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Modern trends in development of international scientific and technological cooperation

Abstract
This paper emphasizes that under conditions of knowledge economy formation the international scientific and technological cooperation will be developed in priority. It seems to be an objective necessity and is institutionally supported at the global level. Analysis of statistical data confirmed the allegation in respect of activation of the international scientific and technological cooperation and distinguished a number of its development trends, encompassing the following ones: international scientific publications and citation, distribution of intellectual property, international patenting, internationalization of R&D and university activities. Application of information and communication technologies as well as international programs, supporting joint researches, becomes of major importance.

Keywords
knowledge economy, international scientific and technological cooperation, international cooperation, information and communication technologies, internationalization

1 Introduction

In the recent decades, we notice a transition towards a new type of economy – knowledge economy that implies efforts focusing on scientific and technological progress. It creates new global social and economic trends and has a significant impact on the system of international economic relations, which should facilitate the new knowledge production and its effective use.

Modern globalization stage is characterized by intensification of international scientific and technological cooperation (ISTC) that is a direct confirmation and characteristic of formation of the knowledge economy. Global informatization creates a new impetus for development of these relationship forms, science and innovations become a part of global cooperation. In terms of national economies, the scientific and technological cooperation provides new advantages and opportunities, associated with obtaining of new knowledge, lowering costs and minimizing risks, involvement of specialists, etc. Governments have to develop and refine the policy in the sphere of ISTC, defining their optimal balance between transparency and privacy, preferential spheres and forms of exchange. On the one hand, considerable gaps in development of countries, diverse strategies and weak potential of the developing countries give rise to a number of problems and contradictions in ISTC. On the other hand, the importance of knowledge for social and economic development of the countries requires its active mainstreaming into ISTC at the global level.

2 Analysis of current research and publications

In recent years, we can see the growing attention of researchers to ISTC development, resulted by the knowledge economy formation in the context of even major globalization. Thus, D. Luk'ianenko considers the paradigm of knowledge economy and global competitive environment transformation. In the context of intellectualization the author distinguishes the knowledge economy components which being developed determine focus area of ISTC [1]. I. Kaleniuk and L. Tsymbal lay emphasis in new determinants of intellectual leadership [2], which compel us to reconsider views of scientific

and innovative activities.

M. Rikken notes that science really turns into international affairs. Therefore, international cooperation becomes not just a component but also a factor of development and effectiveness of R&D, bringing together the researchers from different countries and producing synergy [3]. V. Bilozubenko studies the essence and mechanisms of ISTC development and taking EU as an example demonstrates the way how it leads to international innovation system formation [4].

D. Nepelski and G. De Prato consider international patenting and work of Patent Cooperation Treaty [5]. The authors note the importance of international patent harmonization, which is relevant in the new agenda when ISTC becomes more active and changes the structure of international innovative systems.

It should be noted that modern ISTC is more and more studied in the context of expansion of the role of universities. Therefore, I. Kaleniuk and L. Tsymbal emphasize the activation of university activities in the global economic environment and their competition [6]. In another research I. Kaleniuk and A. Diachenko provide the specifics of entrepreneurial universities functioning in the global educational area which includes active international cooperation [7]. In this context, the concepts of international competitiveness of universities proposed by L. Antoniuk and V. Satsyk [8] also deserve our interest. Studying the university activities in the global economy area, D. Ilnytskyi focuses on competition for knowledge, which encourages it to be included in the processes of knowledge sharing [9].

At the same time, today's problematics of ISTC is very extensive. There are continuously emerge new forms, mechanisms and practices. All these factors confirm the importance of this paper subject and make us focus attention on the trends of ISTC development and individual aspects like use of information and communication technologies (ICT) and international programs to support cooperative R&D.

3 The goal

The goal of the current paper is to demonstrate ISTC activation, its individual types and mechanisms as well as to distinguish basic trends in development of this form of international relations in the context of knowledge economy formation.

