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Science-Policy Tendencies in Armenia Towards the International Collaboration

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Abstract

Since its independence (1991) the Republic of Armenia has faced the challenge of preserving and further development of science and technology. In this regard the role of international scientific cooperation is especially emphasized. The article explores the state policy in this field with the focus on the research of the bilateral.

Methodologically, the study relies on the principles of scientometric analysis. The methods include the desk research, quantitative measurements and data retrieval from Web of Science. The research data were retrieved from the interstate agreements, bilateral competitions, and from Web of Science. The research results showed that 102 cooperation agreements have been signed with CIS and EU member states and countries from Asia and America. By maintaining cooperative relations with the countries of the former Soviet Union, scientific cooperation with European and other countries is also developing. On their basis, bilateral international competitions have been organized since 2009. These competitions secured funding for 332 projects. There are 377 publications[1] linked with the winning programs in the WOS database. Among the funded programs and the publications within their scope, the dominant part is from natural sciences, mainly from physics. The publications were excellently made with co-authorship, which contributed to the development of international cooperation. These results of the study contribute to the creation of the picture of international scientific collaboration in the frames of the bilateral competitions and can help to make the necessary refinements.

Introduction

As a result of the collapse of the Soviet Union at the end of December 1991, the former Soviet Republics, that became independent, found themselves in the face of new challenges and opportunities in the field of international relations. The right to conduct an independent policy and the elimination of the "Iron Curtain" made it possible to establish relations not only with the countries of the former Eastern bloc, but also with many Western and Asian states. In addition to establishing interstate diplomatic, economic and political ties, the Republic of Armenia also pays great attention to the formation of a new network of international scientific cooperation. Armenian scientists faced the following dichotomous options: a) collaboration with the former Soviet states, with which they had long history and tradition of scientific collaboration; b) collaboration with European countries, but it was in many ways a terra incognita. (Sargsyan et al.) The latter option could be broadened and included USA and Canada as well as South Eastern countries. The reason for that was not merely the desire to discover new horizons which were often unavailable under the

[1] As of June 22, 2022.

Soviet rule, but the imperative. The first collaborative article was published in 1665 (Gazni & Didegah, 2011) and since then the collaborative publications started to gain more and more popularity in scientific research. This process reflected the growing importance of scientific collaboration. And since many decades international scientific collaboration is a common feature in scientific research. (Coccia & Wang, 2015) More precisely the real heyday of the international scientific cooperation has been started since the second half of the 20th century. (Astakhova, 2020) As the result it is possible to argue that we are witnessing the era of international collaboration in the field of scientific research. (Gui et al., 2019) International scientific collaboration has shown the steady growth in all research fields. (Coccia & Wang, 2016) The exchange of scientific knowledge and skills make the shift of the focus of science from the national to the global level. (Gazni et al., 2012) Adams claims that now we are witnessing the forth age of research – which is driven by scientific collaboration. (Adams, 2013) He states that the first three ages were the individual, the institutional and the national. The different reasons can be mentioned for the development of the international collaboration: very often the breakthrough research projects are too complicated in order to be conducted in a single state (Astakhova, 2020); scientific collaboration has a proven positive effect on the scientific as well as on the economic productivity (Pfotenhauer et al., 2016); researchers' wish to increase their scientific popularity, visibility and recognition; the growing need of the rationalization of scientific manpower; increasing specialization in science; continuously growing amount of knowledge that needs to be put together in order to have significant advances in science; the phenomenon of cross-fertilization across disciplines (Katz & Martin, 1997); seeking excellence of the research, increase of the visibility of the research which can be resulted of the higher citation rank, capacity building (The Royal Society, 2011) etc.

It is important to mention that research collaboration can take place on three levels – micro (collaboration between individual scientists), meso (collaboration between organizations) and macro (collaboration between countries. Looking ahead it must be said that in case of Armenia all three types of scientific collaborations are available. Scientific collaboration has stronger impact in the "hard" sciences, than in the "soft" ones. (Bote et al., 2012) When speaking about the scientific collaboration and especially the co-authorship it should be kept in mind that sometimes the collaborative papers can be just the "mandatory exercises" in the frames of bilateral agreements on the different levels. (Glänzel, 2001) But in general the growth of scientific output during the last decades is provided mainly due to the international scientific collaboration. It is especially true for the Western countries. (Adams, 2013) The research shows that in the Western hemisphere the number of domestic papers (publications that have authors only from home country) does not go through any visible changes and is stable.

In the Republic of Armenia, the development of science and technology has been declared a priority and an important place is given to the development of international scientific cooperation. As stated by Finardi & Buratti (2016) "International scientific collaboration is strategic for the growth of a country, in particular for developing countries". But it is not a one way process. The

international scientific cooperation can be considered as one of the components of the process of globalization of science. And the latter is a kind of a "win-win" game when both advanced and developing countries benefit. (Freeman, 2010) Moreover there is an approach according to which the best science comes from international collaboration. (Coccia & Wang, 2015) It should be also added that co-authored publications are usually cited more than single author ones and that internationally co-authored papers are also usually cited more than single country ones. (Sooryamoorthy, 2009) The reason for it is the larger potential community. (Schmoch & Schubert, 2008) So it can be stated that the co-authorship increases the papers' impact.

According to a number of researchers, international scientific cooperation becomes possible when certain principles coincide. Indian researcher Nagpaul (2003) believes that geographic, thematic, sociocultural priorities are of fundamental importance for creating a network of scientific cooperation. Schott (1991) concluded that international cooperation depends on "political, cultural and social factors". Moëd et al. believe that "The differences between countries with respect to international scientific integration are affected by both the policies of the national governments and long-term traditions in the political, economic and cultural fields". (Moëd et al., 1991, p. 308) On the one hand, the Republic of Armenia has maintained and developed scientific cooperation with the states of the former USSR; on the other hand, it has found points of intersection of interests that have made it possible to establish cooperation with dozens of states in Europe, Asia and America in the field of science.

