Journal of Scientometric Research, 2026; 15(1):109-123.
https://www.jscires.org

Research Article

Indo-German Research Collaboration: A Quantitative Analysis of the Research Publications During the Last Three Decades

Jyoti Dua[1], Anurag Kanaujia[2,3,*], Vivek Kumar Singh[2,4]

[1]Department of Computer Science and Engineering, Pranveer Singh Institute of Technology, Kanpur, Uttar Pradesh, INDIA.
[2]Delhi School of Analytics, University of Delhi, New Delhi, Delhi, INDIA.
[3]CSIR-NIScPR, New Delhi, Delhi, INDIA.
[4]Department of Computer Science, University of Delhi, New Delhi, Delhi, INDIA.

ABSTRACT

India's international research collaborations have evolved significantly over the past 30 years. They have become bigger and varied, and India is now interacting with a wide variety of countries than earlier. This paper explores Indo-German research collaboration from 1990 to 2020 to learn how this long-term relationship has progressed, particularly in the context of growth and expansion of Indian research collaborations. Even though Indo-German publications have gained in numbers, they have lost their proportion in the total international cooperation in India. This indicates that India has now expanded its number of scientific partners in North America, East Asia, Middle East, and Europe. The collaboration between India and Germany over time has expanded into many more research fields. It now covers more than 170 Web of Science (WoS) subject categories, although the strongest activity continues to be in Physical Sciences, Life Sciences, and Technology. Over the period, the leadership role of Indian researchers in these collaborated publications has reduced. This is evident in the declining share of Indian first authors and a smaller proportion of papers that include a majority of Indian authors. Citation analysis reveals that Indo-German collaborations yield substantially higher impact compared to India's indigenous publications and other international partnerships, highlighting the strategic value of this bilateral relationship. These patterns suggest the need for targeted policy interventions to strengthen India's domestic research capacity, promote more balanced authorship and institutional participation, and leverage Indo-German collaboration in areas that provide clear impact advantages. The broader implication is that India's global research partnerships are becoming increasingly multipolar, and strategic choices will be essential to sustain both the quality and influence of its international scientific engagement.

Keywords: Indian Science, International Collaboration, Research Collaboration, Scientific Collaboration.

Correspondence:
Anurag Kanaujia
Delhi School of Analytics, University of Delhi, Delhi-110007, INDIA.
CSIR-NIScPR, New Delhi-110012, Delhi, INDIA.
Email: anuragkanaujia01@gmail.com
ORCID: 0000-0002-5813-7427

Received: 08-12-2025;
Revised: 21-02-2026;
Accepted: 02-04-2026.

INTRODUCTION

Research Collaboration has been studied for a long period with several studies identifying and quantifying its types, mechanisms and potential impacts (Katz and Martin, 1997; Bukvova, 2010; and Abramo *et al.*, 2009, 2017). Among the different types namely, Institutional (Intra and Inter), Sectoral (University, Industry, Government), and National (Inter and Intra) collaborations, the International collaboration has been seen as an effective and quick approach to augment the available resources and expertise by exchanging them between collaborating countries (Basu and Aggarwal, 2001; Boekholt, 2009). Over the past few decades research activity in India has rapidly increased and it has become the fifth largest knowledge producer in terms of the number of research publications listed in Scopus (Singh *et al.*, 2020). Along with this, the international research collaboration of Indian Institutions with foreign institutes has also increased (Dua *et al.*, 2023). India has international cooperation agreements with about 83 countries (such as, Australia, Canada, France, Germany, Israel, Japan, Russia, the UK, USA and also with the EU etc.) (International Cooperation Division, DST, 2025). These agreements provide opportunities for collaboration, studies and funding for Indian students, researchers and businesses at globally leading universities, research institutions and laboratories. Existing research exploring the role of international research collaboration includes Measuring and Characterizing International Collaboration Patterns in Indian Scientific

OPEN ACCESS

Manuscript TECHNOMEDIA

DOI: 10.5530/jscires.20262129

Publishing Partner : Manuscript Technomedia. [www.mstechnomedia.com]

Research, highlighting the benefits and impact of such collaborations (Dua *et al.*, 2023). Exploring the impact of International Research Collaboration on the performance of China's world-class universities resulting from its "Double First-Class" initiative (Zhang *et al.*, 2022). and study of experiences of fellows and grant recipients from the National Academies to explore the extent, nature, and value addition of international collaboration and mobility in research (Academy of Medical Sciences, 2017). These papers provide insights about significance and impact of international research collaboration in India (Anuradha, and Urs, 2007), China (Zhang *et al.*, 2022) and UK (Academy of Medical Sciences, 2017) based on a variety of investigative approaches. Previous studies have also looked at the International collaborations of India (Dua *et al.*, 2023), its bilateral collaborations with the US (Singh *et al.*, 2020), and the South Asian countries (Gupta *et al.*, 2002; Dua *et al.* 2023), etc. However, such studies related to major collaborators of India, such as Germany, France, etc., could be found.

India and Germany have well-defined bilateral cooperation agreements with even a dedicated institution Indo-German Science and Technology Centre (IGSTC) looking to promote S&T collaboration between them[3]. The S&T collaboration agreement between the countries was signed 50 years ago, and as a result, Indian and German institutions have a long history of working together. Programs for exchange of students, researchers and research facilities between the two countries include, agencies like Deutscher Akademischer Austauschdienst (DAAD)[4], Deutsche Forschungsgemeinschaft (DFG)[5], Department of Science and Technology (DST)[6], Indian Council of Medical Research (ICMR) etc. Further, Germany is the preferred destination for Indian students and academics with the recent European Student Landscape report estimating the yearly enrollment of Indian students in Germany to be 39,600 in 2023 and projected it to increase to about 114,499 by 2030 (University Living, 2024). Programmes for supporting and sponsoring students at Masters and Doctoral level are fairly common. For instance, several students (56,346) have availed the coveted German Academic Exchange Service (DAAD) sponsorship for their higher studies in Germany (*DAAD* & *DZHW*, 2023). Other programs for S&T promotion include, IGSTC industrial fellowships, Women Involvement in Science and Engineering Research (WISER), Paired Early Career Fellowship for Applied Research (PECFAR), Small Immediate Need Grants (SING) etc. Institutions such as Max-Planck Institute, Freiburg University and several universities are favoured by Indian students. Whereas, the Indian Institutes of Technology (IITs), Tata Institute of Fundamental Research (TIFR) and some central universities are commonly involved in most Indo-German collaborations.[4] However, despite the extensive collaboration landscape, the output of the existing collaborations has not been estimated in terms of its contribution to research. There are several questions which need attention, such as, what is the contribution of this collaboration in India's global international collaboration?, which major fields and subject have highest collaboration?, what is the proportional representation of authors from the two countries?, which are the major collaborating institutions?, and whether the Indo-German collaboration has been impactful? While several studies have analyzed India's international research collaboration at a broad level (Dua *et al.*, 2023; Singh *et al.*, 2020) and some have examined India's bilateral ties with the USA or South Asian countries (Gupta *et al.*, 2002; Dua *et al.*, 2023), no comprehensive bibliometric study has been conducted specifically on Indo-German collaboration across three decades (1990-2020). Thus, in order to fill this gap, this study looks at the research publications authored by researchers from India and Germany during the last three decades (1990-2020).

DATA AND METHODS

The data was downloaded from Web of Science scholarly database from the period 1990-2020 (31 years) using following search query:

CU=India and PY=(1990-2020) and LA=English and (DT=Article or DT=Review)

where CU = country name, PY = publication year, LA = language and DT = Document Type.

The reason behind restricting publication data to 'Article" and "Review" as they are the most representative document types reporting research contribution. The "full record and cited reference" record content type was selected and downloaded in different chunks of 500 records each. Thereafter, the downloaded records were merged together and pre-processed to remove null and duplicate values. The duplicate values were removed based on Digital Object Identifier (DI). This resulted in a final set of 863,204 unique publication records.

The publication record data downloaded from Web of Science (WoS) consists of 60 metadata fields, ranging from basic article related information such as author address (C1), Document Type (DT), Publication Type (PT), etc. To more detailed information such as WoS Category (WC), citations received (Z9) etc. For this analysis, processing of information in metadata fields - DI, C1, WC and Z9 was performed using python programming language. Here DI represents Digital Object Identifier (DOI), C1 denotes author's affiliation, including country, WC denotes the Subject Area and, Z9 contains information about the citations received by the articles.

