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EMPIRICAL ANALYSIS OF MULTINATIONAL S&T COLLABORATION PRIORITIES – THE CASE OF RUSSIA

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EMPIRICAL ANALYSIS OF MULTINATIONAL S&T COLLABORATION PRIORITIES –THE CASE OF RUSSIA[6]

The problem of rationalizing S&T cooperation, including identifying the most promising areas and forms for S&T cooperation (geographical and thematic) and state support instruments, is critically important to many countries. In view of the growing complexity of global trends and domestic restrictions on development and the emergence of new factors affecting contacts with foreign countries, there are increasing demands in the international arena to collect and analyse relevant information required to make substantiated administrative decisions on various levels, including with regard to international S&T collaboration. In these conditions, researchers and experts tend to resort to a broad range of empirical methods, while politicians make more active use of their results in administrative practice and international contacts. This working paper describes and systematizes analysis results in the field of international S&T collaboration based on a bibliometric study. The authors combine quantitative methods of bibliometrics and sociology to identify prospective partners and promising areas for collaboration. In addition, the possibility of using the proposed approach to provide information support for current state policy-making is assessed, and key results of the study are examined.

JEL Classification: C00, A00, Z00, F01, F59, O19.

Keywords: science and technology cooperation; international partnerships; priorities for STI cooperation; bibliometric analysis; expert interviews.

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[6] This working paper was prepared using results of the project ‘Identifying priority areas and key instruments of of Russia’s international S&T cooperation with leading foreign countries in the context of establishing the Russian Federation’s S&T Foresight system’, carried out in 2014-2015 at the request of the Russian Ministry of Education and Science. The methodical approaches were developed in the Research Lab for Science and Technology Studies as part of the National Research University Higher School of Economics’ Basic Research Programme and using state subsidy funds allocated to the university to support leading universities in the Russian Federation to increase the competitiveness among the leading global scientific research centres.

1. Introduction

Solutions to problems associated with global (grand) challenges directly affect the scientific and technological community (the 'scientific sphere'), go beyond the remit of individual governments, and are only possible on a regional or international level [EC, 2011; Silberglitt et al., 2006]. Globalization and thus internationalization contribute in part to intensifying the roles and positions of new players, such as China, India, Brazil, and others. Although the main investors in this sphere are still the USA, Western Europe and Japan, the formation of a multipolar 'scientific world' has come to be a long-term trend [ICSU, 2011].

First, alongside state interests, global challenges in many ways define the selection of national S&T development priorities (STDPs) set out in national concepts, strategies, programmes and major projects [Haegeman, 2015; Sutherland, 2015; OECD, 2012; Meissner, 2013; European Commission, 2011].

In Russia, S&T priorities and critical technologies (CTs) have been developed since 1996; the current lists of S&T priorities and CTs were approved by the Russian President in 2011[7]. Their selection is promoted as a basic approach to establishing and implementing a system of measures/actions to overcome the economic and technological gap between Russia and the global leaders, modernize and transform the national economy, increase the competitiveness of the research and development (R&D) sector, and raise the effectiveness and performance of government spending to support and develop this sector. STDPs and CTs are key components of all strategic initiatives and a basis for decision-making in the scientific sphere, including the implementation of S&T achievements in the economy and public life. These priorities are regularly revised and refined based on the results of long-term S&T development forecasts.

The selection of S&T priorities is a fairly complex (both methodologically and organizationally), multi-stage, cyclical process of identifying scientific areas strategic for the national economy and assessing the potential for their development. Without dwelling on a description of the 'canonical' procedure followed to establish the lists of STDPs and CTs, which is widely used in developed countries and has been described in detail in scientific literature[8], it is worth noting that it is based on implementing foresight studies, involving large numbers of experts from science, industry, and other economic sectors throughout the whole process, and combining a wide range of quantitative and qualitative analytical methods. At the end of this 'procedure', detailed characteristics are given f the selected priorities together with recommendations regarding their further development (field of application, goals, effects,

[7] Decree of the President of the Russian Federation № 899 dated June 7, 2011.

[8] Cf., for example: [Georghiou et al, 2008; World Economic Forum, 2011; Battelle, 2011; Sokolov, 2007; Li, 2009; Grebenyuk, Shashnov, 2011, 2012; Sokolov et al, 2014; Haegeman et al, 2015].

groundwork, potential developers, prospective markets, conditions for development and expansion, etc.).

Nowadays in Russia, as in other countries, other approaches are used to select priorities (for instance, in the framework of National Technology Initiative[9]). These do not, however, diminish the value of using and improving the conventional approach, which helps to ensure that state policy measures (documents) are coherent and coordinated, that they are submitted in a common harmonized format, and that they are comparable on an international level.

Given that the current STDP and CT lists in Russia are prepared and modified in the context of best practices of leading foreign countries[10], there is a strong basis for moving towards harmonization of mutual interests, areas, goals and objectives, as well as mechanisms to achieve practical results in international S&T cooperation.

Second, without doubt, it is critically important for Russia to increase its participation in global S&T cooperation [Medvedev, 2015]. This being said, policy measures aimed at developing international S&T cooperation must be chosen with due regard to the level of national R&D development as compared to that of foreign countries, global trends and, at the same time, national priorities. Yet, amid the complex current geopolitical and geo-economic situation, it is becoming critically important for Russia and many other foreign countries to rationalize this cooperation, which includes the identification of most promising areas and forms of S&T collaboration (geographical and thematic) and state support instruments. In particular, there is an increasing role of bilateral contacts as a channel allowing Russia to directly implement its competitive advantages, to take benefit of the opportunities and effects of direct contacts with 'carriers' of modern technologies and products, and to gain access to foreign markets. Such form of international S&T cooperation is all the more important as bilateral partnerships directly affect the effectiveness of participation in the international division of labor,

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[9] National Technology Initiative (NTI) is a programme of creating fundamentally new markets and conditions for Russia's global technological leadership by 2035. The implementation of NTI is one of the key tasks set by the President of the Russian Foundation Vladimir Putin in his Address to the Federal Assembly on December 4, 2014. The programme is aimed at finding system solutions for identifying key technologies, changes in the rules and regulations, effective measures of financial and human resources development, and mechanisms of involment and compensation of carriers of relevant competences. In selecting key technologies, major trends of global development are taken into account, and priority is given to network technologies centered on the person as the end consumer. Currently, NTI is centered around 9 main thematic areas selected by the expert community as a result of thorough expert discussions: distributed power from personal power to smart grid and smart city (EnergyNet), system of personal production and food and water delivery (FoodNet), new personal security systems (SafeNet), personal medicine (HealthNet), distributed systems of unmanned aerial vehicles (AeroNet), distributed systems of unmanned maritime transport (MariNet), distributed network of unmanned management of road vehicles (AutoNet), decentralized financial systems and currencies (FinNet), distributed artificial elements of consciousness and mentality (NeuroNet) (https://www.asi.ru/eng/nti/, last accessed 9/11/2015).

[10] Cf., for example: Decree of the President of the Russian Federation № 899 dated June 7, 2011; Russian Federal Law 'On Strategic Planning' № 172-FZ dated June 28, 2014.

as well as the consolidation of Russian scientific achievements and high-tech products in traditional and emerging markets.

Fourth, a pressing problem today is differentiating approaches to developing bilateral collaboration with a focus on the specifics of different groups of states and improving relations with foreign partners. What is more, in every case, there needs to be a detailed analysis of the areas in which mutually beneficial relations can be built, as well as of the scientific, technological and economic profiles and needs of foreign countries. Obviously, focusing on contacts with a particular group is associated not only with positive expectations, but also with significant barriers and problems coming to light.

In this respect, the appeal factors of the BRICS countries (except Russia: China, India, Brazil and South Africa) for cooperation in science are linked to the fact that they:

- produce 'cheap' and 'reverse' innovation;
- have ambitions in certain scientific and technological fields and high interest in developing cooperation with Russia;
- like Russia, are under pressure from the explicit and implicit constraints of technology exchange with Western countries.

In this group, the main instruments for cooperation might be updating the general framework for international S&T cooperation priorities; commercializing R&D results; concluding complementary agreements with clear, well-calculated benefits for Russia; and serving as places to expand Russia's communications with other countries and international bodies. A Memorandum of Cooperation in Science, Technology and Innovation between the Governments of Russia, Brazil, India, China and South Africa (key areas of cooperation such as medicine, biotechnology, food safety, nanotechnology, high performance computing, support for technology transfer and innovation infrastructure) was signed at the beginning of 2015[11]. Further steps to develop this area include organisation of BRICS Science, Technology and Innovation Ministerial Meetings to discuss and coordinate positions of mutual interest and to identify future areas for cooperation, approval of the BRICS Science, Technology and Innovation Work Plan 2015-2018, and commitment to implementing the BRICS STI Initiative and establishing thematic working groups, etc.[12]

Fifth, an apparent problem in developing Russia's international S&T cooperation is the lack of up-to-date strategic documents in this field. The only document specifically devoted to this area is the Russian Federation State Policy Concept in the field of International S&T Cooperation, which was adopted back in 2000 and is clearly out-of-date, if not in terms of its

[11] http://government.ru/en/docs/17313 (last accessed 15/08/2015).
[12] Long-term strategy for BRICS: a proposal by the BRICS (http://nkibrics.ru/system/asset_publications/data; last accessed 31/08/2015).

general principles and positions, then with regard to its key focus, including on effective areas for development and regulatory instruments. The Concept was developed in a period of stable economic growth which was favourable both for Russia and many other countries (albeit to varying degrees for different countries). It sets out principles and key positions, but does not give any guidelines for selecting cooperation priorities, areas and forms. Today, as already noted, global competition and global challenges have become much more strained and intense, and the conditions for improving or even maintaining a position in the global S&T 'race' have come to be far less favourable.

To meet this problem, the authors propose an approach which allows the choice of priorities to be substantiated with bibliometric and sociological methods. In particular, it should be noted that (in view of the growing complexity of global trends, domestic restrictions on the development of countries, regions and the global economy and policy as a whole, and the emergence of new factors affecting the effectiveness of contacts in the international arena) requirements to collect and analyse relevant information as a basis for making substantiated administrative decisions, including with regard to international S&T cooperation, are clearly becoming more rigorous. Experts increasingly tend to resort to a broad range of empirical approaches, while politicians make more active use of their results in administrative practice and international contacts on different levels.

This working paper systematizes results from studies in the field of analysis of Russia's international S&T collaboration models using modern analytical tools. In particular, the authors demonstrate the possibility of combining quantitative methods of bibliometrics and sociology to identify prospective partners and areas of such cooperation. In addition, the potential of using the proposed approach to provide information support for current state policy-making in this sphere, as well as the results obtained in the course of the study are analysed.

2. Short description of the methodical approach

The *proposed approach* to studying priority areas of international S&T cooperation involves combining:

– a bibliometric analysis of S&T specialisation of Russia and foreign countries and of internationally collaborated publications;

– surveys of Russian and foreign experts on prospective areas for cooperation (broken down by theme and country);

– the results of long-term S&T foresight.