4 The presentation of the material

Modern ISTC is developed within the framework of non-market interaction model. Market model unveils in so called commercial forms of ISTC, namely: purchase-sale (export-import) of technologies in materialized form; provision of technological know-how (transfer of best practices), technical assistance (support); sale of patents or granting of licenses to use; training of personnel; rendering of consulting, management and engineering services (at different stages of technology projects implementation) and expert examination services; contracts for scientific and technological cooperation, establishment of joint ventures, etc. Commercial exchange processes are to a greater extent described by studies of global knowledge market.

At the same time, major part of ISTC is implemented outside the market in non-commercial forms: scientific publications; holding international conferences (scientific tourism), symposiums, exhibitions; exchange of experience; academic mobility; teaching, training and internship of students abroad, international technological support, etc. It should be noted that non-commercial cooperation is directly or indirectly assimilated by market.

Today not only large transnational companies, but also small and medium-sized business and universities become the key drivers. Social (entrepreneurial and innovative) networks and communities also form new channels. International organizations, such as United Nations, United Nations Conference on Trade and Development and World Trade Organization, play more and more increasing role. Such international sectoral organizations as, for instance, World Health Organization, Food and Agriculture Organization and International Atomic Energy Agency are strategic subjects and regulators. They can catalyze or block technological expansion. In general, international organizations form the major part of international policy and institutional environment of ISTC, first of all, in the sphere of intellectual property protection. In general, they perform the functions of settlement of the agreements between countries; organizing multilateral cooperation; development of global agenda for science; development of global rules for scientific and technological activities.

Transnational corporations (TNC) are also the critical subject of ISTC. Active transnationalisation in the XX century resulted in emergence of the new knowledge geography. TNC form international structures of subsidiary enterprises, purchase science intensive technologies, undertake international research-and-development activities and absorb different knowledge. TNC are pooling local intellectual resources, meeting their global challenges. In this respect they become the subjects of management of international knowledge flows, regularize different knowledge, disseminated at the global level.

Individual states are involved in ISTC, depending on the level and strategy of development,

mostly regulating knowledge inflow and outflow. There is always a certain inconsistency between independent generation of knowledge and its acquiring from abroad. Independent generation at the high level is possible in case of availability of the developed scientific and technological capacity, which is not available in all countries and which requires long-term costs and complex organization. Acquisition is possible in case of insufficient potential and provides opportunity of fast and less risky knowledge obtaining.

Activation of ISTC in the modern paradigm is combined with intensification of international competition, including rivalry in the sphere of knowledge. Cooperation is regarded as objective necessity or requirement, having indisputable advantages:

- maximization of the results of research-and-development activities on account of pooling resources and efforts;
- achievement of synergy from cooperation of scientific schools with diverse specialization;
- sharing costs and risks, associated with conduct of cutting-edge researches;
- obtaining access to state-of-the-art knowledge, possessed by partners from other countries, international mechanisms for funding research-and-development activities, capital and labor markets, client and technological databases.

In recent decades, more favorable institutional regime of ISTC has been established along with liberalization and globalization. Apart from informatization, advancement of the system of intellectual property protection which has been forming since the end of the XIX century, primarily, based on signing multilateral conventions (Paris Convention for the Protection of Industrial Property, the Hague Agreement Concerning the International Registration of Industrial Designs, Budapest Treaty on the International Recognition of the Deposit of Microorganisms for the Purposes of Patent Procedure) was of particular importance. Establishment of the World Intellectual Property Organization and entering into the Patent Cooperation Treaty became systemically important. This system was taken to a new level within the framework of the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) of WTO, which coincided with the time of active expansion of WTO and collapse of the socialist system. Under TRIPS the developing countries and countries with economies in transition have undertaken reforms of their patent systems and other regulatory mechanisms for intellectual property rights, thereby globalizing their protection regime.

Study of major trends in development of ISTC implies, first of all, analysis of the dynamics of international scientific publications; analysis of the indices of international patenting; estimation of balance of payments for use of intellectual property; evaluation of the countries participation in international programs, etc.

