expenditure as a percentage of GDP, at 0.28% and 0.27% respectively. Furthermore, according to statistics from the United Nations Educational, Scientific and Cultural Organization (UNESCO), from the perspective of R&D personnel per million inhabitants, Russia, the United Arab Emirates, and Iran are in leading positions, while Ethiopia has the fewest researchers (Table 2). ① Regarding the number of international patents, China has the largest number of international patent applications with 1.46 million, followed by India and Russia, with 38,550 and 19,410 applications, respectively. From the perspective of high-technology product

① Science, Technology & Innovation, https://databrowser.uis.unesco.org/browser/SCIENCE_TECHNOLOGY_INNOVATION/UIS-SDG9Monitoring/t9.5/i9.5.2, Access Time: April 22, 2025.

exports, China, the United Arab Emirates, and India have higher export values, while Ethiopia has the lowest. According to data from the World Bank (WB), China's high-tech export level is the highest as a proportion of total exports, accounting for 27%, followed by India and Brazil at 15% and 11% respectively. Iran and Saudi Arabia have the lowest high-tech export levels, both at 1%.① Most BRICS countries are significant importers of high-tech products, such as electronic equipment, engineering products, precision equipment, tools, and instruments, and their share of high-tech exports is notably below the global average.

Table 1 BRICS Innovation Performance Ranking and 3 Indicators in 2024

BRICS Countries	Ranking	Total R&D expenditure (% of GDP)	Number of international patents	High-tech products export
China	11	2.43%	1.46 million items	$908.15 billion
United Arab Emirates	32	1.5%	112 items	$44.77 billion
India	39	0.65%	38,550 items	$35.24 billion
Saudi Arabia	47	0.46%	2,610 items	$1.92 billion
Brazil	50	1.15%	4,400 items	$7.9 billion
Indonesia	54	0.28%	1,550 items	$10.38 billion
Russia	59	0.94%	19,410 items	$10.97 billion
Iran	64	0.79%	8,270 items	$0.16 billion
South Africa	69	0.6%	1,650 items	$2.64 billion
Egypt	86	1.02%	589 items	$0.61 billion
Ethopia	130	0.27%	16 items	$0.009 billion

Note: There is a lag in some indicator.

Data Source: World Intellectual Property Organization (WIPO)

Table 2 Full-time equivalent of researchers per million inhabitants in BRICS from 2019 to 2023

(Unit: person-year)

BRICS Countries	2019	2020	2021	2022	2023
China	1483.86	1600.31	1685.98	1849.24	——
United Arab Emirates	2476.63	2581.47	2606.78	——	——
India	——	259.26	——	——	——

①Data for Brazil is from 2024, while data for China, India, and Saudi Arabia is from 2023, and data for Iran is from 2022. "World Bank Open Data," World Bank, https://data.worldbank.org/indicator/TX.VAL.TECH.MF.ZS?end=2024&locations=CN-ET-BR-EG-IN-ID-IR-ZA-AE-RU-SA&name_desc=false&start=2007&type=shaded&view=chart.

Saudi Arabia	——	512.06	794.30	958.19	1120.63
Brazil	——	——	——	——	——
Indonesia	387.17	395.34	——	——	——
Russia	2734.69	2710.16	2662.47	2683.95	——
Iran	1588.43	——	2239.74	——	——
South Africa	479.87	459.99	454.80	444.16	——
Egypt	776.56	790.66	808.44	829.28	845.32
Ethopia	——	——	——	——	——

Note: There is a lag in some indicator,
the latest data for Brazil was 903.20 in 2014 and 89.04 for Ethiopia in 2017.
Data Source: The United Nations Educational, Scientific and Cultural Organization (UNESCO)

Based on the various indicators of science and technology innovation included in *The Global Innovation Index 2024*, the expansion of BRICS still demonstrates distinct advantages in science and technology innovation. Among these, China's main advantage in this field is its high-tech product exports, where its percentage of total trade value ranks first globally. The United Arab Emirates' primary advantages are the international mobility of its higher education and the percentage of R&D personnel employed by businesses, ranking first and third, respectively. India's main advantage is its information and communication technology (ICT) service exports, where its proportion of total trade value ranks first. Saudi Arabia's ability to access information and communication technology resources (ICT access) ranks first. Brazil's main advantage in this field is E-participation, where it ranks eleventh. Indonesia's primary advantage in science and technology innovation is its university-industry R&D collaboration, ranking sixth. Russia's number of utility model patents (per billion GDP at purchasing power parity) ranks eighth. Iran's software spending as a percentage of GDP ranks third. South Africa's percentage of GDP spent on education ranks eighth, and its percentage of ICT service imports to total trade ranks eighteenth. Egypt's labor productivity growth ranks twentieth. Ethiopia's labor productivity growth ranks ninth, and its number of utility model patents ranks twenty-fifth.[①] The BRICS can fully leverage their differentiated innovation advantages in scientific and technological cooperation.

① GII Innovation Ecosystems & Data Explorer 2024, https://www.wipo.int/gii-ranking/en/

(II). The Status Quo of BRICS Cooperation in International Science and Technology Innovation

1. The BRICS Mechanism for Cooperation in Science and Technology Innovation Is Maturing

In September 2011, the First Senior Officials Meeting on BRICS Cooperation in Science, Technology and Innovation (STI) was held during the Summer Davos in Dalian. In February 2014, the 1st BRICS Science, Technology, and Innovation Ministerial Meeting was held in Cape Town, South Africa, marking the formal launch of cooperation among BRICS in this field. In March 2015, *the BRICS Memorandum of Understanding on Cooperation in Science, Technology, and Innovation* was signed, which identified 19 priority areas for cooperation.① In October 2015, *the Moscow Declaration* approved *the BRICS STI Framework Programme*, covering broad topics such as implementing BRICS research and innovation initiatives and fomulating key cooperation areas and plans. This established working groups on subjects such as astronomy, ocean and polar science, and geospatial technologies, etc.,② creating a strategic framework for BRICS to cooperate in science and technology innovation and address shared social and economic challenges. As of the end of 2024, BRICS have held 12 STI Ministerial Meeting and 14 Senior Officials Meeting on BRICS Cooperation in STI. They have signed important documents such as the *BRICS Innovation Action Plan 2021-2024*, and over 130 projects initiated by working groups are at various stages of implementation. ③

Under the three core mechanisms—the BRICS STI Ministerial Meeting, the Senior Officials Meeting on BRICS Cooperation in STI, and the BRICS Working Group on STI—BRICS have actively promoted the establishment of relevant cooperation frameworks and platforms, including the BRICS Technology Transfer

① 《科技创新为金砖合作添“成色”》，2024 年 10 月 20 日，https://www.chinanews.com/gn/2024/10-20/10304880.shtml，2025 年 4 月 1 日。

② Сотрудничество со странами БРИКС，Аналитический центр МНИОП，https://mniop.ru/experience/sotrudnichestvo-so-stranami-briks

③ Science and Technology Cooperation of the BRICS countries was discussed at the Young Scientist Forum，Nov 30, 2023, https://impact-mission.org/blog/science-and-technology-cooperation-of-the-brics-countries-was-discussed-at-the-young-scientist-forum/, Access Time: April 1, 2025.

Center, the BRICS Working Group on Science, Technology, Innovation, and Entrepreneurship Partnership (STIEP), the BRICS Funding Partners Working Group, and the BRICS Young Scientist Forum (YSF). These initiatives provide comprehensive support and guarantees for technology transfer, collaborative R&D, entrepreneurship incubation, and talent exchange among the BRICS.① As of October 2024, the BRICS Technology Transfer Platform has accumulated nearly 100,000 research outcomes and compiled over 50,000 technical requirements.② In fields such as artificial intelligence, biomedicine, new materials, new energy, and the digital economy, cooperation mechanisms have been established with 35 official technology transfer agencies in 7 countries, playing a significant role in promoting exchanges and collaboration among these nations.③ In the field of information and communication technology, in September 2024, the BRICS Institute of Future Networks (BIFN) announced the establishment of the Artificial Intelligence Study Groups, the Next Generation Communications Study Groups, the Internet Application in Industry 4.0 Study Groups, and the Electromagnetic Field Exposure Study Groups, to foster cooperation among BRICS in the field of future networks.④

Bilateral science and technology cooperation mechanisms among BRICS are also becoming increasingly diverse. In March 2021, China and Russia signed *the Memorandum of Understanding between the Government of the People's Republic of China and the Government of the Russian Federation Regarding Cooperation for the Construction of the International Lunar Research Station (ILRS)*, inviting multiple countries to participate in the joint construction of the project. In April 2023, the China National Space Administration signed a memorandum of cooperation with the Brazilian Ministry of Science, Technology, and Innovation and the Brazilian Space

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① 《【金砖会晤】科技合作赋能金砖机制发展》，2023 年 9 月 4 日，中国社会科学网，https://www.cssn.cn/skgz/bwyc/202309/t20230904_5683099.shtml，2025 年 4 月 5 日。

② 《技术转移助力"大金砖合作"开创新局面》，2024 年 10 月 25 日，科技日报，https://digitalpaper.stdaily.com/http_www.kjrb.com/kjrb/html/2024-10/25/content_579393.htm，2025 年 4 月 1 日。

③ 《金砖国家技术转移中心——共享科技成果 加强互学互鉴》，2024 年 10 月 23 日，http://world.people.com.cn/n1/2024/1023/c1002-40344875.html，2025 年 4 月 1 日。

④ 《金砖国家未来网络研究院工作计划》，2024 年 9 月 5 日，金砖国家未来网络研究院网站，https://www.bifn.org/zh_CN/news/c_82.html，2025 年 4 月 30 日。

Agency, respectively, to jointly develop Earth resource satellites.① So far, the two sides have jointly developed six China-Brazil Earth Resources Satellites (CBERS), benefiting fields such as agriculture, forestry, water resource management, urban planning, and environmental and disaster monitoring, thereby promoting advances in space technology in both China and Brazil, and even global cooperation in remote sensing applications.② China and Brazil also signed *the Memorandum of Understanding on Research and Innovation Cooperation between the Ministry of Science and Technology of the People's Republic of China and the Ministry of Science, Technology and Innovation of the Federative Republic of Brazil*, to explore new channels for strengthening bilateral cooperation in scientific, technological, and industrial innovation research.③

2. Industry-academia-research Cooperation in BRICS Science and Technology Innovation is Continuously Deepening

First, multi-field scientific research cooperation projects are being carried out. Through joint calls for R&D projects, BRICS have jointly funded five batches of projects, with a total of more than 100 projects,④ covering biotechnology and biomedicine, astronomy, physics, material science, disaster prevention and monitoring, etc. Regarding specific cooperation projects, for example, in 2019, a cooperative project led by Tianjin University of Science and Technology and Durban University of Technology in South Africa, titled "Enzyme Library, Enzyme Compounding Technology and New Species for Comprehensive Bioprocessing of Agricultural Bioenergy" was launched. This project aims to convert agricultural waste into renewable energy through advanced technological means and establish a BRICS research cooperation platform for bioenergy biorefining and a technology cooperation

