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APPENDIX/ANNEXURE

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CONTRIBUTIONS TO BOOKS

- Sharma T., Kwatra, G. (2008) Effectiveness of Social Advertising: A Study of Selected Campaigns, Corporate Social Responsibility, Edited by David Crowther & Nicholas Capaldi, Ashgate Research Companion to Corporate Social Responsibility, Chapter 15, pp 287-303.

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- Schemenner, R.W., Huber, J.C. and Cook, R.L. (1987), "Geographic Differences and the Location of New Manufacturing Facilities," Journal of Urban Economics, Vol. 21, No. 1, pp. 83-104.

CONFERENCE PAPERS

- Garg, Sambhav (2011): "Business Ethics" Paper presented at the Annual International Conference for the All India Management Association, New Delhi, India, 19–22 June.

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- Kumar S. (2011): "Customer Value: A Comparative Study of Rural and Urban Customers," Thesis, Kurukshetra University, Kurukshetra.

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- Garg, Bhavet (2011): Towards a New Natural Gas Policy, Political Weekly, Viewed on January 01, 2012 http://epw.in/user/viewabstract.jsp

INCREASING INTERNATIONAL COLLABORATIONS IN SCIENCE AND TECHNOLOGY AROUND THE WORLD, AND ITS PATTERNS IN INDIA WITH SPECIAL REFERENCE TO INDO-GERMAN COLLABORATION

MUNEEB HUSSAIN GATTOO
RESEARCH SCHOLAR
DEPARTMENT OF ECONOMICS
JAMIA MILLIA ISLAMIA
NEW DELHI

MUJEEB HUSSAIN GATTOO
RESEARCH SCHOLAR
ZAKIR HUSAIN CENTRE FOR EDUCATIONAL STUDIES
JAWAHARLAL NEHRU UNIVERSITY
NEW DELHI

ABSTRACT

In the present global context, higher education is increasing getting internationalized in the past decade or so. A good proportion of students prefer to study abroad, this growth is the result of several factors, which are many a times inter-related; a desire to promote mutual understanding; the migration of skilled workers in a globalised economy; the desire of the institutions to generate additional revenues; or the need to build a more educated workforce in the home countries. Various reasons and explanations have been provided in order to explain the increasing international collaboration in science and technology. Not a single model that has been propounded so far can provide a complete explanation of the ongoing increase in international collaboration independently, yet each one of these models contains an element of reality. In case of India, within last decade or so it has witnessed a tremendous increase in its output of scientific publications. The rise is really impressive given the fact that in 1981, India accounted for just above 14,000 papers. It increased to 30,000 in 2007 which constitutes an increase of roughly 80% in seven years from 2000 (Global Research Report 2009). Further we have noticed that there has been an impressive increase in India's international collaboration both with developed and developing countries. U.S.A, Germany & U.K being the top three collaborators of India, yet when we look at other seven countries in top ten collaborating countries we find that it contains many developing countries of the periphery like Brazil, Russia, South Africa etc. We reach similar conclusions when we analyse the top ten organisations collaborating with India in science and technology. Finally when we probe into the collaboration between India and Germany, we find that even after being 2nd top most collaborator of India, both countries are trying to increase their collaborations by taking various initiatives and tailor-making of policies. Here also we find that both countries have their own areas of specialisation and hence can avail various benefits by collaborating with each other.

KEYWORDS
international collaborations, science & technology, Indo-German collaboration.

I. INTRODUCTION

Thomas Friedman (2007) said the world was flat – by which he means that "we are connecting all the knowledge centres on the planet together into a single global network". Higher education has become increasingly international in the past decade as more and more students choose to study abroad, enrol in foreign educational programmes and institutions in their home country, or simply use the Internet to take courses at colleges or universities in other countries. This growth is the result of several different, but not mutually exclusive, driving forces: a desire to promote mutual understanding; the migration of skilled workers in a globalised economy; the desire of the institutions to generate additional revenues; or the need to build a more educated workforce in the home countries, generally as emerging economies etc. Recent years, have witnessed enormous and consequential increase in international student mobility. Nearly 3 million students now study outside their home countries, a number that has risen steeply in a short period. From 1999 to 2009 alone, the number of students studying outside their home nations increased by 57 percent, according to UNESCO (United Nations Educational, Scientific and Cultural Organization) and OECD data reported by the Institute for International Education (IIE).