Scientific publications are the most widespread form of knowledge exchange, which, in recent years, becomes particularly important and acquires new parameters because of new trends. There are such processes in the sphere of scientific findings publication as creation of scientific metric databases, introduction of the term "citations", commercialization of publication activities, etc. These processes intensify competition between printed publications and scientists, when the first ones try to get into the scientific metric databases, and the second ones – to publish papers in the journals, included in these databases. Statistical data of Scopus scientific metric database confirm the intensive growth of international publications and citations in the advanced countries and, primarily, in such countries as China and India (Table 1) [10].

Besides, the additional competitive advantage becomes the preparation of international publications that reflect joint cooperation of researchers from different countries. In recent years, the sphere of scientific papers publication is

Table 1 Indices of international scientific publications and citations in a few countries of the word (Scopus scientific metric database)*

	Years				
	2000	**2005**	**2010**	**2015**	**2016**
USA					
Publications	347865	491213	583682	635127	601990
Cited documents	334014	446951	507008	546854	532297
Citation	14743692	15410979	11213337	2490436	740612
Germany					
Publications	86594	121171	147806	165845	164242
Cited documents	84150	113336	134854	150091	149645
Citation	2673398	3138920	2668006	688485	217379

	Years				
	2000	**2005**	**2010**	**2015**	**2016**
France					
Publications	62254	82969	106233	115687	112796
Cited documents	60301	78412	97685	105734	103637
Citation	1896528	2143745	1805037	455848	144019
Japan					
Publications	97514	121403	126190	121840	121262
Cited documents	95961	117645	120473	112922	112645
Citation	2292592	2273329	1542794	349318	109674
Great Britain					
Publications	99627	131188	168732	188882	182849
Cited documents	92367	114487	138568	158968	158513
Citation	3614021	3903608	3125895	785092	248158
Denmark					
Publications	9650	13112	18192	25697	25610
Cited documents	9377	12257	16427	23336	23418
Citation	415003	481794	443757	143053	43568
Sweden					
Publications	18867	24787	30196	38579	38702
Cited documents	18470	23253	27643	34968	35404
Citation	727246	824799	666188	186028	59775
China					
Publications	47349	161947	336824	448221	471472
Cited documents	47193	160991	332772	438110	458299
Citation	538411	1765809	2928177	1383577	440673
India					
Publications	24339	40456	79854	135092	138986
Cited documents	23775	38143	74861	125540	128760
Citation	394197	633016	772358	281588	89952

*Source: [10]

intensively globalized and its significance is growing. It happens, first of all, on account of international citation databases, which provided a powerful impetus for proliferation of publications. Most of the countries, demonstrating activity in scientific and technical development, showed steady growth of the percentage of international publications (Table 2) [3].

It is only since 2010 that we can see positive dynamics in growth of international publications

Table 2 Percentage of scientific publications in different countries*

Country	**Years**					
	before 1991	**1991-1995**	**1996-2000**	**2001-2005**	**2006-2010**	**2011-2016**
Australia	29.18	36.26	42.2	47.09	51.97	51.47
Austria	33.67	37.88	46.8	53.8	60.45	63.02
Belgium	33.37	41.67	48.38	54.7	60.01	62.81
Brazil	20.79	37.71	32.84	28.29	26.71	28.65
Canada	29.78	37.41	44.42	50.25	54.09	52.46
China	40.92	49.15	47.22	41.99	38.46	35.36

Country	Years					
	before 1991	1991-1995	1996-2000	2001-2005	2006-2010	2011-2016
France	26.87	32.58	37.83	44	48.73	51.82
Germany	26.89	32.96	38.5	45.06	49.43	50.6
India	22.73	29.66	34.57	37.45	36.08	24.94
Iran	29.48	53.61	46.97	37.15	33.35	26.57
Italy	21.28	27.04	33.23	38.33	42.96	45.03
Japan	12.69	14.32	18.86	23.96	28.25	29.78
Netherlands	27.11	33.67	40.61	46.97	52.33	56.65
Poland	23.14	32.62	33	32.12	31.94	29.7
Russia	18.51	26.69	32.22	36.43	36.39	31.53
Singapore	49.31	54.18	57.94	63.25	67.96	65.76
South Korea	40.51	40.01	35.94	36.33	36.93	32.36
Spain	24.11	29.46	34.38	38.12	43.99	46.42
Sweden	28.43	38.25	46.65	51.81	58.53	60.86
Switzerland	42.97	51.25	56.99	63.05	67.91	68.13
Taiwan	34.32	35.46	35.09	32.96	33.32	33.14
Turkey	22.11	27.45	25.77	23.39	23.44	21.85
Great Britain	30.68	36.1	42.27	49.29	55.05	56.59
USA	16.08	22.34	27.8	32.85	38.1	38.85