① 《开放合作，中国航天走向世界》，中国国家航天局网站，2023 年 4 月 23 日，https://www.cnsa.gov.cn/n6758823/n6758838/c10005053/content.html，2025 年 4 月 10 日。

② 《中国巴西已共同研制六颗中巴地球资源卫星》，2024 年 2 月 10 日，中国政府网，https://www.gov.cn/yaowen/liebiao/202402/content_6931193.htm，2025 年 4 月 30 日。

③ 《科技部与巴西科技创新部签署重要合作协议》，2023 年 4 月 17 日，科技部网站，https://www.most.gov.cn/kjbgz/202304/t20230417_185580.html，2025 年 4 月 30 日。

④ 《成效显著的科技创新合作——<金砖国家科技创新发展与合作研究报告（2023）>发布（下）》，2024 年 11 月 17 日，中国科技网，https://www.stdaily.com/web/gjxw/2024-11/17/content_259197.html，2025 年 4 月 9 日。

platform for efficient utilization of bioenergy, named “BRICS-Bioenergy from Eco-Sustainable Technology(BRICS-BEST)”.[①] In September 2023, China, Brazil, Russia, India, and South Africa jointly launched the Improvement and Demonstration Application of BRICS Ocean Forecasting Models project, which in line with the UN Decade of Ocean Science for Sustainable Development(2021-2030) to enhance the forecasting accuracy of BRICS ocean environment forecasting and analysis systems, and the capacity of BRICS ocean numerical models and operational forecasting.[②] Research teams from China, Russia, and South Africa have collaborated on key R&D projects in the field of remote sensing ecological security. The South African research team utilized China’s geospatial technology to conduct ecological security monitoring in South Africa, which has promoted the technology’s application and utilization within the country.[③] In the fields of information and communication technology and high-performance computing, the “AI+HPC+5G” flagship project addresses the development needs of BRICS in the era of the new industrial revolution. By leveraging abundant human and material resources and making breakthroughs in high-performance computing-based digital simulation technology, the project aims to build a Digital Twin Innovation Platform (DTIP) and an open-source ecosystem, demonstrating applications that facilitate the transformation and upgrading of traditional agriculture and mining.[④] In the field of nuclear fusion, cooperation between the Experimental Advanced Superconducting Tokamak (EAST) and the Nuclotron-based Ion Collider facility (NICA) has been incorporated as a key component of China-Russia intergovernmental science and technology cooperation, driving exchanges and collaboration among BRICS on large-scale scientific

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① 《2018 金砖国家智库国际研讨会暨 23 届万寿论坛在我校举行》，2018 年 9 月 22 日，天津科技大学新闻网，https://news.tust.edu.cn/xygj/e265bb210ed94c4ba67bb622b243df71.html，2025 年 4 月 17 日；《我校王正祥教授出席“金砖最佳”（BRICS BEST）生物能源科研项目启动仪式》，2019 年 4 月 2 日，天津科技大学新闻网 https://news.tust.edu.cn/xygj/e265bb210ed94c4ba67bb622b243df71.html，2025 年 4 月 17 日。

② 《“金砖国家海洋预报模式的改进与示范应用”项目研讨会顺利举办》，2024 年 7 月 19 日，自然资源部第一海洋研究所网站，https://www.fio.org.cn/news/news-detail-12983.htm，2025 年 4 月 10 日。

③ 《坚持创新驱动 增强发展动能》，2024 年 2 月 27 日，人民网，http://paper.people.com.cn/rmrb/html/2024-02/27/nw.D110000renmrb_20240227_1-18.htm，2025 年 4 月 16 日。

④ 《“金砖国家”旗舰项目之“信息通信技术和高性能计算”线上研讨会成功召开》，2021 年 8 月 29 日，广州大学系统流变学研究所网站，https://isr.gzhu.edu.cn/info/1184/2360.htm，2025 年 4 月 17 日。

facilities.①

Furthermore, exchanges and cooperation between BRICS research institutions are becoming increasingly close. In February 2025, the School of Physics of Peking University and the National Research Nuclear University MEPhI signed a memorandum of cooperation to promote cooperation in fundamental scientific areas such as advanced semiconductor technology, optics, and sensing technology.② In April 2025, the Institute of Microbiology of the Chinese Academy of Sciences and the Oswaldo Cruz Foundation in Brazil signed a framework agreement for a Sino-Brazil joint laboratory, which will establish a Brazilian branch of the Beijing Key Laboratory for Research on Drug-Resistant Pathogens, focusing on microbial drug resistance response, microbial data sharing, and the development of testing products. This collaboration will also involve the construction of testing sites in Beijing and Rio de Janeiro, the selection and recommendation of resident scientists, and the sharing of biospecimen bank data.③

Second, scientific research cooperation has produced abundant results. In 2024, the five BRICS countries co-authored 12,504 SCI papers, covering material science, astronomy and astrophysics, electrical and electronic engineering, chemistry, and environmental science etc. Among them, material science, astronomy and astrophysics, and physical chemistry were the most co-authored fields, accounting for approximately 10%, 7.3%, and 6.9% of the total co-authored papers, respectively.④

Table 3 Top 10 Fields for Co-authored Papers Among the Five BRICS Countries in 2024

Ranking	Co-authored Fields	Number of Papers
1	Materials Science	1268

① 《中科院启动磁约束聚变能研究开放创新试点》，2023 年 5 月 9 日，人民网，http://finance.people.com.cn/n1/2023/0509/c1004-32681827.html，2025 年 4 月 17 日。

② 《北京大学物理学院与俄罗斯国家核物理研究大学-莫斯科工程物理学院签署合作备忘录》，2025 年 2 月 21 日，北京大学物理学院网站，https://www.phy.pku.edu.cn/info/1182/10832.htm，2025 年 4 月 11 日。

③ 《中国科学院微生物研究所与巴方签署联合实验室框架协议》，2025 年 4 月 11 日，新华丝路网，https://www.imsilkroad.com/news/p/535320.html，2025 年 4 月 17 日。

④ Using the Web of Science Core Collection, Science Citation Index Expanded (SCI-Expanded) as the data source, a paper is defined as a co-authored paper among the five BRICS countries if its country field contains any two of the five countries: China (in this report, China refers only to mainland China), Russia, India, Brazil, and South Africa. The document type is limited to Article, the language of publication is English, and the final publication year is 2024. https://www.webofscience.com/wos/woscc/summary/682db5a7-2866-421b-bf9d-bac8bdf98ca5-015996c790/relevance/1

	(Interdisciplinary)	
2	Astronomy and Astrophysics	915
3	Physical Chemistry	858
4	Environmental Science	730
5	Electrical and Electronic Engineering	706
6	Applied Physics	658
7	Interdisciplinary Sciences	652
8	Physics, Particles and Fields	631
9	Chemistry (Interdisciplinary)	599
10	Energy and Fuels	550

Data Source: Web of Science

According to *The Nature Index 2024 Research Leaders* published by Springer, which records high-quality research output in natural sciences and health sciences, eight of the enlarged BRICS are ranked among the top fifty in research output. These are China (1st), India (9th), Russia (22nd), Brazil (23rd), Saudi Arabia (28th), Iran (30th), South Africa (34th), and the United Arab Emirates (42nd). What's more, Egypt ranks 52nd, Indonesia 56th, and Ethiopia 70th.① From the perspective of research cooperation, the primary partners for most countries are still developed countries. Within the BRICS, the countries that cooperate most with China are Russia, Saudi Arabia, and India. China is the country with the most cooperation among other member states (except South Africa and Ethiopia). The BRICS country that cooperates most with South Africa is India, and South Africa is also the second-ranked BRICS country for cooperation with India. The BRICS country that cooperates most with Ethiopia is South Africa. In addition to China, India is the most cooperative BRICS country for Russia, Brazil, Saudi Arabia, the United Arab Emirates, Egypt, and Indonesia. Brazil is the most cooperative BRICS country for Iran.②

① Nature Index, https://www.nature.com/nature-index/country-outputs/generate/all/global
② The connected world of international research collaboration, https://www.nature.com/nature-index/country-outputs/collaboration-graph/

Cooperation in science, technology, and innovation industries has been strengthened. In the field of agriculture, in May 2022, the China-based enterprises Longping High-tech Agriculture Co., Ltd., Longping Brazil and Paracatu City, Brazil, jointly signed a cooperation agreement on the construction of a China-Brazil Agricultural Science and Technology Industrial Park. At present, the park has established 4 seed processing plants, 10 R&D sites, and 3 cold storage facilities for seeds in Brazil,① which has provided an important platform for science and technology innovation in Brazilian crop seed R&D and has promoted cooperation between the two sides in areas such as breeding technology exchanges.② In February 2024, the China-Brazil Agricultural Mechanization Cooperation Demonstration Project was launched in Apodi, Brazil. Jointly implemented by China Agricultural University, China Association of Agricultural Machinery Manufacturers, the Northeast Consortium of Brazil and International Association for Popular Cooperation, the project has promoted the application of smart agricultural innovation technologies such as precision sowing and fertilization, drone plant protection, and mechanized harvesting on Brazilian farms.③

In the field of nuclear technology application, in November 2024, China Isotope & Radiation Corporation, a listed company under China National Nuclear Corporation (CNNC), and the Brazilian Energy and Nuclear Research Institute signed a Memorandum of Understanding on cooperation in nuclear technology applications to strengthen collaboration in radiopharmaceuticals and irradiation, and to jointly promote the healthy and sustainable development of both sides in the field of nuclear technology applications.④ In the field of quantum computing, Russia's State Atomic Energy Corporation Rosatom and Indian enterprises are actively exploring the

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① 《中巴农业科技产业园区建设合作协议签约》，2022 年 5 月 4 日，中国一带一路网，https://www.yidaiyilu.gov.cn/p/242915.html，2025 年 4 月 11 日。

② 《坚持创新驱动 增强发展动能》，2024 年 2 月 27 日，人民网，http://paper.people.com.cn/rmrb/html/2024-02/27/nw.D110000renmrb_20240227_1-18.htm，2025 年 4 月 16 日。

③ 《巴西和中国农业合作持续惠及两国人民》，2024 年 8 月 15 日，人民网，http://world.people.com.cn/n1/2024/0815/c1002-40298903.html，2025 年 4 月 10 日。