Cooperation developed on three levels. At the first level, the Armenian government and the authorized state body for science have signed cooperation agreements with dozens of foreign countries. In addition to cooperation with the states of the former Soviet Union, the importance of cooperation with Western states was emphasized at the state level. At the second level, academic institutions, universities and other scientific organizations of Armenia have established cooperation with relevant foreign structures. The third level is the individual one: researchers from Armenia collaborate with their foreign colleagues, resulting in thousands of joint scientific papers. As the result of it, there is an interaction and mutual influence of different cultures, mutual cognition and localization of international scientific achievements. According to Gomez et al. (1999) "Globalization of science reflects itself in an increasing cooperation between nations which originates different types of scientific collaboration networks, frequently enhanced by science policy measures taken at national and supranational levels".

State research grants (as well as delivered from private sector/industry) have significant impact on seeding and fostering fundamental and cutting-edge research projects, which leads to research innovations and scientific discoveries. (Wang et al., 2020) Bilateral competitions can be considered as the part of the science diplomacy. The latter can be described using the words of Nina Fedoroff, once science and technology adviser to the US Secretary of State: "science diplomacy is the use of scientific collaborations among nations to address the common problems facing

twenty-first century humanity and to build constructive international partnerships." (Ruffini, 2018, 11-12)

In this article, we aim to find out the activities carried out by the Republic of Armenia in the direction of establishing international cooperation in the field of science at the level of agreements reached with foreign countries and conducted competitions, the opportunities created by competitions in the development and internationalization of various fields of science. To achieve this goal, the following issues were discussed:

1. With which countries have cooperation agreements been signed and with which countries is cooperation more active and developing?
2. Which part of signed international agreements led to practical work in the context of organizing bilateral competitions?
3. Which specialties granted the opportunity to participate in the competitions and which specialties met the requirements of the competitions?
4. The volume of international articles published within the framework of the winning programs, their distribution by fields. What part of those articles is the result of international cooperation?

Previously the Center for Scientific Information Analysis and Monitoring has already conducted the research concerning the collaboration of Armenian and Russian scientist in the frames of the Russian-Armenian bilateral competitions which resulted with publishing of two articles that presented the role of such competitions in the promotion of scientific collaboration between Armenia and Russia (Gzoyan et al., 2017) collaboration of the Armenian and Russian scientists in the frames of bilateral competitions (Glukhov et al., 2017). This article presents the logical continuation of the aforementioned research and deals with its whole specter.

Data and method

This work is based on the international documents[2] signed by the scientific policy makers of the Republic of Armenia - the Government[3] and the authorized state body in the field of science,[4] joint international competitions[5] held on their basis and their results.[6]. On the basis of this information we have created 3 databases: documents on scientific cooperation, announced bilateral competitions and winning projects of competitions. The information for the analysis of the articles published in the winning projects was extracted from the international scientific information database Web of Science. The time frames include the entire period of independence of the Republic of Armenia, starting from 1991 until the first half of 2022.

[2] We have considered agreements, contracts, memoranda, programs, which we used in scientometric calculations as documents of equal force.

[3] Legal information system of Armenia, https://www.arlis.am/

[4] Science Committee of Ministry of Education, Science, Culture and Sports RA, http://scs.am/am/0652fc7e4429cb2579571955.

[5] Science Committee of Ministry of Education, Science, Culture and Sports RA, http://scs.am/am/ef52f2239b1bc62940173436

[6] Science Committee of Ministry of Education, Science, Culture and Sports RA, http://scs.am/am/6954e433a4402db729623210

In the first stage quantitative measurements have been carried out to find out the total number of signed international bilateral documents in science, their dynamics, regional orientation (grouping the states by regions and unions) the specific weight of each group in the total. Using the method of cluster analysis, we divided the states into groups and conducted a comparative analysis.
In the second stage, competitions jointly held by Armenia and other states have been analyzed. To determine the share of specialties in the total number, the full count method was used. (Robertson et al., 1980) In other words, one point was given to each specialty for the opportunity to participate in the competition. Then, adding up the points received for the opportunity to participate in all competitions, and comparing with the total number of points, the percentage weight of each profession in total was obtained. Thus, the priorities of professions have been determined. Then, to determine the classification of specialties, the total scores of all specialties in a given area have been correlated with the number of specialties. After that, the indicators obtained at this stage have been compared with those retrieved at the first stage in order to analyze the applicability and viability of the signed international instruments.
In the third stage the results of the competitions have been analyzed subjecting the winning projects to quantitative measurements. By applying the method presented for the second stage, it has been revealed which scientific fields have more selected projects, and how priorities have changed due to the regional cooperation. The results obtained in this round have been compared with the results of the previous two rounds.
In the fourth stage we have discovered which projects have ended up with publications in the journals indexed in Web of Science. It helped to find out the correlation between the winning projects and the number of articles published in well-known international journals, the overall dynamics of articles' publication, the fields of science, the number of received citations.
All specialties are grouped into 6 major scientific fields and 36 subfields using the Frascati classification. There are slight changes from the original version of Frascati classification, presented for the first time in 1963.[7] Originally there are 42 scientific subfields (Kutlača et al., 2015) and Science Committee uses 36 out of them. Also it has included Armenian Studies or Armenology it this classification. The six main scientific fields are: 1) Natural Sciences (mathematics, informatics and computer science, physics and astronomy, chemistry, geosciences and related environmental sciences, biological sciences), 2) Engineering and Technology (urban planning and architecture, computer science and information technology, mechanics, machine science and mechanical engineering, chemical technology, materials science, medical instrumentation, ecology, biotechnology, nanotechnology), 3) Medical Sciences (general medicine, clinical medicine, medical biotechnology), 4) Agricultural Sciences (animal husbandry and veterinary medicine, horticulture, soil science and plant protection, agricultural biotechnology), 5) Social Sciences (psychology, economics and business, pedagogical sciences, sociology, law,

[7] Detailed information can be found in Frascati Manual 2015.

political sciences, social and economic geography, media), 6) Armenology and the Humanities (history and archeology, linguistics and literary criticism, philosophy and ethics, theology and religious studies, art history).