Governments of every nation, along with universities and companies all over the world actively engage in the development of science and technology to survive in the new environment of a knowledge-based economy. Hence, the use of science and technology for national, local, or organizational wealth creation is a universal phenomenon. Research has become a global activity and the cross border collaboration is increasing tremendously. Spending on science based research initiatives around the world has increased by about 45 percent, which has exceeded to more than one trillion U.S dollars since 2002. Taking 2008 as reference, 218 countries have generated more than 1.5 million research papers, with contributions ranging from Tuvalu's one paper to the U.S's 320,000 papers. Both in terms of investment and research publications USA is way ahead of all other countries, with investment at whopping $ 400 billion, while its publications account for worlds 21%. However, the recent increase in research publications have come from the developing world viz-a-viz China, India, brazil and South Korea. Also, the paradigm alteration that the world has witnessed from past two decades or so has been the increase in international collaborations among researchers from different countries, which amount for an impressive 35%. The number of internationally co-authored publications has more than doubled since 1990. The top hubs of international collaborations in science research continue to be lead by USA, followed by U.K, France and Germany. Researchers in other developed and developing countries have more actively been collaborating with scientists from these research hubs. According to the Royal Society report, "while links between the BRIC countries (Brazil, Russia, India and China) have been growing in recent years, they fade in comparison to the volume of collaboration between these individual countries and their partners in the G7" (Global Science Research).

A July 2007 study by Britain's Office of Science and Innovation, for instance, found that in 2001–5, the percentage of papers by American scientists written with co-authors from other nations rose to 25 percent, up from 19 percent during the 1996–2000 period. The degree of international collaboration rose even more in Britain, growing from 29 to 40 percent between the two periods. Another study, which examined 2.4 million scientific papers written at 110 leading American research universities from 1981 to 1999, found increased collaboration in general—as scientific teams grew larger—as well as a greater degree of international collaboration (Wildavesky, 2010). Cozens et al(2011) mention that the most recent data on international co-authorship of published research show that articles with two or more collaborating countries are the fastest growing segment of the world's scientific publications. The United States and European Union countries collaborate less internationally than would be expected based on their number of publications, but Asian countries collaborate more than would be expected, and a new intra-Asian zone of collaboration is emerging. Collaboration between Asian countries has increased in recent years even without the kind of encouragement the European Commission has provided in an attempt to build collaborations within that region (National Science Board, 2010 cited in cozens et al, 2011).

This paper is an attempt to study the international collaboration in science and technology. Section I provides a brief account of recent increase in international research collaboration globally. Section II provides the conceptual framework and rationale for studying the international collaboration in research. Section III

describes India's international collaboration in science and technology and tries to show the diversity of India's collaborative research. Section IV explains the indo-German collaboration in science and technology in details for a period of 2004-09, Germany being a second most productive partner of India in collaborative research. Finally section V provides the concluding remarks of the paper.

II. CONCEPTUAL FRAMEWORK AND RATIONALE

In a networked global environment in which every university is visible to every other, and the weight of the global dimension is increasing, it is no longer possible for nations or for individual higher education institutions to completely seal themselves off from global effects (Marginson and Van der Wende,2007). Research has become a global activity and the cross border collaboration is increasing continuously. Over past years, a number of reasons have been suggested to explain the growth of international collaborations.