The possibilities and limitations of a bibliometric analysis of publication activity for international comparison of the effectiveness of scientific systems and of the global ranking of countries in science are well known. An in-depth, comprehensive evaluation of various trends in this field allows the foundations to be laid to increase the adaptability and effectiveness of state policy, including the selection of areas and instruments of international S&T cooperation. This means in particular identifying the scientific specialisation of countries and identifying fields where there are most likely to be prospective and fruitful contacts between them [Barré, 1987; Grupp, 1995; Wagner, 1995; Tijsen et al, 2002; Klitkou et al, 2005; Ja Peclin and Juznic, 2012; Jarneving, 2009; Arencibia-Jorge and de Moya-Anegón, 2010; Schneider, 2010; Kotsemir, 2012; Confraria and Godinho, 2014; Zacca-Gonzalez et al, 2014].

The largest international bibliographic databases are Web of Science and Scopus[13], which, as of the start of 2015, had indexed roughly 58 and 56 million records of documents respectively. This study is based on data from Web of Science. The main advantage of Web of Science in terms of analysing the thematic structure of publications is that it has a detailed classification of research areas. The 'research areas' field allows to search for publications in 151 different areas. The 'Web of Science categories' field classifies scientific journals into 263 research areas[14]. The main problem with using Web of Science is that it does not have aggregate classifications for research areas (unlike Scopus[15]). Web of Science specialists have developed a tool to match between the OECD Fields of Science classification and the Web of Science categories[16]. Web of Science has virtually no predatory journals publishing paid articles which have not been peer reviewed.

[13] For more on international scientific citation databases see [Brusoni et al., 2005; Brusoni and Genua, 2005; Yang and Meho, 2006; Fingerman, 2006; Falagas et al., 2008; Archambault et al. 2009; Jacsó, 2009].

[14] These differences can generally be disregarded as there are very few publications that have been published 'outside its journals'. Both 'research areas' and 'Web of Science categories' can be considered as classifications of publications.

[15] One significant shortcoming of Scopus when analysing the thematic structure of publications is the lack of detailed classifications for research areas. Scopus only allows them to be grouped under 27 main areas. A detailed classification of scientific fields (314 research areas in 27 main areas) can only be found on the electronic analysis resource SCImago Journal and Country Rank, developed on the basis of Scopus, but not within Scopus itself. Scopus also indeces a number of journals of questionable quality, which publish low-grade unreviewed articles for money.

[16] This tool can be accessed at http://incites.isiknowledge.com/common/help/h_field_category_oecd_wos.html.

The *scientific specialisation* of a country can be determined by comparing the thematic structure of its publications with the global structure of publications. The scientific specialisation index (SSI) of country j in scientific field i is calculated as the relationship between the share of its publications in scientific field i in the total number of its publications j to the equivalent figure for the global structure of publications [see Gokhberg, 2003; Gokhberg and Sagieva, 2007]. Areas of knowledge with ISS more than 1 are considered formally as 'fields of specialisation'. However, genuine fields of specialisation are those, in which ISS is significantly more than 1 (e.g. 1.50 or 1.75). On the contrary, when the values of ISS are significantly less than 1, it is considered that the specific research area does not comply with the level of existing groundwork, potential, or development interests of the country [Akneses et al., 2014; Barre, 1991; Bongionni et al., 2013].

The scientific specialisation index can also be calculated for organizations, as well. In this case, the basis for comparison can be either the number of publications worldwide or the number publications in the country in which the organization operates.

The SSI is used to identify the scientific fields in which the majority of a country's (organization's) publications are concentrated. It can be used to search for potential partners (on both macro and micro levels). However, it is important to note that the value of this index is highly dependent on the thematic structure of journals in the bibliographic database and in the country in question. On Scopus and Web of Science, a significant number of journals fall under the medicine, biological and natural sciences categories. Moreover, in social sciences and humanities, the level of publication activity is traditionally lower. E.g., in Web of Science in the thematic structure of global volume of publications, the share of clinical medicine for 2010 – 2014 is 16.8%, share of biological sciences is 13.3%, share of physical sciences - 12.4%, share of chemical sciences – 13.3%. On the contrary, the share of economics and business is 3.1%, psychological sciences - 2.5%, and the contribution of other social sciences and humanities in accordance to the OECD fields of science classification is less than 2%. In Russia, the situation with low values of SSI in social sciences and humanities is further intensified due to a poor representation of Russian journals in these fields of science in international bibliographic databases. In addition, Russian authors are rarely included in foreign journals of social science and humanities. The historical traditions of science of individual countries also need to be taken into account. In many poorest African countries, for example, areas such as tropical medicine, parasitology, virology, and entomology have high specialisation indices. In 90% of cases, these publications are joint studies with leading foreign countries rather than results obtained by African states independently. Finally, the scope of publication activity of a country is particularly important. When the volume of publications is low (several hundred publications over a relatively long period of time), as a general rule, the structure of sciences is largely distorted: in some areas, the SSI is extremely high, but in others very low. On the contrary, in traditional technology leaders with large overall numbers of publications, such as the USA, Western Europe, Japan and some other counties, whose journals, conference proceedings, books, book series etc in a given science citation database are presented in all fields of science and which can be taken as a "small copy" of a given database, the thematic structure of publications is more balanced. This means that searching for partners using SSI indicators is advisable only for groups of countries with more or less comparable number of publications or within specific scientific fields [Pianta and Archibugi, 1991; Barre 1991; Nagpaul 1993; Guena 2001; Tuzi, 2005; Laursen and Salter, 2005; Murmann, 2012; Bongioanni et al, 2013, 2014; Abramo et al., 2014; Acosta et al. 2014; Askens et al. 2014].

Another area in which bibliometrics is actively used is the analysis of *internationally collaborated publications* [Luukkonen et al., 1993; Katz and Martin, 1997; Dumont and Meeusen, 2000; Grupp et al. 2001]. The information produced in this case is useful both for researchers and policy-makers as it allows them to tackle a wide range of issues – identifying key partners in different countries, prospective areas for cooperation, specific features of forming co-authorship networks, and the intensity of these networks[17].

Since the number of internationally collaborated publications only gives a general overview of cooperation, it is important to look at (evaluate) other processes too: existence of common research interests; availability of modern equipment for joint centres/groups to carry out experiments; strong skills in a particular area; personal contacts; youth exchange programmes; joint educational programmes; international research laboratories; new scientific journals, joint monographs and reports; and regular communications. For this, various *expert methods, such as expert surveys, panels, and interviews, and sociological surveys* are used. These often serve as a basis for direct selection (description) of priorities [EC, 2011; ICSU, 2011; Silberglitt et al., 2006; UNIDO, TUBITAK, 2003]. Currently, distance personalized questionnaires and face-to-face and online working conferences are the most widespread [NISTEP, 2010; Sokolov et al, 2014; Syrjänen et al, 2009].

Based on the bibliometric analysis, sociological surveys and expert interviews, *the study involved:*

Analysis of the scientific specialisation profiles of Russia and 25 foreign countries with high publication activity indicators (high position and / or positive dynamics in the global ranking based on the total number of publications). A list of these countries is provided in Table 2 (cf. also the tables in the Appendices). The search was carried out on all current Web of Science databases[18]. For each country, the following indicators were analysed:

- number of publications in Web of Science;

[17] Cf. for example: [El Alami et al., 1992; Gomez et al., 1995; Basu, Kumar, 2000; Glanzel, 2001; Wang, 2005; Zhou and He, 2009; Glanzel, 2010; Hoekman et al. 2010; Chinchilla-Rodríguez et al, 2010; Perc, 2010; Ding, 2011; Liu et al, 2012].

[18] Articles, reviews, and proceedings papers in all languages, in all fields of science, indexed in Web of Science were taken into account. The search was performed on all databases of Web of Science. Data is current as of April 2015.

- share of country in the global number of publications;
- position of country in the global ranking on the total number of publications;
- thematic structure of publications (according to OECD fields of Science classification);
- values of scientific specialisation index in different fields of science.

– For Russia, an in-depth analysis of internationally collaborated publications with selected 25 countries was done. In particular, the volume and fields of publications prepared by Russian researchers jointly with academics from 25 countries was assessed, including such indicators as the number of internationally collaborated publications, their ratio in the total volume of Russian publications in co-authorship with foreign researchers (broken down by country), and growth in volumes of internationally collaborated publications in 2003-2013;

– The study covered 39 fields of science combined into 5 meta research areas according to the OECD fields of Science classification. A breakdown of thematic areas based on Russian Long-term S&T Development Forecast for the period up to 2030 was also used in the bibliometric and sociological analysis [HSE, 2014].

– Written questionnaire surveys of representatives from 38 Russian universities and research institutions which are involved in international programmes; semi-structured interviews with science advisors at 15 foreign embassies in Moscow[19]; and online questionnaires for foreign experts. These resulted in additional information on the current state and development prospects of international S&T cooperation for Russia, partner countries and organizations, thematic areas and cooperation instruments. Information on the respondents and description of the questionnaires are provided in section "Results of expert surveys" of this working paper.

3. Specific features of the scientific specialisation of Russia and foreign countries

Bibliometric measurements of research performance based on the analysis of scientific publications and citation have for a long time been a key instrument in evaluating scientific achievements. Studying publication activity is often used to compare the effectiveness of national research systems between countries. This means in particular identifying the scientific specialisation of countries and fields, in which prospective and fruitful contacts between countries are most likely. Limitations of bibliometric analysis are taken into consideration when conducting the analysis. All country specific figures in Scopus, Web of Science and other databases are defined (especially in social and humanities studies) by the presence of journals/conference proceedings/books/book series etc. of a specific country in a given

[19] Science advisors of the embassies of the following foreign states in Moscow were interviewd: USA, Untited Kingdom, People's Republic of China, Japan, France, Austria, Republic of Korea, Norway, India, Finland, the Netherlands, Germany, Israel, Hungary, and Taipei-Moscow Economic and Cultural Coordination Commission.

bibliographic database. In other words, weak publication activity in Bulgaria in business management and accounting in Scopus could be attributed either to the absence of research on business management and accounting in this country in principle, or to the presence of only one Bulgarian journal on business management and accounting in Scopus[20]. This would therefore require further analysis of a given country. In any event, a clear and well-financed government policy for promotion of national journals into international science citation database is very important.

Another very important aspect here is the language of publications. Since currently the key language of science is English, the English-speaking countries by definition have preferences among other countries. Thus, authors from countries like Russia have to write their articles in non-mother tongue to be published in journals indexed in Scopus or Web of Science[21]. This English-language bias can do the process of preparation of publications more complicated.

Finally, the "culture of journal issuing" should be taken into account. In many Russian journals indexed in Scopus and Web of Science, there was no stable tradition (especially in early issues) to identify author affiliations (however, the situation in the past 10 years became much better). Therefore, many publications of Russian authors can not be identified by Scopus/Web of Science automatic author and affiliation identifiers as Russian publications by definition. On the contrary, for North American and Western European journals one of the key goals is to be as visible in Scopus/Web of Scince and other databases as possible. Therefore, in these journals, general affiliations of all authors are registered very accurately.

