

Scientometric facts on international collaborative Indian publications

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The upward trend in collaborative S&T research at the international level is significant in the present Information and Communication Technology era. The present study focuses on analysing India's strengths and weaknesses in collaborative research at the international level and collaborative fields are analysed for their macro- and micro-levels. The chronological trend of international collaboration, the collaborative countries, quality of the collaborative publications, collaborative fields, specialization in collaboration, etc. are the main criteria evaluated in the present work.

Keywords: Collaborative research, domains of collaboration, multilateral collaboration, scientometric analyses.

SCIENCE has become increasingly a collaborative endeavour due to its growing complexity and the increasing specialization of scientists¹. The nature and magnitude of collaboration vary from one discipline to another and with the nature of the research problem, the research environment and demographic factors. Also, a high degree of correlation between collaboration and research productivity, and between collaboration and financial support for research is observed². Even though the organizational dynamics of scientific research and technological development is influenced by the political structure and socio-economic factors, science is supra-national in nature. Government initiatives in promoting international scientific programmes and providing funding for projects, etc. encourage collaboration³.

The degree of collaboration at the international level was found to be higher in basic fields of science than applied fields. The extent of international collaboration was inversely proportional to the size of a country's scientific enterprise, and extra-scientific factors such as geography, politics and language played a strong role in determining who collaborates with whom in the international scientific community⁴. Derek J. de Solla Price⁵ had earlier noted that the proportion of multi-authored papers had accelerated steadily since the beginning of the 20th century, and that if the same trend continued, there would be no single-authored paper by 1980. Even after 1980, the same trend has continued and the beginning of the 21st century witnessed a surge in collaborative papers due to the technological advances in Information and Communication Technology (ICT). There are many factors which directly or indirectly affect the collaboration among

nations – economic and educational exchanges with political relationship being the most important⁶. Collaborative research is generally expected to provide a right platform to depict the best expertise available in both the countries. A study by Gupta *et al.*⁷ on India's collaboration in science and technology with Southeast Asian countries points out that sufficient infrastructure and human resources availability are the main reasons for the strong dominance of India's bilateral collaborative research with other countries. It is also possible to use available resources effectively, generally leading to quality publications. However, participation of several countries is related to the use of large facilities/systems and reflects the global trends and may not necessarily share the best expertise available in the countries involved. Basu and Vinu Kumar² tested whether international collaboration has an effect on the impact factor of papers in the case of India publications; the average impact of collaborative papers was compared with the rest. Prathap^{8,9} has discussed second-order indices for assessing the impact of international collaboration in some of the recent studies.

Objectives and data sources

Very few studies have been carried out on the trend of international collaboration of Indian science research. The extent of collaboration cannot be easily determined by traditional methods of survey and observation. Bibliometric methods offer a convenient and non-reactive tool for studying collaboration in research. The objective of the present work is to depict the international research collaborative trend of Indian science and technology with a special focus on quality of the collaborative publications and subject specialization of the collaborative work. *Web of Science* (Thomson Reuters) is the most prevalent

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and highly used database for citation analysis, which is used as a data source for records on collaborative publications of India. The records in *Web of Science* with at least one Indian affiliation in the author field and published during 1991–2010 are considered for the study and citations are elicited for the 1991–2012 citation window. The publications are co-authored by either authors from two countries (India and another country) or more than two countries. The publications of the countries are analysed for their domainary research index (DRI). DRI is defined as the ratio of percentage of publications of a country (c) in a specific field/domain (d) to percentage of publications in a specific field/domain. DRI is formulated as

$$\text{DRI}_{cd} = X_{cd}/Y_d,$$

where X_{cd} is the percentage of publications of country c in field/domain d (e.g. percentage of publications of Canada in chemical sciences) and Y_d is the percentage of publications in field/domain d .

A scientometric analysis report on Canada–US collaborations in clean energy research was published by Foster *et al.*¹⁰, where scientific production and collaborative landscape in the field of clean energy R&D and in three subfields of interest: future generation biofuels, clean energy vehicles and green buildings were discussed and a concept of specialization index (SI), similar to DRI, was applied.

Results and discussion

The *Web of Science* bibliographic database (period 1991–2010) has 492,403 bibliographic records where at least one author is from India. Among these, 71,792 (14.58%) records are collaborative in nature with other countries. The internationally collaborative publications are further analysed according to the objectives of the study and the results are discussed in the following sections.

Growth of international collaborative publications

India's share in international collaborative publications is growing linearly, rising from 4.56% in 1991 to 22.77% in 2010. The number of citations per publication (both collaborative and without collaboration) is 7 and the number of citations per publication without collaboration and collaborative publications is 6 and 12 respectively. The study has categorized the bilateral collaborative publications into 11 macro-fields and 75 micro-fields based on *Web of Science* categories. Chronological trend of international collaborative publications as shown in Figure 1 reveals that even though there is growth in the number of publications in environmental sciences, geological sciences, agriculture and mathematics, it is many-fold in

other fields. When the physics field is considered, the average growth in the number of internationally collaborative publications is 90%.