[1]Australia: https://india.highcommission.gov.au/ndli/Australia-India_Relations.html
[2]Japan: https://www.indembassy-tokyo.gov.in/eoityo_pages/NjI,
[3]IGSTC Annual Report: https://www.igstc.org/images/annual/173322438820241203.pdf
[4]DAAD - German Academic Exchange Service - https://www.daad.de/
[5]DFG - German Research Foundation - https://www.dfg.de/
[6]DST - Department of Science and Technology, India - https://dst.gov.in/international-st-cooperation

To identify country level collaboration, the publication records were categorized into three groups: a) Indigenous - publications with authors only from India, b) Indo-German collaborated - publications with authors from Germany and from India, and c) Internationally Collaborated Papers (ICP) - publications with authors from India and any other country, by processing the country information in the C1 field. A total of 648,475 publication records were identified as indigenous papers, 25,098 were Indo-German collaborated papers and 2,14,729 were Internationally Collaborated Papers (ICP). The proportionate share of these identified categories was analysed and recorded year-wise.

Approach for Data analysis, and Computation of results

The categorised records were analysed to compute the Compound Annual Growth Rate (CAGR) of publications, year-wise pattern in collaborated publications, subject area wise collaboration pattern, major-collaborating institutions in India and Germany. These measures were then used to compute compound collaboration impact indices, namely Relative Intensity of Collaboration (RIC), Productivity Boost (Bp), Citation Boost (Bc), Boost ratio of impact per unit boost in productivity (Yc), Citedness boost (Brc) and Boost ratio of impact per unit boost in citedness (Dc). For these calculations the methodology proposed in Fuchs, Sivertsen, Rousseau, (2021) and Dua *et al.*, (2023) was followed (Figure 1).

To summarise the approach, the following relations were used for the calculations.

$$\text{CAGR}\ (\%) = \left(\left(\frac{Vfinal}{Vbegin}\right)^{\frac{1}{t}} - 1\right) * 100 \qquad \ldots (1)$$

where, V_{final} is number of publication records in the year 2020, V_{begin} is the number of publication records in the year 1990, and t is the time period in years.

$$\text{RIC (X, Y):} \quad \frac{Cxy*(T-Cx)}{Cx*(Cy-Cxy)} \qquad \ldots (2)$$

where, Cxy denotes the number of collaborations between two countries X and Y, Cx is the total number of collaborations of country X, Cy is the total number of collaborations of country Y and T represents the total number of pairwise collaborated publications of countries under study.

$$\beta_P = \left[\frac{TP}{TIP} - 1\right] \times 100\% \qquad \ldots (3)$$

$$\beta_C = \left[\frac{TC}{TIC} - 1\right] \times 100\% \qquad \ldots (4)$$

Where, Total Productivity (TP) and Total Indigenous Productivity (*TIP*) of a country

$$\gamma_c = \frac{\beta_C}{\beta_P} \qquad \ldots (5)$$

$$\beta_{rc} = \left[\frac{r_T}{r_{TI}} - 1\right] \times 100\% \qquad \ldots (6)$$

Where, $r_T = \frac{total\ number\ of\ cited\ publications}{total\ number\ of\ publications} = \frac{TP_{cited}}{TP}$

and, $r_{TI} = \frac{total\ number\ of\ cited\ indigenous\ publications}{total\ number\ of\ indigenous\ publications} = \frac{TIP_{cited}}{TIP}$

and,

$$\delta_c = \frac{\beta_C}{\beta_{rc}} \qquad \ldots (7)$$

RESULTS AND DISCUSSION

Output of Indo-German Research Collaboration

Table 1 reveals period-wise trends in India's publication output, its Internationally Collaborated Papers (ICP), and the proportional contribution of Indo-German collaborations. The research output of India in 1990-1994 was however still minimal with indigenous publication constituting the majority and ICP constituting approximately 13% of the total publications. Indo-German cooperation contributed about 11% of these ICP, which was a stable and yet somewhat minor cooperation. The total publications and international collaborations increased in 1995-1999, the share of Indo-German in ICP also reached its maximum of 14.3%, the largest of the entire period of study, which suggests a comparatively healthy bilateral activity. During the next two years (2000-2004), ICP remained on the rise, but the Indo-German share started decreasing a little as India started to have more partners in the international arena. This pattern is escalating in 2005-2009 and in 2010-2014, when ICP increased steadily by 21% to almost 24%, yet the Indo-German share declined by 14.38% to 12.59%. As of 2015-2020, India had the most collaboration with its international partners, with ICP comprising more than 28% of all publications; however, the Indo-German share is the lowest (10.10%), although the total number of publications has risen. Generally, although the numbers of Indo-German collaborations grew in all periods, the proportion of these collaborations in the international research of India decreased over time indicating the growing and diversifying international research participation in India.

However, in the overall period (1990-2020), the rate of growth (CAGR) of ICP instances (14.97%) and Indo-German instances (14.11%) is higher as compared to the rate of growth of total research output (11.30%).

Figure 2 presents the growth trends of India's internationally collaborative papers and those involving Indo-German collaboration. Three different periods of collaboration growth viz. 1990-1997, 1998-2009, 2010-2020 can be observed with distinct rates of annual growth in publications. During the first period (1990-1997), ICP and IGP grew at a similar rate reaching ~15% of TP and ICP respectively. In the second and third periods however, the growth in ICP outpaced the IGP, indicating diversification of Indian International research collaboration.

Figure 3 provides a more detailed understanding of the proportion of Indo-German share with respect to ICP, plotted

Table 1: Total papers, internationally collaborated papers and Indo-German collaboration share for India (1990-2020).

Year	Total papers	Indigenous		Internationally Collaborated (ICP)		Indo-German share in ICP	
		# of papers	Percentage	# of papers	Percentage	# of papers	Percentage
1990-1994	18594	16091	86.54	2503	13.46	277	11.07
1995-1999	30735	30209	98.29	6113	19.89	874	14.30
2000-2004	65012	51486	79.19	13526	20.81	2136	15.79
2005-2009	116848	91543	78.34	25305	21.66	3638	14.38
2010-2014	215711	164538	76.28	51173	23.72	6443	12.59
2015-2020	410717	294608	71.73	116109	28.27	11730	10.10
Total	863204	648475	75.12	214729	24.88	25098	11.69
CAGR	**11.30%**	**10.37%**		**14.97%**		**14.11%**	

year-wise. It can be observed that the Indo-German share in ICP is only 11.69%. By visualising an area presented in the figure, it can be seen that collaboration between two countries increased during the period 1994-2005, after this period a decline can be observed from 2009-2020. The relative contribution of German publications decreased as the global ICP of India increased in this period.

India's major research collaboration partners

In order to analyse the collaborating patterns of the Indo-German collaboration network, the Relative Intensity of Collaboration (RIC) of India and Germany is computed with respect to their 24 major collaborating partners. RIC is an index that addresses the issue of biasness when the sizes of collaborating partners are highly skewed (Fuchs, Sivertsen, & Rousseau, 2021). It is an asymmetric index that measures the collaboration within a collaboration network.

The RIC plot for India with respect to its major collaborating partners is plotted in Figure 4a. The Relative Intensity of Collaboration (RIC) graphs offer valuable insights into India's key research partners and the evolution of their collaboration trends. The RIC of India with respect to the US, Japan, China, Australia, and Russia shows a similar trend until 1999. In contrast during the period 2000-2020, varying patterns can be identified. We can see that RIC values have declined with respect to Malaysia, South Africa, Brazil, the Netherlands, Sweden, Switzerland, Belgium, Denmark, France, Germany, Italy, Spain and China. On the other hand, RIC values increased for Japan, Australia, England, Canada, Saudi Arabia, Russia, Japan, Poland, Israel, Austria, Denmark and Taiwan. For Poland and Russia RIC values showed a rapid increase until 2018, but it decreased in the last two years.

China's RIC showed considerable fluctuations in the early years before gradually declining, possibly indicating shifts in research priorities and/or political factors affecting its partnership with India. The USA-India collaboration maintained a consistent trend, suggesting stable research collaboration. A notable rise in South Korea's RIC can be observed, reflecting its expanding research engagement, which corresponds with India's increasing scientific and technological ties with South Korea. Meanwhile, Germany and Japan demonstrate steady trends, indicating long-term collaborations that may also involve India. While direct data on India's RIC would provide a more precise comparison, broader trends indicate that India's research partnerships with the USA, Germany, and South Korea continue to strengthen.

The Relative Intensity Collaboration (RIC) graphs for Germany illustrate its scientific research collaboration levels with its top 20 partner countries over time (Figure 4b). The RIC of Germany with respect to the USA, Poland, India, Taiwan, China, Russia, Austria and Malaysia has a downward trend. In contrast, RIC with respect to Japan, Spain, Italy, England, Canada, Netherlands, France, Denmark and Switzerland shows an upward trend. The USA consistently has the highest RIC values, indicating a strong and stable partnership with Germany. This is likely due to the USA's global leadership in research and development, along with well-established academic and industrial connections. South Korea and China show increasing RIC values, reflecting their growing investments in research and their deepening collaborations with Germany. Meanwhile, France and England maintain relatively stable RIC values, possibly benefiting from their geographical proximity. Italy and Canada display moderate to high RIC values, signifying steady research collaboration with Germany, possibly driven by their shared interests in advanced technology and innovation. Italy and Australia exhibit lower but consistent RIC values, indicating ongoing but less intensive cooperation. India, however, shows a noticeable decrease in RIC values, likely due to its expanding research capabilities and research partners across other parts of the world.