Figure 1 shows the share of top 40 countries in the global number of publications in Web of Science in 2013. The global leader is the USA with almost 25% of world publication output. However, China is not so far behind with 17.3% of global publication output[22]. Moreover, little by little, in certain fields the United States is conceding its leadership to China[23]. By 2013, India has entered the top 10 countries with the highest volumes of publications (9th place), and Brazil is closing in (13th place). Russia is taking 16 th place with 1.93% of contribution into global scientific output. Among the traditional leaders in S&T development, publication figures rose only slightly since 2003: in the USA by a factor of 1.3, in Japan by 0.9, in the UK by 1.4, in Germany, France and Finland by 1.3, and in Canada by 1.5.

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[20] For problems of coverage of different fields of science in difference science citation database see e.g.: Nieminen andIsohanni, 1999; Norris and Oppenheim, 2007; de Moya-Anegón et al., 2007; López-Illescas, 2008, Mikki, 2010; Grindlay, 2012; Mingers, and Lipitakis De Groote and Raszewski, 2010, 2012; Michels and Schmoch, 2012

[21] Problems of English language bias in science were analyzed implicitly and explicitly in many research. See e.g. Garfield, 1976; Yitzaki, 1998; Egghe et al., 1999; Bookstein and Yitzhaki, 1999; van Leeuwen et al., 2000; Van Leeuwen et al., 2001; Tardy, 2004; Enrique Hamel, 2007; Wagner and Wong, 2011; Clavero et al., 2011.

[22] Factors affecting country's ranking in the global number of publications include, inter alia, size of population and state policy measures for promotion of national journals in international bibliographic databases.

[23] The fastest promotion in the rankings; leadership in areas such as materials engineering, computer and information sciences, chemical sciences and chemical engineering, civil engineering.

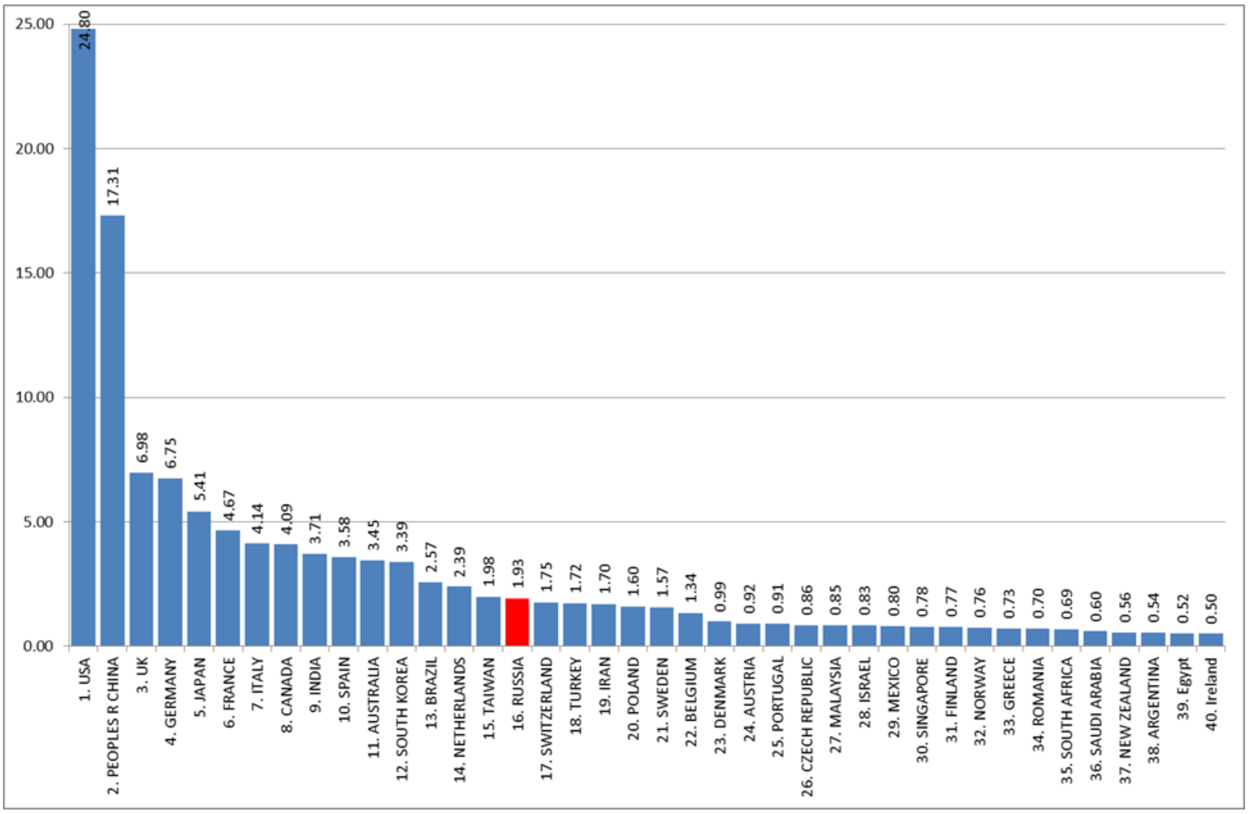

Figure 1 - Share of countries in the global number of publications in scientific journals indexed in Web of Science, 2013, %

Notes: Compiled from Web of Science (April 2015).

New industrial states and countries with rapidly expanding economies[24], including the BRICS nations, are increasing their publications output far more actively. Table A1 in the Appendices shows that since 2003 the number of publications in Malaysia increased by a factor 8.1, in China by 4.6, in Brazil by 2.7, in Turkey, South Africa and India by 2.5, and in the Republic of Korea by 2.3. Malaysia is a particularly interesting case, having made surprising breakthroughs in nanotechnology (moving from 63rd to 17th place, and from 51st to 20th place in terms of total publications)[25]. Taiwan (16th place; growth by a factor of 2.1) and Iran (19th place; growth by a factor of 7.8) have come to be the new major players in the global science by the volume of publications. Argentina has strengthened its position in publications on electrical engineering, electronic engineering, information engineering, computer and information sciences, and environmental engineering, and Mexico has done likewise in nanotechnology, chemical engineering, environmental biotechnology, and veterinary science.

Some interesting observations were made when analysing the *scientific specialisation indices*. In particular, they showed (Tables A2 and A3 in the Appendices) that virtually all

[24] Bearing in mind the nature of this type of grouping, which is used in the analysis solely for ease of interpretation.

[25] In nanotechnology, the number of publications by the country increased by 275 times, while in interdisciplinary studies by 86 times.

countries organize their profile to tie in with new technology trends [Silberglitt, 2006; Massachusetts Institute of Technology, 2013].

In the recent years, countries have been paying increasing attention to scientific fields such as biotechnology, cell and tissue engineering, agricultural biotechnology, medical sciences (new prognosis methods, diagnostics, disease treatment), nanotechnology and new materials, ICT, alternative energy sources, and transport systems and logistics. New industrial and rapidly developing countries have been particularly active in these areas.

Over the last 10 years, industrial biotechnology has been the area of scientific specialisation of countries such as Singapore (SSI 2.98), Republic of Korea (1.95), Japan (1.69), Malaysia (1.34), China (1.44), Taiwan (1.41), Brazil (1.14), and India (1.11), and nanotechnology in the Republic of Korea (SSI 2.41), Singapore (3.22), and Taiwan (2.12). However, there are countries which have a high degree of specialisation in specific fields, for instance, Brazil (SSI 3.59) and Argentina (2.16) in agriculture, forestry and fisheries, Iran (2.55) in chemical engineering, and China (2.24) in materials engineering. For the majority of traditional global economic leaders, the specialisation profile is, as a general rule, wider and characterised by close (and not especially high) SSI values, both for traditional (physics, chemistry) and relatively new areas in science (biotechnology, ICT, clinical medicine, etc.).

Table 1 – Key characteristics of the publication activity of Russia in 2003–2013

Characteristic	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Key indicators of publication activity of Russia											
The total number of publications	28 707	28 876	28 422	27 508	28 997	30 825	31 201	29 627	31 135	31 044	31 911
Position in the global ranking by total number of publications	11	12	13	15	15	16	16	16	17	17	17
Share in the global number of publications (%)	2.74	2.64	2.45	2.24	2.16	2.16	2.08	2.01	2.01	1.88	1.93
Fields of Leadership of Russia (Position in the global ranking by total number of publications)											
Physical sciences	6	7	7	8	7	7	7	8	7	8	8
Mathematics	10	9	9	11	11	11	11	11	11	11	11
History and archaeology	11	11	10	10	10	12	10	9	9	9	11
Chemical sciences	7	8	8	10	10	9	11	11	11	12	12
Mechanical engineering	8	9	11	11	11	12	11	13	12	13	12
Materials engineering	9	9	10	10	11	10	10	13	11	12	12
Critically weak fields of Russia (Position in the global ranking by total number of publications)											
Civil engineering	40	18	42	36	40	38	52	52	60	56	47
Health sciences	39	39	41	40	42	48	50	49	53	51	54
Other agricultural sciences	46	46	52	60	46	57	53	66	57	58	57
Media and communications	10	30	32	36	40	47	38	40	38	42	57
Animal and dairy science	70	73	71	57	67	64	76	68	91	79	68
Veterinary science	58	68	80	62	70	67	67	69	73	67	69
Main areas of Russian science (Share in total number of Russian publications, %)											
Physical sciences	38.0	37.7	37.2	37.1	36.4	35.8	35.1	34.6	34.8	35.2	34.0
Chemical sciences	20.9	21.6	20.9	20.2	20.5	19.6	19.3	19.4	19.8	18.1	18.8
Biological sciences	10.7	11.1	10.4	10.9	10.9	10.6	10.4	11.3	11.0	11.1	10.9
Materials engineering	9.3	9.8	8.5	9.3	8.7	8.8	8.4	7.9	8.8	8.9	9.1
Earth and related environmental sciences	8.6	8.6	8.1	8.7	7.9	8.5	8.6	8.2	7.9	7.6	7.9
Mathematics	6.8	7.1	7.9	7.8	7.1	8.1	8.1	8.4	8.0	8.1	7.3

Notes: Compiled from Web of Science (April 2015). The system of matching between Web of Science categories and OECD fields of Science classifications can be found on http://incites.isiknowledge.com/common/help/h_field_category_oecd_wos.html.

In contrast to many other countries, the publication activity of Russian researchers rose slowly, and Russia's global position worsened (Table 1). It managed to remain in the top twenty only in natural sciences and engineering and technology: Russia ranks 6–7th in physics and 7–12th in chemistry. The SSI for physics is 2.78 and for mathematics and chemistry 1.78. The preponderance of publications in natural and exact sciences has led to them being key in shaping Russia's scientific specialisation. In the context of Russia's technological modernization, the fact that the SSI for technical sciences is close to one is important, while for medical and agricultural sciences the figure is no higher than 0.4.