Disciplinary collaborations

Each collaborated discipline is characterized by its own historically determined set of knowledge production parameters, communication practices and governance systems that collectively determine the shape, size and dynamics of research collaboration patterns. The trend of Indian collaboration in each field is given in Figure 2. More than 65% of collaborations had occurred in the fields of physical sciences, medical sciences, chemical sciences and biological sciences. The quality of the collaborative publications is assessed based on citations per publications in all the 11 macro-fields. This is shown in Figure 3 with a benchmarking with the overall quality of the collaborative publications. Publications in dynamic areas could make good impact on researchers, even though it is not advisable to make comparisons between subject areas using citations per publication.

Collaborative countries

Collaboration patterns and processes are likely to be country-specific up to a certain degree. Small and less-developed countries may be more likely to engage in cross-border collaboration than large, advanced countries¹¹. It is evident from the publications that India has collaborated (at least one publication in collaboration) with 180 individual countries during the period of study. USA, Germany, Japan, England and France are the most favourite collaborative countries and the trend of collaborative publications of the most collaborated 38

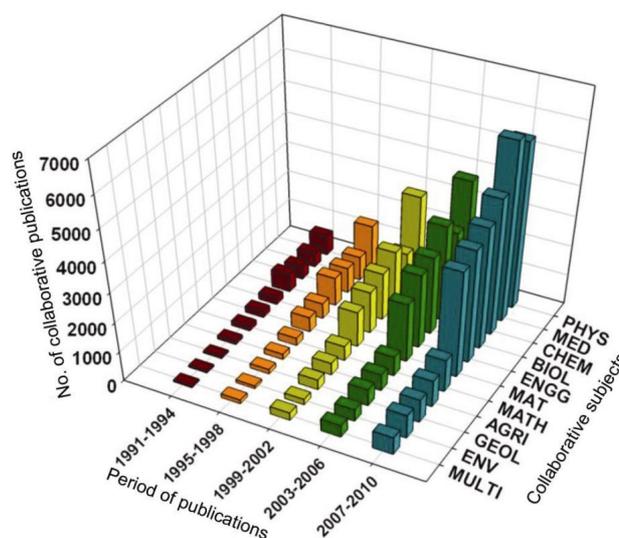


Figure 1. Chronological trend of international collaborative Indian publications in various fields (1991–2010).

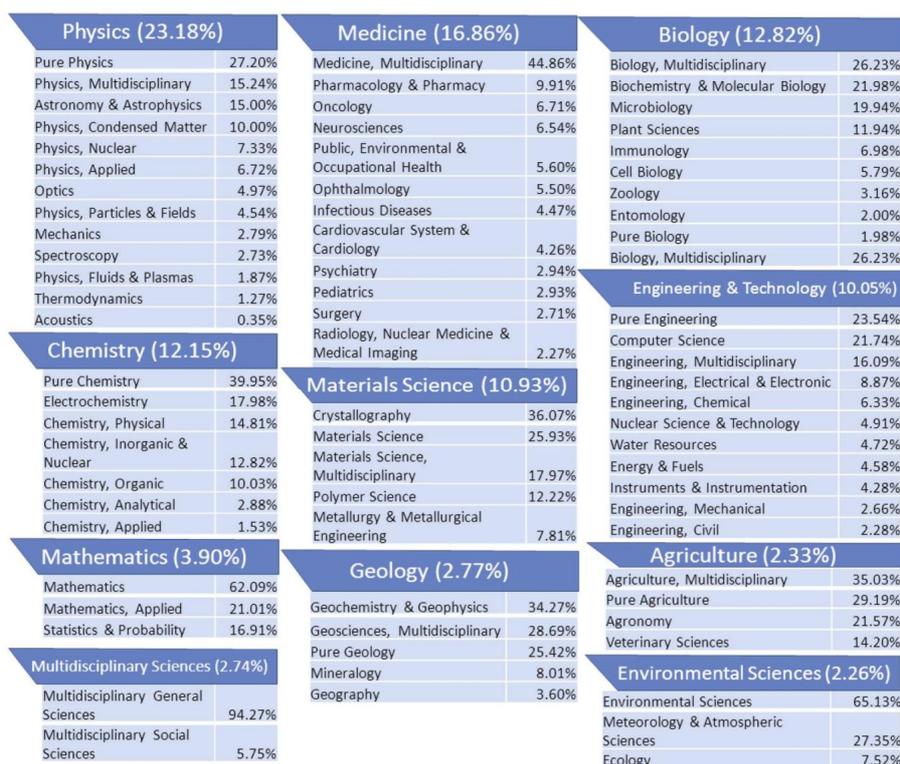


Figure 2. Field and micro-field-wise break-up of collaborative Indian publications (1991–2010; percentage in parenthesis indicate overall value).