④ 《打造中巴合作新标杆！中核集团与巴西签署核技术应用合作协议》，2024 年 11 月 29 日，国家核安全局，https://nnsa.mee.gov.cn/ywdt/hyzx/202411/t20241129_1097620.html，2025 年 4 月 17 日。

prospects for cooperation, which includes the creation of a quantum computer.① In the field of the artificial intelligence industry, the China-BRICS Artificial Intelligence Development and Cooperation Center was launched in July 2024, aiming to promote the information exchange and technical cooperation among the BRICS in the field of artificial intelligence, deepen industrial connection and project cooperation, promote application empowerment, capacity improvement, and governance cooperation and standards and norms.② In addition, in November 2023, the China-BRICS Science and Innovation Incubation Park began construction. Projects such as the Russia House (Xiamen) Collaborative Innovation Center, Steinbeis (Xiamen) Collaborative Innovation Center, Transfong International Technology Transfer Center, and Novosibirsk State University (Xiamen) Technology Transfer Center, along with the BRICS Technology Transaction Platform and the BRICS Intellectual Property Operation Platform, have settled in the incubation park.③ In November 2024, the China-BRICS Science and Innovation Incubation Network was officially launched, with the goal of promoting the commercialization of scientific and technological achievements and industrial upgrading.④

① 《俄原子能集团：俄印正在积极研究量子计算领域合作前景》，2024 年 7 月 10 日，俄罗斯卫星通讯社，https://sputniknews.cn/20240710/1060334596.html，2025 年 4 月 17 日。

② 《中国—金砖国家人工智能发展与合作中心启动仪式在京举行》，2024 年 7 月 20 日，中国—金砖国家人工智能发展与合作中心网站，https://bricsai.cn/#/activeDetail?id=2&type=活动，2025 年 4 月 17 日。

③ 《中国—金砖国家新时代科创孵化园在厦门启动建设》，2023 年 11 月 16 日，新华网，https://www.news.cn/2023-11/16/c_1129979526.htm，2025 年 4 月 16 日。

④ 《中国—金砖国家新时代科创孵化园协作网络成立》，2024 年 11 月 19 日，中国科技网，https://www.stdaily.com/web/gdxw/2024-11/19/content_260597.html，2025 年 4 月 16 日。

II. The Impact of BRICS Cooperation on China's Scientific and Technological Innovation Cooperation

(I). The Positive Impact of BRICS Cooperation on China's Scientific and Technological Innovation Cooperation

With the acceleration of the Fourth Industrial Revolution, global energy transition, and development model transformation, along with the return of great power competition, techno-nationalism is resurfacing globally. Some developed countries are leveraging their technological and industrial advantages to go against the trend of global science and technology innovation development, attempting to maintain a "center-periphery" technological development structure between the Global North and the Global South. In the post-pandemic era, the world faces an urgent need to revive economic development, optimize industrial structures, and improve people's well-being. Developing countries share extensive common interests in cultivating independent science and technology innovation capabilities, transforming and upgrading traditional industries, and fostering emerging industry clusters. BRICS and even the Global South are deeply connected by shared historical experiences, reform demands, and the common development vision etc. Currently, they all face geopolitical and economic pressure from some Western countries, and their demand for international scientific and technological cooperation has risen significantly, and they possess vast market capacities and application scenarios. The expansion of BRICS provides new opportunities and resources for China to carry out international innovation cooperation.

1. BRICS cooperation reflects the urgent need for modernization and international science and technology cooperation in the Global South

At present, changes in the world, the times, and history are unfolding in unprecedented ways and speed. The world has entered a new period of turbulence and transformation, with frequent risks such as increasingly fierce great power games, accelerating transformation of the international landscape, continuous prolongation of regional conflicts, and disorders in industrial and supply chains. China faces external pressures and challenges on an unprecedented scale. At the same time, a large number of developing countries have long been constrained by the "center-periphery" system, trapped in science and technology deficits, governance deficits, security deficits, inefficient social governance, slow economic development, and a lack of scientific and technological innovation. They have an urgent need for modernization and are seeking sustainable and digitized economic development models. The expansion of BRICS is timely and in line with the aspirations of the Global South to use scientific and technological revitalization to reconstruct industrial and value chains, and to improve the quality and efficiency of economic growth. Meanwhile, the expansion of BRICS also provides a model for mutual learning and exchange among countries with significant differences in political systems, industrial structures, resource endowments, ideologies, and cultural traditions etc., and will help foster a pattern of diverse and rich civilizational interactions based on mutual learning and exchange.

First, the enlarged BRICS reflects the collective voices and appeals of the Global South, which is conducive to building a more just and equitable development ecosystem. The so called great power competition poses a serious threat to world peace and development. Profound changes are occurring within the existing global governance system, the shift from West to East in the global balance of power is accelerating worldwide, and the dominant position of the US and some Western countries is becoming increasingly difficult to sustain. The trend of manipulating the international landscape to suppress developing countries and maintain economic and technological hegemony is becoming more evident. The BRICS share a common identity, as they are all second-tier countries with great development potential but significant suppression from the West. Thus, they hold a consistent position on building a more open and fair international environment for science and technology innovation, and are committed to making global governance more inclusive, representative, and participatory. The enlarged BRICS mechanism aggregates more countries from the Global South, further increasing its economic growth and its influence and voice in the international order. It injects vitality into world peace, builds a strong platform for common security, and makes a significant contribution to cultivating the global science and technology innovation ecosystem.

Second, BRICS cooperation points the way forward for global science and technology governance. *The Kazan Declaration* from the 16th BRICS Summit further emphasized the significant role of scientific and technological innovation in promoting the economic development of BRICS and improving the quality of life of their people. Unlike the retrogressive moves of some developed countries to politicize, securitize, and form blocs in technological cooperation, China adheres to the concept of open and inclusive scientific and technological cooperation and actively engages in science and technology innovation cooperation with countries worldwide. With the continuous rise in the discourse power and institutional power of emerging countries represented by China, the BRICS mechanism is increasingly becoming a new force in global science and technology governance. It upholds the governance concept of win-win cooperation, calls for adjusting and optimizing the global science and technology governance order, strengthens inclusive multilateralism, and curbs the trends of techno-nationalism and bloc formation. The BRICS mechanism has provided a breakthrough strategy for global science and technology governance and made a significant contribution to the scientific and technological innovation and developmental progress of all human societies.

2. BRICS cooperation will significantly enhance the foundation for China's international science and technology innovation cooperation

The Kazan Declaration from the 16th BRICS Summit noted the immense potential for cooperation in science and technology innovation. It stated that the development of high-tech products based on domestic technological capabilities is a prerequisite for national economic competitiveness and for achieving sustainable and inclusive economic growth, and it encouraged the BRICS to strengthen technological cooperation. Following its expansion, the BRICS has further increased its representation and influence, injecting more constructive power into maintaining world peace and promoting global development.

First, the joining of new member states has brought new advantageous resources and cooperation needs, which help to enrich and deepen relevant cooperation issues. The newly joined BRICS countries possess abundant resource advantages in areas such as energy, minerals, and agriculture etc. Iran, the UAE, and other Middle Eastern countries have resource advantages in fossil fuels, ranking among the world's leading oil producers and LNG exporters. For example, the UAE's oil and gas resources are extremely rich, with proven oil reserves of approximately 13 billion tons, ranking eighth globally, and proven natural gas reserves of 4.24 billion tons, ranking ninth globally. Indonesia is a major global mining country, the world's third-largest producer of coal and nickel, and also holds the world's largest nickel reserves. It supplies more than a quarter of the world's minerals, including coal, copper, gold, tin, bauxite, and nickel.① Furthermore, Indonesia ranks ninth globally in natural gas exports.② Egypt has a well-developed agricultural sector and is rich in mineral and natural resources, possessing various natural resources such as oil, natural gas, iron, gold, and copper etc. Ethiopia has a comparative advantage in agriculture and livestock, ranking among the top in Africa for coffee production and first in livestock population. The addition of these major resource countries will provide abundant raw materials for production capacity cooperation and industrial production among BRICS, helping to optimize global resource allocation.

Second, the layout of global industrial and supply chains is expected to be optimized. To begin with, most countries in the Global South are at the lower end of the current global industrial division of labor, primarily engaged in low-tech or low-value-added activities such as assembly and processing, and have a strong need for industrial upgrading. Secondly, the BRICS are at different stages of industrial development, and their distinct industrial development characteristics create favorable conditions for promoting division of labor, market expansion, and industrial

① "Indonesia-Country Commercial Guide," *Official Website of the International Trade Administration*, January 9, 2024, https://www.trade.gov/country-commercial-guides/indonesia-mining

② "Leading natural gas exporting countries in 2023, by export type," *Statista*, July 22, 2024, https://www.statista.com/statistics/217856/leading-gas-exporters-worldwide/

collaborative upgrading within the BRICS. After the expansion in 2025, the BRICS mechanism's share of the world's population increased from 40.7% to 48.7%, its economic aggregate rose from 24.7% to 28%,① its export value of trade in goods grew from 20.2% to 25.9%,② its proportion of crude oil exports increased from 15% to 49.6%,③ and the proportion of global GDP at purchasing power parity rose from 31.6% to 39.3%.④ Some Western countries have imposed tariffs on intermediate goods in an attempt to shake China's position in industrial and supply chains. However, the enlarged BRICS has significantly broadened the total amount and variety of resources that the BRICS can mobilize, and has enhanced the discourse power and agenda-setting capabilities of relevant countries in fields such as the global economy, finance, oil, and critical minerals etc. This provides more cooperation mechanisms and platforms for all member states, effectively raising the level of economic cooperation among the BRICS. It is conducive to building a coordinated and reasonable international division of labor system based on the different endowments of member states, promoting technological transformation and upgrading of traditional industries in these countries, and forging a more competitive, just, and reasonable model of industrial division of labor. This will effectively counteract the damage caused by some Western countries' supply chain securitization measures to the international industrial ecosystem.

3. The enlarged BRICS will facilitate the deepening and broadening of China's international science and technology innovation cooperation

Despite being developing countries, BRICS differ in geographical location, development level, development stage, development needs, and resource endowments. These differences present challenges for BRICS science and technology cooperation, yet they also offer significant opportunities for China to further broaden and deepen

① "World Bank Open Data," World Bank, https://data.worldbank.org/indicator/NY.GDP.MKTP.CD?most_recent_value_desc=true

② World Trade Statistics 2023, https://www.wto.org/english/res_e/statis_e/statistics2023_e.htm

③ Crude Oil Exports by Country, https://www.worldstopexports.com/worlds-top-oil-exports-country/

④ "World Bank Open Data," World Bank, https://data.worldbank.org/indicator/NY.GDP.MKTP.PP.CD?most_recent_value_desc=false its science and technology innovation cooperation with the BRICS.