*Source: [3]

in the European countries – from 40 to 73% (Table 3) [11]. Unfortunately, a growth of international publications in Ukraine for the period between 2010 and 2016 made just 32%.

EU shows the highest percentage of international co-publications in total number of publications, leaving behind their major external partner – the USA. Data, provided by Rathenau Instituut (Web of Science/CWTS), also confirms the leadership of European countries. High

Table 3 Number of international scientific co-publications*

	Years							Growth rate
	2010	2011	2012	2013	2014	2015	2016	2016/2010
Switzerland	1918.7	2072	2233.4	2384.9	2481.8	2580.6	2798	1.46
Austria	890.2	971.9	1037.6	1123.8	1179.9	1236.8	1335.9	1.50
Belgium	989.1	1065	1126.6	1221.1	1295.6	1369.5	1408.1	1.42
Denmark	1291.8	1443.2	1592.5	1739.9	1892	2087.7	2228.9	1.73
Sweden	1258.4	1350.3	1470.1	1584.5	1678.6	1794.1	1938.8	1.54
Norway	1120.8	1237.7	1360.2	1422	1532.7	1608.4	1760.2	1.57
Netherlands	1045.1	1123.4	1257.2	1349	1399.3	1464.7	1569	1.50
Finland	1027	1094.3	1183.6	1285.1	1414.5	1499	1576	1.54
Ireland	808.2	877.1	909.5	991.3	1050	1092.7	1196.7	1.48
Great Britain	756.7	808	861	942.7	992.6	1069.4	1151.3	1.52
France	517.6	549.5	575	614.8	632.9	656.6	700.2	1.35
Germany	553.4	603.7	640.6	682.4	704	735.5	778.2	1.41
EU (average)	335.5	362.6	386.5	418.6	439.1	463.5	493.6	1.47
Ukraine	45.8	50.5	52.1	55.1	59.5	58.4	59.9	1.32

*Source: [11]. Number of scientific publications where at least one co-author is from abroad (where the co-author from abroad is not an author from the EU member country for EU28). Data from Web of Science, provided by CWTS under the contract with DG Research and Innovation.

dynamics of international publications is shown by the countries of Northern Europe and small European countries, which are characterized by high degree of internationalization due to small scale of internal cooperation (Table 4) [12; 13].

The data presented shows strongly marked trend towards growth of the number of scientific publications, prepared within the framework of international cooperation. It is typical for the developed countries and for the most active developing countries. The growing number of scientific publications confirms the trend towards enhanced cooperation in the sphere of fundamental researches.

Table 4 International co-publications in selected countries*

Country	Joint international publications as share in total publications*, % 2012 - 2015	Joint international publications, pcs 2014 - 2016
Switzerland	69.2	1227
Austria	66.7	832
Belgium	65.2	696
Dania	61.8	1731
Sweden	61.8	2358
Norway	61.4	–
Netherland	59.5	1646
Finland	59.4	854
Ireland	58.9	302
Great Britain	57.9	2826
France	56.0	1707
Germany	53.3	2356
Australia	51.5	1113
Canada	50.6	1219
USA	35.5	3426
Japan	29.4	789
South Korea	28.9	229
China	24.7	988

*Source: [12, 13]

Patent statistics confirms and demonstrates the enhancement of international knowledge flows and cooperation. Until 2014 the amount of foreign property in domestic inventions and domestic property in inventions, produced abroad as well as the number of patents, developed jointly with foreign co-author, have been steadily increasing throughout the world. According to experts of Thomson Reuters, 70-90% of new knowledge is available in the patents; therefore, patenting indices are the most critical factor in assessment of international scientific activities. Data, shown in Table 5, demonstrates total dynamics of the indices of intellectual property registration and its distribution by regions of the world.