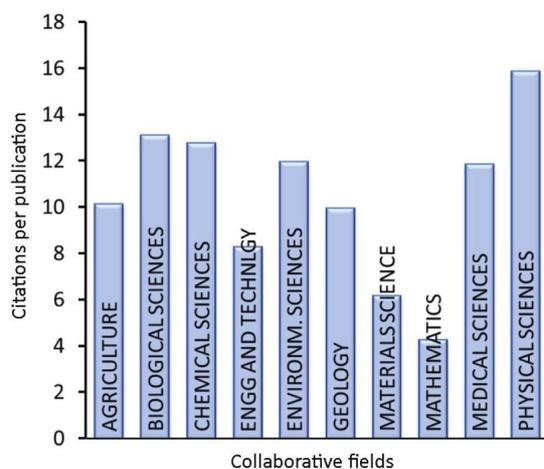


Figure 3. Trend of citations per publication of international collaborative Indian publications across disciplines.

countries (which have at least 500 collaborated publications) is depicted in Figure 4. When the correlation factor is observed between the number of publications and citations per publication, some countries are potentially weak for making bigger collaborations with India, but the level in terms of quality of publications is strong. Though Finland has less number of collaborative publications with India when compared to USA and Germany, the high citations per publication may be due to its publications in high impact factor journals, with average impact factor of 4.12 when compared to USA (2.59) and Ger-

many (2.79). The reason may be that the average number of other countries collaborating with India along with Finland is found to be 9, whereas it is 3 for USA and 4 for Germany. On the contrary, the quantity of collaborative publications with certain countries, especially USA is comparatively high, but the quality is nearer to the overall average.

Domainary research index

DRI measures the field-wise intensity of a country which participated in international collaborative publications. The value of DRI tending to 1 implies that the country is approaching the world average number of collaborations in the specific field and DRI values above one show the subject affinity is more than the world average. Higher the values, higher the specialization in collaboration. The study has calculated DRI of the highly collaborative five countries with India and the intensity is shown in Figure 5. As indicated by the general trend, agriculture is the least favoured area of collaboration among all these five countries.

Conclusions

Despite widespread excitement about dispersed collaboration reflected in terms like ‘virtual team’, ‘eScience’ and ‘cyberinfrastructure’, there remain several challenges

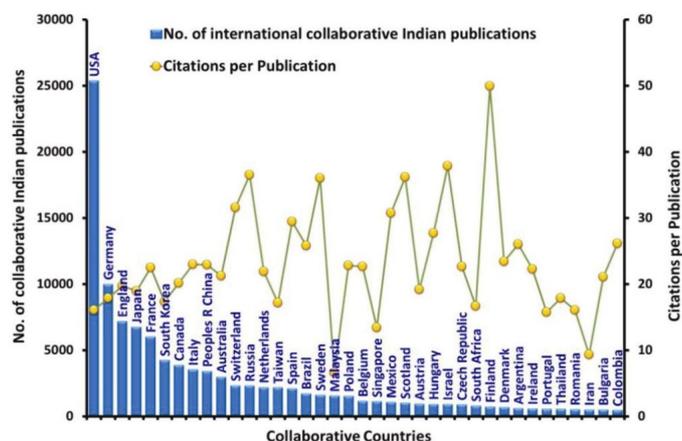


Figure 4. Countries most collaborated with India (≥ 500 collaborative publications) with the number of collaborative publications.

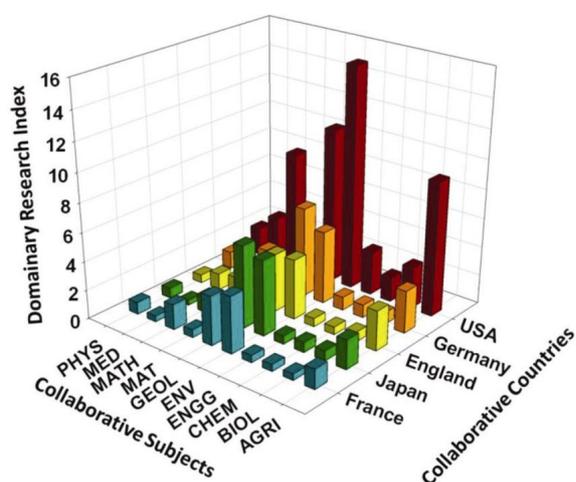


Figure 5. Domainary research index of the five most collaborative countries with India.

that scientists encounter when they work across organizational boundaries¹².

The findings reported in this study could be of interest to those who are involved in the introduction of Indian collaborative research programmes in various disciplines and in the planning of future collaborations with other countries. An upward trend in the number of internationally collaborative Indian publications is evident from the fact that India had only 4.56% internationally collaborative publications in 1991 and it has risen to 22.77% in 2010. Collaborative publications are found to be more qualitative in terms of the number of citations per publication than publications without collaboration. India's broad scientific collaborative nature is evident from the fact that it has collaborated with 180 countries (the number of collaborative publications may range from one to even thousands). USA, Germany, Japan, England and France were the most favourite collaborative countries during the time period 1991–2010. More than 86% of the collaborations happened in physical sciences, medical

sciences, chemical sciences, biological science, engineering and technology, and materials science. The collaborative research trends across macro-fields and micro-fields may be useful to those who allocate funds for internationally collaborative research projects.

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