First, the newly joined BRICS countries each hold distinct advantages in various technological fields, which can deepen the scope of China's international science and technology cooperation through complementary strengths. According to the WIPO PATENTSCOPE database, while China holds a dominant position in total patents, other BRICS member states like Russia (Food Chemistry), India (Pharmaceuticals), and Brazil (Specialized Machinery) also possess their own distinct advantages. The newly joined UAE and Saudi Arabia have high levels of technology in fields such as petrochemicals and aerospace. Iran possesses a certain degree of technological R&D capability in areas like nuclear energy and petrochemicals. Indonesia's fintech innovation capability is continuously growing. Egypt has achieved certain results in the technological transformation of traditional industries like textiles and steel. These technological advantages will provide a broad space for the BRICS to deepen their science and technology innovation cooperation and offer significant opportunities for China to enhance its international cooperation in this field. In fact, China's cooperation with the BRICS is largely concentrated in their respective areas of strength. According to the Derwent Innovation patent database, from 2011 to 2020, China's science and technology innovation cooperation with Brazil focused on fields such as manufacturing, components, transformers, compressors, agriculture, medicine, materials, biology, and other fields. Meanwhile, cooperation with India primarily centered on medicine, manufacturing, computers, lighting, wind power generation, energy, and other fields.

Second, the newly joined BRICS countries have diverse science and technology development needs, which can broaden the scope of China's international science and technology cooperation through market cultivation. On the one hand, the technological innovation policies of most BRICS countries are obviously industry-oriented. For example, India focuses on information, pharmaceuticals, and space, while Brazil concentrates on biotechnology and the energy industry, and South Africa on the energy industry. On the other hand, there is a clear tiered differentiation in technological development among the BRICS, with varying needs for science and technology cooperation and different capacities to absorb technological achievements. The expansion of BRICS provides opportunities and markets to broaden the scope of China's international science and technology innovation cooperation, and creates a multi-field and multi-focus scientific and technological cooperation pattern. Surveys have found that the most promising areas for cooperation among the BRICS include offshore oil and gas production, nuclear power, the construction of small hydropower stations, transportation, and high-speed networks and equipment. **In the digital economy,** in May 2022, a pilot commercial service for a 5G network built in collaboration between Huawei and Ethio Telecom was launched. In February 2023, Ethio Telecom once again partnered with Huawei to launch the Ethiotel Innovation Program, aimed at supporting startups in digital finance, technology, and other fields. **In the energy sector,** in April 2024, the Ethiopian Electric Power and Huawei signed a memorandum of understanding to provide alternative power to communities living in off-grid areas, including electric vehicle charging stations and advanced technologies to improve facility operations. **In the field of electric vehicles,** China has certain advantages in new fields and sectors, which allow for the tiered transfer of technology. In July 2024, BYD collaborated with Golden Arrow Bus Services (GABS), a prominent South African bus operator, to customize 120 new energy buses for GABS. Gwede Mantashe, Treasurer-General of the African National Congress of South Africa stated that China holds a leading position in multiple emerging fields such as clean energy and electric vehicles, and Africa and China have great potential for cooperation in jointly promoting modernization. **In information and communication technology,** Huawei and ZTE have partnered with local Indonesian telecom companies and universities to establish training centers, providing cybersecurity training to Indonesian officials, technology workers, and students. This helps Indonesia address the lack of cybersecurity talent and technology, thereby assisting its digital economy development. Additionally, in November 2024, Indonesia's National Research and Innovation Agency signed a cooperation document with China's Ministry of Science and Technology to strengthen research and innovation cooperation in health, energy, and climate change, and to support joint research projects in sub-fields such as renewable energy, biofuels, electric vehicles, and biotechnology etc.①

4. Promote the form of innovation in China's international scientific and technological cooperation and form a demonstration effect

Since the reform and opening-up, China's main partners for international science and technology cooperation have been developed countries in the US and some Western countries, with the primary forms being the absorption and introduction of advanced technological achievements. With the continuous growth of China's scientific and technological strength, the forms and content of international science and technology exchange and cooperation are gradually changing, and the BRICS are becoming an important hub for the secondary transfer of technological achievements.

First, BRICS science and technology innovation cooperation provides a vivid example for China's multilateral science and technology cooperation. Historically, China's international science and technology innovation cooperation has mostly focused on bilateral or trilateral arrangements, with fewer practices in multilateral collaborative science and technology innovation. The BRICS science and technology cooperation mechanism is a vivid practice of multilateral science and technology cooperation. In 2014, the 1st BRICS Science, Technology, and Innovation Ministerial Meeting announced the establishment of a strategic partnership for science and technology innovation, clarifying the key cooperation areas and mechanisms for innovation under the BRICS framework. Subsequently, a series of documents, including *the BRICS Memorandum of Understanding on Cooperation in Science, Technology, and Innovation*, *The BRICS STI Framework Programme*, *The BRICS Action Plan for Innovation Cooperation*, *the Protocol to the Memorandum of Understanding on Science, Technology, and Innovation Cooperation*, and *the BRICS Science and Technology Innovation Framework Project Outline*, were signed. These established 19 priority areas for cooperation, created 14 working groups in astronomy,

① Indonesia, China Deepen Research Collaboration in Strategic Fields, November 5, 2024, https://en.antaranews.com/news/332777/indonesia-china-deepen-research-collaboration-in-strategic-fields marine and polar science, and geospatial technology, and built platforms like the BRICS Young Scientist Forum. In August 2023, China announced the establishment of the China-BRICS Science and Innovation Incubation Park for the New Era to assist in the transformation of scientific and technological achievements and cooperation in relevant industries among the BRICS. Following the BRICS expansion, the stage for China's multilateral science and technology innovation cooperation has become broader, the fields more diverse, and the effects more prominent, laying a solid foundation for future multilateral innovation cooperation. At the same time, the newly joined BRICS members can also provide channels for obtaining external innovation factors or energy supplies.

Second, BRICS science and technology innovation cooperation enriches the forms of China's international science and technology innovation cooperation. The BRICS officially launched science and technology cooperation in 2014, and in the past decade, they have achieved a leap from scratch to a substantial scale, with cooperation content being continuously enriched and cooperation forms becoming more diverse. *The Johannesburg II Declaration* from the 15th BRICS Summit stated a commitment to strengthening cooperation within the BRICS and enhancing the BRICS Partnership on New Industrial Revolution to create new opportunities for accelerating industrial development. The Declaration proposed establishing collaborative mechanisms such as the BRICS Center for Industrial Competences (BCIC), the BRICS Partnership on New Industrial Revolution Innovation Center, and the BRICS Startup Forum. At the BRICS Forum on Partnership on New Industrial Revolution 2024, the competent authorities of 15 countries, including China, Russia, and Brazil, jointly issued *the International Cooperation Initiative on New Industrialization*.

Third, BRICS science and technology cooperation can generate a positive demonstrative effect and attract more technology partners. The technological and development gaps between the North and the South continue to persist and widen, with developing countries facing increasing challenges, especially in the digital era. The efficient implementation of BRICS science and technology innovation cooperation will help showcase the achievements of China's international science and technology innovation cooperation, create a positive demonstrative effect, attract more partners in this field, and enhance China's technological soft power and international influence. For example, since the establishment of the BRICS Joint Committee on Space Cooperation in May 2022, the effective cooperation among the BRICS in space, lunar exploration, and other areas is having a positive demonstrative effect, promoting China's space cooperation with other countries. As of November 2023, China's Fengyun meteorological satellites have provided data services to 115 countries and regions worldwide. In September 2023, the China National Space Administration (CNSA) and Venezuela's Ministry of Science and Technology signed *A Framework Agreement on Cooperation in the Space Field*. China's Chang'e-7 lunar mission, planned for launch around 2026, will also carry six payloads from seven countries or international organizations, including Egypt, to conduct scientific research.

(II). Risk Analysis of BRICS Science and Technology Innovation Cooperation

1. Internal Challenges of BRICS Cooperation

While the expansion of BRICS brings broad prospects for international science and technology cooperation, prominent issues such as a potential loss of organizational effectiveness, heightened risks of institutional competition, and wavering attitudes of some BRICS members also present risks and challenges for international science and technology innovation cooperation.

1.1 The expansion of BRICS affects organizational effectiveness and may lead to issues such as decision-making divergence, uneven benefits, and weak implementation. In multilateral cooperation, how to address issues of equitable benefits, ensuring the reliability of cooperation mechanisms, and avoiding the collective action problem that most multilateral mechanisms must address. Moreover, the more members there are, the more obvious the collective action problem (non-cooperation) tends to be. If these issues are difficult to resolve, multilateral mechanisms may inevitably become perfunctory. It is precisely because of the failure to adequately address these issues that some multilateral mechanisms which were initially met with high expectations, have increasingly shown a tendency to become high-sounding rhetoric with limited results.

First, there is still differences in identity among the enlarged BRICS. Although they are all developing countries, BRICS members have differences in their stages of social development, political and economic systems, and historical and cultural traditions. The population of the UAE is less than 1% of China's, Russia's territory is more than 200 times that of the UAE, and China's economic scale and total trade volume are more than 160 times and 340 times larger than Ethiopia's, respectively. At the same time, member states hold different expectations on what kind of international order should be established. Russia aims to build a "World Majority", Iran seeks to create a Global East", while Saudi Arabia and the UAE consider themselves the "Heartland", belonging to neither the South nor the East. With the joining of new members, the BRICS identity urgently needs to be further strengthened.

Second, there is still a growing difficulty in balancing economies of scale among the enlarged BRICS. Currently, BRICS science and technology cooperation is predominantly based on bilateral arrangements (e.g., China-Russia, China-Africa, China-UAE), or trilateral participation (e.g., the China-Russia-India trilateral partnership), with a lower degree of multilateralism. The expansion of participants could lead to issues such as wider gaps between members, increased communication costs, and reduced cooperation efficiency, especially since most of the newly joined countries are developing countries with smaller economies and relatively lower technological levels, whose priorities may differ from those of more advanced countries that are focused on frontier technologies. In this situation, the overall science and technology cooperation of BRICS may struggle to leverage its cluster advantages and could even lead to diminishing marginal returns, thereby reducing each member state's access to technological public goods. Therefore, BRICS cooperation needs to balance the issues of bilateralism versus multilateralism and equity versus efficiency.

Third, there is contradiction between equal consultation and efficient cooperation among the enlarged BRICS. As an innovation for comprehensive cooperation among emerging countries and the Global South, the BRICS mechanism moves beyond the traditional international mechanism of coordination between major powers and small countries on the sidelines. It adopts a mode of collective decision-making, collective action, and consensus. While this approach certainly has its advantages, it also requires higher costs for communication, coordination, and decision-making, especially in the case of the varying development stages and different demands of the newly joined BRICS countries. For example, China and India are more focused on digital information technology, Brazil and South Africa on agriculture, Middle Eastern countries on technological infrastructure and the application of high-tech, and Indonesia on prioritizing digital economic development. Furthermore, the BRICS mechanism also faces challenges related to the lack of formal institutions and supervision for implementation. Currently, BRICS science and technology cooperation is primarily government-led, functioning more as a coordination mechanism than as a cooperation implementation mechanism. The forms of cooperation are relatively loose, lacking sustained and stable investment and guarantees for financial support and project implementation.