Results and discussion

After declaring independence, the Republic of Armenia, as an independent subject of international relations, is active in forming a new network of international cooperation. 102 bilateral and multilateral agreements with foreign partners and international scientific organizations were signed by the Government of RA and the authorized state body responsible for science between the years 1991 and 2022 aimed at establishing cooperation in the field of science, upgrading the local science to the international standards and integrating it into the international scientific community (*Appendix 1*). This table reveals that the process of establishment of interstate scientific ties was permanent, continuous and expanding in nature. Only in 2004-2007 the process has stalled and no contracts have been signed. It is difficult to give an exact explanation what caused this, but it could be claimed that the implementation of preparations for the transition to a qualitatively new phase played an important role in it.

Figure 1 revealed that in the field of scientific collaboration RA has had multi-vector orientation. In consequence of simple comparison of the number of states the first place belongs to the EU countries, followed by CIS and Asian ones. But it should be mentioned that EU's first place is due to the fact that it has more member states than CIS. Moreover, Armenia has bilateral and multilateral agreements with almost all CIS member states,[8] whereas in the case of EU this rate is 60%. And in the case of Asian countries the percentage is much lower.

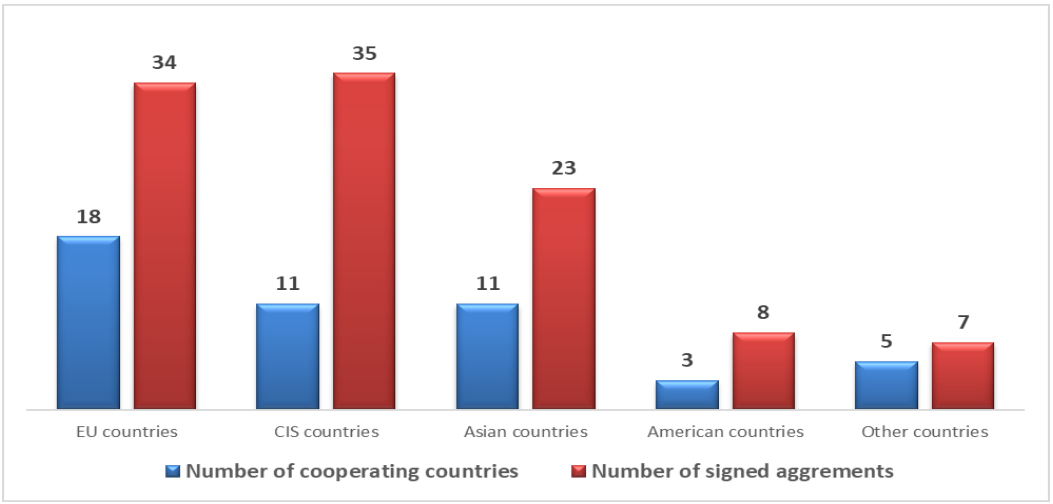

Figure 1. International agreements of RA in the field of science.

[8] There are no bilateral agreements only with Azerbaijan and Moldova. The reason for it is the lack of diplomatic and good neighborly relations in the case of the former, and the passivity and lack of interest in the bilateral relations in the case of the latter.

Figure 1 also shows that the closest, deepest and most multi-vector relations have been established with CIS countries. This is due to the longstanding historical, cultural, political, regional and lingual cooperation and mutual relations between Armenia and CIS countries. On the other hand there are continuously developing relations with EU countries. There is also a trend of deepening the relations with developed and developing Asian countries. And when it comes to the interstate scientific relations with American countries it should be mentioned that they are developing very slowly.

At the level of bilateral relations, the largest number of agreements was signed with Russia – 15, followed by the Republic of Belarus with 6 agreements when considering the CIS countries. Among the EU countries, relations with Italy (8 agreements), Romania (4 agreements), France (2 agreements) and Germany (2 agreements) are more active. The number of agreements signed with these countries testifies the deepening and intensifying nature of scientific ties with them, since these agreements include and regulate various aspects of cooperation.

It should be noted that not all signed interstate agreements were implemented, and some of them had no results. In order to eliminate this negative phenomenon, as well as to increase the coordination of science and regulate the state support provided to science, the Science Committee was created under the Ministry of Education and Science in 2007. Thanks to its efforts, international agreements on scientific cooperation lead to significant results. The first result is bilateral competitions between Armenia and other foreign countries, through which numerous of scientific projects have been financed.

During its activity the Science Committee signed 42 international agreements in the sphere of scientific cooperation, on the basis of which 35 competitions were realized. This is about 36% of the total number of competitions[9] organized by the Science Committee. According to the results of international competitions the winning projects received short-term funding, mainly for 12 or 24 months.