Fluctuations in RIC values can be attributed to various factors, such as changes in research funding, policy shifts, global economic conditions, and the formation of new bilateral agreements. Rising RIC values often result from strengthened research initiatives, joint projects, and international conferences, whereas declines may be linked to geopolitical tensions, funding reductions, or

evolving research priorities. Overall, Germany's collaboration intensity with these countries reflects its strategic approach to maintaining robust scientific partnerships with both established and emerging research nations.

In comparing the RIC of both the two countries (India and Germany), it could be observed that while European countries are increasing their collaboration with Germany, the non-European countries which have come to the forefront of scientific research are increasing their collaborations with Indian institutions possibly indicating towards a shift from euro-centric scientific dominance.

Domains of collaboration between India and Germany

Figure 5 presents the number of fields in which India and Germany collaborated. It has been observed that the number of collaborative fields has shown a mixed pattern of growth during the period 1990-2020. The distribution of co-authored papers in various Web of Science (WoS) subject categories is slightly uneven.

In the year 1990, the number of categories in which India and Germany collaborated was below 100. Further, by 2020, the two countries collaborated in more than 170 fields. For instance, Astronomy and Astrophysics; Biochemistry and Molecular Biology; Biology and Chemistry, Multidisciplinary etc., are few fields in which India collaborated with Germany from 1990 to 2020. Acoustics, Agricultural Engineering, Anatomy and Morphology, and Architecture etc., are few fields in which India and Germany have not initially collaborated, but by the end of the 1990s the two countries started collaborating. Classics, Criminology and Penology, Dance, Folklore, Literary Reviews, Literary Theory and Criticism, Literature, American, Literature, British Literature, Romance, Medieval and Renaissance Studies, Poetry, and Music etc., are some fields of WoS in which India and Germany never collaborated.

Major subject areas with high collaboration volume

Table 2 presents the top 10 subject areas (arranged in descending order of collaborated papers) for 252 subject areas provided by Web of Science. It is seen that Astronomy and Astrophysics; Physics, Particles and Fields subject areas have relatively more Indo-German collaborative papers, with 3475 and 3292 respectively. The other top collaborative thematic categories are Material Science, Multidisciplinary; Physics, Nuclear; Physics, Applied etc.

Change in broad subject areas of collaboration over time

The Indo-German collaborative research publications were identified in five broad categories. Table 3 presents the distribution of collaborative research papers for every five broad subject areas over a five-year window. It has been found that collaboration has increased in every window. It is observed that among five subject areas, physical sciences and life sciences and biomedicine have a relatively higher share of publications than the other three (arts and humanities, social sciences, and technology) in Indo-German collaboration.

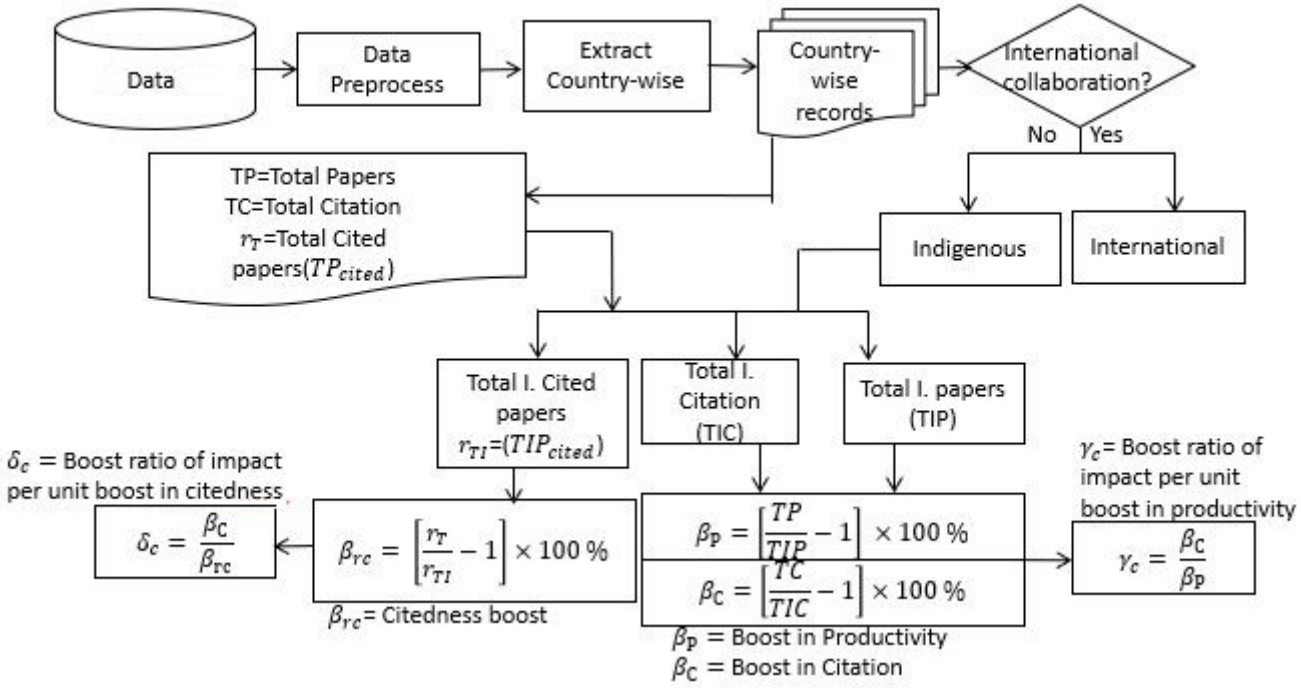

Figure 1: Detailed diagram for the approach and methods used in the study.

As illustrated in Figure 3 representing the growth of Indo-German collaboration in Web of Science subject categories, the disciplinary foundation of collaboration has expanded noticeably and steadily since 1990 to 2020. During the early years, collaboration was limited to less than 100 fields, and most of them were focused on the physical sciences- a fact that is like Table 3 that shows that Physical Sciences and Life Sciences and Biomedicine occupy most of the collaboration volumes during the early years. As Figure 3 depicts the steady rise to more than 170 subject categories by 2020, this broadening aligns with the upward trends seen in Table 3, particularly the significant growth observed in Life Sciences and Biomedicine and Technology after 2005. The emergence of collaborations in new fields such as Acoustics, Agricultural Engineering, Anatomy and Morphology, and Architecture indicates a diversification of scientific engagement that was not present in the early 1990s.

However, despite this expansion, Figure 3 also reveals that some areas do not enter into Indo-German cooperation in particular in the Arts and Humanities and Literature. This can be summed up in Table 3, where Arts and Humanities have registered the least activity and have been the least contributor throughout all periods. Combining Figure 3 and Table 3, one can propose that Indo-German cooperation has developed into a more multidisciplinary, though primarily STEM-oriented collaboration environment. The growing emergence of collaborative disciplines implies greater institutional connectedness and differentiation of research interests, and the continued lack of humanities, as well as some social sciences, is a sign of structural or priority constraints in the partnership. In general, these trends suggest that the scope of cooperation has intensified greatly, but the topical focus is inline with the scientific and technological capabilities of both nations.

Author participation patterns

Table 4 shows distinct shifts in authorship patterns within Indo-German collaborated publications over the six time periods. In the early years (1990-1994), Indian researchers served as first authors in about one-third of the papers (34.30%), and more than half of the publications (49.82%) had at least 50% Indian authors, indicating substantial Indian-led contribution. During 1995-1999, these proportions remained stable, but the period 2000-2004 marked the peak of Indian participation: 42% of papers had an Indian first author, and more than 54% contained at least 50% Indian authors, reflecting the strongest Indian leadership in the collaboration. This trend continued through 2005-2009, when the Indian first-author share rose to its highest level (45.35%), even as the proportion of papers with at least half Indian authors remained around 50%. However, from 2010 onward a clear decline emerged. Between 2010-2014, the share of Indian first authors dropped to 36.63%, and papers with at least 50% Indian authors decreased sharply to 36.18%. The downward trend intensified in 2015-2020, when only 32.53% of papers had an Indian first author and just 27.97% had at least half Indian authors, the lowest values in the entire timeline. Overall, while Indo-German collaboration expanded substantially in volume, the relative leadership and authorship representation of Indian researchers declined after 2010, suggesting shifting collaboration dynamics, larger team sizes, increased participation of German institutions, and broader mobility or diversification patterns influencing author roles within co-authored research. There could be multiple reasons for the decrease, such as shift towards more team-oriented science, mobility of Indian scientists, finding new collaborators etc. Thus, this indicates the knowledge flow participation of Indian authors in Indo-German collaborated papers.