1.2 BRICS multilateral science and technology cooperation faces competition from different types of institutions. Institutional competition is increasingly becoming a significant phenomenon in the current international community. To pursue their goals for power, interests, and values, the leading and participating countries of institutions actively seek to shape and influence various forms of institutions, making institutional competition extremely intense across different levels and issues. While all member states attach great importance to BRICS cooperation, it may not be their top priority cooperation mechanism, which could disperse or even hedge the motivation of BRICS science and technology cooperation.

Firstly, BRICS science and technology cooperation faces competition from multilateral mechanisms such as the QUAD and the G7. Currently, the QUAD has established a Critical and Emerging Technology Working Group, with initiatives such as the Semiconductor Supply Chain Initiative and the Technical Standards Contact Groups. It has also formed the Cybersecurity Partnership, the Space Working Group, and the Quad Partnership for Cable Connectivity and Resilience. The 2023 G7 Hiroshima Summit significantly increased its emphasis on developing countries, inviting six counties, including India and Brazil, to participate in the meeting, and adopting documents such as *the G7 Clean Energy Economy Action Plan* and *the G7 Leaders' Statement on Economic Resilience and Economic Security*. The 2024 G7 Apulia Summit further increased its attention to the Global South, inviting leaders from countries such as Türkiye, India, Saudi Arabia, the United Arab Emirates, Brazil, Argentina, South Africa, and Algeria to attend the Outreach session. This could lead to more prominent internal divisions within multilateral mechanisms and escalating intra-organizational and inter-institutional competition.

Secondly, BRICS science and technology cooperation faces competition and interference from thematic multilateral cooperation mechanisms like the Artemis

program and Alliance for the Future of the Internet. In October 2020, NASA signed *the Artemis Accords* with the space agencies of countries including Australia, Canada, and Italy to jointly participate in the Artemis program, which aims to return humans to the Moon. Subsequently, with the invitation of the US and some Western countries, not only BRICS countries such as Saudi Arabia, the UAE, Brazil, and India, but also Global South countries like Argentina, Angola, and Rwanda, have joined *the Artemis Accords*. As of June 2024, the number of member countries in the program has reached 47. Furthermore, some Western countries have exercised long-arm jurisdiction, interfering with BRICS science and technology cooperation. In March 2023, the China-UAE cooperation on the Chang'e-7 mission was disrupted on the grounds that the Rashid 2 Rover was carrying American-made components. At the request of the US government, G42, an AI and cloud computing company in the UAE, withdrew its investment from China and removed Chinese equipment from its operations. In April 2024, Microsoft announced a $1.5 billion investment in G42.

At the same time, the BRICS cooperation mechanism urgently needs further upgrading and primarily includes three aspects. First, there is a lack of specialized institutions among the BRICS to advance science and technology cooperation, resulting in differences in the implementation of scientific and technological cooperation and the depth of cooperation, which ultimately affects the effectiveness of such collaboration. Taking the timeliness of funding and technology transfer as an example, although the BRICS have committed to providing financial and technological support, the speed of fund disbursement, the actual scale, and the effectiveness of technology transfer are often affected by the complexities of multilateral coordination, resulting in project delays or even failure to proceed as scheduled. Second, there is insufficient centripetal force in the BRICS mechanism due to its weak constraints. Currently, the BRICS primarily adopt a soft cooperation mechanism. While this is conducive to member states seeking common ground while respecting differences on some issues, the limited consensus on major science and technology cooperation topics or key projects, and the lack of incentives from successful precedents of major collaborations, result in a lack of enthusiasm and a sense of achievement among the BRICS member states. In fact, member states also hold differing opinions on whether and how to carry out institutional reform. Third, there is the issue of strategic swing and competition among the BRICS member states. For example, India participates in both the Quad and the "I2U2" (India, Israel, the UAE, and the US) mechanisms, seeking to attract investment from Western technology companies in the context of Sino-US technological decoupling. Furthermore, traditional geopolitical tensions exist within the BRICS, including Egypt and Ethiopia, and Saudi Arabia and Iran. How to prevent these issues from affecting the efficiency of science and technology cooperation among the BRICS is a key focus of institutional development. Fourth, current science and technology cooperation among the BRICS is predominantly government-led, and there is still space for professional institutions and market entities to play a greater role.

1.3 Some BRICS member states or potential member states show wavering attitudes toward the BRICS mechanism. The purpose of a country creating or joining an international organization is to address and resolve common issues in a collective and mutually acceptable manner, while adhering to certain rules. A member state's attitude toward an international organization depends on a rational calculation of costs and benefits. When the benefits from the organization decrease, the cost of maintaining it rises, or the priority of common issues declines, a country's attitude toward the organization may change. Following adjustments in the domestic and foreign policy priorities of some BRICS countries, their attitudes toward the BRICS cooperation have wavered. It is a concern that countries with closer ties to the West may worry that engaging in science and technology cooperation within BRICS could potentially have a negative impact. It has been noted that some countries express concern about some science and technology projects and initiatives launched or led by China, which may hinder large scale technological investments.

First, India's deep strategic ties with the US and some Western countries, along with its ongoing caution towards China, appear to casue competition within the BRICS. On one hand, India's close technological ties with the US and some Western countries have led to the formation of a network of technological partnerships. In 2021, the US and India launched the US-India Artificial Intelligence(USIAI) Initiative and reached an interim agreement regarding the imposition of a digital services tax. In January 2023, the US-India Initiative on Critical and Emerging Technology (iCET) was launched by the two countries, aiming to strengthen the innovation ecosystems of both countries, build resilient semiconductor supply chains, and enhance cooperation in space and next-generation telecommunications. In June, the US and India announced the establishment of a Global Digital Development Partnership to bring together the technology and resources of both sides to develop and deploy digital public infrastructure in developing countries. The US-India Business Council also formally launched the India-US Defense Acceleration Ecosystem (INDUS-X) to advance cooperation on cutting-edge technologies between India and the US. Furthermore, India is a key member of multilateral mechanisms such as the Quad. The engagement with these mechanisms could lead to a higher likelihood of India pursuing critical and emerging technology cooperation outside the BRICS framework, which would likely have an impact on India's enthusiasm within the BRICS mechanism.

On the other hand, India, positioning itself as a representative of the Global South, has engaged in competition with China in various fields, aiming to seek a leading position. Initially, India was reportedly opposed to the expansion of BRICS, expressing concerns that an enlarged BRICS might become a platform for China to expand its international influence. However, India later adjusted its position to express active support for the expansion of the BRICS, while emphasizing the need for broad consultation with stakeholders and focusing on clear procedures and eligibility criteria for the expansion. Swaran Singh, a professor at the School of International Studies, Jawaharlal Nehru University, noted that "the expansion of the BRICS demonstrates its growing attractiveness. However, it also means that when admitting new members, the BRICS must be particularly cautious. Given that China's economy is three times the size of other BRICS member states, it is necessary to be patient to avoid giving other countries the impression that China is showing favoritism."

India holds a dual attitude toward BRICS science and technology cooperation.

On one hand, India has shown a certain level of caution regarding science and technology cooperation with China. Under the slogan “self-reliant India”, it seeks to reduce its dependence on Chinese supply chains. Based on concerns regarding national security and tax evasion, a number of Chinese-funded enterprises, such as Xiaomi, and several China-related applications, including TikTok and WeChat, have been subject to government measures in India. On the other hand, India has a positive attitude toward other Global South countries within the BRICS mechanism. The Global South has become a crucial pillar of India’s diplomatic strategy. India has hosted the Voice of the Global South Summit and promoted Digital Public Infrastructure (DPI), the Unified Payments Interface (UPI), and digital identity projects (Such as Aadhaar) in the Global South. This has led to a more competitive environment for China and India in the export of digital products.

Second, there are complexities in Saudi Arabia’s attitude toward the BRICS mechanism. Saudi Arabia is a key ally of the US in the Middle East, having long followed US policies on security and diplomacy. However, as a crucial pivot country for the Belt and Road Initiative, Saudi Arabia’s interactions with China in economic and technological fields are becoming increasingly frequent. This dynamic bilateral relationship requires Saudi Arabia to make careful choices when managing its ties with the two major powers, China and the US. Saudi Arabia’s self-positioning is nuanced, and it appears to be seeking to benefit from both sides in its science and technology cooperation with China and the US. On one hand, Saudi Arabia’s cooperation with China is growing closer. In February 2024, Dahua Technology and Alat, a wholly-owned subsidiary of Saudi Arabia's Public Investment Fund (PIF), reached a strategic cooperation agreement in Riyadh, Saudi Arabia. They established a joint venture, AIVisio, with a total investment of approximately $200 million. Chinese artificial intelligence companies are also actively participating in Saudi Arabia’s future city projects. Pony.ai, an autonomous driving company, has received an investment of about $100 million from the future city investment fund. Furthermore, Alibaba Cloud and Saudi Telecom Company have initiated cooperation in the 5G technology field. In May 2024, Lenovo and Alat reached a strategic cooperation agreement. At the same time, Saudi Aramco's Prosperity7 Ventures has invested in the latest funding round for the Chinese generative AI startup ZHIPU AI, becoming the first foreign investment institution to publicly support a leading Chinese AI company. On the other hand, Saudi Arabia has also pursued closer collaboration with the US. In May 2025, during the visit to the Middle East by Trump, Saudi Arabia committed to invest $600 billion in the US to strengthen cooperation in areas such as energy security, defense industry, and leading technologies etc. Saudi Arabia's DataVolt has invested $20 billion in the US to advance its plans for building AI data centers and energy infrastructure. As part of the UAE's investment plan, the US and the UAE established the US-UAE AI Acceleration Partnership Framework to enhance cooperation in AI and other emerging technologies. ① It has been noted that the position adopted by Saudi Arabia introduces some uncertainty for BRICS science and technology cooperation.

Beyond the factors related to the US, it is also a consideration for countries like Russia and Indonesia that the benefits of science and technology cooperation may be accompanied by potential risks, including technological dependency, data security, and privacy protection etc. Russia may place a greater emphasis on its political and economic influence within the Commonwealth of Independent States (CIS), including in scientific and technological fields. While Indonesia has openly cooperated with companies such as Huawei and ZTE, it has also expressed its requirements for the security of critical information infrastructure and data sovereignty, noting the necessity of building indigenous cybersecurity capabilities.② As a result, until the enlarged BRICS can achieve a high level of mutual understanding on key issues like technology transfer, information security, and cross-border data flows, the countries involved may maintain their reservations regarding collaboration on large-scale scientific programs and in critical fields.