Figure 2 shows that international bilateral scientific competitions were held mainly with CIS and EU countries, that is why in the Figures 3 and 4 we have concentrated only on these two groups of countries. In other words, the above-mentioned arrangements with Asian, American (except Canada) and other countries did not lead to the announcement and holding of joint competitions. In total 25 competitions were organized with CIS countries and 8 with EU countries (one Armenian-German and one Armenian-Italian competitions have been summarized recently but they are out of the time span of the article and due to it have not been considered). Both in terms of the signing of interstate agreements and the organization of joint competitions, among the CIS countries the most active relations are with Russia and Belarus, and among the EU countries - with France, Germany and Italy. Figure 2 also shows that 2016 was the most productive year in terms of international competitions: 8 competitions were organized with both CIS and EU countries, as well as with Canada.

[9] 93 domestic and international competitions were held by the Science Committee in RA in order to finance scientific programs.

The next fact that becomes clear from Figure 2 is that the established bilateral relations are mostly developing and continuous. The bilateral Armenian-Russian competitions, which began in 2012, continue to this day: 10 calls have been announced since then. The same picture is with the Armenian-Belarusian competitions, which started in 2011 and were held 7 times. France was the first EU country to organize bilateral competitions, but this process was interrupted in 2013. Joint Armenian-German and Armenian-Italian competitions have continuous nature. But they are organized with long interruptions.

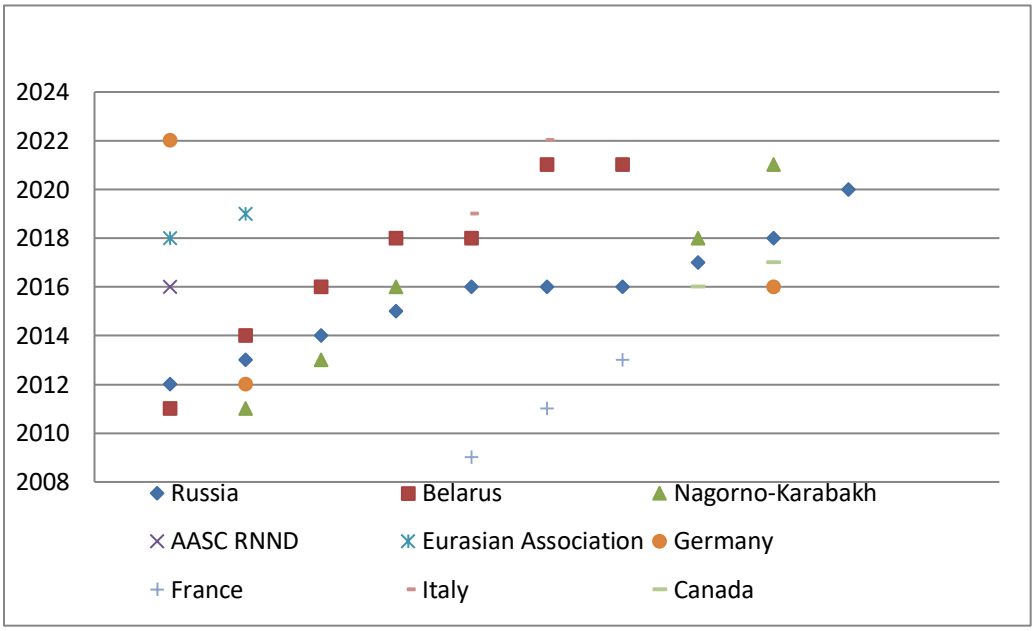

Figure 2. Timetable of international scientific competitions.

The announced international competitions differ in purpose, focus, and preferred specialties. Accordingly, in terms of eligibility, projects in different specialties have unequal opportunities for participation. Moreover, the picture is different when looking at the CIS and EU countries separately. Figure 3 shows that the biggest number of international competitions belongs to natural sciences, 21 of which were for biological sciences (16 competitions with CIS countries and 5 with EU countries). Next are Physics and Astronomy - a total of 20 competitions (15 times with CIS countries and 5 times with EU ones). Chemistry and Earth Science had a little bit less opportunities. Agricultural sciences had the least chance to participate. Projects in Mechanics, Mechanical Engineering, Chemical Engineering, and Ecology had not opportunities to participate in competitions with EU countries. History and Archaeology received the most opportunities among the Humanities - 16 competitions (9 times with the CIS countries and 7 times with the EU countries), and among the Social Sciences Sociology is the leader - 15 competitions (9 times with the CIS countries and 6 times with the EU countries). This picture shows the degree of development of science in Armenia and the range of interests with foreign countries.