The last decades an intensive growth of international patenting have been observed and that was enabled by R&D internationalization processes and globalization in knowledge commercialization. The central role in the

Table 5 Intellectual property distribution by regions of the world*

	Years				
	2005	2010	2013	2014	2015
Africa					
Industrial designs	17700	16200	16000	16500	16400
Patents	10900	12700	14800	15200	15000
Trademarks	149700	188800	191900	229100	230500
Utility models	70	130	200	210	260

	Years				
	2005	**2010**	**2013**	**2014**	**2015**
Asia					
Industrial designs	318000	588700	861300	764800	777800
Patents	854600	1028700	1497700	1607500	1785300
Trademarks	1757900	2394600	3482700	3966700	4828700
Utility models	193600	439490	919010	893330	1152630
Europe					
Industrial designs	255600	258700	295000	290100	281500
Patents	326000	343300	346000	346200	360200
Trademarks	1927700	1981700	2042600	1973600	2040400
Utility models	48250	52530	52940	49550	46410
Latin American countries					
Industrial designs	15300	14200	16700	15600	15100
Patents	49800	55200	63400	63800	65200
Trademarks	477800	596600	612800	632500	664200
Utility models	4520	4290	4580	4290	4260
North America					
Industrial designs	30200	34200	41400	41100	46000
Patents	430600	525700	606400	614300	626400
Trademarks	456500	501100	584100	618300	672200
Utility models	-	-	-	-	-
Oceania					
Industrial designs	8000	8900	9900	7900	8400
Patents	30900	31600	36600	33800	35200
Trademarks	123000	139700	152700	159600	173500
Utility models	1060	1460	1670	1520	1840

*Source: [14]

international patenting is played by so called Triad, including patent offices of USA, EU and Japan (United States Patent and Trademark Office, European Patent Organization, Japan Patent Office).

Patent Cooperation Treaty (PCT), which simplifies and reduces the price for protection inventions at the international level, became one of the foundations of modern international patenting system, Patent Cooperation Treaty creates conditions for patents obtaining by non-residents [5]. Statistical data confirms steady positive dynamics in the number of patent applications under this treaty around the entire world (Table 6) [14].

Data of the World Intellectual Property Organization (WIPO) also show a stable growth of

Table 6 Patent applications around the world, 2005 – 2015*

	Years						
	2005	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Patents. Direct system[1]	1340000	1510300	1648300	1813700	1998900	2085100	2263000
Patents. National stage of PCT[2]	362800	486900	509800	542900	566000	595700	624300

[1]*Direct system for submission of individual patent applications simultaneously in all countries (in some cases, regional patents) or Paris route – submission of application to the country within the framework of Paris convention and then submission of application for patent in other countries of the convention.*

[2]*National phase (stage): upon completion of the procedure of PCT, the patents are presented to national patent offices of the countries, where the applicant expects to obtain the patent.*

*Source: [14]

patent applications from residents and non-residents (see Table 7) [14].

In this ratio the number of applications and patents of non-residents and residents is reduced, which is driven by the growth of nationally-directed protection of intellectual property in the developed countries as well as in the developing ones. At the global level the dynamics of non-residents' patenting demonstrates a growth of the scopes of knowledge diffusion. We would like to emphasize that the most powerful developing countries become a special partner in the international patenting as their patenting indices increase in such areas as eco technologies, nature protection activities, water management and struggle against climate change.

During 2005 – 2016 the total amount of made and received payments has generally more than doubled, showing an increase of the world knowledge market, enhancement of the volumes of trade in knowledge and other objects of intellectual property, high-tech goods and science intensive services [15]. Developed countries (OECD) are their major providers and these countries predominantly keep positive balance. Developing countries are predominantly the buyers of intellectual property, including knowledge.