Table 2: WoS categories with high Indo-German research collaboration volume.

WoS Categories	No. of Papers
Astronomy and Astrophysics	3475
Physics, Particles and Fields	3292
Materials Science, Multidisciplinary	2313
Physics, Nuclear	1714
Physics, Applied	1621
Physics, Multidisciplinary	1479
Chemistry, Physical	1423
Biology	1354
Physics, Condensed Matter	1250
Chemistry, Multidisciplinary	1180

Table 3: Indo-German research collaboration volume in different research areas.

WoS Categories	Time Period					
	1990-1994	1995-1999	2000-2004	2005-2009	2010-2014	2015-2020
Arts and Humanities	0	0	6	5	13	77
Life Sciences and Biomedicine	180	415	814	1472	2938	6179
Physical Sciences	346	1146	2484	3755	6161	9694
Social Sciences	5	7	37	76	199	477
Technology	52	192	756	968	1724	3891

Table 4: Nature of authorship in Indo-German collaboration.

Year	Indo-German Collaborated papers	Collaborated papers with Indian first author (%)	Collaborated papers with at least 50% Indian authors (%)
1990-1994	277	95 (34.30%)	138 (49.82%)
1995-1999	874	296 (33.87%)	441 (50.46%)
2000-2004	2136	897 (41.99%)	1153 (53.98%)
2005-2009	3638	1650 (45.35%)	1834 (50.41%)
2010-2014	6443	2360 (36.63%)	2331 (36.18%)
2015-2020	13297	3816 (28.70%)	3281 (24.67%)
Total (1990- 2020)	**25098**	**9114 (36.31%)**	**9178 (36.57%)**

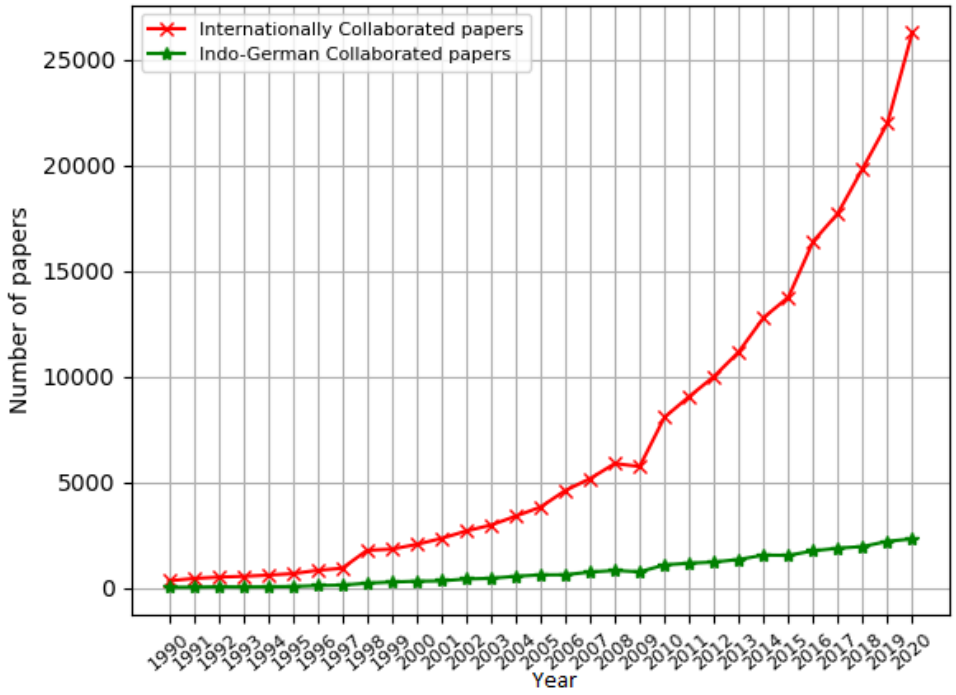

Figure 2: Growth of India's internationally collaborated papers and those involving Indo-German collaboration.

Major Collaborating partner Institutions

For better understanding of the collaboration pattern between Indian and the German institutions, Figures 6a-6c present the collaboration strength between the institutions of the two countries. The three figures present 50 major collaborating institution pairs in the form of a bipartite network, where the left side indicates Indian institutions connected with Germany institutions placed on the right side. The size of a country node varies with respect to the weighted degree of a node. The top 5 Indian Institutions during each period are identified along with their three German collaborating Institutions.

Figure 6a shows the collaborating partners during the 1990s. Tata Institute of Fundamental Research (TIFR), Indian Institute of Science (IISc), and Bhabha Atomic Research Centre (BARC), Physics Research Lab, Banaras Hindu University (BHU) of India were the top five major partners of the German institutions. The top three collaborating partners of TIFR are the Rhein Westfal Technical University Aachen, University of Hamburg, and DESY. IISc has strong ties with the Free University Berlin, Forschungszentrum Jülich, and Philipps University. Similarly, the top three collaborating partners of BARC were the Forschungszentrum Jülich, Johannes Gutenberg University, and University of Munster. BHU collaborated with University Erlangen Nurnberg, University of Munich and Max Planck Institute of Astronomy. Physics Research Lab collaborated with Max Planck Institute for quantum optics, DESY and Ruhr University Bochum.

In the period 2000-2009, the top five Indian Institutions with German collaborators were TIFR, Indian Institute of Science (IISc), BARC, Saha Institute of Nuclear Physics (SINP) and Punjab University (PU). The top three collaborations of TIFR

Table 5: Citation Impact of Indo-German collaboration.

Citation Impact				
	TP	ICP	Non-ICP	Indo-German Collaborated
No of papers	863204	214729	648475	22798
Cited %	86.19	87.47	85.76	90.84
Citations per paper	16.78	22.32	14.95	38.83

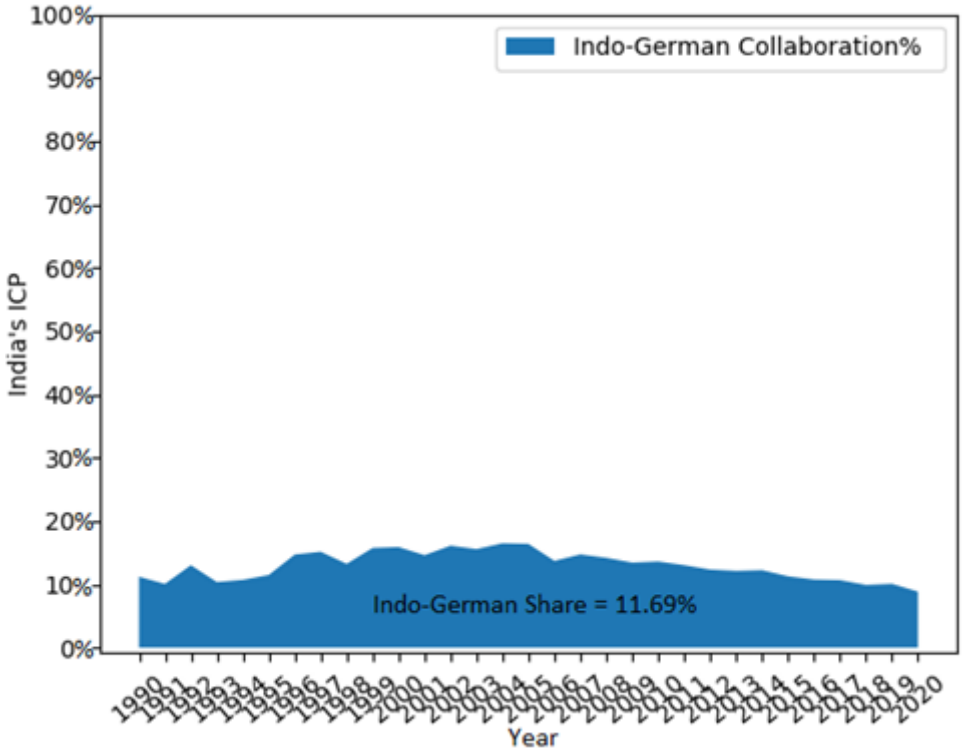

Figure 3: Indo-German Research Collaboration share in India's ICP.

were with University of Aachen, Johannes Gutenberg University of Mainz and University of Bonn. IISc collaborated with Leibniz Institute of Solid State and Material Research Dresden, University of Wurzburg, and Technical University of Darmstadt. Similarly, University of Munster, Max Planck Institute of Physics and Astrophysics, and Goethe University of Frankfurt formed the top three collaborator pairs with BARC. SINP of India formed its pair with Ruhr University Bochum, Max Planck Institute for the Physics of Complex System Dresden and Goethe University of Frankfurt. The PU, collaborated with the University of Aachen, Johannes Gutenberg University of Mainz, and Goethe University of Frankfurt of Germany (Figure 6b).

