Indo-Russian collaboration in S&T: An analysis through co-authored publications, 1995–99

The number of co-authored publications is growing steadily worldwide, rising from 7.8% in 1986–88 to 14.8% in 1995–97 (ref. 1). This is largely due to the role of international cooperation, which helps in capabilities development and access to new knowledge in science and technology (S&T)[2]. India's share in internationally collaborated papers is also growing, rising from 6.87% in 1990 to 17.62% in 1998 (ref. 3). Moreover, the list of countries with which India is collaborating is also expanding. India was a collaborating partner with 87 countries in co-authored publications in 1986–88, and this figure rose to 109 in 1995–97 (ref. 1), in the field of S&T. The collaborating partners have been both from the developing and developed world, including countries like USA, Germany, UK, France, Italy, Japan, Russia, China, Australia and Brazil.

In this correspondence, Indo-Russian collaboration in S&T has been analysed through the co-authored publications during the period 1995–99. The study revealed that there were two streams of collaboration; the first was bilateral in which only Indian and Russian institutions/scientists were involved and in the second, scientists/institutions from other countries like USA, UK, Japan, etc. also participated, besides Indian and Russian. It is astonishing to find that out of 355 jointly-authored papers in S&T, a majority of 294 papers had multilateral collaboration, and only 61 were under bilateral collaboration. The study included an analysis of co-authored papers by main fields and sub-fields and the impact of such collaboration in different fields, and identification of major participating institutions involved in collaborative research, and also provided a few suggestions for improving further collaboration between the two countries.

India has strategic ties with Russia since long and informal contacts between Russian and Indian scientists started as early as 1920s. However, it was only in 1960, that a formal agreement on the Cultural, Scientific and Technological Cooperation was signed. It shifted the focus of cooperation between the two countries from the ordinary exchanges of scientists to formulation of joint projects in selected areas. On 9 August 1971, the historical Treaty of Peace, Friendship and Cooperation was signed, which laid a strong foundation of cooperation between the two countries in the areas of economy, science, technology and culture. As a follow-up of this Treaty, an Inter-Governmental Soviet-India Joint Commission on Economic, Trade, Scientific and Technical Cooperation was set-up in 1972. A Joint Working Group on Science and Technology, set up subsequently, coordinated all the activities in this area.

The S&T cooperation between the two countries received a boost with the launching of Integrated Long-Term Programme (ILTP) in 1987 by the then Prime Minister of India and the then Secretary General of CPSU. This cooperation was strengthened further when the visiting Russian President Vladimir Putin and the Indian Prime Minister A. B. Vajpayee signed the 'Declaration on Strategic Partnership between India and Russia' on 3 October 2000 at New Delhi. The agreement provided an extension to ILTP up to 2010 (ref. 4).

Since 1987, Indo-Soviet Union (now Russia) cooperation has proceeded along two streams. Under the first stream, the cooperation has been at an informal level among individual scientists and at a formal level through specific agreements between S&T academies and research agencies of the two countries. Setting up of working groups in early 1990s in different broad fields further broadened S&T activities and also evolved a centralized structure for coordinating these activities. These Joint Working Groups were set up initially in areas of building materials, meteorology, oceanography, standardization, certification and metrology, and agricultural research, and were later extended to medical sciences, biotechnology, and industrial realization of high technologies. These Joint Working Groups helped in the formulation and implementation of joint R&D projects, programmes of economic relevance based on effective utilization of the S&T potential of the two countries, organization of S&T seminars and exhibitions, and exchange of scientists and scientific information.

Under the second stream, the cooperation has been continuing since 1987 under the framework of ILTP, a centralized programme coordinated, funded and sponsored by both the governments. This programme was initiated with the twin objectives of creating new technologies, equipments and materials needed for the economic development of the two countries. At present, it includes projects under 12 thrust areas of S&T, namely biotechnology and immunology, engineering materials, electronic materials, lasers, catalysis, space science, physics and technology of accelerators, water prospecting, computer and electronics, biomedical sciences, radio electronics, and ocean science. In addition, the programme includes projects for basic research under six select areas in science, mathematics, applied mechanics, earth sciences, radio-physics and astrophysics, ecology and environment, chemical sciences and biology. Till 1999, a total of 144 joint projects were completed and about 1485 Russian and 955 Indian scientists had undertaken exchange visits under this programme[5].

In addition to this bilateral cooperation, India and Russia are jointly participating in a number of international programmes of United Nations and other international agencies such as UNESCO, UNDP, WHO, IAEA, etc. in different areas of science and technology[6].

Joint research publications have been the natural output of these bilateral and international collaborative programmes between India and Russia. Here an analysis of 355 co-authored research publications of Indian and Russian scientists, published in international journals covered by the *Science Citation Index* (*SCI*) during the period 1995–1999 is presented. *SCI* has been selected because it covers more than 4000 main journals published worldwide in major fields of S&T. The publication data downloaded from *SCI* have been classified according to the procedure developed by CHI, Inc., USA. The impact of collaborative papers has been studied indirectly through the impact factor of the reporting journals, for which the data were culled from *Journal Citation Reports*, published by ISI, Philadelphia, USA.