The countries, which are intensely developing show significant positive changes. Southeast Asian countries show dynamic inflow of knowledge, which shows the positions in the international division of labour and strategic growth prospects of the region. South Korea is an active consumer of knowledge. A balance between knowledge acquisition and increase in the volume of merchandise export is the evidence of its turning into even more powerful centre of knowledge management. Poland, which has been transformed from net importer into exporter of intellectual property, is an interesting example.

The importance of ISTC informatization process development should also be mentioned as far as modern ICT form a basis for creation of new optimal international regimes of ISTC. It is ICT that form dynamism and ensure fullness of ISTC, ensure dissemination of huge volume of diverse knowledge, both scientific and social knowledge. ICT enabled making national boundaries fully transparent and porous. Internet more and more "takes roots" in national systems of science and education, strengthening their information and communication component and facilitating their progression to the global level. ICT change organization of science, based on new interaction mechanism. Development of special information portals, websites, databases, etc. is an evidence of information infrastructure creation in the sphere of knowledge. For the last two decades, such infrastructure radically transformed the systems of scientific and technological information (elements of the infrastructure will be considered below).

With expansion of ICT use, network models of interaction between communities are becoming more predominant and their new type emerges – network communities, which are mostly informal, are created and function based on self-organization and today's social media in the Internet (both general and professional). Communities of intensive knowledge can be created around one subject area of science, certain technology, innovation, centre for researches, group of researchers and international programs. Such structures can achieve significant sizes and have impact on scientific sector of a certain country.

Many large universities establish network communities in different areas of research, which are focused on development of ISTC, for example:

- Interdisciplinary Network «A Global Network for Dynamic Research and Publishing», Oxford University, Great Britain;
- Research Network «New Directions in the Humanities», University of Illinois, the USA;

Table 7 Number of the patent applications submitted by residents and non-residents, and patent grants by these residents and non-residents (2005-2015)*

	Years						
	2005	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
	Number of patent applications, including						
Total by residents	966151	1161547	1291997	1441507	1625381	1713208	1862548
Total by non-residents	590061	673074	713149	743933	771081	793697	809702
ratio**	0.61	0.58	0.55	0.55	0.47	0.46	0.43
	Number of patent grants, including						
Total by residents	1038800	1236900	1365200	1519800	1709000	1799400	1972800
Total by non-residents	664000	760300	792900	836800	855900	881400	914500
ratio**	0.64	0.61	0.58	0.55	0.50	0.49	0.46

* Source: [14]

**ratio between the number of applications, submitted by non-residents, and number of applications, submitted by residents.

- Research Network «Technology, Knowledge & Society», University of Toronto, Canada;
- Academic Organization for Advancement of Strategic and International Studies (Academic OASIS), the USA;
- International Academy for Advancement of Business Research (IAABR), the USA;
- Global Science and Technology Forum, Singapore.

Such network structures organize cooperative researches, are involved in analytics and forecasting, hold conferences, training seminars, training and courses, render consulting services.

One of the basic phenomena in the sphere of ISTC is R&D internationalization, which covers R&D by request, and well as cooperative R&D (for example, based on research programs and grants). In recent years, as a result of R&D internationalization, new innovative areas (science parks, agglomerations, etc.) have been forming and scientific and research outsourcing has been developing which becomes a global phenomenon in the sphere of knowledge. Outsourcing can also be considered as a stage towards formation of GIS and a part of GIS as well as within the framework of trade in services. The special legal and organizational enforcement mechanisms and its varieties (expert networks, temporary teams, consulting services, etc.) are also required. Outsourcing has a significant impact on corporate structures of R&D, and it is described by a number of operations, has the respective advantages and disadvantages.

An internationalization of university activity, which has also been dynamically developed in recent decades becomes a critical phenomenon. Universities remain to be the major centre for obtaining and reproduction of knowledge, conduct of fundamental and applied researches, and they perform indispensable functions of knowledge dissemination through education. At the same time, their role in the innovative processes is expanding, including on account of university entrepreneurship development. Universities, as an integral element of innovation systems, join international processes, become independent subject of competition and cooperation at the global level [1; 6; 8; 9].