Hwang talks about the re-enactment of colonialist discourse which provides an understanding of the hierarchical structure of international relations in science. The basic premise in this contains the notion that sociocultural elements, such as nationality, scientific heritage, and infrastructures,predetermine the status of an individual scientist and engineer,or an individual institution that stands in the core or periphery in the hierarchicalstructure of international relations.Traweek(1988, cited from Hwang 2008) states that there exists a stable ranking of institutionsin particle physics, internationally, and that all the major and eminentlaboratories for particle physics in the world are located in North Americaand Europe (1988, 109). This is well documented for big science, such asparticle physics, and it seems likely that this holds for other areas of scienceas well. Zaltman (1968, cited in Hwang 2008) and Crane (1972, cited in Hwang 2008) mention that United States and the European countries have dominated the international scientific community networks. Rothboeck (cited in Hwang 2008) is also notoptimistic about whether the workings of the Information and CommunicationTechnologies (ICT) industry enable some latecomers to move into thegroup of pace-setting countries and argues that empirical evidence showsthat the ICT industry seems to maintain the divisions between the core andthe periphery (2000, 55).Arrow (1962, cited in Hwang 2008) is of the view that knowledge is not simply the end product of inventiveactivity but also a major input into the process of new knowledge creation. Periphery scientific endeavour is reliant on the provision of this knowledge, which it consumes but doesnot produce itself: its output—technological application—is seen as beinginferior, even parasitical. When a country seen as peripheral is in fact, producing some core knowledge, that activity may be prejudged in the lightof this assumed lower status.

Schott (1998), following Ben-David (1971) and Shils (1983), explains international collaborationby ties between centre and periphery[1] in the scientific world system. He argues thatCountries at the periphery (often smaller countries) emulate the organisation, orientation, and excellence of scientific work at the centre. As they emulate and adapt the practices of the core country, the capacities of the peripheral countries grow. He states that during the twentiethcentury, the region that attracted most deference and became most centralin the network of deference is evidently North America, and the second-mostcentral region in this network is Western Europe, while other regions areperipheral.The network of deference is a particularly important concept for internationalcollaboration in that scientific actors from the periphery try to haveconnection with the centre in various collaborative ways, such as sojourningfor education and training, knowledge transfer, andinformal networks. This connection between centre and periphery in the viewof scientific actors from the periphery is closely related to their recognition,reward, emulation, and competence as scientific actors at both global andlocal levels. Schott states, "In peripheries of the world of learning, a sojournto the centre is a credential in itself, enhancing prestige of the sojourner, andin some peripheral countries it is even somewhat necessary and sufficientcondition for certain appointments" (cited in Hwang 2008). Collaboration betweensupervisors and research students, and formal and informal collaborationand close relationships between them after students' education, are not newphenomena, and this applies to educational sojourners fromperiphery to centre (Schott 1998 cited in Hwang 2008). Thus, sojourners fromperiphery to centre promote international collaboration.However, the theoretical concept of colonialist discourse is too dichotomousto apply to the multilayered structure of the real world (Hwang 2008),and this suggests a problem with the centre-periphery notion: there isa middle or gray area that belongs to neither the centre nor the periphery.Wagner and Leyderoff are of the view that dynamics of centre-periphery may have been at work in the past, but the data on international collaboration presented for the decade of the 1990s suggests that the centre-periphery model of international scientific collaboration can be replaced with a model that accounts for various centres that both collaborate among and compete with one another for partners from smaller national systems. A core group of scientifically advanced countriesis both competitive and highly related. At the lowest levels of the hierarchy, smaller, more peripheral countries are more likely to link to the international network through regional hubs rather than through an advanced country.

Some scholars tried to explain the international collaboration in science and technology increase in interdisciplinary and multidisciplinary in science. Multidisciplinary collaboration is a mode of producing integrated knowledge from different areas. Sophistication of equipment and sharing rare and expensive instruments, especially in big science, such as high-energy physics and astronomy,inevitably require collaboration. Thus, interdisciplinary application and manipulating and building equipment are the main determinants of collaboration in the category of the scientific content (Hwang, 2008). However this notion has been criticised in Wagner &Leydesdorff (2003, cited in Wagner & Leydesdorff 2004) examining disciplinary linkages in the field of geophysics and the more specialized subfield of seismology cannot support this assertion. Although the subfield of seismology is more specialized, geophysics remains the more highly internationalised of the two fields. Moreover, it has been observed that growth in International Collaboration occurs across all fields of science, not just those that are highly specialized. Furthermore it is also argued that financial demands or cost sharing of "big science" or "mega science" alone cannot explain the international collaboration completely.