In the table, the structural distortment of Russian sciences is distinctly clear: there are relatively high specialisation indices in traditional fields (physics, materials engineering, mechanical engineering), a 'hole' in computer sciences, chemical engineering, nanotechnology, and low figures in prospective segments such as industrial biotechnology and social sciences and humanities. Even a preliminary analysis of bibliometric data clearly shows that Russia's problem lies not only in the fact that it is falling behind many countries in advanced S&T fields, but that it is continuing to develop in directions different from those of other countries, both in terms of scales and structure.

These structural imbalances are largely linked to the 'scientific' legacy of the USSR, as well as the ineffectiveness of STI policy in the post-Soviet period [Gokhberg (ed.), 2011; Gokhberg, Kuznetsova, 2011].

According to the authors' calculations, in 1975, the number of publications (all types) in the USSR on the Web of Science database was 28,900; in 1990 it was 42,600. In 2007, former Soviet countries overtook the level of publication activity achieved by the USSR in 1990; in 2014, the total number of publications by these countries was 53,600. For comparison, the number of publications in China in the period 1975–1990 increased from 62 to 8,186, and by 2014 had reached 319,600. In 1975–1992, the USSR's proportion of physics in total internationally collaborated publications increased from 19.9% to 28.2%, while chemistry reduced from 30.9% to 24%.

4. Dynamics and structure of joint publications

Before analysisng the dynamic and thematic structure of Russian international scientific collaboration, a bibliometric retrospective journey was taken into the history of Soviet science to show a very strong path-dependence of Russian scientific contacts with the rest of the world on the tendencies built in the Soviet era. The closed-off nature of the USSR towards the rest of the world had a significant impact on cooperation between Soviet researchers and the global scientific community. The intensity of cooperation was extremely low, but did still increase over time. According to the authors' calculations, the proportion of such publications was 1.25% in 1973 (315 publications) and roughly 5% in 1990 (2,100 publications). During perestroika and after collapse of the USSR, this figure started to grow rapidly. In 1992, the proportion of joint publications with foreign researchers (Russia and other former Soviet countries) reached 10.6% (3,900 publications). In 1994, it was 16.7% (6,300 publications).

The geographical structure of Russia's scientific contacts also formed back in the Soviet era, and later remained virtually unchanged (in relative terms at least). The USSR's main partners were Germany (primarily East Germany) and the USA. Germany accounted for 27% of the total number of joint publications in 1973–1990 and the USA 14%. Recently, the share of each of these countries in total joint publications has been virtually unchanged, fluctuating between 23% and 27%.

Among the USSR's main scientific partners during this period, it is also worth mentioning Czechoslovakia (14.5% of total joint publications), France (7.8%), Bulgaria (7.5%), Hungary (6.8%) and Poland (6.6%).

Scientific cooperation between the USA and the USSR fluctuated and was highly dependent on the political circumstances at the time. In 1973–1980, the USA's share of joint publications by the USSR with other countries increased from 13.3% to 17.2%. In 1981, with Ronald Reagan coming to power and the general cooling of relations between the two powers, this figure dropped to 11.2%, and later (right up to the start of perestroika in the USSR) fluctuated between 9.2% and 13.3%. When Reagan left the presidency in 1989, scientific cooperation between the USSR and the USA intensified: in 1989 the USA's share of joint publications with the USSR was 14.7%, in 1990 17.9%, in 1991 21.6% and in 1992 25%. The parallels with the current situation in Russia (with regard to the Western sanctions) are clear.

There is also a marked similarity between Russia and the USSR in the thematic structure of its joint publications. In 1973–1990, the main areas of cooperation were interdisciplinary studies in physics (10.4%), condensed matter physics (9.6%), biochemistry and molecular biology (7%), interdisciplinary studies in chemistry (5.9%), physical chemistry (5.6%), applied physics (5.2%), interdisciplinary studies in materials engineering (5.1%), interdisciplinary studies (5%), astronomy and astrophysics (4.7%), particle physics and quantum field theory (4.6%).

However, in recent years, a sustainable trend has started to take hold, linked to increased international cooperation (Table 2). The number of joint publications by Russian academics with other countries fluctuates and has grown by 22% since 2003. The number of partner countries is growing (including stable partner countries, with which 100 or more publications were prepared), as well as the average number of partner countries in each joint paper (Figure 2)[26].

Table 2 – Dynamics of Russian internationally collaborated publications in 2003–2014

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Number of publications in international collaboration	8 914	9 347	9 439	9 089	9 123	9 048	8 986	8 693	9 246	9 508	10 238	10 854
Share of publications in collaboration in total number of Russian publications	31.0	32.4	33.2	33.0	31.5	29.4	28.8	29.3	29.7	30.4	31.5	32.4

Notes: Compiled from Web of Science (April 2015).

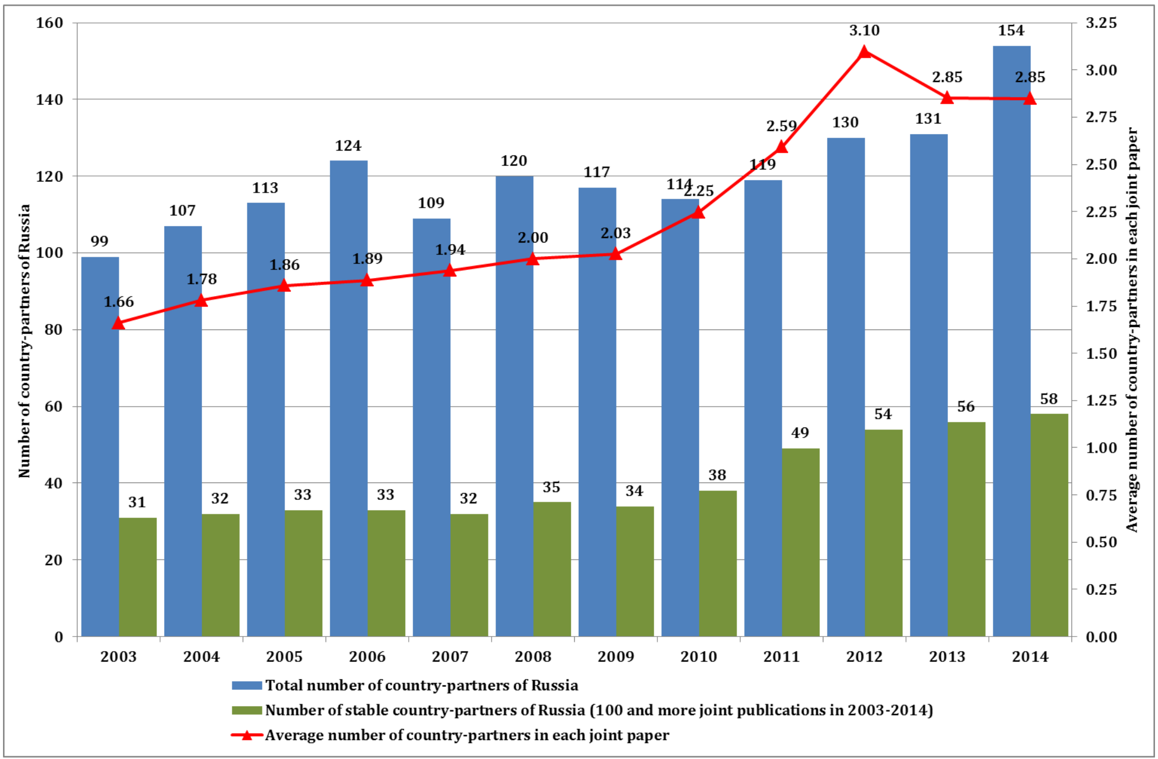

Figure 2 – Key indicators of international scientific collaboration of Russian in Web of Science in 2003 – 2014.

Notes: Compiled from Web of Science (April 2015).

Table 3 gives data on 25 countries; it identifies the partners showing the best figures for international co-authorship with Russian academics in absolute terms or in terms of growth in 2003-2014. Russia's key partners in joint publications are still Germany and the USA (roughly

[26] The number of partner countries in 2003-2014 increased from 99 to 152, stable counterparties from 31 to 58, and the average number of partner countries in each joint paper from 1.66 to 2.85.

26% each of the total number of joint publications). France, the UK and Italy are also among the main counterparties. This can be explained both by the traditional connections between academics in these countries and Russia and the emigration into these countries after the collapse of the USSR of large numbers of Russian researchers who kept professional and personal contacts in their homeland. In absolute terms, the USA, Germany, France, Italy and China lead the way; in terms of growth, Turkey (sevenfold growth), India (roughly fourfold), Australia and China (threefold) are ranked highest. The observed trend can be explained not only by mutual interests, but also by the involvement of academics from different countries in large-scale international collaborations, carrying out research at mega-science facilities (the Large Hadron Collider at CERN, among others), which give rise to papers in which dozens of authors are involved.

Table 3 – Key scientific partners of Russia on internationally collaborated publications (2003, 2014)

№	**Country**	**Share in total number of Russian internationally collaborated publications, %**		**Number of internationally collaborated papers**		**Growth for 2003 – 2014, %**
		2003	**2014**	**2003**	**2014**	
1	USA	25.3	27.3	2 257	2 965	31.4
2	Germany	26.9	26.7	2 400	2 895	20.6
3	France	12.3	15.7	1 096	1 699	55.0
4	UK	9.1	14.5	815	1 571	92.8
5	Italy	8.1	11.1	723	1 202	66.3
6	PR China	2.9	9.7	262	1 049	**300.4**
7	Spain	4.0	9.2	353	999	**183.0**
8	Poland	5.4	8.3	481	900	87.1
9	Japan	8.5	7.9	757	856	13.1
10	Switzerland	4.4	7.2	394	779	97.7
11	Ukraine	3.2	7.1	287	772	**169.0**
12	Netherlands	4.8	6.4	431	700	62.4
13	Sweden	4.9	5.8	433	633	46.2
14	Finland	3.1	5.6	276	604	118.8
15	Czech Republic	2.2	5.4	192	589	**206.8**
16	Canada	3.7	5.3	327	578	76.8
17	Brazil	1.7	5.0	154	542	**251.9**
18	Australia	1.5	4.9	133	535	**302.3**
19	India	1.2	4.8	110	522	**374.5**
20	Republic of Korea	2.9	4.6	257	503	95.7
21	Austria	1.8	4.1	164	447	**172.6**
22	Belgium	3.2	4.1	284	443	56.0
23	Turkey	0.6	3.8	51	408	**700.0**
24	Belarus	1.4	3.6	127	392	**208.7**
25	Taiwan	1.3	3.5	113	379	**235.4**

Notes: Compiled from Web of Science (April 2015).

Table 4 illustrates the distribution of joint publications in certain thematic areas with the highest number of publications (over the period 2003-2014) or where the largest changes have been registered.

As expected, in absolute terms ‘traditional’ physics, mathematics, materials engineering, and certain engineering and technology sciences dominate. The most dynamic growth was seen in publication activity in fields such as interdisciplinary studies, nanotechnology, applied mathematics, metallurgy and certain fields in the medical sciences. Unfortunately, some negative changes were discovered in a number of key areas for Russia: Engineering Electrical Electronic, Engineering Aerospace, Physics Nuclear, Nuclear Science and Technology, and Physics Condensed Matter.