The basic forms of internalization of university activities are, as follows [7; 16]:

- Partner programs to conduct cooperative R&D and implement education projects;
- Umbrella agreements on cooperation of universities;
- Establishment of diverse partnerships and associations;
- Joint creation and/or exploitation of common objects of R&D infrastructure;
- Joint participation in international programs and obtaining of grants;
- Scientific co-publications and international publications;
- International scientific teams;
- International research consortiums;
- Interactive information systems.

Among the specific examples of university cooperation in various firms, we can distinguish the following ones: Regional Network for Education and Training in Nuclear Technology STAR-NET (12 universities from 6 countries); Turkic Universities Union (16 universities from 4 countries); Association of Universities of Asia (42 universities from 8 countries); International Association of Universities founded by UNESCO (616 institutions from 120 countries); International Association of Universities (650 universities from 130 countries); Eurasian Universities Association (139 universities from 13 countries); Global U8 Consortium (8 universities from 7 countries); International Network of Universities; Inter-university Consortium for Political and Social Research (759 universities from 34 countries); League of European Research Universities (21 universities from 10 countries); European University Association (850 participants from 47 countries). Despite a huge variety, these organizations are focused on harnessing unique advantages of cooperation and expansion of the global role of universities. Creation of the global system of monitoring of university international activities is also natural [17].

The European example distinguishes a few types of international organizations, as follows:

- International research centres (e.g., European Organization for Nuclear Research, Institut Laue-Langevin, European Southern Observatory, European Centre for Medium-Range Weather Forecasts);
- International associations of research and technology organizations (European Association of Research and Technology Organizations);
- International communities (European Association for Research on Plant Breeding);
- international laboratories (European Molecular Biology Laboratory);
- international agencies (European Space Agency);
- forums (Forum of European Intergovernmental Scientific Research Organizations);
- organizations to support researchers (European Molecular Biology Organization);
- consortiums (European Consortium for the Development of Fusion Energy).

Therefore, international scientific organizations function in Europe as a new phenomenon of ISTC and they have been transformed into a standing subject of the system of international relations with a certain sphere of competences and the extending range of functions. Such organizations

have their own resources, institutional capacity, bureaucracy and their impact on national policy of member countries is increasing. Such organizations develop a part of international policy of cooperation and coordination where the participation of state is secondary.

A separate mechanism of cooperation, which is more widely used in the worldwide practice, is represented by international programs of scientific researches and their support, being the basis for organization of ISTC. The most striking example is the multi-year framework programs of EU (at the moment it is the Horizon 2020), which is specially focused on activation of ISTC not only in the member countries of EU, but also in the other countries of Europe and the entire world. Multiple large national and international organizations have international research programs as a plan of joint researches.

ISTC is the key element of the innovative system of EU. The following structures and mechanisms are specially focused on development of ISTC: European Research Area, Innovation Union and European Strategy Forum for Research Infrastructures. Technological platforms and framework platforms, namely Horizon 2020 (Table 8) become the critical tool of ISTC.

At the modern stage, information platforms (portals), having an independent meaning or servicing organizational mechanisms, creating a number of advantages (cutting interactive and information costs, enhancing the degree of coordination, Big Data search capabilities, etc.) acquire a critical importance for development of ISTC. Increasing significance of information platforms is owing to the needs in intensification and expansion of the actors, engaged in cooperation that, in its turn, is associated with dynamism of

Table 8 National participation in Horizon 2020*

Basic list	The number of projects on Main list	Planned contribution of the European Economic Community for projects on Main list, Euro	Average project financing, Euro	Number of participations in projects according to the Main list	Average subsidy, Euro
All countries	31951	23 638 395 547,18	739 832,73	55 705	424 350
EU 28	14178	21 932 700 566,63	1 546 953,07	49 729	441 044
EU 15	11971	20 784 810 468,38	1 736 263,51	45 073	461 137
EU 13	2207	1 147 890 098,25	520 113,32	4 656	246 540
Associated countries	1188	855 975 124,04	720 517,78	1 727	495 643
Candidate countries	506	194 410 537,89	384 210,55	729	266 681
Third countries	1901	655 309 318,62	344 718,21	3 520	186 167

*Source: [18, 19]

science and innovations development. On the other hand, it is a result of opportunities, provided by modern ICT and Internet, which enabled activation of international knowledge flows. It is ICT that allowed ensuring stability of external interactions on a global scale, including interaction between individuals and encompassing a wide range of the areas of cooperation. ICT are considered as a driver of ISTC development and formation of new partnership and communication culture.