Beaver and Rosen (1978, cited in Wagner and Leydesdorff 2004) suggest that collaboration grew historically as science became "professionalised"—taking place in dedicated institutions of science. Using a historical, nationally-based approach, they show that "collaboration becomes a mechanism for both gaining and sustaining access to recognition in the professional community" (1978). They claim that collaboration is neither a historically recent phenomenonnor that it is principally a response to specialisation. Collaboration is intrinsically advantageous to scientists, they argue, particularly when it occurs between a "master" and an "apprentice." Wagner and Leydesdorffare of the view that it is difficult to compare this with data at the global level, yet this theory can be helpful in understanding the dynamics at the sub-field level.

Hwang (2008) is of the view that scientific networks can also provide general explanation that what compels scientists to collaborate, without considering the scientific content as such. This category includes insecurity in highly competitive environments, uncertainty of scientific findings, social networks of collaborators (e.g., previous supervisor, previous research team members, core set in controversies), and career seeking. Hwang argues thatscientists use formal and informal contact with other scientists to obtain information on other scientists' research for their knowledge production. Collaboration is a salient source of scientists' social contact because it provides intensive communication, which can offer scientists research ideas and information on similar research. Thus, scientists predominantly need to participate in social networks for obtaining information. Collaboration is one of the ways that scientific actors are involved in social networks.

Some have suggested that the availability of the Internet is causing a growth in international collaboration. While Internet and information technology generally are important factors, research shows that nearly all collaborations begin with a face-to-face meeting (Laudel 2001 cited in Wagner &Leydesdorff2004). Once collaboration is underway, researchers use the Internet to exchange data and text, but the majority of collaborations begin in the richer communication environment provided at conferences or research sites. This suggests the information and communications technology cannot be considered as a driver for the initiation of collaboration, only as a facilitating agent.(Wagner & Leydesdorff 2004)

Hwang (2008) also mentions that extraneous factors inextricably linked with scientific content and scientists' networks can also explain the increase in scientific collaboration. This category pertains to contextual changes including social changes, Scientific capacity including international reputation and recognition (Ben-David 1971, Wagner and Leydesdorff 2004), political and policy promotion including governments' fostering of international collaboration (Wagner et al. 2001 cited in hwang), historical factors including geographic proximity and colonial relationships (Zitt, Bassecoulard, and Okubo 2000 cited in Hwang), and

[1]Wallerstein's world systems framework, visualizing the world into a system of core and periphery's, that are linked to each otherby a network of unequal exchanges.

globalization of science and technology (Gibbons et al. 1994; Wagner and Leydesdorff 2003) are all social context factors influencing general collaboration as well as international collaboration.

Given the fact above mentioned factors donot explain the increase in collaboration completely, Wagner and Leydesdorff (2004) maintain that international co-authorships within fields of science can be shown to self-organize based on rules of preferential attachment among productive researchers, suggesting that the spectacular growth in international collaborations may be due more to the dynamics at the sub-field level created by individual scientists linking together for enhanced recognition and rewards than to other structural or policy-related factors. They are of the view that choices of individual scientists to collaborate may be said to be motivated by the reward structures of science where co-authorships, citations and other forms of professional recognition lead to additional work and funding in a virtuous circle. Highly visible and productive researchers within the field, able to choose among potential collaborators, choose those most likely to enhance their productivity and credibility. These "continuants" thus mediate the entrance into this network. This creates a competition within a field of science for collaborators.