By the period 2010-2020, many new Indian and German institutions came to the fore and elevated their strong collaborations. In addition to TIFR, PU, BARC, Homi Bhabha National Institute (HBNI) and SINP, there were other new Indian institutions that were added to the top collaborators list. They include IIT Hyderabad, IIT Madras, and National Institute of Science, Education and Research (NISER). TIFR with DESY, Rhein Westfal Technical University Aachen and University of Hamburg. PU collaborated with Rhein Westfal Technical University Aachen, DESY, and University of Hamburg. BARC made its collaborations stronger with Rhein Westfal Technical University Aachen, DESY, and University of Hamburg-HBNI collaborated with Rhein Westfal Technical University Aachen, DESY, and University of Hamburg. Similarly, SINP collaborated with the DESY, Rhein Westfal Technical University Aachen, and University of Hamburg (Figure 6c).

It is observed that some major institutions from both countries have maintained their collaborative partnerships. While some new institutions such as IITs, IISERs etc. have built new collaboration partners in Germany.

Impact of the Indo-German collaborated research

The cited percentage (% cited articles) and Citations Per Paper (CPP) for indigenous, inter-collaborated and Indo-German categories of research papers is computed. Indo-German participated papers received marginally more citations (90.84%) than India's other ICP (87.47%) (Table 5). Thus, there is around 4% difference of potential impact between ICP and Indo-German research outputs. Similarly, for citations per paper the value for ICP is 22.32 compared to 38.83 for Indo-German collaborated

papers while the citation per paper for Non-ICP or indigenous papers is 14.95. The citation per paper for total research output (TP) is 16.78. Thus, Indo-German collaboration provides a clear advantage in terms of citation impact over ICP and indigenous publications.

To further explore this impact, the *boost in productivity* of India was calculated as follows:

$$\text{Productivity boost of India } (\beta_P) = \left[\frac{TP}{TIP} - 1\right] \times 100\% = \left[\frac{673573}{648475} - 1\right] \times 100\% = 3.87\%$$

As India's productivity boost is only 3.87%, far less than 50%, there is no over reliance of India's productivity on international collaborations. This indicates the sufficient strength of India's indigenous scholarly ecosystem in publishing. However, the value is moderately high, indicating that some reduction either through keeping only highly rewarding collaborative ties active or strengthening indigenous research through internal ties at individual or organizational level or both is preferable.

Citations boost for India

The publications from India with the citations received by them as follows:

International Cited papers	1,87,822
International Total Citation	47,92,358
Indigenous (India) cited papers	5,56,149
Indigenous Total Citation	96,92,229
Total Indo-Germany Cited papers	22,798
Total Indo-Germany Citation	9,74,493

Since the citation boost for Germany and India is being calculated, therefore,

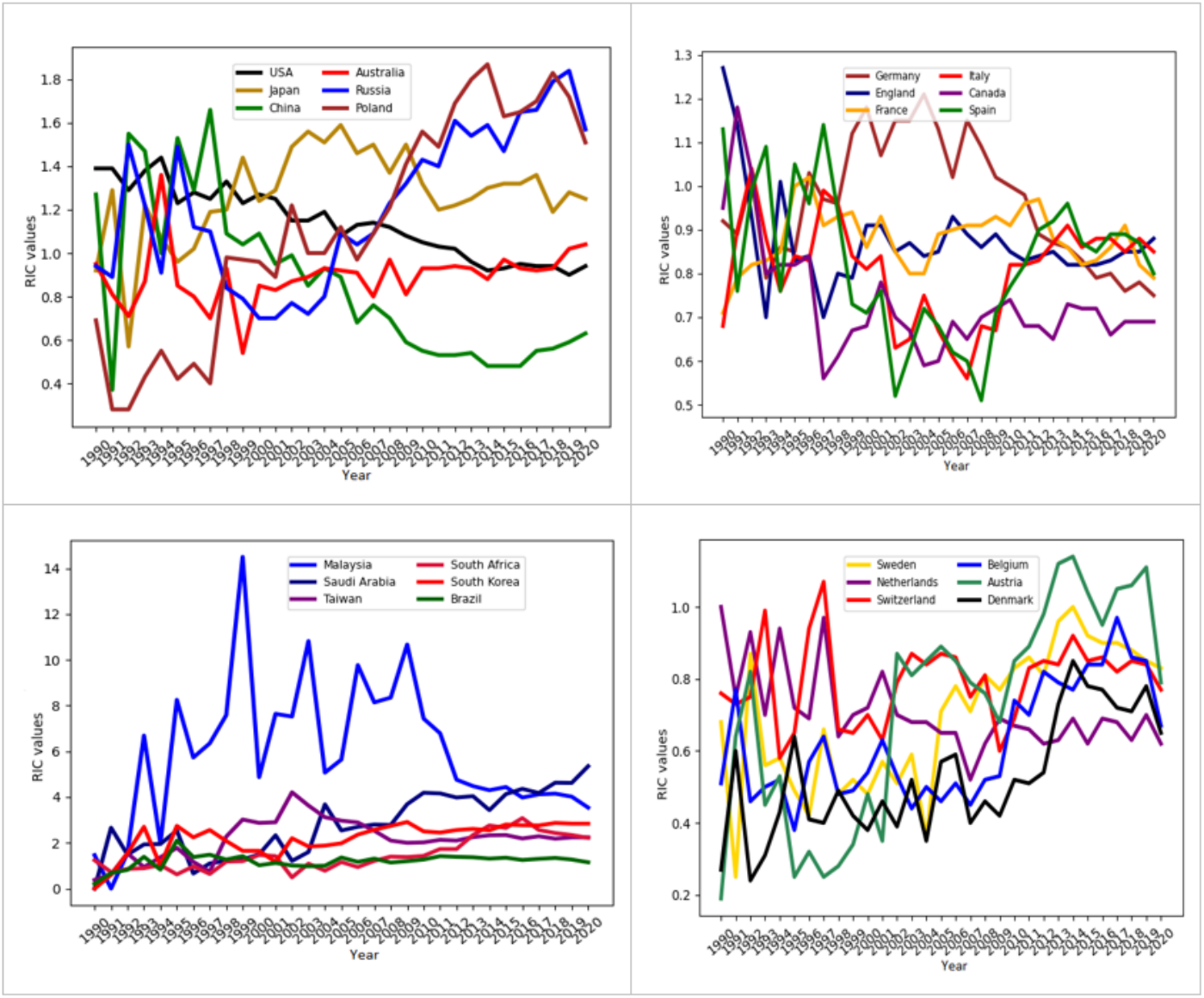

Figure 4a: RIC of India with respect to major collaborating countries.