Table 4 – Thematic areas with the most dramatic change in the intensity of scientific collaboration of Russia with foreign countries in 2003–2014

№	Field of Science	Publications in co-authorship with foreign researchers			Share in the overall number of Russia’s publications in co-authorship with foreign researchers in 2003-2014, %	Increase in the number of publications in co-authorship with foreign researchers in 2003-2014, %
		2003	2014	2003-2014		
	Thematic areas with more than 15% decrease of the intensity of scientific collaboration for 2003-2014					
1	Engineering Aerospace	84	20	569	0.5	-76.2
2	Polymer Science	153	81	1 371	1.2	-47.1
3	Computer Science Theory Methods	70	38	495	0.4	-45.7
4	Nuclear Science Technology	341	199	3 244	2.9	-41.6
5	Physics Condensed Matter	1 046	689	10 065	8.9	-34.1
6	Virology	36	24	375	0.3	-33.3
7	Toxicology	27	19	255	0.2	-29.6
8	Physics Nuclear	420	319	4 418	3.9	-24.0
9	Engineering Electrical Electronic	229	179	2 344	2.1	-21.8
10	Spectroscopy	250	201	2 654	2.4	-19.6
11	Acoustics	37	30	426	0.4	-18.9
12	Crystallography	144	121	1 444	1.3	-16.0
	Thematic areas with more than twofold increase of the intensity of scientific collaboration for 2003-2014					
13	Evolutionary Biology	27	54	590	0.5	100.0
14	Pharmacology Pharmacy	58	117	889	0.8	101.7
15	Paleontology	40	83	665	0.6	107.5
16	Geography Physical	31	65	604	0.5	109.7
17	Psychiatry	14	35	269	0.2	150.0
18	Oncology	40	103	733	0.7	157.5
19	Nanoscience Nanotechnology	101	268	2 158	1.9	165.3
20	Medicine General Internal	14	39	282	0.3	178.6
21	Chemistry Medicinal	28	87	653	0.6	210.7
22	Operations Research Management Science	10	33	257	0.2	230.0
23	Zoology	62	209	1 493	1.3	237.1
24	Cardiac Cardiovascular Systems	13	45	315	0.3	246.2
25	Energy Fuels	26	101	625	0.6	288.5
26	Economics	14	61	328	0.3	335.7
27	Mathematical Computational Biology	9	46	331	0.3	411.1
28	Multidisciplinary Sciences	64	343	1 578	1.4	435.9

Notes: Compiled from Web of Science (April 2015). Only those thematic areas with more than 250 internationally collaborated publications for 2003–2014 in total have been analysed.

In the thematic areas, the number of joint publications with foreign authors over 2003-214 increased in interdisciplinary studies (by 435.9%), nanoscience and nanotechnology (by 165.3%), applied mathematics (by 61.1%), metallurgy (by 59.1%) and multidisciplinary chemistry research (by 56.9%). In addition to this, there was growing cooperation with foreign colleagues in oncology, pharmacology and pharmacy, and zoology. In some disciplines, however, there was a fall in the intensity of contacts. Among these were condensed matter physics, nuclear physics, aerospace engineering, polymer science, and nuclear science and technology.

The results of the bibliometric 'exercises' demonstrated that cooperation with global leaders, the BRICS nations, and certain newly developed economies showing high growth in publication activity in certain scientific fields continues to be promising and probable for Russia. The approach adopted made it possible to show fields where there are 'absolute' gaps in Russia linked to the development and support of sciences such as cell and tissue engineering, neuroimaging, robotics, medical informatics, etc. These areas, as a general rule, are some of the most advanced and promising segments where searching for partners has been made more difficult for various objective reasons. Evidently, there need to be special decisions on support measures for Russian developments and measures to ensure access to foreign scientific achievements.

The results of the bibliometric analysis of the scientific specialisation and joint publications of Russian and foreign academics were used when establishing the summary tables with the thematic and geographical priorities of Russia's international S&T cooperation (cf. Tables A.4 – A.5).

5. Results of expert surveys

The expert surveys carried out in addition to the bibliometric analysis allowed to refine the list of countries and promising areas for S&T cooperation and to assess the overall direction of Russia's international S&T cooperation development.

As noted above, various surveys were carried out as part of this study. The largest of these surveys was the *distance survey of foreign experts* on prospective areas for international S&T cooperation with Russia.

To select the experts, based on information from the international scientific citation database Web of Science, foreign authors of 10 per cent most cited publications prepared jointly with Russian researchers were identified. More than 10,000 foreign authors went into this initial database. They were then invited to take part in expert discussions remotely. With the involvement of these specialists, who had confirmed their interest in discussing prospective areas for cooperation, 7 approved priority areas in Russia were examined (ICT, biotechnologies, medicine and health, new materials and nanotechnology, rational use of natural resources, transport and space systems, energy efficiency) together with more than 30 prospective thematic areas for Russia in applied research (technologies), which were identified in the framework of Russian Long-Term S&T Development Foresight for the period up to 2030.

The experts were asked to answer the following questions:

- Which key S&T areas from the list of thematic fields in the electronic survey are the most promising for cooperation between Russia and a specific foreign country (the one represented by the expert) in order to narrow the gap between Russia and global levels and/or to consolidate its international position?
- Which other S&T areas are promising for cooperation?

After preliminary contact with foreign researchers and discarding some of the surveys, more than 530 completed questionnaires from 19 countries were received and analysed[27].

Russian participants in international research projects were also surveyed. Representatives from the fields of biology, engineering, physics and mathematics, chemistry, medicine, and geology all took part in the survey. A number of respondents represented major multidisciplinary organizations working across a broad spectrum of disciplines (Skolkovo Institute of Science and Technology, National Research Nuclear University 'MEPhI', Voronezh State University, Tomsk Polytechnic University, Institute of Oceanography of Russian Academy of Sciences, National University of Science and Technology "MISiS", Southern Federal University, Immanuel Kant Baltic Federal University, etc.). All of them work in one or more STDP areas. In total, 38 questionnaires were received and analysed. Experts were asked not only about priorities of international S&T cooperation (broken down geographically and thematically), but also about preferred and prospective forms and restrictions on cooperation and state support.

[27] Austria, Canada, China, Finland, France, Germany, India, Israel, Italy, Japan, Republic of Korea, Mexico, Netherlands, Spain, Switzerland, Taiwan, Turkey, UK, USA.

The results showed that the geography of the respondents' international research cooperation was extremely varied and covered dozens of countries (Fig. 3). Analysis of the survey results also proved that key partner countries of the surveyed organizations are the global leaders (Germany, the USA, China, the UK, Japan), as corroborated by the bibliometric analysis, as well as countries like India.

In the next 5-10 years, according to the experts, the leading countries will probably continue to be Russia's main partners. These may be joined by states such as Sweden, Netherlands, Finland, Spain, Norway, Austria, Singapore, Switzerland, Czech Republic, Brazil, Kazakhstan and a number of other countries.

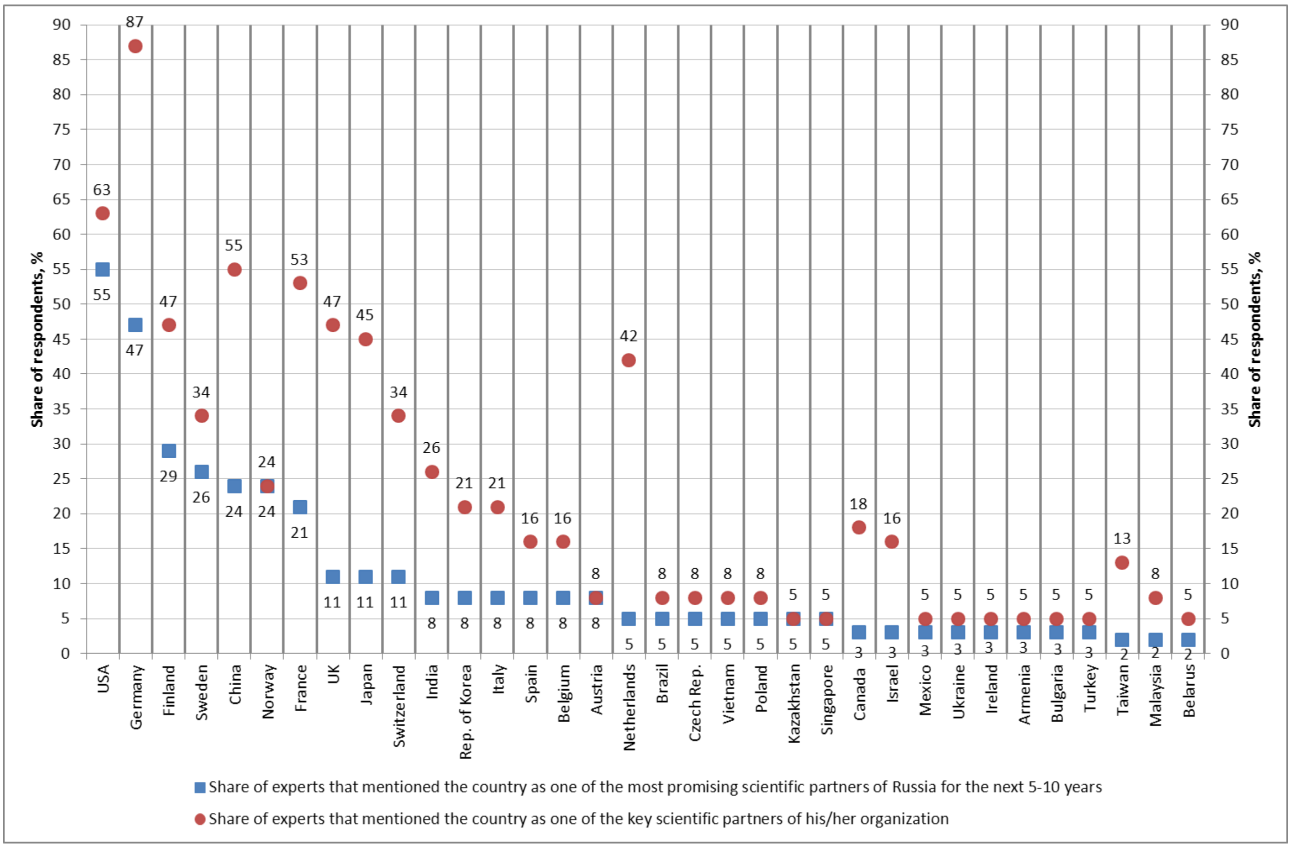

Figure 3 – Countries with which surveyed organizations collaborate in science and technology at present and the most promising countries for collaboration in the next 5-10 years

In addition to the surveys, the *scientific advisors at the embassies of 15 foreign states in Moscow were interviewed.* The main scope of the discussions was identifying problems and barriers impeding international cooperation with Russia, promising thematic areas for bilateral contact, as well as the research centres of specific foreign countries which are already participating in or could participate in S&T cooperation. The results obtained were used to refine the lists of prospective countries and knowledge areas for partnership, as well as to prepare broader recommendations on development of international S&T cooperation for the authorities.