III. INDIA'S INTERNATIONAL COLLABORATION

In the modern era, science and technology have been central to India's development efforts since the nation achieved independence in 1947. Since then, via government directives such as the Scientific Policy Resolution (1958), the Technology Policy Statement (1983), and Science and Technology Policy (2003), the nation has achieved notable scientific successes.Within a last decade or so India has witnessed a tremendous increase in its output of scientific publications in Thomson Reuters. The rise is really impressive given the fact that in 1981, India accounted for just above 14,000 papers. It increased to 30,000 in 2007 which constitutes an increase of roughly 80% in seven years from 2000(Global Research Report 2009).[2] Nonetheless, the absolute volume for India is still only about half that for countries such as the UK, Germany, China or Japan.

India is collaborating with several developed and developingcountries in S&T over the years. This collaboration has resulted in 46042 papers in six years between 2004 and 2009. United States is the India's largest collaborating partner with 15928 collaborating papers, accounting for 34.59% share in India's total collaborative papers during 2004-09. Germany and United Kingdom is the second and third largest collaborators, having published 5954 and 5769 papers with India and accounting for 12.93% and 12.53% share of India's total collaborativepapers during 2004-09. They are followed by Japan with 4154 collaborative papers (9.02% share), France (3571 papers, 7.76% share), South Korea (2975 papers, 6.46% share), Canada (2644 papers and 5.74% share), Australia (2071 papers and 4.50% share), China (1733 papers and 3.76% share), Russia (1148 papers and 2.49% share), Brazil (1043 papers and 2.27% share) and South Africa (601 papers and 1.31% share).

The diversity of India's research ties is elaborated in Global Research Report 2009, which presents a selection of international organizations that have made especially numerous collaborations with India institutions in 2003-2007. The list is not a complete reflection of just the top ten organizations, but has been selectively edited to give a more diverse flavour to the richness of India's links. Even so, the relative scarcity of European partners—and the absence of UK institutions—will be a surprise to policy observers. The list was topped by university of Tokyo (Japan) with 686 co-authored papers, followed by university of Texas (USA) with 642 co-authored papers. They were followed by Tohoku university (Japan 639 papers), centre national de la recherché scientifique (France 534 papers), Korea university (South Korea 534 papers), Chinese academy of science (China 533 papers), National Taiwan university (Taiwan 466 papers), National university of Singapore (Singapore 429 papers), University of Melbourne (Australia 423 papers), University of Amsterdam (Netherlands 384 papers).

IV. INDO-GERMAN COLLABORATION IN SCIENCE AND TECHNOLOGY

India has always been a major partner for Germany in Asian region. Although, a more active and holistic R&D collaboration has developed only during the past 30 years, collaboration between Germany and India dates back to the era of 1960's. India and Germany signed Science and Technology Cooperation Agreements in 1971 and 1974. Co-operation in Science and Technology has been earmarked as one of the prime strategic goals for future relations between India and Germany. As a result, an Indo German Commission on Science and Technology, which meets every 18 months, alternately in India and Germany, coordinates the Indo-German cooperation in science and technology Research. TheDST, Government of India, and German Federal Ministry of Education and Research (BMBF), Government of Germany, are the nodal agencies for the implementation of bilateral agreements at the inter-governmental level. Under various Indo-German programs, so far more than 2,000 joint projects have been successfully undertaken, resulting in more than 7,000 short-term/long-term exchanges of scientists, more than 6,000 joint publications and more than 400 Indo-German workshops and seminars.At present, more than 170 joint projects are in progress and the number is on the rise (Matussek, 2011 cited in Gupta & Fischer 2013). Additionally, from 1996 to 2010 (15 years), 11,161 Indo- German joint collaborative papers have been published, based on the Scopus database searched on May 27th, 2011. Within the bilateral umbrella of agreements, a number of special co-operative arrangements have been concluded and activities implemented by a number of agencies from the Indian and German side. Some of the departments and organisations involved from the Indian side are: DST, DBT, DAE, Indian Space Research Organisation (ISRO), CSIR, ICMR, Ministry of EarthSciences (MoES), MNRE, MoEF and Indian National Science Academy (INSA). From the German side, some of the institutions involved are: ForschungszentrumJülich, German Aerospace Centre (DLR), Helmholtz Association (HGF), German Academic Exchange Service (DAAD), Society for Research in Radiation & Environment (GSF), Max Planck Society (MPG), Fraunhofer-Gesellschaft, German Research Foundation (DFG) and the BMBF. To coordinate S&T cooperation, both countries have posted Science Counsellors in their respective Embassies since mid-1980s (Gupta &fischer, 2012).