Information platforms can ensure bilateral (e.g., platforms: EU-USA, EU-India, EU-Ukraine) and multilateral cooperation (internal EU information systems, ensuring functioning of European Research Area).

The following forms of cooperation can be created based on the Internet:

- platforms for cooperation with involvement of universities and business;
- virtual network research structures;
- scientific teams, expert communities (virtual, network);
- databased of scientific and technology information, researchers, projects, solutions, etc.;
- professional social networks;
- scientific media;
- open data sharing (open data).

Informatization brought organization of science conferences and other events, education programs, search for scientific and technology information and partners for R&D to a new level. In the ISTC sphere ICT are involved not just in organization of communication, but also in performance of special operations, primarily, in the area of data sharing in the course of scientific researches. A special infrastructure of data processing and sharing (e-Science central, labs, data factory) is created for this purpose and it is represented as a network environment for researches.

With advancement of information environment, integrating national systems of science and

education, one could speak of consolidation of the world system of knowledge as a set of special structures and institutes, maintaining the transition of global economy to knowledge economy. At least, we can say about the progress in a number of spheres and areas of such system formation, in particular, development of international organizations and protection of intellectual property.

Formation in EU of a Single Information Space, created by diverse services and systems (CORDIS, information websites, activities within the framework of Innovation Union, etc.) and representing an independent mechanism of innovation policy, is of major importance. Moreover, the innovative policy of EU includes European regional scientific and technological organizations, where EU is direct or indirect (through member countries) participant. Consolidating factors of EU innovation system are represented by the system "Four freedoms" (mobility of capital, goods, services, labor), integration of education systems based on Bologna process as well as active supranational innovative policy of EU with wide range of priorities and methods of support.

5 Conclusions

Consequently, the major trends in development of global processes of international scientific and technological cooperation are, as follows:

1) development of global system of ISTC, including international legal institutions and organizations, information infrastructure, legal regimes and mechanisms;
2) increase in the volumes of international transfer of technologies and ISTC as a whole; intensification of knowledge flows (in comparison with XX century) between regions of the world, between developed and developing countries as well as inside the groups of developed and developing countries;
3) dissemination of network forms of communications and expansion of exchange through professional, entrepreneurial and innovation networks as well as via university networks, which develop a new scientific organization at the international level; all the above-stated networks have spatial, time, functional and information characteristics as well as diverse effects (synergy, accumulation, coordination, etc.);
4) strengthening of positions of non-government agents in ISTC system, first of all, transnational corporations, national companies and universities; small and medium-sized business becomes actively involved in the sphere of ISTC; it is related to sale of patents on both primary and secondary markets, identifying interests and problems of business;
5) growth of international knowledge sharing in the sphere of business that is also related to entrepreneurial and innovation networks, development of global value chains;
6) expansion of ICT use for implementation and maintenance of ISTC, especially transfer of technologies; informatization is accompanied with intellectualization of the processes of knowledge search and obtaining;
7) expansion of ISTC within the framework of international (cooperative) research projects and programs, focused on science and innovation support; special regimes of knowledge production and sharing have been developed within the framework of international programs;
8) expansion of the role of patent-information systems and information scientific metric databases in the global processes of knowledge sharing.

It appears that the relevant problem to be addressed by further scientific researches should be the study of new contemporary processes, taking place in the sphere of international scientific and technological cooperation. We would like to emphasize the necessity of creating new multilateral mechanisms of ISTC and improving the existing ones, both institutional and information, providing new opportunities and facilitating progress of different countries. It is also required: to enhance coordination and mutual assistance between the countries, to develop new agenda in the context of post-industrial development paradigm, to expand opportunities of the developing countries involvement in global information networks.

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