It should be noted that in all of the surveys the respondents were asked to *specify their responses* (choice of countries and scientific areas) as follows. The chosen area (country) is promising for:

– development of basic and/or applied research;

– narrowing the gap from the global level (cooperation with foreign countries in fields where Russia is lagging behind global technological leaders);

– consolidating Russia's international position (cooperation with foreign countries in fields which are well developed in Russia);

– developing equitable cooperation.

This allowed to choose, for each priority and thematic field, the most promising countries for cooperation in basic and applied research (an extract of the final distribution is given in Table 5) and to group countries according to the aims of the partnership (Table 6).

Without dwelling on the analysis of the final results, it is worth noting that the tables make it possible to observe not only the overall direction of international S&T cooperation development, but also the promising countries and areas for cooperation depending on the focus of Russia's state policy in the given field.

6. Some preliminary conclusions

In the last few years, Russia has intensified the formation of an effective S&T policy, including its international component [Gokhberg, Kuznetsova, 2011]. At the same time, a number of problems still persist (and are even intensifying, as the events of 2014-2015 demonstrated), holding back the integration of the Russian R&D sector into global processes and intensifying the marked unevenness in the development of Russia's cooperation with foreign countries. At the same time, it is clear that some areas and forms of international S&T cooperation have been ineffective for a long time, have not paid Russia the expected dividends (and sometimes even had negative effects in the form of outflows of 'ideas and brains') and need to undergo significant changes.

Involvement in global cooperation could bring Russia significant 'dividends', as shown by the experiences of foreign countries. Among the real and potential advantages are the creation of long-term ties with leading foreign research centres and researchers, identification of promising S&T areas and enhanced opportunities to intensify their development, rationalization of the forms and mechanisms for integration into the global S&T sphere, improvement of the quality and importance of the national S&T system, including the research infrastructure; joint use of unique research facilities, participation in major international research collaborations, acquisition of additional skills/competences, benefits associated with the wide spread of knowledge and technologies, mutual support in skill sets, risk and cost sharing in promising large-scale S&T projects, achieving a critical mass of resources for their implementation, and involvement in solving global challenges.

If successfully implemented, the radical improvement of the existing model of international S&T cooperation will help to intensify Russia's role as an equal participant in international scientific relations. Strategically, there has to be a serious 'rationalization' of partnership contacts with virtually all countries. It is crucial to secure complementary agreements with clear and well thought-out benefits for Russia. For this, Russia needs to overcome barriers to the development of its international S&T cooperation, many of which are linked to the increasingly complex economic situation in Russia itself (the depreciation of the rouble, the budget deficit, structural imbalances) and the clear sluggishness of Russian bureaucracy. Although overcoming external restrictions is not a simple task, as they often arise in an unfavourable political climate, quick and flexible solutions are needed here, too. One of these solutions, as the results of the study show, may be the practical ('not on paper') broadening the geography of Russia's international S&T cooperation. In this respect, partners such as the BRICS, ASEAN and APEC countries will play a more important role.

Improving the existing model of international S&T cooperation is inextricably linked to the selection and adaptation of existing state policy instruments. For example, expanding the geography of Russia's international S&T cooperation requires the adoption of a differentiated approach to the instruments, mechanisms and forms of cooperation with different groups of countries. The choice of regulators may be the most varied depending on the mutual interests, goals and objectives of collaboration. In planning international S&T cooperation, preference needs to be given to instruments which have already proven their effectiveness. In particular, in view of the successful experience of multilateral S&T programmes in the framework of ERA-NET joint funding scheme, it can be recommended to use this instrument to organize international calls for S&T projects within BRICS and other groups of countries.

The proposed approach to selecting priorities of international S&T cooperation has its limitations, of course. However, the authors did not set themselves the aim of precisely defining thematic priorities and partner countries. Moreover, as international practice shows, this should not be the aim of researchers. The intention was to obtain additional reference and analytical information and expert opinion for the policy-makers who make the decisions having studied all of the available information and having negotiated with partners. Using more diverse data will ultimately help to protect Russia's national interests, including in terms of overcoming the after-effects of economic and political crises, implementing economic modernization priorities, and bringing scientific achievements up to global levels. The intensifying and increasing level of international cooperation is (or should be) key factors behind the successful implementation of measures and the achievement of Russian S&T complex development targets.

This study will be continued in the context of a more detailed and in-depth analysis of the publications of foreign countries in narrow applied research areas in the framework of thematic priorities identified in the Russian S&T Development Forecast for the period up to 2030, in order to substantiate the selection of the most promising countries for Russia's international cooperation. The analysis is planned to be supplemented with the conclusions derived from the results of the series of expert discussions on improving the existing system of state S&T policy instruments and on identifying promising areas for international S&T cooperation involving a wide range of international experts.

Appendix

Table A.1 – Growth in the number of publications of 25 countries for 2003-2014, times (in selected fields of science)

	Austria	UK	Germany	Spain	Italy	Netherlands	Finland	France	Switzerland	Canada	USA	Japan	Israel	Argentina	Mexico	Brazil	India	China	South Africa	Republic of Korea	Malaysia	Singapore	Taiwan	Iran	Turkey
Other natural sciences (multidisciplinary)	9.25	4.40	4.00	8.14	3.42	6.64	5.51	4.67	5.59	4.99	3.15	4.80	3.62	5.05	7.29	6.81		12.75	3.70		86.56		17.30		
Nano-technology	4.24	3.73	3.60	5.83	5.10		3.73	3.46	3.85		4.24	2.54	3.76		2.87			13.92		6.96	275.50	5.96	6.13		
Health sciences	2.35		2.03	2.88	2.28	2.54				2.27						4.68			3.70	5.28	10.65	4.95	3.26	12.62	
Industrial Biotechnology											2.23														
Earth and related environmental sciences	2.29			2.72																	12.38			10.47	
Other agricultural sciences	2.34				2.27											5.78			3.36						
Chemical engineering				2.53	2.69										3.52	3.14	14.34		3.88					10.41	
Environmental biotechnology	2.14														2.56			8.37				2.83			
Veterinary science															2.52										
Clinical medicine																3.35				4.14					
Agricultural sciences																3.68		8.28							
Mathematics																					19.26				4.71
Electrical, electronic, information engineering														3.48					3.59						3.48
Medical engineering	2.38		2.18																						
Chemical sciences																						3.05			
Agriculture, forestry, and fisheries																3.80									
Biological sciences																						2.86			
Environmental engineering				3.08			2.25							2.63											
Basic medicine																									
Physical sciences																					11.29				
Materials engineering																	4.40				24.22			11.99	3.48
Mechanical engineering																	4.52				19.44				
Civil engineering	2.39			3.83				2.09																	
Other engineering and technologies																									
Computer and information sciences														3.07											
Sociology	2.46		2.25			2.58	2.41											31.02	3.67						

Notes: Compiled from Web of Science (April 2015).

Table A.2 – Indices of scientific specialization for 2003 – 2014 for 25countries, % (in selected fields of science)

Field of science	Austria	UK	Germany	Spain	Italy	Netherlands	Finland	France	Argentina	Mexico	Brazil	India	China	South Africa	Israel	Iran	Canada	USA	Turkey	Switzerland	Republic of Korea	Malaysia	Singapore	Taiwan	Japan
Industrial Biotechnology							1.21				1.14	1.11	1.44						1.11	1.16	1.95	1.34	***2.98***	1.41	**1.69**
Physical sciences	1.09		**1.43**	1.04	1.23			**1.41**	1.07	1.41		1.24	1.17		1.22					1.24	1.40		1.38	1.30	**1.50**
Materials engineering												1.45	**2.24**			1.18					1.85	1.47	1.58	1.43	1.35
Chemical sciences			1.03	1.21				1.02	1.10			**1.95**	1.58			1.71					1.37	1.37	1.18	1.05	1.33
Environmental biotechnology				1.14			1.10		1.32	1.31	1.06	1.67	1.05	1.30					1.02		1.62	1.60	1.13		1.30
Nano-technology			1.00									1.41	1.57			1.32					**2.41**	1.80	***3.22***	**2.12**	1.25
Basic medicine	1.05	1.14	1.07		**1.29**	1.27	1.00		1.07		1.16				1.07		1.19	1.34							1.17
Other agricultural sciences				**2.15**	1.18		1.17		**2.32**	1.63	1.92	1.48		1.25		1.34			1.85		1.47	**2.32**		1.10	1.15
Biological sciences	1.17	1.13	1.09	1.22	1.02	1.14	1.22	1.10	**2.04**	1.47	1.44			1.60	1.15		1.20	1.21		1.18					1.09
Mechanical engineering					1.01			1.10				1.04	1.48			1.80					1.26	1.16	1.01	1.12	1.09
Clinical medicine	**1.43**	1.24	1.21		**1.37**	**1.59**	1.17	1.01							1.33		1.16	1.26	1.81	1.27					1.07
Electrical, electronic, information engineering													1.50			1.27					1.55	1.77	2.16	**2.13**	1.04
Other engineering and technologies												1.09	**1.87**			1.28					1.32	1.44	1.22	1.50	1.01
Medical engineering	1.12				1.12	1.12											1.07	1.15		1.09	1.17	1.20	1.94	1.27	
Agricultural sciences				**1.56**	1.01		1.17		**2.06**	1.98	**3.08**	1.58		1.60		1.50	1.09		1.83			1.35			
Agriculture, forestry, and fisheries				**1.62**	1.03		**1.57**		**2.16**	2.33	**3.59**	1.55		1.59		1.51	1.28		1.27			1.17			
Environmental engineering												1.11	1.66	1.10		1.44	1.02		1.34		1.00	1.69		1.12	
Other natural sciences (multidisciplinary)	1.16	1.36	1.13		1.13	1.31	1.07	1.14	1.05			1.46	1.12	**1.93**	1.28		1.06	1.37		**1.48**		1.79			
Chemical engineering				1.26					1.68	1.50	1.11	1.65	1.44	1.18		**2.55**			1.76		1.43	**2.20**	1.43	1.12	
Computer and information sciences	1.02			1.04									1.60			1.08					1.16	1.70	1.68	1.67	
Animal and dairy science				1.33	**1.37**	1.17			1.61	2.25	**3.41**	**2.60**		**1.98**		1.69	1.28		1.28						
Civil engineering													**1.96**			1.67	1.04		1.33		1.34	1.25	1.41	1.32	
Health sciences		**1.51**				**1.55**	**1.41**				1.90			**1.83**			**1.48**	**1.45**		1.23					
Media and communications		1.18		1.32		1.11	**1.60**							**1.87**				1.21				**2.12**	1.61	1.28	
Sociology		**1.68**				1.27								**1.80**	**1.55**		1.32	**1.51**				1.23			

Notes: Compiled from Web of Science (April 2015).