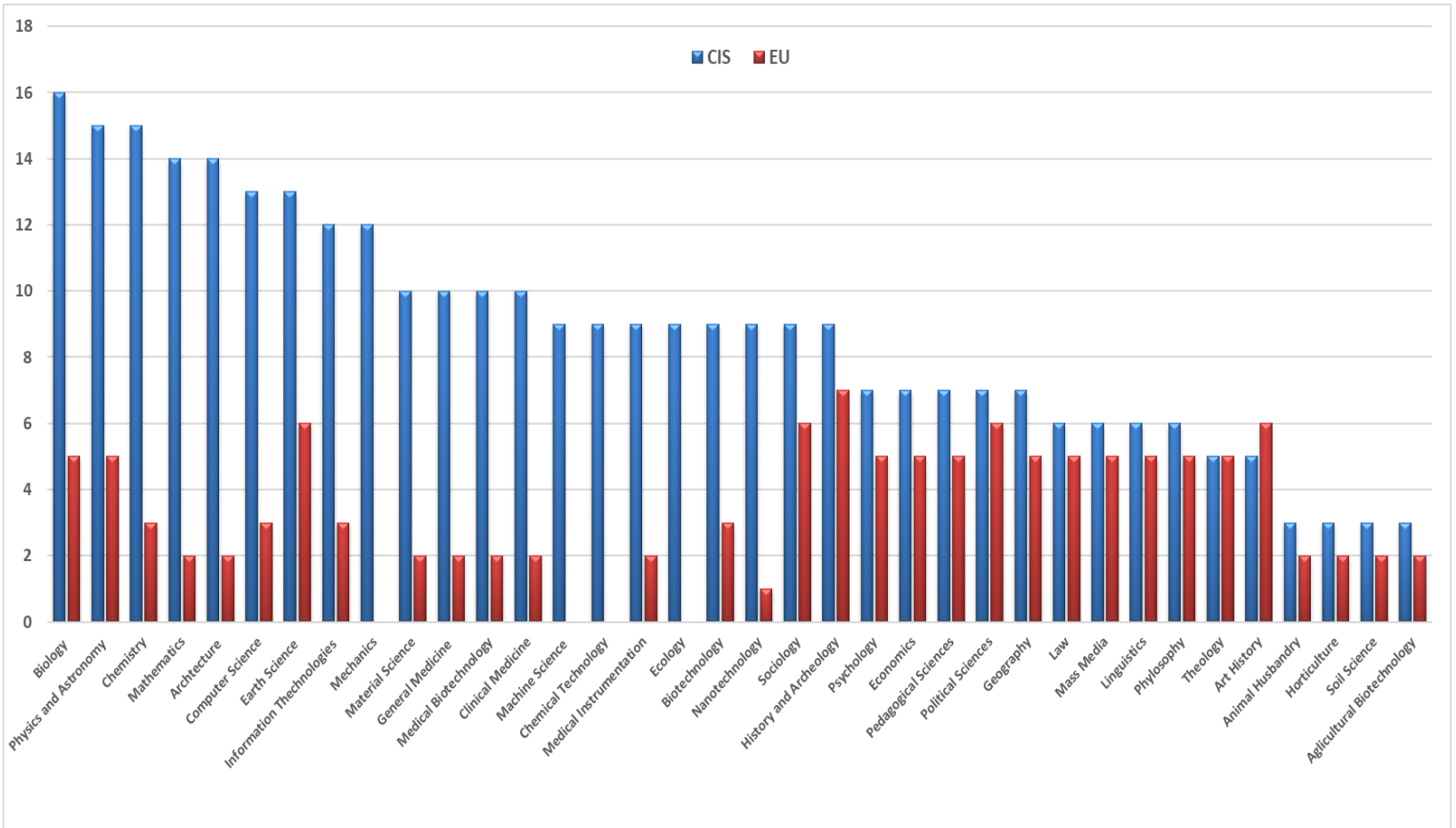

Figure 3. International scientific competitions by specialties.

If we compare the total number of opportunities to participate with the total number of international competitions, we see that in the case of Biological Sciences the opportunity to participate is 60%, Physics and Astronomy is 57.5%, Earth Science – 54.2%, Chemistry - 51.4%, History and Archaeology - 45.7%, Sociology - 42.8%, and in the case of Agricultural Sciences - 14.2%.

A total of 1,089 projects have been submitted to the 33 international competitions organized and held so far, of which 332 (30.4%) won and received funding. 119 of these programs have been submitted to bilateral competitions with EU countries, of which 47 (39.4%), have been announced as winners. Of the 871 projects submitted to bilateral competitions with CIS countries 242 (27.7%) were winners. The most effective were the bilateral competitions organized by the SCS RA and RFBR RF, in which 556 projects participated, of which 119 (or 21.4%) were guaranteed for funding.