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① US, UAE to Improve Collaboration in AI, Emerging Technologies Development, May 19, 2025, https://govconexec.com/2025/05/us-partnership-with-uae-to-advance-ai-emerging-technologies/

② Gatra Priyandita, Dirk van der Kley, and Benjamin Herscovitch, Localization and China's Tech Success in Indonesia, https://carnegieendowment.org/research/2022/07/localization-and-chinas-tech-success-in-indonesia?lang=en

2. External Risks of Greater BRICS Science and Technology Cooperation

2.1 Differences in member states' relationships with the Western countries pose challenges to BRICS science and technology cooperation

On one hand, Russia and Iran are currently subject to sanctions from the US and Europe, while China is facing technological pressures from the US and some Western countries. It has been noted that Russia and Iran have been subject to unilateral and multilateral sanctions by the US and some Western countries, with restrictions encompassing areas such as technology, investment, trade, and finance. These measures are understood to have limited their opportunities for exchange and cooperation with the international community in the scientific and technological fields. The scope of many of these sanctions is not only directed at nuclear and military-related sectors but is also observed to impact other key technological areas, such as computing and communications, which has been associated with constraints on capital flows and challenges to technology transfer. Due to the long-term sanctions on Russia and Iran, relevant international science and technology cooperation projects may be perceived as potentially violating US export control regulations and various long-arm jurisdiction requirements. Consequently, BRICS international science and technology cooperation projects might face increased security scrutiny from the US and some Western countries, potentially adding to the uncertainty. To avoid being affected by sanctions, some BRICS member states may adopt a cautious approach in their science and technology cooperation with Russia and Iran, which could impact the overall efficiency of BRICS science and technology cooperation. Furthermore, as the Ukraine crisis continues and the US accelerates technological decoupling from China, the US is leveraging its alliance system to accelerate de-Sinicization in fields such as 5G, semiconductors, artificial intelligence, and quantum technology, etc., through methods like export controls, investment screening, market access restrictions, and the setting of emerging technology standards. Under these circumstances, the primary agendas, cooperation frameworks, and institutional outcomes of BRICS science and technology innovation cooperation might be prone to politicized interpretations. There is a possibility that these efforts could be framed by some countries as an “anti-Western bloc” or a “China-Russia order” challenging the Western order, which could be seen as a threat to national security and regional stability.

On the other hand, BRICS member states such as India, the UAE, and Saudi Arabia, as allies and strategic partners of the US, have close technological ties with the US and some Western countries. They are also reportedly taking on a significant amount of business relocation from US and European technology companies, which could put them in a position where they are responsive to pressure from the West. **Firstly, BRICS member states with close ties to Western countries may encounter trust issues with countries like Russia and Iran,** and there is a concern that cooperation with Russia and Iran could lead to negative assessments or economic sanctions from Western countries. Consequently, a cautious approach may be adopted in science and technology cooperation with Russia and Iran, which could affect of overall BRICS cooperation. **Secondly, public discourse from the US and some Western countries has reportedly drawn attention to a perceived imbalance in the three pillars of BRICS cooperation,** leading to characterizations of collaboration led by China and Russia as “Sino-Russian dominance”. The struggle of sanctions and counter-sanctions between the US/Europe and Russia has also led to a “Russia-related suspension” within the BRICS cooperation mechanism. Furthermore, the uncertainty surrounding the New Development Bank’s timeline and procedures for resuming projects in Russia may give rise to concerns among other BRICS member states about participating in Russia-related cooperation. **Thirdly, BRICS member states have differing views on issues related to the US-Iran relationship.** If the BRICS is seen as supporting Iran’s possible violations of international norms, such as developing nuclear weapons, it could damage the image of BRICS as a responsible international actor. **Fourth, fluctuations in Sino-US relations and the techno-nationalism and long-arm jurisdiction of the US are creating obstacles and uncertainty for BRICS science and technology cooperation.** It has been observed that the US is currently engaging in a global technology competition with China, and is also discouraging some pro-US BRICS countries from exchanging cutting-edge technological achievements with China by building a specific technological ecosystem, setting up technology transfer barriers, exerting geopolitical pressure, and restricting the export of key facilities or infrastructure. For example, in 2020, Keith Krach, the Under Secretary of State for Economic, Energy, and Environment of the US, expressed the view that cooperation between Egypt and Chinese companies would undermine security and data protection, and he urged Egypt to join the so-called “The Clean Network” to block Egypt’s cooperation with Huawei. In January 2024, the Biden administration announced sanctions against two Egyptian computer experts for endangering the US national security. In February 2024, to avoid sanctions, G42, a Middle Eastern AI giant headquartered in Abu Dhabi with business areas including cloud computing and autonomous driving, reached an agreement with the US government, reportedly leading it to halt a series of collaborations with Chinese technology companies and instead partner with US enterprises.

The second Trump administration has further increased the complexity and uncertainty of great power competition. In the technology sector, the Trump administration has adopted a series of measures to maintain its global technological leadership. On the one hand, it has sought to reduce regulations on technological innovation. Trump revoked executive orders from the Biden administration concerning areas such as artificial intelligence and digital assets, aiming at promoting technological innovation and removing obstacles to the US’s leading position in cutting-edge technologies. On the other hand, it has promoted scientific and technological innovation in key areas. The Trump administration is committed to advancing the development of AI, quantum computing and communication technologies, viewing them as crucial for national defense, space exploration, and the protection of critical infrastructure. Following the meeting between Trump and Italian Prime Minister Giorgia Meloni, the White House issued a statement indicating that the two sides share a common interest in developing future technologies, including quantum.① In the space sector, the Trump administration will accelerate lunar and Mars exploration through a series of financial investments, while still prioritizing key scientific and technological research.② Regarding supply chain restructuring, the US is encouraging the reshoring of manufacturing through high tariffs, export controls, and regulatory frameworks. In the semiconductor industry, Trump has modified semiconductor export regulations from the Biden administration, placing a specific focus on bilateral agreements with various countries.③ During Trump's visit to the Middle East, agreements were reached with Saudi Arabia and the UAE concerning greater access to advanced AI chips from Nvidia and Advanced Micro Devices (AMD).④ In the field of critical minerals, in March 2025, Trump signed an executive order to increase US mineral production, dedicated to strengthening domestic mineral production, reducing dependence on mineral imports, enhancing national security, and supporting emerging technologies.⑤ In the field of international scientific research cooperation, the Trump administration has intensified its visa screening for the sake of national security. In June 2025, Trump issued two orders concerning international students. One was to prohibit citizens of 12 countries from entering the US and to strengthen visa restrictions for citizens of another 7 countries. The second was to block all international students, researchers, and other exchange visitors from entering Harvard University.⑥

Furthermore, the US is engaged in technological competition in the Global South. Facing increasing power limitations, American companies are seeking to exchange advanced semiconductor technology for Brazil's renewable energy resources. For

① Trump Administration Makes Deep-Tech Bets as Agencies Lean into Quantum for National Security, Infrastructure And Space, April 19, 2025, https://thequantuminsider.com/2025/04/19/trump-administration-makes-deep-tech-bets-as-agencies-lean-into-quantum-for-national-security-infrastructure-and-space/

② President Trump's FY26 Budget Revitalizes Human Space Exploration, May 2, 2025, https://www.nasa.gov/news-release/president-trumps-fy26-budget-revitalizes-human-space-exploration/

③ Donald Trump's Administration to Overhaul US Semiconductor Export Policy Amid Flood of AI Chip Deals in Saudi, UAE, 14 May 2025, https://www.livemint.com/news/us-news/donald-trump-administration-overhaul-us-semiconductor-export-policy-nvidia-amd-saudi-ai-chip-deals-middle-east-uae-news-11747199176426.html

④ US Tech Firms Nvidia, AMD Secure AI Deals as Trump Tours Gulf States, May 15, 2025, https://www.reuters.com/world/middle-east/saudi-arabia-partners-with-nvidia-spur-ai-goals-trump-visits-2025-05-13/

⑤ President Trump's Bold Shift in Domestic Minerals Policy, April 9, 2025, https://mineralsmakelife.org/blog/president-trump-bold-shift-domestic-minerals-policy/

⑥ International Students Hit with Back-to-Back Orders, June 6, 2025, https://www.insidehighered.com/news/global/international-students-us/2025/06/06/trump-proclamations-escalate-international-student example, Microsoft recently committed to a $2.4 billion investment in Brazil for cloud computing and AI infrastructure, while Amazon plans to invest $1.8 billion by 2034.① Microsoft has also announced a $1.7 billion investment in Indonesia over the next four years to develop cloud computing and AI infrastructure.② The Trump administration may continue to put pressure on the BRICS or its allies, which could interfere with technological cooperation among these countries. This could not only create obstacles for the technological development of the BRICS but also potentially have a profound negative impact on global technological cooperation. High-tech companies from the US are also competing with China in the Global South. For example, Google has opened applications for the 2025 Startup Accelerator program to support tech startups in Africa and Latin America, and Amazon plans to invest an additional $1.7 billion in Africa by 2029 to expand its cloud computing and AI services.

2.2 The Instability of BRICS Member States' Development Environments Poses Higher Demands on Science and Technology Cooperation Planning

On one hand, some BRICS member states have weak economic foundations and relatively complex social environments. For example, Ethiopia, the newly joined BRICS country, has faced a combination of climate change, social conflicts, and pandemic, with issues of food security and public health presenting serious challenges to its economic stability. Although the new member Egypt has developed comprehensive short-term, medium-term, and long-term science and technology development plans, its technological industry has developed relatively slow due to multiple factors such as weak infrastructure, brain drain, incomplete regulatory systems, and poor financing channels. Consequently, it has not yet become the core force driving national development and economic transformation, and many research and development projects have been difficult to initiate or have been suspended due to

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① Digital Dams: How U.S.-Brazil AI Cooperation Could Help America's AI Ambitions Flow, April 10, 2025, https://www.rand.org/pubs/commentary/2025/04/digital-dams-how-us-brazil-ai-cooperation-could-help.html

② US Giants Bet Big on AI in Indonesia, May 24, 2024, https://asiamattersforamerica.org/articles/us-giants-bet-big-on-ai-in-indonesia a lack of funding and talent shortages. Some member states face domestic development risks, leading their governments to focus on stabilizing the situation. As a result, science and technology cooperation tends to be a lower priority on the official agenda. At the same time, domestic development risks may also shake the confidence of partner governments and businesses, leading to a cautious approach toward exchanges and investments due to concerns about the security of their overseas interests. In addition, regime changes in some member states may also impact science and technology cooperation. These realities will restrict the depth and breadth of science and technology cooperation under the BRICS framework, which are issues that must be carefully considered when designing future long-term strategic plans for BRICS technological cooperation.