Table A.3 – Key research areas in 25 countries for 2003 – 2014 (in selected fields of science; share in total number of publication of a given country, %)

Field of science/Country	Austria	UK	Germany	Spain	Italy	Netherlands	Finland	France	Argentina	Mexico	Brazil	India	China	South Africa	Israel	Iran	Canada	USA	Turkey	Switzerland	R. of Korea	Malaysia	Singapore	Taiwan	Japan
Physical sciences	14.6	12.1	19.2	14.0	16.6	11.2	13.1	18.9	14.4	18.9	10.7	16.7	15.8	8.1	16.4	10.8	9.5	12.2	7.5	16.7	18.8	11.0	18.5	17.5	20.2
Clinical medicine	24.5	21.2	20.8	15.5	23.4	27.3	20.0	17.4	12.3	9.9	17.0	9.1	6.5	11.7	22.8	10.9	20.0	21.7	31.0	21.7	14.6	6.9	11.9	13.9	18.3
Biological sciences	16.2	15.6	15.1	16.9	14.0	15.8	16.9	15.1	28.2	20.3	19.9	13.4	9.7	22.0	15.9	9.3	16.5	16.6	9.9	16.2	11.7	9.7	11.3	8.9	15.1
Chemical sciences	9.0	7.4	11.5	13.5	9.6	6.8		11.4	12.3	10.2	9.5	21.8	17.6	8.3	7.3	19.1		7.3	9.9	9.8	15.2	15.3	13.2	11.7	14.9
Basic medicine	9.6	10.4	9.8	8.7	11.8	11.6	9.2	8.7	9.8	8.2	10.6				9.8		10.9	12.3	8.0	11.3	7.9				10.7
Electrical, electronic, information engineering			6.1	7.5	8.1		9.6	7.8				9.3	15.3			13.0	9.1	7.9			15.8	18.0	22.1	21.7	10.6
Materials engineering			6.1									10.1	15.6			8.2					12.9	10.2	11.0	9.9	9.4
Other engineering and technologies			5.9	7.6	7.0								14.7			10.1			7.8		10.4	11.3	9.6	11.8	
Computer and information sciences	7.9		5.8	8.0	6.2								12.3		7.6	8.3					8.9	13.1	12.9	12.8	
Mechanical engineering													6.1			7.5									
Agricultural sciences									9.2	8.9	13.8								8.2			6.0			
Earth and related environmental sciences		6.7	5.8		6.7	6.6			9.5					10.2			8.1			7.4		5.2			
Mathematical Sciences															8.0										
Health sciences		7.6				7.8					9.5			9.2				7.3							
Nano-technology																									
Agriculture, forestry, and fisheries											7.4														

Notes: Compiled from Web of Science (April 2015).

Table A.4 – Priority areas for science and technology collaboration of Russia with foreign countries (1- basic research, 2 - applied research, 3 – combined research activities)

№	Priority science and technology areas of Russia	Countries	1	2	3
	Information and Communication Technologies				
1.	Computer architecture and systems	Germany, Israel	x	x	x
2.	Telecommunication technologies	Germany, Israel	x	x	x
3.	Data processing and analysis technologies	Germany, USA, India	x	x	
		Germany			x
4.	Hardware components, electronic devices and robotics	Germany			x
5.	Predictive modeling and simulation	France	x		
		EU Member States			x
6.	Information security				
7.	Algorithms and software	Israel, Germany, Italy	x	x	x
	Biotechnologies				
8.	Development of the scientific and methodological basis of biotechnology R&D Industrial biotechnology	Spain, Japan, Sweden, France, Germany	x	x	x
		UK, Israel, USA, Belgium	x		
		UK, Israel		x	
9.	Industrial biotechnology	China, France, Germany	x	x	x
10.	Agrobiotechnology	United States, Germany, UK, Japan, France, Germany	x	x	x
		Netherlands	x	x	
		Poland		x	
11.	Environmental biotechnology	Netherlands, Brazil	x	x	
		UK, Italy, France, Germany	x	x	x
12.	Food biotechnology	Netherlands	x	x	
		Italy, Spain, France, Germany	x	x	x
13.	Forest biotechnology	Finland	x	x	
		France, Germany	x	x	x
14.	Aqua biotechnology	France, Germany, Norway	x	x	x
	Medicine and Health				
15.	Discovery of candidate drugs	USA, Germany, India	x	x	x
		UK, France		x	
		Sweden, China	x		
16.	Molecular diagnostics	USA, Singapore, Taiwan, Japan, Portugal, China, Germany, Armenia, UK, Finland	x	x	x
		Italy, France	x		x
		Sweden, Norway	x		
17.	Molecular profiling and identification of molecular and cellular pathogenesis mechanisms	USA, Germany, Sweden	x	x	x
		Japan, UK		x	

№	Priority science and technology areas of Russia	Countries	1	2	3
		France, China, Italy	x		
18.	Biomedical cell technologies	Japan		x	
		Portugal	x		
		Sweden, USA, Sweden, UK	x	x	x
		Germany, Italy	x		x
19.	Biocomposite materials for medical application	Germany, Israel, Switzerland	x	x	x
		France		x	
20.	Bio-electrodynamics and radiation medicine	USA, Israel	x	x	
		China, Finland, Germany	x	x	x
		France		x	
21.	Genomic passportisation of humans	USA, UK, Singapore, Japan, Sweden	x	x	x
New materials and nanotechnologies					
22.	Structural and functional materials	USA, Germany, Japan, Italy	x	x	x
		Finland		x	
		France, Israel	x	x	
23.	Hybrid materials, converging technologies, biomimetic materials and medical supplies	France, Czech Republic	x	x	x
		USA	x		
		China, Spain			
		Germany, Finland		x	
24.	Computer simulation of materials and processes	USA, Germany, Japan, Finland, Israel, UK	x	x	x
		China	x		
25.	Diagnostics of materials	USA, Germany, Japan, Italy	x	x	x
		Finland		x	
Rational use of natural resources					
26.	Environmental protection and safety technologies	Germany, Sweden, USA, China	x		
		EU countries, Japan, Republic of Korea, Hungary	x	x	x
		Kazakhstan, Saudi Arabia, Germany, USA		x	
27.	Monitoring of environment, assessment and forecasting of natural and technogenic emergencies	Norway, USA, France, Japan, the participating countries of the World Meteorological Organization of the UN, the EU, Republic of Korea, Italy, Germany	x	x	x
		UK	x	x	x
		Finland, Saudi Arabia		x	
		Finland, Sweden	x		
28.	Exploration of subsoil assets, mineral prospecting and integrated development of mineral and hydrocarbon resources	Saudi Arabia, Germany, USA		x	
29.	Exploration and utilisation of oceanic resources, the Arctic and Antarctic	USA, Germany, Norway, France, Finland	x	x	x
		Saudi Arabia		x	
Transport and space systems					

№	Priority science and technology areas of Russia	Countries	1	2	3
30.	Development of a single transport space	Finland, Brazil		x	
		Canada, USA, Germany, France, Italy	x	x	x
31.	Improving the safety and environmental performance of transport systems	Sweden, USA	x		
		Germany, France, Brazil	x	x	x
		Netherlands	x	x	
32.	Prospective transport and space systems	USA, Germany	x		
		France, China	x	x	x
		Netherlands	x	x	
Energy Efficiency					
33.	Efficient exploration and mining of fossil fuels	Saudi Arabia, Germany, USA	x	x	x
34.	Efficient and environmentally clean heat and power engineering	Germany, USA	x		
		Saudi Arabia		x	
		France			
35.	Safe nuclear power engineering	Saudi Arabia		x	
		Germany, USA	x		
36.	Efficient utilisation of renewable energy sources	Czech Republic	x		
		Saudi Arabia		x	
		Germany, UK, Brazil	x	x	x
37.	Prospective bioenergy	Saudi Arabia		x	
38.	Deep processing of organic fuels	Saudi Arabia		x	
39.	Efficient storage of electric and thermal energy	Saudi Arabia		x	
40.	Hydrogen power	Saudi Arabia, Germany, USA		x	
41.	Efficient transportation of fuel and energy	Saudi Arabia		x	
42.	Smart power generation systems of the future	Germany, USA, Canada	x	x	x
		Saudi Arabia		x	
43.	Efficient energy consumption	Saudi Arabia, Germany, USA		x	
44.	Modeling prospective power generation technologies and systems	USA	x		
		Saudi Arabia		x	
		EU countries, Germany, France	x	x	x
45.	Development of advanced electronic component base for power engineering	Saudi Arabia		x	
		Germany, China, USA	x	x	x
46.	New materials and catalysts for power engineering of the future	USA, UK, BRICS countries, Germany, Netherlands, France	x	x	x
		Saudi Arabia		x	
		Australia	x	x	

Note: compiled by the authors based on the survey results.

Table A.5. List of priority areas for Russia's science and technology collaboration with foreign countries (by aims of the partnership)

Promising areas for S&T collaboration	Catching up with global leaders	Consolidating the position of Russia in global science	Equitable S&T collaboration
Russian Long-Term S&T Development Forecast for the period up to 2030			
Information and Communication Technologies			
Telecommunication technologies	USA, China, Japan, Germany, Republic of Korea, Finland, Canada, India, Iran, Malaysia, Singapore, Taiwan, Israel, Spain, Italy	--	--
Data processing and analysis technologies	USA, China, Japan, Republic of Korea, Canada, Malaysia, Singapore, Taiwan, Finland, Germany, Israel	Argentina, South Africa	--
Hardware components, electronic devices and robotics	USA, China, Malaysia, Republic of Korea, Singapore, Taiwan, Finland, Japan, Germany, France, Canada, UK, India	--	--
Predictive modeling and simulation	USA, China, Germany, Republic of Korea, Singapore, Taiwan, Malaysia, Iran, Japan, Finland, India	Austria, Brazil, Turkey, Israel	Switzerland, Spain, Netherlands
Algorithms and software	USA, China, Japan, Germany, Austria, Israel, India, Iran, Spain, Malaysia, Mexico, Republic of Korea, Singapore, Taiwan, Finland, France	--	--
Information security	USA, China, France, Germany, UK, Italy, Austria, Iran, Spain, Malaysia, Singapore, Taiwan, Finland	--	--
Computer architecture and systems	USA, Austria, Israel, Spain, China, Malaysia, Singapore, Taiwan, Finland, France, Germany, Italy, UK	--	--
Biotechnologies			
Development of the scientific and methodological basis of biotechnology R&D Industrial biotechnology	USA, China, Japan, Germany, UK, Austria, Israel, Spain, Canada, Netherlands, Singapore, Taiwan, Finland, France, Switzerland	--	--
Industrial biotechnology	USA, China, Germany, UK, Japan, Austria, Italy, Malaysia, Netherlands, Republic of Korea, Singapore, Taiwan, Finland, France, Switzerland, South Africa	--	--
Agrobiotechnology	USA, Argentina, Austria, Brazil, Germany, Israel, India, Iran, Spain, Italy, Canada, China, Malaysia, Mexico, Netherlands, RepublicofKorea, Turkey, Finland, France, Switzerland, Poland, SouthAfrica, Japan, UK	--	--
Environmental biotechnology	USA, Argentina, Austria, Brazil, UK, Germany, Spain, Canada, Mexico, Netherlands, Finland, France, Switzerland, South Africa	Singapore, India, Iran, Republic of Korea, Taiwan, Turkey	Italy, Israel
Food biotechnology	USA, China, Japan, Argentina, Brazil, India, Iran, Germany, Spain, Italy, Netherlands, Malaysia, Mexico, Republic of Korea, Taiwan, Turkey, Finland, France, South Africa	--	--
Forest biotechnology	USA, Argentina, Austria, Brazil, Germany, Spain, Canada, Malaysia, Mexico, Turkey, Finland, Switzerland, France, South Africa, Japan	--	--
Aqua biotechnology	USA, Argentina, Brazil, UK, Spain, Italy, Canada, Malaysia, Mexico,	Singapore	Austria, Israel, Turkey, India, Iran,