Recently (Oct 2012) The German House for Research and Innovation (DWIH), established by a 14-member consortium of German organisations, was inaugurated. The DWIH-New Delhi is intended to serve, "as a 'one-stop shop' for Indian researchers, providing information on Germany and its research community, showcasing its strengths and opportunities." The aim is to enhance the cooperation between the two countries in academics and research. It is expected to bring more synergy and joint initiatives between Indian and German institutions and organisations and will form one of the major pillars of the Research and Academic Relations Initiative in India by the German government. It is being jointly sponsored by the German Federal Foreign Office and the German Federal Ministry of Education Research (The Hindu, 2012). Similarly the Indo-German Science and Technology Centre has been established in India with its present office in Gurgaon (Haryana). The Indo-German Science & Technology Centre (IGSTC) is supported by Indian and German governments with equivalent contribution of 2 million euro's per year from German side and rupees 13 crores per year from Indian side for an initial period of 5 years. The Indo-German Science & Technology Centre (IGSTC) is registered as a "Society" under Societies Registration Act (Act XXI of 1860, Punjab Amendment Act 1957) as extended to NCR Delhi. The IGSTC is governed by a Governing Body (GB) having equal members from India and Germany. The IGSTC is steered by an Indian Director to be appointed by GB on nomination by Indian government. The IGSTC shall support mega joint research projects with co-funding from both sides in rupee as well as euro's components and participation of industry from both sides. The objectives of the IGSTC are to play a pro-active role to:

(i) facilitate participation of industry in joint R&D projects; (ii) provide/ assist in mobilizing resources to carry out industrial R&D projects, (iii) facilitate and promote Indo-German bilateral collaborations in basic and applied science, research and technology through substantive interaction among government, academia and industry; (iv) encourage public-private partnerships (PPP) to foster elements of innovation, application and cultivate a culture of cooperation between science and industry; (v) develop cooperation through the identification of scientists and scientific institutions of the two countries etc. (Bureau, Press Information, The Government of India)

The global publication share of Germany in 15 broad subjects varies from 4% (engineering 5th world rank) to 9.36% (physics 4th world rank). On the other hand India's global publications share among 15 broad subjects varies from 1.84% (medicine 9thworld rank) to 5.45% (Chemistry 5THworld rank). Yet there are important fields in which India has shown higher specialisation compared to Germany in terms of rankings such as chemistry, veterinary science, pharmacology, toxicology & pharmaceutics, agricultural & biological sciences etc. At the same time there are other fields where in Germany has shown higher specialisation compared to India in terms of rankingsas physics, public health, neuroscience, biochemistry, genetics & molecular biology, immunology & microbiology,

[2]references have been made in science policy research for India as sleeping giant.

mathematics etc. Thus there are various fields where in the collaboration between the countries can take place and each country can get benefitted from other countries specialised field.