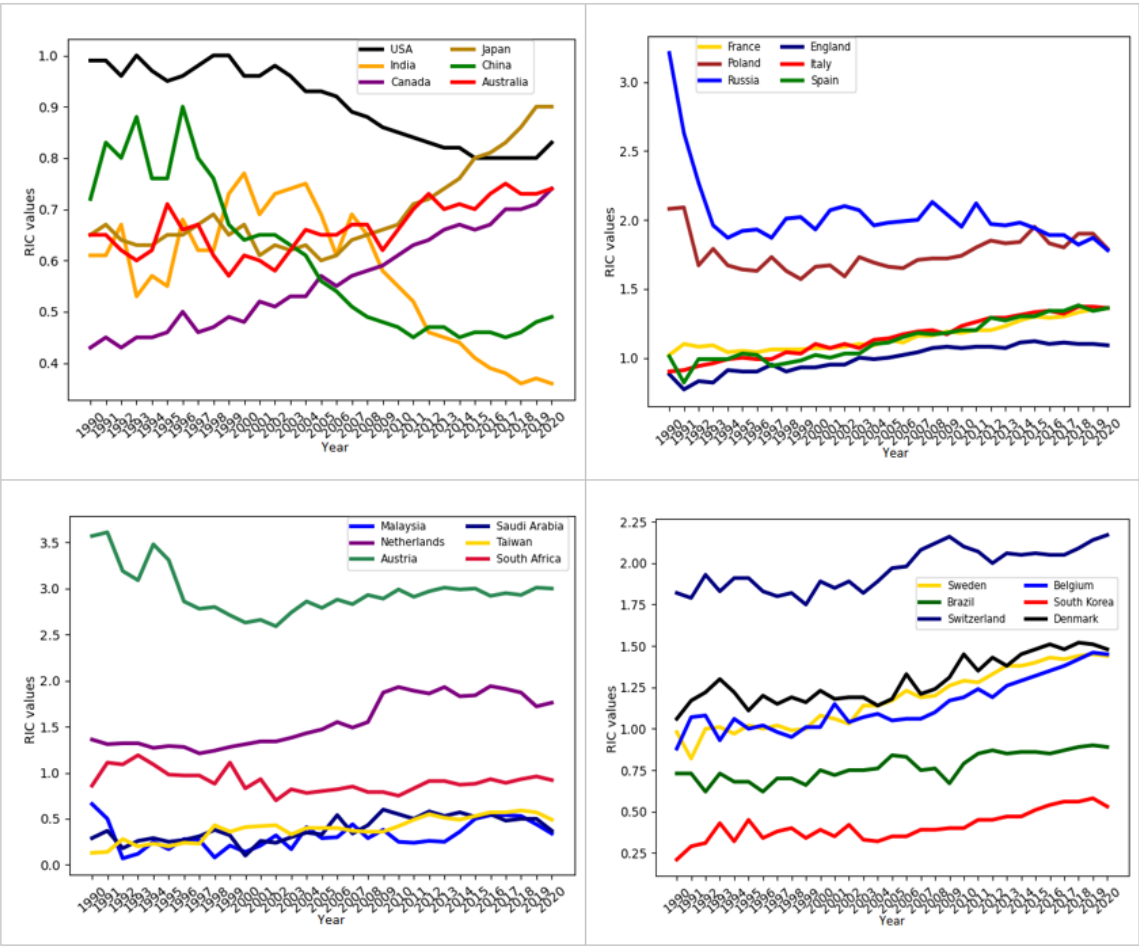

Figure 4b: RIC of Germany with respect to major collaborating countries.

TC = (Total Citation of Indo-Germany + Total Citation of India)

So,

$$\text{Citation boost } (\beta_C) = \left[\frac{TC}{TIC} - 1\right] \times 100\% = \left[\frac{1,06,66,722}{96,92,229} - 1\right] 100\% = 10.05\%$$

This value indicates that India is slightly dependent on collaborations for citations than the indigenous publications. These observations indicate that though the scholarly ecosystem of India is highly productive, it does not have a proportional impact on the knowledge production from its domestic research publications as reflected by citation boost. In this context, the impact of every unit percentage increase in collaborative publications can be seen by computing the boost ratio of impact as follows.

$$Boost\ ratio\ of\ impact\ (\gamma_c) = \frac{\beta_C}{\beta_P} = \frac{10.05}{3.87} = 2.60$$

Thus, for India, for each 1% boost of productivity achieved through collaboration, about 2.60% boost in citations is achieved. In case if India wants to keep collaborative ties that bring more reward, the ones that increase Yc without much improvement in Bp can be considered. Further analysis may bring more clarity into this. Specially, how much boost in citedness is achieved with international collaborations needs to be determined.

Citedness boost of India can be computed in the following way:

$$r_T = \frac{total\ number\ of\ cited\ publications}{total\ number\ of\ publications} = \frac{TP_{cited}}{TP} = \frac{578947}{673573} = 0.860$$

$$r_{TI} = \frac{total\ number\ of\ cited\ indigenous\ publications}{total\ number\ of\ indigenous\ publications} = \frac{TIP_{cited}}{TIP} = \frac{556149}{648475} = 0.8576$$

$$\beta_{rc} = \left[\frac{r_T}{r_{TI}} - 1\right] \times 100\% = \left[\frac{0.860}{0.8576} - 1\right] \times 100\% = 0.22\%$$

Citedness boost achieved is found to be less than 1%, which may indicate that indigenous publications are attracting citations, but not frequently enough in proportion to their numbers. More light into this can be shed with the indicator boost ratio of impact per unit boost in citedness which is calculated as follows.

$$\delta_c = \frac{\beta_C}{\beta_{rc}} = \frac{10.05}{0.22} = 45.61$$

In the case of India, per unit percentage boost in citedness achieved by collaboration is 46%. i.e., a collaborated article has a ~46% more chance of being cited as compared to indigenous ones. This may be an indication of a possible systemic issue in the Indian indigenous scholarly ecosystem, contributing to the low citedness of indigenous articles. One factor contributing to this

can be the scarcity of high impact and well reputed journals from India. Another reason for the low impact can be, the tendency of Indian scholars to target for publishing their research in 'easy to publish' kind of journals that may have limited reach and thereby impact. but to ensure their quality of research work and target high end journals in respective fields that can ensure citedness as well citations.

DISCUSSION

This paper examines the evolution and dynamics of Indo-German research collaboration. Together Table 1 and Figures 2-3 indicate that even though Indo-German co-authored publications grew in absolute terms over the decades, their proportion of papers on the list of international collaborated paper in India became smaller, which suggests that India is diversifying its research partners. Considering this tendency together with Figure 3 and Table 3, it is evident that this diversification is not only quantitative, but thematic: the rise of less than 100 fields of collaboration in the early 1990s to more than 170 by 2020 is a phenomenon that reflects the increase of the Indo-German joint activity into new areas of activity such as Technology and Life Sciences, although Physical Sciences continued to dominate. Table 4 further introduces a critical dimension (indicating a decline after 2010 in the representation of Indian first-authors and papers with 50% authors of Indian origin), indicating a possible changing structure of collaboration and possibly increasing asymmetry of leadership. Combined, these patterns of relations can indicate that Indo-German cooperation, though increasing in scale, has experienced a comparative weakening of its proportional power and intensity of Indian leadership, although its disciplinary imprint has become larger. These findings enhance the policy recommendations in the sense that specific strategic interventions are necessary, especially in terms of capacity building, institutional matching, authorship equity, and high-impact domain prioritization to make sure that India optimizes the quantity as well as quality, visibility, and leadership value of the long-standing partnership between India and Germany.

There are a few qualitative reasons to explain the decrease in the proportional status of India in Indian-German collaborations. First, geopolitical changes since the 2000s have pluralized the international research interests pursued by India, and its options have multiplied with growing partnerships with the USA, UK and East Asia, and therefore, decreasing relative influence of Germany. Second, fluctuation in bilateral funding schemes over the years facets the extent and direction of cooperation projects e.g. there have been fluctuations to funding allocations in Indo-German Science and Technology Centre (IGSTC) and the changing EU research and funding structures. Third, academic mobility flows also were a factor, as Indian scholars

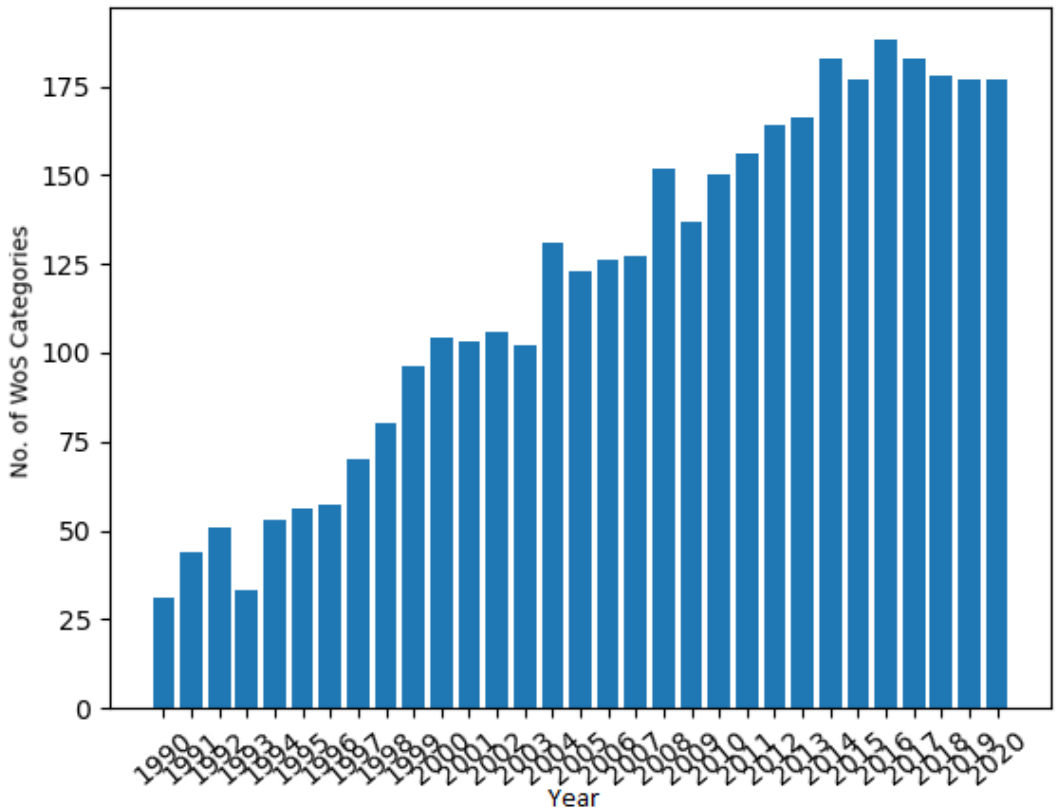

Figure 5: Number of WoS categories in which India and Germany collaborated.