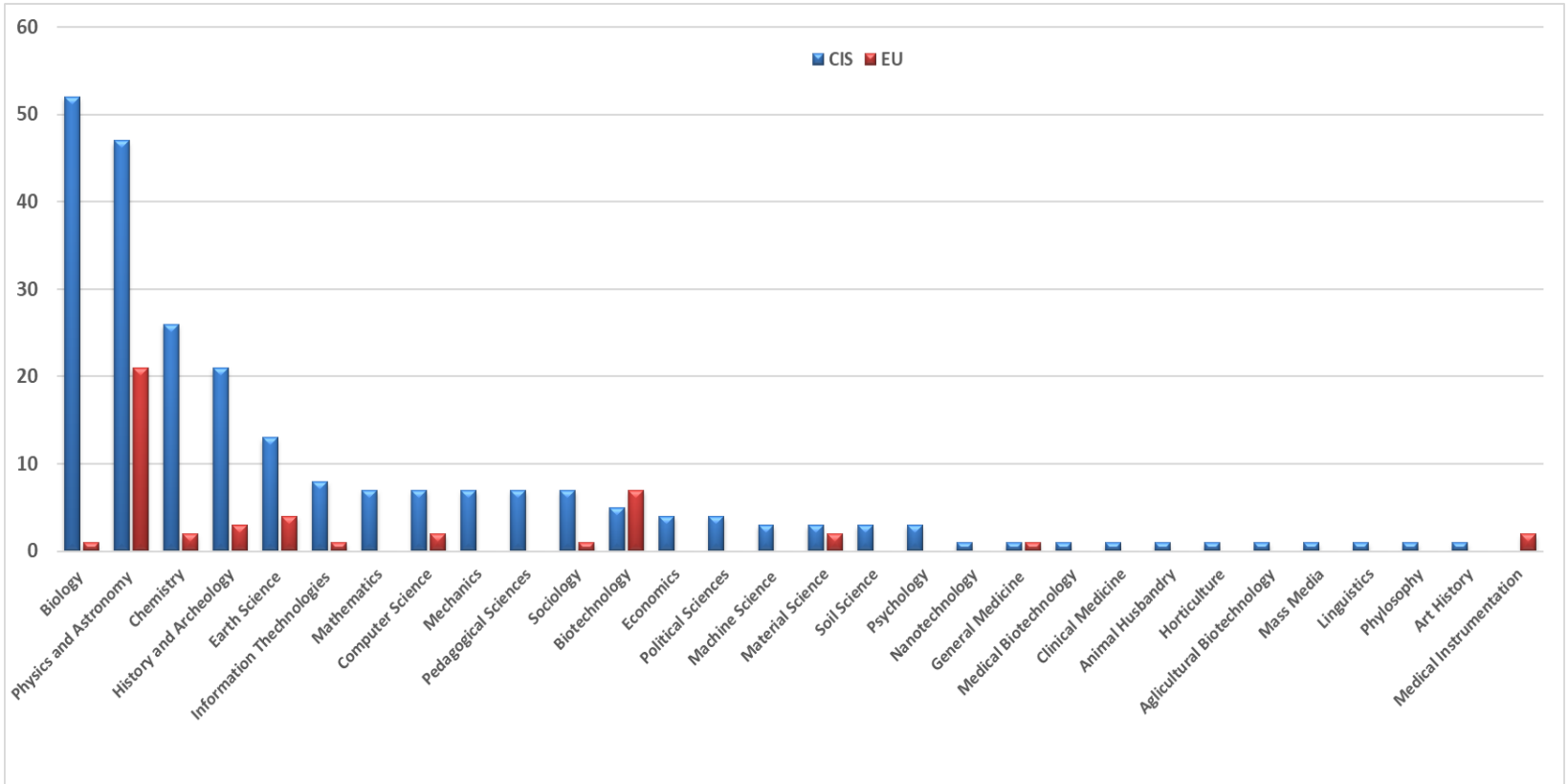

Figure 4. The total number of winning projects in international competitions by specialties.

Figure 4 shows that in bilateral competitions organized with CIS and EU countries, the greatest number of winning projects belongs to natural sciences - 213 ones which is 64.1% of all financed projects. Biology ranks first in the number of winning projects in competitions held with CIS countries, with 52 projects receiving funding. It is followed by Physics and Astronomy and Chemistry with 47 and 26 winning projects respectively. History and Archeology are leaders (21 projects) in the field of Humanities in the terms of the number of winning projects. Among the winning projects in joint competitions held with the EU countries the absolute leaders are Physics and Astronomy (21), followed by Biotechnology (7). For a number of specialties there were no winning projects at all (Ecology, Law, Geography, Theology, Architecture, Chemical Technology).

One of the important achievements of the international competitions is thousands of articles written in co-authorship by Armenian and foreign scientists. Most of them have been published in journals indexed in international scientific databases. For example, in the frames of 106 winning projects 377 publications have been published in journals indexed in the Web of Science database, of which 351 are articles. 341 of these publications are the result of collaborative work. It should also be mentioned that the collaborations established through the competitions have influenced the publication of joint new articles beyond these competitions. This fact is the further evidence that the number of joint publications by Armenian scientists with their foreign colleagues has been growing steadily in recent years.

Figure 5 reveals that the number of articles is increasing significantly. At the same time, the number of articles published in recent years has increased several times compared to the first years. All articles were published in English, except one, which published in Russian.

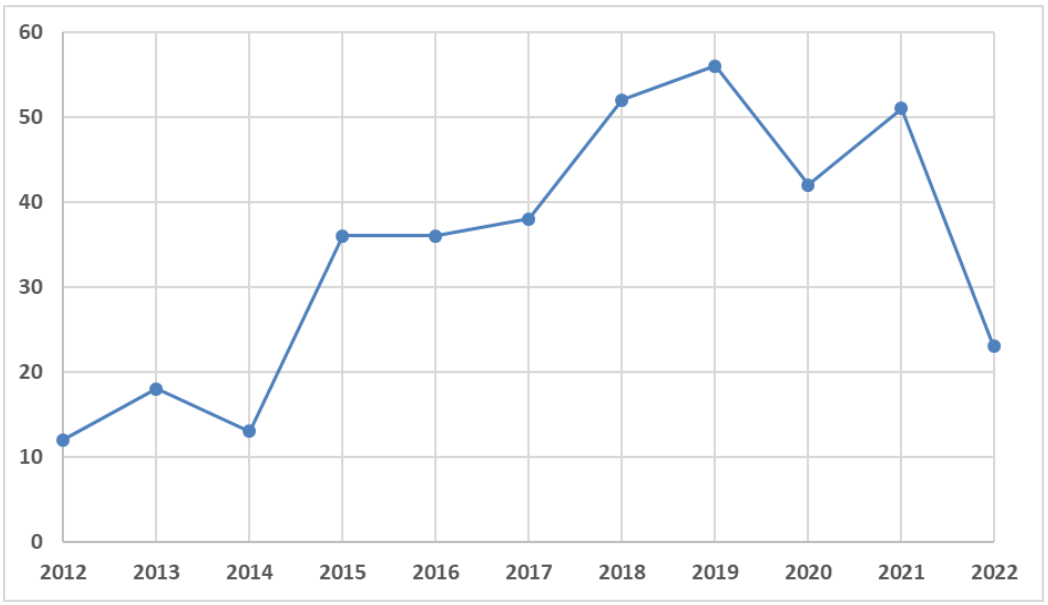

Figure 5. The articles published in the frames of bilateral competitions in the WOS indexed journals.

Figure 6 shows that Armenian scientists collaborate mainly with their Russian colleagues. Armenian and Russian scientists are co-authors of 46.4% of the articles published in WOS in the frames of the winning programs of bilateral competitions. This is logical, since Russian-Armenian bilateral competitions and winning-projects have a large share in the total volume. This collaboration is followed by cooperation with Germany, Belarus, France and Italy. The noteworthy fact is that although bilateral competitions were held more often with Belarus than with Germany, and more projects were guaranteed for funding, cooperation with German scientists is more intensive.