On the other hand, some BRICS member states have complex geopolitical environments surrounding them. For example, tensions exist between Iran and its neighboring countries. The instability of this geopolitical environment can also have an impact on BRICS science and technology cooperation. In addition to the above-mentioned concerns about how some member states balance their relationships with Iran and the US and some Western countries, geopolitical spillover effects can also affect the progress and quality of scientific and technological cooperation. In the event of a regional conflict, the personal safety of relevant researchers and the integrity of critical experimental facilities could be under threat. Regional instability can also impact the consistency and continuity of local policies, which in turn has a chain reaction affecting the stability of project funding and international market confidence. At the same time, due to the external pressures they face, some member states may prioritize cooperation in areas that can enhance their strategic capabilities and regional influence, such as military technology, nuclear technology, and aerospace etc. This kind of regional strategic consideration could potentially lead to friction between the BRICS member states and other countries in the region, and with Western countries, making it difficult to implement relevant cooperation projects.

2.3 Cultural Differences Among BRICS Member States Introduce Uncertainty into BRICS Science and Technology Cooperation

Cultural differences among BRICS member states may potentially lead to communication and cognitive discrepancies during the process of advancing science and technology cooperation. With the expansion of the BRICS mechanism, the membership now spans multiple regions, including Asia, Europe, Africa, and South America. This has further highlighted differences among member states in culture and religion, which could present certain challenges to deepening science and technology innovation cooperation. The enlarged BRICS possess different language systems and political environments, and their diverse historical and cultural backgrounds and development paths create high demands for effective cross-cultural communication. Addressing this issue is an unignorable part of advancing science and technology innovation cooperation within the BRICS.

In South Asia, India is currently actively promoting Hindu culture as a core concept for its technological cooperation. The traditional Hindu concept of "Swaraj" has provided theoretical support from religious thought for India's techno-nationalist ideas. The central ideas of this concept is "self-rule" and "self-reliance", which advocates for the protection and support of indigenous enterprises and industries. Furthermore, the blueprint for promoting economic reform through indigenous technological innovation to ultimately make India a great power is also one of the main ideas of the Bharatiya Janata Party (BJP). At present, techno-nationalism has emerged as a key tool for the BJP to attract voters and foster social cohesion. To achieve this goal, it is a concern that the Indian government has implemented a series of measures, including strengthening regulations and conducting anti-monopoly investigations. Additionally, it has been reported that India requires foreign technology enterprises to utilize local manufacturing and sales networks and to engage in joint production and development activities with Indian domestic companies. However, these requirements may not always be in line with the interests of foreign technology companies. It is a consideration that many technology companies, including those from the BRICS, might find that these regulations limit their market flexibility, which could have implications for their business interests and technological innovation.

In South America, Brazil, as a significant BRICS member state, has a cultural background that is deeply influenced by the Latin American cultural sphere. On a personal level, the Brazilians are generally characterized by an optimistic and cheerful character, and they are known for being warm and energetic. Consequently, there is a tendency among Brazilians to prioritize a comfortable lifestyle. However, on a political level, Brazilian trade unions are very influential, and their strong emphasis on protecting workers' rights has contributed to a complex dynamic in labor-management relations. On a societal level, income inequality has resulted in a degree of polarization in educational attainment, with a relative lack of opportunities and willingness for people from disadvantaged groups to pursue higher education. This has also contributed to a significant outflow of high-tech talent from the country. Many high-tech talents choose to leave Brazil to seek better career opportunities in the US and European countries. This brain drain has posed considerable challenges to Brazil's technological development, which not only impact Brazil's own technological innovation capabilities, but also affect its international science and technology cooperation.

In the Middle East, there remains a degree of tension between traditional religious culture and national modernization. Some member states have had relatively limited experience in modernization, and their legal frameworks are perceived as relatively lagging, particularly concerning intellectual property protection. This issue could potentially be a source of concern for international investors. Although the Saudi Arabian government has begun to set up its efforts to combat intellectual property infringement and has announced a national strategy aimed at protecting intellectual property rights, the effectiveness of these measures remains to be observed and evaluated. Furthermore, influenced by religious and cultural factors, Saudi Arabia and Iran face a shortage of technological talent, as their science and engineering education may not fully meet current needs. About two-thirds of the workforce tends to be employed in the government's public sector, while the private sector is largely dominated by expatriates. These factors may have an unfavorable impact on the BRICS to carry out technology transfer and collaborative research with them.

In Southeast Asia, influenced by religious and cultural factors, most Indonesians do not take the development of science as their primary goal; instead prioritizing a harmonious, peaceful, and stable life. Public understanding of science and its importance is relatively limited, which could result in a lack of enthusiasm for the government's science and technology cooperation initiatives. In terms of academic output, research in Indonesia is mainly concentrated in the arts and humanities, with a relatively limited number of research findings in science, technology, engineering, and mathematics (STEM). Indonesia's education system is currently unable to provide sufficient STEM talent, and educational infrastructure in some regions is relatively underdeveloped. According to statistics, Indonesia has one of the highest proportions of adults aged 25-64 with an education level below the primary school level.[①] Indonesia also faces a significant shortage of ICT talent, with a need for more highly-qualified graduates and skilled technical workers. The Indonesian government maintains relatively strict control over research funding, often favoring areas that are considered practical, scalable, and marketable, and the overall R&D expenditure is considered insufficient.

① Indonesia, Overview of the Education System (EAG 2024), https://gpseducation.oecd.org/CountryProfile?primaryCountry=IDN&treshold=10&topic=EO

III. Methods and Pathways for Promoting BRICS Science and Technology Cooperation

Faced with the opportunities and challenges of BRICS science and technology cooperation, it is essential to ensure that cooperation projects are in line with long-term national interests, organizational interests, and science and technology development goals. While fully leveraging and strengthening the expanded BRICS mechanism, it is important to demonstrate the mechanism's flexibility and take into account the cooperation needs of different countries in the field of science and technology. By seeking common ground while respecting differences, it is possible to leverage minilateral initiatives to drive larger-scale cooperation, hedge against the influence of competitive blocs, and inject vitality and confidence into the expanded BRICS cooperation. At the same time, it is crucial to prevent and resolve the various issues and challenges brought about by the expansion of the BRICS mechanism, and to effectively enhance the resilience and sustainability of BRICS science and technology cooperation.

To begin with, minilateral cooperation can be used to overcome the collective action problem, serving as a model to drive greater BRICS science and technology cooperation and leverage the snowball effect of early gains. President Xi Jinping has stated the BRICS mechanism is not high-sounding rhetoric, but rather teams that unify knowledge and action. **First, by carrying out minilateral cooperation, the negative impacts following the expansion of the BRICS mechanism can be offset to the maximum extent possible, and the realization of established strategic goals can be advanced.** If a large multilateral framework cannot produce effective results in the short term, it is possible to explore minilateral cooperation within the larger framework, such as projects involving China, Brazil, India, or South Africa. Additionally, there is an opportunity to try combining the BRICS mechanism with existing bilateral cooperation mechanisms between China and BRICS member states. Minilateral cooperation mechanisms adhere to the principle of critical mass, and they have certain thresholds for cooperation, and can solve the problem of insufficient consensus based on essential symbolic gestures and specific interests. This allows member states to advance established goals within a defined small group, even if some members are absent or have reservations. On the basis of consolidating and expanding cooperation, China could establish mechanisms in key areas such as energy, agriculture, and critical minerals. Furthermore, it could facilitate the establishment of "exchange groups" that are focused on BRICS and responsive to specific needs in fields like governance, green development, and industrial cooperation etc,with the goal of using smaller-scale coordination to drive larger-scale collaboration.

Second, cooperation can be focused on small but practical projects to ensure early benefits for participating member states, thereby leveraging a snowball effect of cooperation. The ability to gain benefits within a mechanism is a fundamental factor influencing a country's participation in international cooperation. The greater the scale of benefits and the more timely the positive feedback, the stronger a country's willingness to participate. The term "small but practical" is a concept that corresponds to "large and high-cost" projects like large-scale infrastructure, which refers to small-scale initiatives that involve modest investment, focus on livelihood needs, and achieve quick results. China has formed high-quality foreign aid brands such as Juncao technology, Artemisinin, Hybrid Rice, Luban Workshop, the "Wancuntong" project, and the Brightness Action, which have enhanced the ability of China's international scientific and technological cooperation. In greater BRICS science and technology cooperation, China can focus on small but practical projects to conduct pragmatic collaboration, prioritizing them based on the needs of different member states, ensure the rapid realization of benefits and the gradual accumulation of cooperative gains, thereby leveraging cooperation on large and high-cost projects and providing institutional support for industries to expand globally within the BRICS framework. Furthermore, it's important to adhere to the principle of orderly expansion and avoid formalities. Many member states participate in multiple intersecting multilateral mechanisms, and there can be overlapping interests between different domestic departments. This can lead to institutional redundancy, competition, and friction, which in turn could undermine the effectiveness of greater BRICS cooperation.

What's more, it is necessary to establish and improve BRICS science and technology cooperation mechanisms for risk monitoring, early warning, assessment, and response to hedge against pressure from competitive blocs. In managing the possible relationship risks such as those between Iran and the US, or Russia and the US, the enlarged BRICS require not only diplomatic wisdom but also insight and predictive ability to the international political and economic landscape. **First, establishing a legal risks monitoring mechanism is vital to ensure that BRICS cooperation is compliant, thereby avoiding negative chain reactions and protecting the positive image of the enlarged BRICS.** The enlarged BRICS need to adopt a pragmatic strategy, balance the interests of all sides, and leverage their own advantages to address the risk and challenges, diversification and complexity of export controls and sanctions against Russia and Iran by the US, Europe and other countries, relevant think tanks, chambers of commerce, law firms, and consulting companies should actively cooperate with frontline departments to timely and accurately assess the intentions of BRICS science and technology cooperation and related changes in political relationships, especially political, economic, and surrounding geopolitical security risks. It is recommended to use an information platform to promptly publish detailed updates on the latest sanctions against Russia and Iran, and to issue and regularly update warnings for innovation cooperation under sanction conditions. This would ensure that research institutions and enterprises can quickly check the sanction status of various cooperative entities, establish and implement an effective compliance system, and conduct full-cycle monitoring of jointly invested, incubated, and operated science and technology innovation projects.

Second, it is possible to conduct staggered technological cooperation within the BRICS framework, focusing on key areas where the Western countries are less involved. At the same time, diversifying cooperation methods can help technological collaboration return to a market-driven approach and mitigate political risks. Some BRICS member states have established certain technological cooperation relationships with the West, for example, such as public health, climate change, and renewable energy etc. The enlarged BRICS could focus their efforts on technology empowerment for infrastructure, fintech, and other technologies that serve public livelihoods, such as 5G networks, the digital economy, mobile payments, and cloud computing etc. For countries such as Iran and Russia, which are under financial and industrial sanctions from the West, the enlarged BRICS needs to explore diversified cooperation methods to reduce sanction risks and ensure the financial security of technological collaboration. This could involve exploring innovative financial mechanisms and actively promoting local currency settlements.