Figure 6a: Indo-German Institutional pairs from 1990-1999.

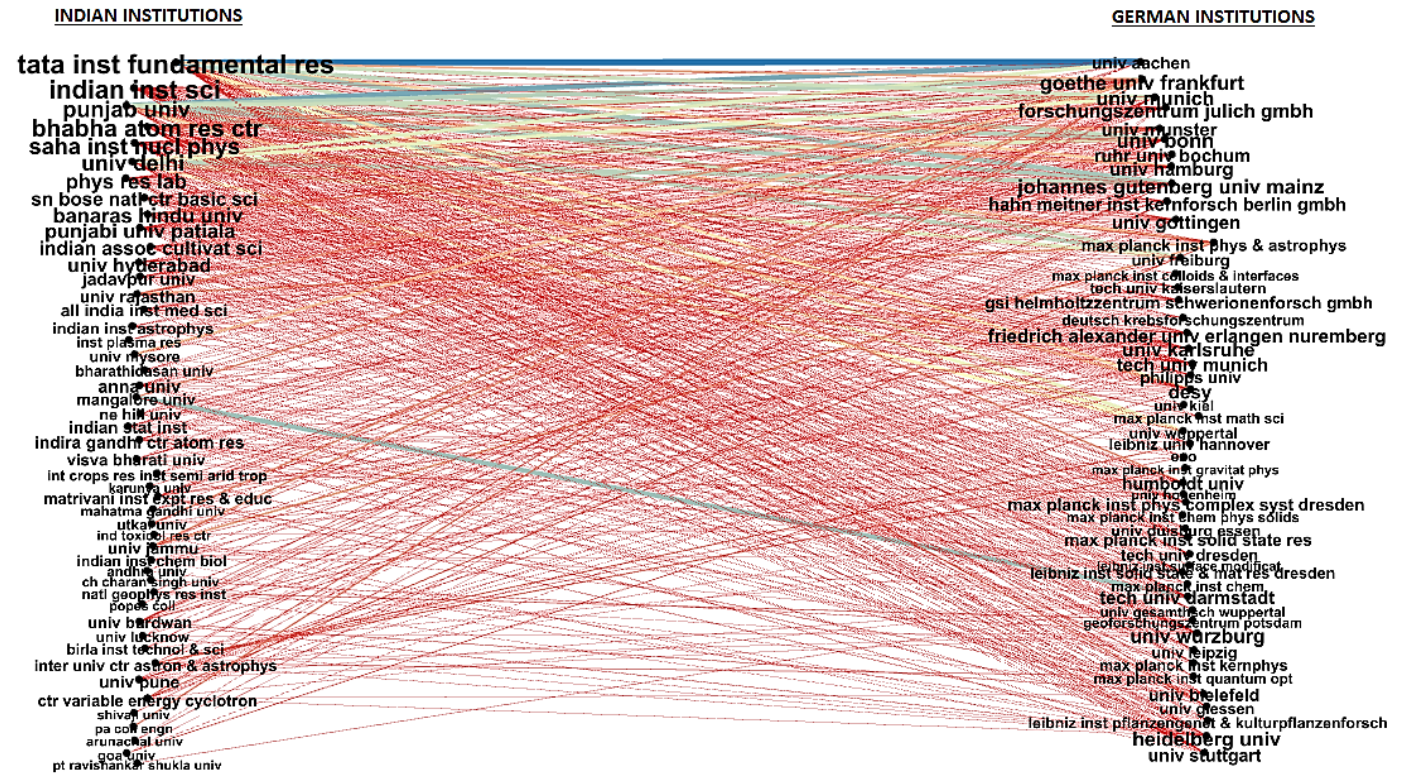

Figure 6b: Indo-German Institutional pairs from 2000-2009.

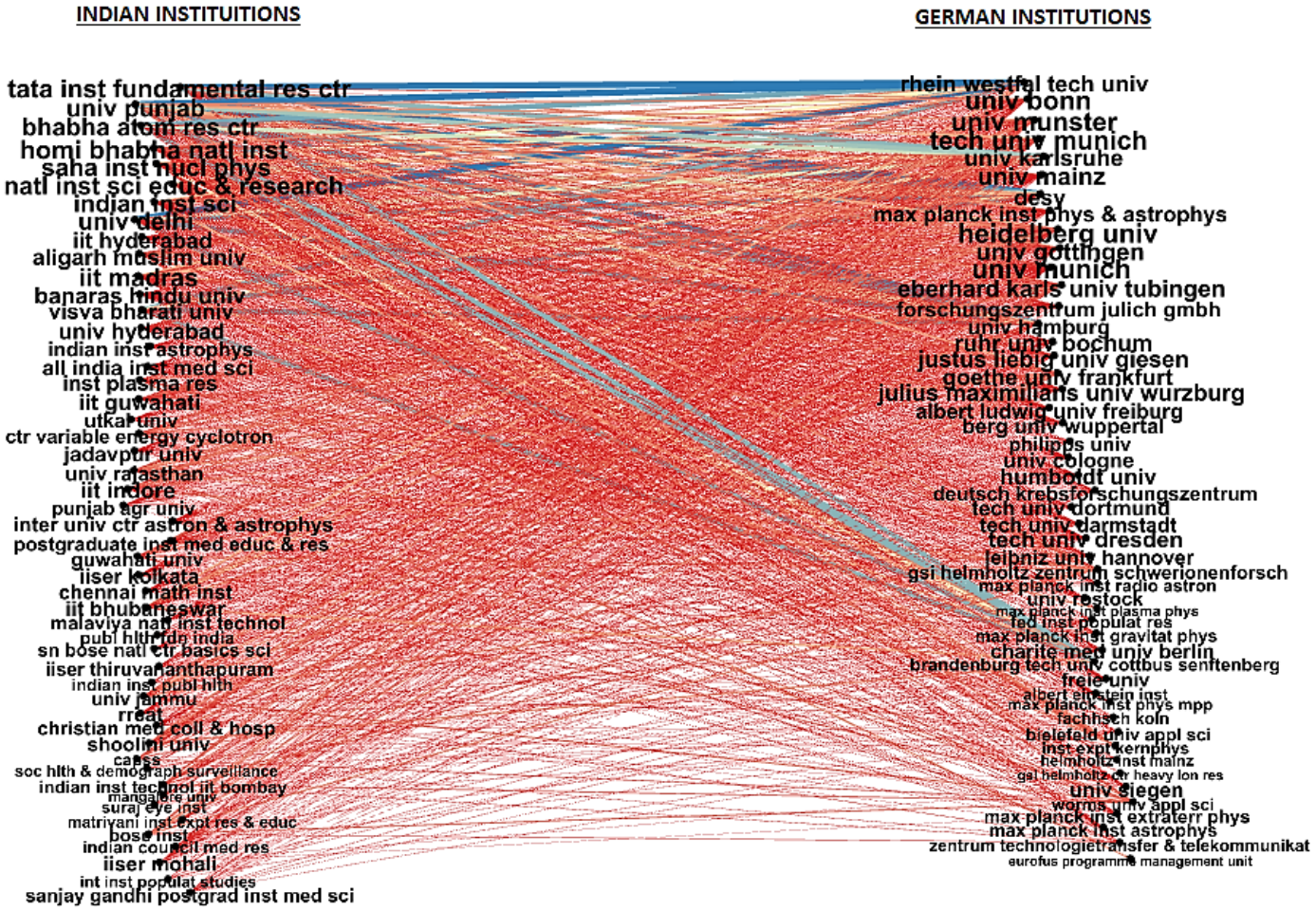

Figure 6c: Indo-German Institutional pairs from 2010-2020.

have increasingly sought North American and Australian higher education and research exchange opportunities, where Germany drew strongly in engineering and the applied sciences but also in a more disciplinary-specific way. Taken altogether, these aspects are strong indicators that collapse is not related to the lowered Indo-German relations specifically, but are reflective of the growth, and diversification of India International research partnerships.

Policy perspectives

Germany is considered a world leader in efficient S&T infrastructure and leads in Clean Energy, Sustainable Transportation, Material Sciences etc. (Global Innovation Index, 2025). These are also among the topics which emerge as the major ones in the thematic distribution of Indo-German collaborated publications. Efforts should aim to further strengthen the Indo-German collaboration in these areas and further promote technology transfer agreements. The funding and collaborating institutions should focus on improving the effectiveness of cooperation programs.