It has been found that under the bilateral category (involving at least one

Indian and one Russian institution), there were 61 co-authored papers, which accounted for only 18% of the total output during 1995–1999. The remaining 294 were multilateral papers and involved the participation of India, Russia and 40 other countries.

The subject-wise distribution of 355 co-authored papers by Indian and Russian scientists has shown that the major collaboration had been in the area of physics, with 274 papers (77%). The remaining 81 papers (23%) were distributed as follows: earth and space sciences (28 papers), chemistry (17 papers), engineering and technology (11 papers), biomedical research (11 papers) and clinical medicine (8 papers).

The impact of co-authored papers varied from 0.5 to > 12.0. The average impact factor of all the co-authored papers was computed as 3.3. The impact of co-authored papers differed from discipline to discipline. Except for multidisciplinary science papers, the impact was high (4.78) in clinical medicine, followed by 3.58 in physics, 2.97 in biomedical research, 2.24 in earth and space sciences, 1.75 in chemistry, 0.67 in biology, and 0.52 in engineering and technology.

A total of 67 Indian and 81 Russian institutions participated in collaborative research during this period. The leading collaborating institutions from India were Tata Institute of Fundamental Research (TIFR), Mumbai (189 publications), Punjab University, Chandigarh (99), University of Delhi (70), and University of Jammu (31). The major collaborating institutions from Russia were Institute of Theoretical and Experimental Physics, Moscow (131 publications), Institute of Nuclear Physics, St-Petersburg (104), MV Lomonosov State University, Moscow (81), Institute of High Energy Physics, Provonio (76), Joint Institute of Nuclear Research, Dubna (42). On the whole, the institutional participation from India was widespread as it involved most funding agencies like DAE, DOS, DRDO, CSIR, DST, UGC, etc.

There were 40 institutions in India and 55 in Russia that produced only 'one' paper during this period. The collaboration was in clusters of institutions, varying from 2 to 5 per paper. Two specific clusters, viz. '*one* Indian and *one* Russian institution' and '*one* Indian and *two* Russian institutions' accounted for 239 co-authored papers out of 355.

Coming to bilateral papers first which were 61 out of 355, it is found that these were distributed across four major disciplines: physics (38%, 23 papers), earth and space sciences (20%, 12 papers), chemistry (18%, 11 papers), and engineering and technology (15%, 9 papers). The average impact factor of these papers varied from 0.15 to 2.37. As many as 88% of all bilateral papers have been reported in journals having impact factor less than 1.38, the average impact factor of all bilateral papers. The impact factor was highest (2.37) in earth and space sciences, followed by 1.90 in chemistry, 1.26 in biomedical research, 1.06 in physics, and 0.49 in engineering and technology.

The number of Russian and Indian institutions involved in bilateral collaborative research, contributing papers in the range of 1 to 7 is given in Table 1.

A majority of institutions, 95 Indian and 40 Russian contributed only one collaborated paper during this period. There were only 11 Indian and 7 Russian institutions, which contributed papers in the range of 3–7. Conversely, one Russian and one Indian institution cooperated in majority of the papers (45 out of 61). One Indian and 2 Russian institutions cooperated in 9 co-authored papers, 2 Indian and 1 Russian in 5 co-authored papers, and 3 Indian and 1 Russian in 2 co-authored papers.

The major Indian institutions involved in bilateral collaborative research were: Center for Advanced Technology (CAT), Indore (5 papers); Physical Research Laboratory (PRL), Ahmedabad (5 papers); National Physical Laboratory (NPL), New Delhi (5 papers); IUCAA, Pune (4 papers); TIFR, Mumbai (3 papers); Indian Institute of Chemical Technology, Hyderabad (3 papers); B.M. Birla Science Centre, Hyderabad (3 papers); Indian Institute of Science, Bangalore (3 papers); and Indian Institute of Technology (IIT), Madras (3 papers).

Table 1. Number of Russian and Indian institutions involved in bilateral collaborative research

Cluster in joint publication	Number of institutions involved	
	Indian	Russian
1	19	26
2	5	7
3–7	11	7
Total	35	40

The strength of bilateral collaboration between any two institutions depends upon the length and output of collaborative research. There are only a few pairs of institutions, which produced three or more collaborative papers. These were CAT, Indore and PN Lebedev Physics, Institute, Moscow (4 papers); PRL, Ahmedabad and Vernadsky Institute of Geochemistry and Analytical Chemistry, Moscow (3 papers); B.M. Birla Science Centre, Hyderabad and Joint Institute of Nuclear Physics, Dubna (3 papers); and IIT, Madras and Institute of Material Superplast Problems, UFA (3 papers).