Third, it is important to strive for greater coordination and reconciliation among the enlarged BRICS. This would involve leveraging diplomacy, identifying common interests, setting a model for cooperation among developing countries globally, and attracting more members who pursue fairness and peace to participate in greater BRICS cooperation projects, thereby supporting the BRICS member states' efforts to build their own technological self-reliance. It is noted that the influence brought by the West does not fundamentally shake the overall strategic choice of countries like Saudi Arabia and the UAE to pursue strategic autonomy and deepen cooperation with emerging economies. The greatest appeal of joining BRICS is that it is in line with the development interests of the Global South, and science and technology cooperation is a key consideration within this as developing countries expect to achieve broader technological benefits under the BRICS mechanism. Therefore, it is important to actively use the appeal of technological cooperation to highlight the development-oriented nature of the BRICS mechanism and the common interests of its members. It is advisable to avoid making an explicit alignment with either China or the US a prerequisite for countries joining the BRICS cooperation mechanism. In response to pressure from great power competition and center-peripheral system, the enlarged BRICS could leverage its influence in multilateral organizations such as the UN to strengthen coordination and collaboration with relevant international organizations like the International Telecommunication Union, the World Intellectual Property Organization, and the

United Nations Conference on Trade and Development. Additionally, it could mean uniting with the Global South to advance proposals for technological innovation and exchange, thereby promoting international science and technology cooperation initiatives to be recognized and accepted by more countries, and actively promoting the establishment of international technology standards, particularly digital standards. At the same time, it is worthwhile to explore ways to use the BRICS mechanism to break away from traditional Western-dominated technological cooperation frameworks. This would involve advancing the institutionalization of the BRICS mechanism to form a third-party market cooperation model for science and technology, such as by initiating an international science and technology organization or cooperation platform for the Global South.

Furthermore, it is important to accelerate the improvement of multilateral science and technology cooperation mechanisms under the BRICS framework, form a multi-level and multi-field scientific and technological landscape of cooperation, transform strategic political guidance into a refined scientific and technological cooperation mechanism, and ensure the formation of a more operational and multi-layered scientific and technological cooperation network and path under the framework of the BRICS mechanism. The first is to enrich the content of science and technology cooperation and expand the space for scientific and technological and people-to-people exchanges to foster consensus. The advantages of the enlarged BRICS lie in their market size and application scenarios, and this strength should be leveraged to facilitate the flow of relevant factor markets and the connectivity of scenarios. Overall, based on the current situation, the focus of science and technology cooperation with the enlarged BRICS may not only be on new quality producticity or cutting-edge technologies, but also on fundamental areas such as scientific and technological infrastructure, digital transformation, etc. Specifically, on one hand, the focus should be on the current trends in frontier technological development. The BRICS mechanism has already established a series of science and technology innovation policy frameworks and formed 14 working groups. Under the framework of *the BRICS Memorandum of Understanding on Cooperation* *in Science, Technology, and Innovation*, it is advisable to consider establishing additional working groups on semiconductors and clean energy. Additionally, the BRICS mechanism has already designated the digital economy as a development priority. Given that most BRICS member states hold a position on data localization, there is a need to address both data flow and data protection among member states, encouraging the establishment of relevant regulations for data flow among them to reduce institutional barriers to digital economic development. On the other hand, attention should be given to fields of mutual concern among member states that hold the greatest potential for cooperation. For example, in energy development, utilization, and transition, the enlarged BRICS includes energy exporters, consumers, and transit countries, which could foster supply and demand cooperation. The fields of traditional energy consumption reduction and new energy development are also currently receiving significant attention. In climate governance, the enlarged BRICS encompasses a variety of climate types. In the field of the transformation and upgrading of the manufacturing industry, there is considerable room for cooperation as the total factor productivity of the enlarged BRICS is not yet optimal. In disaster response and management, extreme climate change brings about issues such as drought and flooding, making the establishment of disaster risk reduction systems and capacity building highly important, such as monitoring, early warning and management systems and other infrastructure construction. In the field of agricultural cooperation, supply chains are blocked after the Ukraine Crisis, and food security in the Middle East and other regions is facing challenges. In the field of marine science and technology, important issues such as the development and transfer of marine and sustainable development technologies are worth noting. Water resources, biomedicine, aerospace and other fields also have potential for cooperation.

The second is to improve the communication and coordination mechanisms for science and technology cooperation. Faced with numerous obstacles in the field of scientific and technological exchange, the enlarged BRICS should promptly refine their multi-level strategic communication mechanisms as soon as possible, establishing communication groups that include key stakeholders such as government officials, important enterprises representatives, and experts and scholars on emergencies and interference factors in scientific and technological cooperation, and disclose the decision-making processes, standards, and evaluation mechanisms for cooperation. Simultaneously, a joint committee should be established to interpret and coordinate the resource endowments of BRICS member states and science and technology development plans issued by the government. This would help to identify common priorities and implement cooperation into specific projects. In terms of cooperation entities, cooperation at the team or individual level is actually the fundamental aspect of international science and technology cooperation. The most cost-effective channel for conducting technological cooperation is through multinational companies, which obtain scientific and technological cooperation increments by integrating into the global supply chain system. Therefore, it is possible to seek pathways to provide knowledge or institutional support for enterprises or industries going overseas within the BRICS framework, offering better services and stronger guidance. Additionally, consideration could be given to supporting the establishment of sound and well-regulated local science and technology cooperation mechanisms to form a community of shared interests with local partners. At the same time, it is important to leverage the role of international students in the fields of science, technology, engineering, and mathematics (STEM) education.

The third is to build exchange platforms, improve talent exchange and training systems, and promote cooperation between senior and young scientists to leverage the role and influence of scientists themselves. By organizing training courses for senior scientific personnel, holding regular BRICS science and technology seminars or forums, conducting joint research projects, and establishing the BRICS fund for the exchange of scientific personnel, it is possible to advance the exchange of scientific and technological experience and achieve complementary advantages. Based on the scientific and technological development advantages and demands of member states, different countries can be designated as the leading countries of the corresponding scientific and technological development groups. This can drive the effective cooperation mechanisms through the joint establishment of the BRICS

Science Fund and the BRICS Science and Technology Development Roadmap. Beyond the governmental level, the enlarged BRICS should also encourage non-governmental entities such as academia and the business community to participate in BRICS science and technology exchange and cooperation. Through academic seminars, university exchanges, enterprise summits, and other industry-university-research integration models, it is possible to enhance understanding of cooperation among all sides. For different needs, it is also possible to explore models of cooperation with third-party countries or institutions, establishing multi-level, multi-channel scientific and technological innovation cooperation platforms to conduct flexible cooperation with multiple participating entities, diverse cooperation content, and multiple operational modes, all of which would enhance mutual understanding and trust.

The fourth is to improve the science and technology cooperation evaluation mechanism. A robust tracking and evaluation mechanism for BRICS science and technology cooperation should be established to conduct full-process assessments of cooperation projects. Based on the evaluation results, the direction and methods of cooperation can be adjusted in a timely manner to guide the overall trajectory of technological collaboration. It is recommended to use modern information technology, platforms such as cloud computing and blockchain, data analysis, and other digital tools to strengthen the dynamic monitoring and evaluation of the performance of scientific and technological cooperation projects, and build a digital collaboration platform to enhance information sharing and business collaboration among member states, thereby improving overall operational efficiency.

The fifth is to strengthen the collaborative demonstration of scientific and technological cooperation under the Belt and Road Initiative (BRI), actively facilitate the sharing and exchange of China's science and technology innovation experiences, and provide a broader platform for BRICS scientific and technological cooperation. Currently, a number of countries participating in the BRI have established science and technology cooperation parks, incubation bases, and joint laboratories with China. It is recommended that a BRI-based science and technology innovation platform be established to form a set of institutionalized rules and implementation plans, integrate the positive experiences of technological cooperation along the BRI, and extend them to the BRICS mechanism. Specifically, the roles of various entities, including governments, enterprises, and research institutions, should be leveraged to create a linkage mode of official guidance with private exploration. Attention should also be given to the talent-achievement-industry system model of scientific and technological innovation, which provides sufficient talent and intellectual support for scientific and technological development and promotes the industrialization and commercialization of scientific achievements, thereby offering actual benefits to member states. It is also important to actively shape circulation-oriented technological cooperation under the BRICS mechanism, moving beyond simple technical assistance to instead use this as a connection point to form a tiered industrial chain relationship and improve the stability of cooperation.

The sixth is to learn from the cooperation models of international organizations such as the New Development Bank (NDB) and the Shanghai Cooperation Organization (SCO) to provide successful examples and experiences for BRICS scientific and technological cooperation. Both the NDB and the SCO have undergone multiple rounds of expansion with positive outcomes. The commonality between them is their focus on representativeness of expansion, and they have a clear functional positioning in the process of expansion. Therefore, to promote BRICS science and technology cooperation, the criteria for expansion could consider basing acceptance on economic and scientific and technological potential. It would be advisable for countries to first engage as dialogue partners to foster mutual understanding before initiating the formal process of accession. Procedurally, consensus should be adopted as a fundamental principle on expansion issues, such as by formulating explicit expansion standards and formalizing them in the form of guidelines.

Finally, it is necessary to insist on BRICS's role as a benevolent reformer rather than a so-called anti-West bloc, highlight the global public good nature of BRICS scientific and technological innovation cooperation, build a model

centered on cooperative and shared development, and strengthen the supervision and regulatory mechanisms in scientific and technological collaboration to alleviate international doubts. For the BRICS cooperation, it is essential to firmly adhere to the original aspiration of the BRICS, promote reform of global governance, and unite the Global South. This would mean solidifying the BRICS' role as a benevolent reformer of the international order. A key focus should be on strengthening cooperation in digital governance and broader technology security governance to highlight the public good nature of BRICS scientific and technological cooperation. Under the framework of *the BRICS Memorandum of Understanding on Cooperation in Science, Technology, and Innovation*, with public welfare as the top priority and basic science as the focus of development, consideration could be given to adding new working groups on scientific research infrastructure, clean energy, AI and industrial capacity cooperation, etc. At the same time, cooperation should be carried out on scientific and technological governance and risk prevention in addition to technical collaboration. For China, it is advisable to continue leveraging the BRICS mechanism to help amplify the voice of the Global South, provide more high-quality science and technology public goods, and strengthen the Global South's right to join rule-making in areas such as supply chains and the digital economy. It could also sponsor scientists from the BRICS and members of scientific and technological NGOs to visit and study in China, providing them with a convenient and open research environment to help enhance their capacity building and the cultivation of technological talent, and building the platforms for scientific and technological exchange, experience sharing, and joint research that is oriented toward the knowledge community.

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