The coordinating agencies such as Indo-German Science and Technology Centre (IGSTC), and DST's International Cooperation Division have been acting towards promoting the S&T collaboration between the two countries. The roles of these agencies can be further specialised and pinpointed to promote increased activity and impact of the opportunities for bilateral collaboration. As a higher impact of collaborated papers is observed, one possible step can be that these bodies can be made the nodal agencies for promoting knowledge transfer, and given the responsibility to ensure that Indian researchers learn from German counterparts on how to publish more impactful research. Similarly, other German and Indian organisations can be identified for different roles and sectors, linked to each other either through MOUs or other coordination arrangements. These organisational pairs can then facilitate and ensure a higher level of engagement between researchers and institutions ensuring higher productivity and impact. Further, a survey-based study should be conducted to identify if the differences in citedness of research articles is due to some differences in tacit procedural knowledge of Indian and German researchers or a case of advantage due to north-south divide in science. The findings of the survey can

provide strong evidence to base future capacity building efforts for India's domestic research ecosystem. It would also be useful to look at the major contributors in India's ICPs by undertaking a more in-depth analysis of the collaborated publications.

In the policy roadmap, primary concentration is made in formally establishing the Indo-German Science and Technology Centre (IGSTC) and the International S&T Cooperation (ISTC), DST as nodal agencies to facilitate the planning, monitoring and taking of stock of the Indo-German collaborative ventures. With this structure, it would be possible to have a simplified and consistent selection of projects, allocation of resources and evaluation of the progress. To supplement this, capacity-building programs should be developed and implemented so as to enable specific training of the Indian researchers by their German counterparts with particular focus on high impact publishing behavior, research methods and functioning within international scientific networks.

The roadmap also proposes the initiation of detailed survey grounded research to identify differences in procedural research knowledge, and access to the infrastructure, and publication plans that exist between the two countries with the findings allowing and driving specific interventions to improve the quality and visibility of research.

There is also a recommendation that existing technology transfer agreements be extended especially in areas where Germany has technological strengths but India has the potential in innovation. Some of these areas are clean energy, sustainable transportation, material sciences etc. Given the rapidly changing word order and India's dynamic relations with major leading countries in Science and Technology, it would be interesting to use the evidence provided by this study to explore instituting newer and more intense collaboration opportunities with Germany.

Lastly, bibliometric analyses need to be conducted in more detail to help document which Indo-German collaborative networks are performing well, to provide targeted policies and financial resources in their directions. Collectively however, such actions will show a concrete and implementable way forward to strengthen bilateral science and technology cooperation, providing short-term benefits in terms of outcomes as well as strategic student payoffs in the long term.

CONCLUSION

The paper has looked at the major patterns in productivity in publications resulting from Indo-German collaborations. It is observed that over the last three decades, the international R&D collaborations of India have significantly increased as reflected by the increase in total publications from just 2963 papers (in 1990) to 81,966 (in 2020) showing a CAGR of 11.30%. While the proportion of ICP has increased from ~12% to ~32%, the share of Indo-German Papers has decreased from 11% to 8%. This could be a result of India having S&T exchange programmes with more countries, as reflected from the fact that agencies such as the Department of Science and Technology, India, and several Universities of India are entering into multiple international collaboration agreements with several countries and institutions. On further exploration using RIC of India, it is observed that Russia, Austria, Denmark, Sweden, Saudi Arabia, Malaysia and Poland are some countries whose co-authored publications have increased. In contrast, Germany's collaborated research publications, while increased in absolute numbers, now contribute to a smaller percentage of India's ICP.

The major areas of collaboration between India and Germany are Physical Sciences, Life Sciences and Biomedicine and Technology disciplines. Institutions such as TIFR, IISc, Panjab University, University of Delhi, Bhabha Atomic Research Centre (BARC), Vishwa Bharti collaborating with Karlsruhe University, Max-Planck Institute of Physics (MPP), Rhine Westfalen Technical University, Charite Med. Univ. Berlin etc. are the most intensive contributors in Indo-German research publications. Notably, the publications resulting from Indo-German collaborations received on average a higher visibility and citations when compared to papers published indigenously by Indian authors only. Thus, βc, β_{rc} and together indicate a need to strive for ensuring maximum quality of indigenous research and publishing it through sources capable of providing maximum reach and thereby improving the chances of increasing the impact. Thus, the study provides strong evidence as the basis for further exploration of research collaboration patterns of India. Given the rapidly changing word order and India's dynamic relations with major leading countries in Science and Technology, it would be interesting to use the evidence provided by this study to explore instituting newer and more intense collaboration opportunities with long term collaboration partner countries like Germany.

CONFLICT OF INTEREST

The authors declare that there is no Conflict of interest.

REFERENCES

Abramo, G., D'Angelo, C. A., & Di Costa, F. (2009). Research collaboration and productivity: is there correlation?. Higher education, 57(2), 155-171. https://doi.org/10.1007/s10734-008-9139-z.

Abramo, G., D'Angelo, A. C., & Murgia, G. (2017). The relationship among research productivity, research collaboration, and their determinants. Journal of Informetrics, 11(4), 1016-1030. https://doi.org/10.1016/j.joi.2017.09.007.

Anuradha, K., & Urs, S. (2007). Bibliometric indicators of Indian research collaboration patterns: A correspondence analysis. Scientometrics, 71(2), 179-189. https://doi.org/10.1007/s11192-007-1657-4.

Basu, A., & Aggarwal, R. (2001). International collaboration in science in India and its impact on institutional performance. Scientometrics, 52(3), 379-394. https://doi.org/10.1023/A:1014239731175.

Boekholt, P., Edler, J., Cunningham, P., & Flanagan, K. (2009). Drivers of international collaboration in research. https://doi.org/10.2777/81914.

Bukvova, H. (2010). Studying research collaboration: A literature review. AIS Electronic Library (AISeL), 10(3). https://aisel.aisnet.org/sprouts_all/326.

Dua, J., Lathabai, H. H., & Singh, V. K. (2023). Measuring and characterizing research collaboration in SAARC countries. Scientometrics, 128(2), 1265-1294. https://doi.org/10.1007/s11192-022-04606-0.

Dua, J., Singh, V. K., & Lathabai, H. H. (2023). Measuring and characterizing international collaboration patterns in Indian scientific research. Scientometrics, 128(9), 5081-5116. https://doi.org/10.1007/s11192-023-04794-3.

Fuchs, J. E., Sivertsen, G., & Rousseau, R. (2021). Measuring the relative intensity of collaboration within a network. Scientometrics, 126(10), 8673-8682. https://doi.org/10.1007/s11192-021-04110-x.

German Academic Exchange Service (DAAD), & German Centre for Higher Education Research and Science Studies (DZHW). (2023). Wissenschaft weltoffen 2023: Facts and figures on the internationalisation of studies and research in Germany. DAAD/DZHW. https://www.wissenschaft-weltoffen.de.

Global Innovation Index, 2025. Germany ranking in the Global Innovation Index 2025. GII Database, World Intellectual Property Organization (WIPO). https://www.wipo.int/gii-ranking/en/germany.

Gupta, B. M., Munshi, U. M., & Mishra, P. K. (2002). S&T collaboration of India with other South Asian countries. Current Science, 83(10), 1201-1209. https://www.jstor.org/stable/24106472.

International Cooperation Division, DST, New Delhi, India. Accessed on March 03, 2025 from https://dst.gov.in/international-st-cooperation.

Katz, J. S., & Martin, B. R. (1997). What is research collaboration?. Research policy, 26(1), 1-18. https://doi.org/10.1016/S0048-7333(96)00917-1.

Singh, P., Singh, V. K., Arora, P., & Bhattacharya, S. (2021). India's rank and global share in scientific research: how data sourced from different databases can produce varying outcomes?. Journal of Scientific & Industrial Research, 80(04), 336-346. https://doi.org/10.56042/jsir.v80i04.38273.

The Academy of Medical Sciences, UK. The role of international collaboration and mobility in research, London. March, 2017. https://acmedsci.ac.uk/file-download/96518966.

University Living. The European Student Landscape: Beyond Beds and Benches. 2023; retrieved on March 03, 2025 from http://www.eun.org/documents/411753/817341/Report_on_the_European_Educational_and_Training_Landscape.pdf/

Zhang, D., Ding, W., Wang, Y., & Liu, S. (2022). Exploring the role of international research collaboration in building China's world-class universities. Sustainability, 14(6), 3487. https://doi.org/10.3390/su14063487.

Cite this article: Dua J, Kanaujia A, Singh VK. Indo-German Research Collaboration: A Quantitative Analysis of the Research Publications During the Last Three Decades. J Scientometric Res. 2026;15(1):109-23.