Now let us look at the multilateral papers (294 out of 355). The discipline-wise distribution showed that physics was the main discipline for collaboration with 251(85%) papers. The remaining 43 papers were as follows: 16 in earth and space sciences, 9 in biomedical research, 8 in clinical medicine, and 10 in all other disciplines.

The collaborative research at multilateral level assessed in terms of impact factor revealed that 74% papers were published in journals having impact factor above the average value of 3.73 for all journals reporting multilateral papers. Though the value of the impact factor varied subject-wise, it was high in clinical medicine and physics.

The 40 collaborating countries (including India and Russia) under multilateral research collaborated in teams of different sizes, varying from 3 to 25 countries per co-authored paper. Clusters formed by 10 to 25 countries accounted for 49.25% co-authored papers, and those formed by 3 to 5 countries accounted for 31.55% co-authored papers. As could be expected, USA was the leading collaborating partner in the multilateral research, recording its presence in 81% publications. France, South Korea, Germany and Switzerland were the other collaborating partners showing their involvement in 51–80% papers. It was interesting to note that Italy, China, and the Netherlands were also involved in 41–50% publications. The average number of institutions involved per paper was 15.67 for USA, 14.24 for Italy, 5.53 for Switzerland, 4.91 for the Netherlands and 3.62 for Germany. USA, Italy and Germany were leading with the first institutional author in 70% publications. Indians and the Russians appeared as the first institutional authors in only 14% publications.

Among multilateral research output, R&D institutions from nearly 40 countries collaborated in clusters of sizes varying from 3 to 72 institutions per paper. The clusters formed by 41 to 72 institutions accounted for 50% papers, and those formed by 3 to 10 institutions accounted for 30% papers.

Even as both India and Russia are potentially and scientifically strong for making bigger contributions, their cooperation at the bilateral level in terms of quantity and quality publications is still weak. Institutional participation is also low, as it remained confined to two institutions per paper only. Physics and earth and space sciences were the preferred areas for collaborative research at the bilateral level. Within physics, 93% output pertained to papers in nuclear and particle physics, general physics, and applied physics. This may be attributed to the strong interest India and Russia share in defence, space, aeronautics and nuclear research for which physics provides the base. In terms of impact, the earth and space sciences and chemistry have shown better performance and received above the average impact of all disciplines. These two disciplines occupied 1st and 2nd rank under bilateral research compared to their 4th and 5th rank under multilateral research. It suggests that the impact of bilateral co-authored papers in these two disciplines was good and comparable to international standards. The low output from bilateral research might have been due to the applied nature of joint research, which sometimes leads to outputs such as technology development, normally not documented for public consumption.

The collaborative research at multilateral level involving participation of India, Russia and other countries has been relatively better in terms of impact compared to bilateral research. The study shows that participation by as many as 40 countries of the world along with India and Russia in collaborated research could be instrumental in influencing high-impact research output. In multilateral papers, India and Russia were apparently secondary players. The key players were USA, Italy and Germany. They were the first authors in about 70% of co-authored multilateral papers. India and Russia were first authors in just about 14% co-authored papers. The impact of multilateral papers was quite high. About 74% of multilateral papers had an impact factor higher than the average value of all multilateral papers. The top two major disciplines under multilateral research were clinical medicine and physics.

In order to make collaboration between India and Russia more effective, there is a need to understand the shortcomings in the mechanism of participatory research by Indian institutions. This mechanism needs to be modified in the light of the changing priorities of the two countries in S&T. For promoting collaborative research, both Russian and Indian institutions may offer more fellowships, travel grants, etc. to researchers. There is also a need to extend the scope of cooperation to frontier areas of S&T, particularly to those areas where Russia has a strong base.

The findings reported in this study could be of interest to managers in various scientific agencies in planning future collaborations with Russia and nearer home, with other neighbouring countries.

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Rb–Sr isotopic studies of Puga gneiss and Polokongka La granite from Tso-Morari region of Ladakh, J&K, India

The Rb–Sr dating using thermal ionization mass spectrometer coupled with isotope dilution technique is widely used in the studies of granite rocks to understand their petrogenesis and emplacement ages. This technique has been used to carry out Rb–Sr dating of Puga gneiss from Kiagar La and granites from Polokongka La of the Tso-Morari Crystallines in Ladakh Himalaya, J&K.

The NW-SE trending Tso-Morari crystallines lie between Indus Suture Zone to the north and Tethyan Himalaya to the south (Figure 1). The Puga Formation of the Tso-Morari crystallines comprises quartzo-feldspathic gneisses (Puga gneiss), schistose bands, and lenticular bodies of garnet amphibolites and eclogitic rocks. Also, undeformed granite is exposed at several places within this gneissic complex. One such body is observed at Polokongka La forming main outcrop, while several other undeformed granite bodies of variable size have been encountered at various places in the higher regions of Tso-Morari gneisses (cf. Girard and Bussy[1]). For many decades, the Puga gneiss was considered to host the medium-to-coarse-grained undeformed Polokongka La granite[2–6]. However, Girard