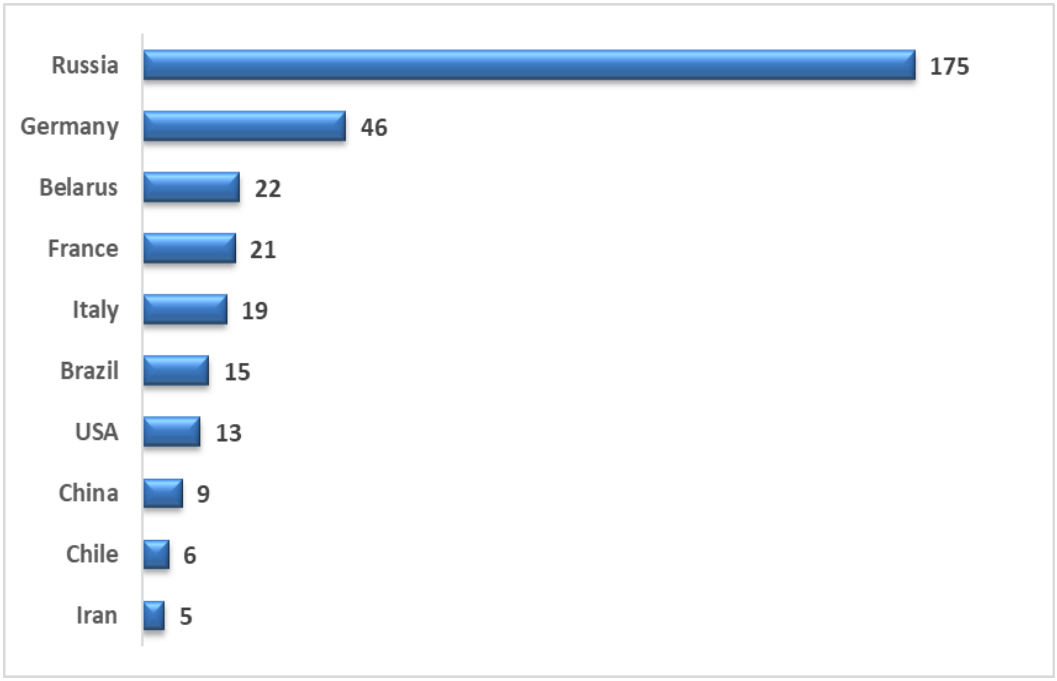

Figure 6. Top 10 countries of scientific collaboration based on joint publications of winning projects.

Table 3 shows that international cooperation is especially active in the field of Physics and its results exceed the total result in other areas. Articles published in this area of research account for 53.8% of the total number of articles. Physics is followed by Chemistry (10.3% of published papers), then by material science (9.8%) and mathematics (9.2%). An interesting picture emerges when comparing the number of published articles with the number of winning projects (Fig. 4). Physics is in first place both in terms of the number of winning projects and the number of published articles. There is a tiny gap between physics and biological sciences in terms of winning-projects number. Although a significant amount of articles have been published in the field of biological sciences it cannot be compared with the number of published articles in the field of physics. There is a controversial picture when comparing material science with history and archaeology. In the case of former, 37 papers were published in the frames of 5 winning projects. And in the case of latter

no articles have been published in any of WOS indexed journals although this field ranks 4th in the terms winning projects number - 24.

One of the most important ways to measure the quality characteristics, importance, and applicability of articles is the number of received by citations. From 377 published articles only 270 received citations. Table 1 shows that the total number of citations received by articles published in the field of Physics is extremely high – 1491. Although the total number of articles published in the field of Chemistry was second only to physics, but in terms of the number of citations received (221), it is also inferior to Material Science (410) and Science Technology Other Topics (300). Articles published in the field of Chemistry are in the middle positions in terms of the average value of the received citations. According to this indicator the leaders are Material Science (11.08), Engineering (11.36), and Environmental Sciences Ecology (13.3).

Table 1. Number of publications and received citations by Web of Science Subject Categories.

WOS subject categories	Number of Publications	Number of Received Citations
Physics	203	1491
Chemistry	39	221
Material Science	37	410
Mathematics	35	98
Science Technology Other Topics	32	300
Optics	31	185
Astronomy Astrophysics	26	107
Biochemistry Molecular Biology	13	66
Engineering	11	125
Environmental Sciences Ecology	10	133
Geology	8	37
Pharmacology Pharmacy	7	35
Computer Science	6	15
Genetics Heredity	6	45
Geochemistry Geophysics	6	51
Radiology Nuclear Medicine Medical Imaging	6	9
Biothechnology Applied Microbiology	5	38
Biophysics	4	24
Crystallography	4	21
Life Sciences Biomedicine Other Topics	4	2

If we consider the number of articles published in the frames of the winning projects and the number of received citations by group of countries (Figure 7) it will become apparent that the cooperation with CIS countries is in first place with 190 published articles and 990 received citations. This is followed by cooperation with the EU countries with 101 articles and 904 received citations. It should be noted that the citation per publication is greater for EU countries than CIS. It is interesting that bilateral competitions were not held with the countries of America and Asia, but articles were published in co-authorship with scientists from those countries. At the same time, publications in co-authorship with scientists from American countries are in first place in terms of the average index of citations received by them.