Promising areas for S&T collaboration	Catching up with global leaders	Consolidating the position of Russia in global science	Equitable S&T collaboration
	Netherlands, Finland, France, South Africa, Japan, Norway		Republic of Korea, Taiwan, Switzerland
Medicine and healthcare			
Discovery of candidate drugs	USA, Japan, UK, Germany, Austria, Argentina, Brazil, Israel, India, Iran, Spain, Italy, Netherlands, Republic of Korea, Finland, France, Switzerland, South Africa	--	--
Molecular diagnostics	USA, China, Japan, Germany, Austria, Italy, Canada, Malaysia, Netherlands, Republic of Korea, Singapore, Taiwan, Turkey, Finland, Switzerland, Spain, South Africa, Argentina, Brazil, India, Iran	--	--
Molecular profiling and identification of molecular and cellular pathogenesis mechanisms	USA, Japan, Germany, UK, Austria, Israel, Italy, Canada, Netherlands, France, Switzerland	Iran, South Africa, Malaysia	Argentina, Brazil, India, Spain, Mexico, Taiwan, Turkey, Finland, Singapore
Biomedicall cell technologies	USA, UK, Germany, Japan, Israel, Italy, Canada, Netherlands, Republic of Korea, Singapore, Switzerland	--	--
Biocomposite materials for medical application	USA, China, Japan, Germany, Italy, UK, Brazil, India, Iran, Malaysia, Netherlands, Republic of Korea, Singapore, Taiwan, Turkey, Finland, Switzerland	--	--
Bio-electrodynamics and radiation medicine	USA, Japan, Austria, UK, Germany, Israel, Italy, Canada, Netherlands, Republic of Korea, Turkey, Finland, France, Switzerland	--	--
Genomic passportisation of humans	USA, Germany, Japan, China, UK, Austria, Argentina, Brazil, Israel, India, Spain, Italy, Canada, Finland, France, Malaysia, Mexico, Switzerland, Netherlands, RepublicofKorea, Singapore, SouthAfrica	--	Iran, Taiwan, Turkey
New materials and nanotechnologies			
Structural and functional materials	China, Japan, Republic of Korea, India, Iran, Malaysia, Singapore, Taiwan, USA, Germany, France, UK	Argentina, Brazil, Israel, Mexico, South Africa, Turkey, Netherlands, Switzerland, Austria, Finland	Spain, Italy, Canada, Taiwan, Iran
Hybrid materials, converging technologies, biomimetic materials and medical supplies	China, USA, Japan, Germany, Republic of Korea, India, Iran, Malaysia, Singapore, Taiwan, Turkey, France, UK	--	Brazil, Israel, Mexico, Netherlands, Switzerland
Computer simulation of materials and processes	China, Japan, Germany, USA, Republic of Korea, Malaysia	Argentina, Brazil, Israel, India, Taiwan, South Africa, Spain, Italy, Netherlands, Finland, Switzerland	Iran, Austria, UK, Mexico, France, Singapore, Turkey
Diagnostics of materials	China, Japan, Germany, USA, Republic of Korea, Malaysia	--	Austria, UK, Iran, Mexico, Singapore, Turkey, France

Promising areas for S&T collaboration	Catching up with global leaders	Consolidating the position of Russia in global science	Equitable S&T collaboration
Rational use of natural resources			
Environmental protection and safety technologies	China, Canada, UK, USA, Germany, Austria, Argentina, India, Iran, Spain, Italy, Malaysia, Mexico, Netherlands, Saudi Arabia, Taiwan, Turkey, Finland, France, Switzerland, South Africa	--	--
Exploration of subsoil assets, mineral prospecting and integrated development of mineral and hydrocarbon resources	USA, China, Germany, France, Finland, UK, Japan, Italy, Canada	Argentina, Brazil, Israel, Iran, Malaysia, Mexico, Singapore, Taiwan, Turkey, South Africa	Austria, India, Spain, Netherlands, Norway, Republic of Korea, Saudi Arabia, Switzerland
Monitoring of environment, assessment and forecasting of natural and technogenic emergencies	USA, China, UK, Germany, France	Austria, Brazil, Israel, India, Iran, Malaysia, Netherlands, Republic of Korea, Saudi Arabia, Singapore, Taiwan, Turkey,	Argentina, Spain, Italy, Canada, Mexico, Norway, Finland, Switzerland, South Africa, Japan
Exploration and utilisation of oceanic resources, the Arctic and Antarctic	USA, China, UK, India, Canada, Germany, Spain, Italy, Netherlands, France, South Africa, Japan	Austria, Singapore, Israel, Finland,	Argentina, Brazil, Iran, Malaysia, Mexico, Norway, Republic of Korea, Saudi Arabia, Taiwan, Turkey, Switzerland
Transport and space systems			
Development of a single transport space	Austria, Canada, China, Finland, France, Germany, Italy, Japan, Switzerland, Republic of Korea, Taiwan, Turkey, USA	--	Brazil, India
Improving the safety and environmental performance of transport systems	China, Netherlands, Republic of Korea, Singapore, USA, Taiwan, Canada, Iran, Italy	--	Brazil
Prospective transport and space systems	--	--	Austria, China, Finland, France, Germany, India, Italy, Japan, Republic of Korea, Spain, Switzerland, Taiwan, UK, USA
Energy efficiency			
Efficient exploration and mining of fossil fuels	Malaysia, Republic of Korea, USA, Iran	South Africa, Singapore	Germany, China, Austria, Finland, France, Italy, Switzerland, Mexico, Spain, Taiwan, UK, Turkey, Japan, India
Efficient and environmentally clean heat and power engineering	China, France, USA, Germany, India, Italy, Japan, Republic of Korea, Spain, Switzerland, Turkey, UK	--	--
Safe nuclear power engineering	Malaysia, Republic of Korea, USA, Iran	--	China, Austria, Finland, France, Italy, Japan, Republic of Korea, Mexico, Switzerland, Taiwan, Turkey, India, UK, Germany
Efficient utilisation of renewable	Malaysia, Republic of Korea, USA, Iran	--	China, Austria, France, India, Italy,

Promising areas for S&T collaboration	Catching up with global leaders	Consolidating the position of Russia in global science	Equitable S&T collaboration
energy sources			Japan, Taiwan, UK, Canada, Finland, Netherlands, Spain, Switzerland, Turkey, Germany
Prospective bioenergy	Malaysia, Republic of Korea, USA, Iran, India, Turkey	--	Finland, France, Italy, Japan, UK, China, Japan, Germany
Deep processing of organic fuels	Malaysia, Republic of Korea, USA, Iran, India, Turkey	--	Austria, China, Finland, Spain, Switzerland, Germany
Efficient storage of electric and thermal energy	India, Republic of Korea, USA, Iran, Turkey	--	China, Finland, France, Germany, Italy, Japan, Switzerland, Taiwan, UK, Netherlands
Hydrogen power	Republic of Korea, USA	--	China, Finland, Germany, Italy, Spain, Taiwan, Turkey, UK
Efficient transportation of fuel and energy	India, Republic of Korea, USA, Turkey	--	Austria, China, Finland, France, Germany, Italy, Japan, Spain, Switzerland, Taiwan
Smart power generation systems of the future	Republic of Korea, USA, China, India, Turkey	--	Finland, France, Germany, Spain, Japan, Switzerland, UK
Efficient energy consumption	USA, Turkey	--	China, Finland, France, Germany, India, Japan, Switzerland, UK
Modeling prospective power generation technologies and systems	Republic of Korea, USA, India	--	China, Finland, France, Germany, Japan, Taiwan, Turkey
Development of advanced electronic component base for power engineering	Austria, China, France, Germany, India, Italy, Japan, Republic of Korea, Spain, Taiwan, Turkey, UK, USA	--	--
Efficient exploration and mining of fossil fuels	USA, Republic of Korea, Turkey	--	China, Finland, France, Germany, India, Japan, Switzerland, UK
Fundamental sciences			
Biological sciences	Argentina, Austria, Brazil, UK, Germany, Israel, India, Spain, Italy, Canada, China, Mexico, USA, Finland, France, South Africa, Japan	Malaysia	Iran, Netherlands, Republic of Korea, Singapore, Taiwan, Turkey, Switzerland
Basic medicine	USA, UK, Germany, Japan, Canada, China, Italy, France, Netherlands, Spain, Brazil, Switzerland, Republic of Korea, India, Turkey, Israel, Taiwan, Finland, Austria, Argentina	--	--
Mathematical sciences	USA, China, France, Germany, UK, Italy	Argentina, India, Brazil, Malaysia, Netherlands, Republic of Korea, Singapore, Taiwan, Finland, Switzerland, South	Austria, Israel, Iran, Spain, Canada, Mexico, Turkey, Japan

Promising areas for S&T collaboration	Catching up with global leaders	Consolidating the position of Russia in global science	Equitable S&T collaboration
		Africa	
Physical sciences	USA, China, Japan, Germany	Argentina, Austria, Brazil, Israel, Iran, Spain, Canada, Malaysia, Mexico, Netherlands, Singapore, Taiwan, Turkey, Finland, Switzerland, South Africa	France, UK, Italy, Republic of Korea, India
Chemical sciences	China, USA, Japan, Germany, India	Argentina, Austria, Brazil, Israel, Malaysia, Mexico, Netherlands, Singapore, Turkey, Finland, Switzerland, South Africa	UK, Spain, Iran, Italy, Canada, Taiwan, France
Other applied sciences			
Clinical medicine	Austria, Brazil, UK, Germany, Israel, India, Spain, Italy, Canada, Netherlands, USA, Taiwan, Turkey, Republic of Korea, Finland, France, Switzerland, Japan	--	--
Health sciences	Argentina, Austria, Brazil, UK, Israel, India, Iran, Spain, Italy, Canada, Malaysia, Mexico, Netherlands, RepublicofKorea, USA, Taiwan, Turkey, Finland, France, Switzerland, Germany, SouthAfrica, Japan	--	--
Technical sciences (engineering)	China, USA Japan, Germany, UK, France, Republic of Korea, India, Canada, Taiwan	Austria, Argentina, Brazil, Israel, Mexico, Netherlands, Finland, Switzerland, South Africa	Spain, Italy, Iran, Malaysia, Singapore, Turkey

Note: compiled by the authors based on the survey results.

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