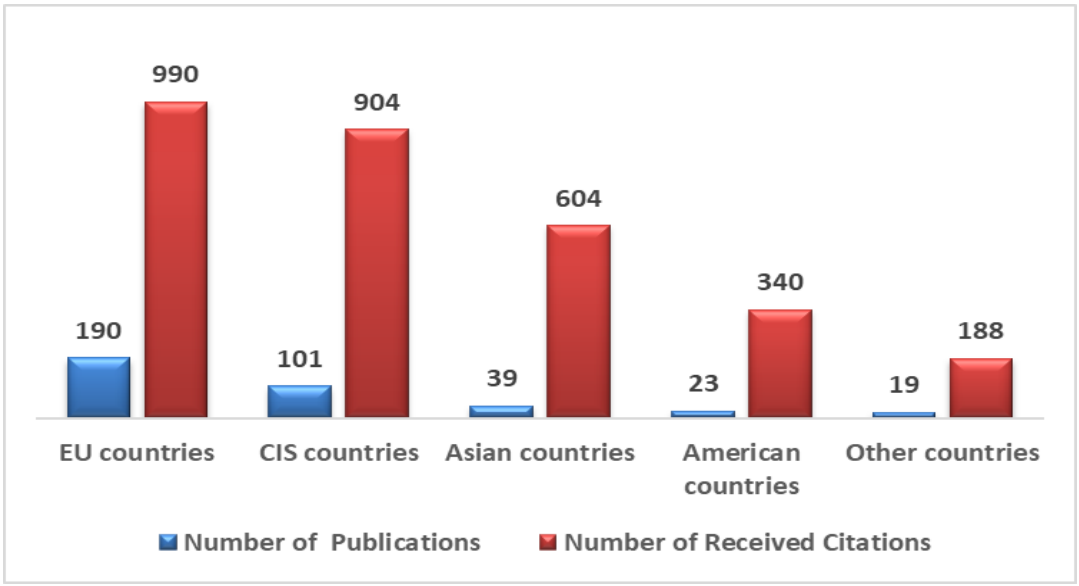

Figure 7. The number of publications and citations by groups of countries.

Conclusion

International scientific cooperation can be measured using different methods (Wang L. et al., 2017). Analyzing international scientific cooperation in Armenia from the point of view of state-established international scientific cooperation and the results achieved due to it, we found out that the general state policy in Armenia was aimed at internationalizing science, localizing international scientific achievements and experience, using new methods and means, and integrating into the international scientific market.

After gaining independence, the Republic of Armenia pursued a multi-vector policy of establishing scientific ties. On the one hand the signed agreements preserved and developed relations with the former Soviet states. In particular, bilateral scientific cooperation has been established with the Russian Federation and the Republic of Belarus. On the other hand, taking advantage of the opportunity to pursue an independent policy, new scientific ties were established with dozens of countries in Europe, America and Asia. Thus, local science received a new impetus, overcame a

number of outdated frameworks. Furthermore, it was created an opportunity to discuss many issues from the fundamental points of view which are common in modern world.

2009 was an important milestone in the further development of international scientific cooperation, when international bilateral scientific competitions were launched. They provided an opportunity for Armenian and foreign scientists to form research groups and work together on the implementation of various scientific projects. The number of such competitions has increased over the years, leading to more interest in them. During the implementation of projects, Armenian scientists had the opportunity to cooperate with their colleagues from France, Germany, Italy, Russia and Belarus and learn from their experience. Joint efforts were directed to new research and discoveries. Through collaboration, partners can share knowledge, skills, and techniques and improve productivity (Katz & Martin, 1997). In general, there was an interaction of scientific cultures with all positive consequences.

In the course of this study, it became clear that international scientific collaboration is developing most actively in the field of natural sciences and they have more opportunities both in terms of participation in competitions and in terms of success in them. It is no coincidence that the lion's share of the winning-projects falls on ones in the fields of biology, physics and astronomy, chemistry, and earth sciences. Among the humanities, there is a strong interest in the field of history and archaeology. In the frame of bilateral competitions with the CIS countries it had a significant success.

Hundreds of co-authored articles published in journals included in international scientific databases are also among the important outcomes of international bilateral competitions. For example, 377 papers published in the frames of bilateral competitions can be found in Web of Science, 341 of which are co-authored. More than half of the articles are in physics.

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Appendix

International agreements signed by Republic of Armenia with other countries and organizations.

1991	Romania	2010	Czech Republic
1992	China		Kazakhstan
	Vietnam		Belarus
	Iran		Russia
	Argentina		Russia
1993	Russia		Belarus
	Russia	2011	CIS
	Turkmenistan		Russia
	Georgia		Russia
1994	Argentina		Germany
	Romania		Italy
	Greece		Germany
	United Kingdom		Switzerland
1995	Romania	2012	Lithuania
	Iran		Russia
	India		China
	Israel		China
	Russia		Turkmenistan
	Lebanon		Vietnam
	INTAS international organization		Spain
	Russia		Iraq
1996	France	2013	Russia
	Ukraine		Italy
1997	USA		Italy
	Egypt		Belarus
	CIS		Belarus
	Kyrgyzstan		Ukraine
1998	Georgia	2014	Estonia
	Ukraine	2015	China
	Poland		Italy
	International Science and Technology Center		EU, Georgia, Japan, Kingdom of Norway, Kyrgyzstan, Kazakhstan, Korea, Tajikistan, USA
	Cyprus	2016	Russia

	Lebanon		India
	Georgia		Russia
2000	Slovakia		Russia
	Portugal		Georgia, Moldova, Ukraine, Azerbaijan
	Belarus		Belarus, Vietnam, Mongolia, Kyrgyzstan, Russia
2001	Russia		Canada
	Romania		Korea
	Bulgaria		EU
2002	India	2017	Bulgaria
2003	Tajikistan	2018	Italy
	Italy	2019	Vietnam
2008	Russia		Italy
2009	Croatia		China
	USA		Canada
	Kuwait		CIS
	Latvia		Russia
	France	2020	Canada
	International Science and Technology Center	2022	China
2010	Slovenia		Italy