Germany is the second most productive partner collaborating with India in S&T research as reflected in the co-authored papers after USA, accounting for 12.93% publications share during 2004-09. Germany is the second most productive partner in collaborative research with India in nine out of 15 subject areas studied in this paper: physics, materials science, chemistry, biochemistry, genetics & molecular biology, mathematics, earth & planetary sciences, chemical engineering, computer science and energy during 2004- 09. Germany was the third most productive collaborative partner with India in five subject areas, *i.e.* engineering, agricultural & biological sciences, environmental sciences, immunology & microbiology and pharmacology, toxicology & pharmaceutics. In medicine, Germany was the fifth most productive collaborative partner with India during 2004-09. India-Germany overall scientific collaboration, as reflected in their joint co-authored research output during 2004-09 has grown at an average annual growth rate of 6.78%. But, certain broad subject areas have shown higher annual average growth rate in Indo-German collaborative research than the national average of all disciplines (6.78%) during the same period, namely in computer science (23.59%), immunology & microbiology (18.88%), medicine (18.21%), environmental science (17.46%), materials science (16.28%), energy (15.55%), agricultural & biological sciences (14.38%), physics (13.56%) and chemistry (13.22). (Gupta & Fischer 2012)

Physics, material sciences, chemistry and biochemistry, genetics and molecular biology have been found to be most collaborative fields in the Indo-German collaboration, each contributing a publication share between 15.63% and 42.66%. Engineering, agriculture and biological sciences, medicine mathematics and earth and planetary sciences have been rated as medium productivity collaborative fields in the Indo-German collaborative research, each contributing a share between 6.6% and 10.1% during 2004-2009. At the same time the average citations per paper for Indo-German collaborative output for different subjects varied between 0.8 and 11.74 during 2004-09. It was highest (11.74) in medicine, followed by physics(8.44), biochemistry, genetics & molecular biology(6.69) and chemistry(6.22). It was lowest in computer sciences(0.80) and environmental sciences (2.44). (Gupta & Gupta 2011)

In all, 77 German organisations (contributing 20 or more papers) have participated in Indo-German collaborative researchduring 2004-09. Of these 77 German organisations, 47 are universitiesand 30 research institutes and their cumulative contributionaccount for 89.33% and 23.32% share, respectively in totalIndo-German collaborative output during 2004-09. Among the 47 German universities, the largest contribution(351 papers) to Indo-German collaborative research during 2004-09 had been made by Technical University, Darmstadt, followedby Ludwig Maximilians Universität, Münich (305 papers), University of Bonn (301 papers) and RWTH Aachen University, Aachen(288 papers). Among the 30 German research institutes, the largest contribution(143 papers) to Indo-German collaborative research during 2004-09 had been made by Forschungs zentrum Jülich (Gupta & Fischer 2012).

In all, 69 Indian organisations (contributing 20 or more papers)have participated in Indo-German collaborative researchduring 2004-09. Of these 69 Indian organisations, 31 are universities,28 research institutes and 10 institutes of national importance. Among the 31 Indian universities, the largest contribution(416 papers) to Indo-German collaborative research output during2004-09 had been made by Punjab University, Chandigarh,followed by Mangalore University (304 papers). Among the 28 Indian research institutes, the largest contribution(447 papers) to Indo-German collaborative research outputduring 2004-09 had been made by Tata Institute of FundamentalResearch, Mumbai, followed by Bhabha Atomic Research Centre,Mumbai (295 papers). Among the 10 Indian institutes of national importance, thelargest contribution (254 papers) to Indo-German collaborativeresearch during 2004-09 had been made by Indian Institute ofTechnology, Mumbai, followed by Indian Institute of Technology,Kanpur (226 papers) (Gupta & Fischer 2012).

There were 3892 collaborative linkages between top most productive 10 Indian and German organizations during 2004-09. The largest number of collaborative linkages (214 linkages) was between RWTH Aachen University, Aachen and Tata Institute ofFundamental Research (TIFR), Mumbai, followed by 208 collaborative linkages between Technical University, Darmstadt and Mangalore University and 192 collaborative linkages between RWTH Aachen University, Aachen and Punjab University, Chandigarh (Gupta & Fischer 2012).

V. CONCLUDING REMARKS

Thus various reasons and explanations have been provided in order to explain the increasing international collaboration in science and technology. Not a single model that has been propounded so far can provide a complete explanation of the ongoing increase in international collaboration independently, yet each one of these models contains an element of reality. Further we have noticed that there has been an impressive and consequential increase in India's international collaboration both with developed and developing countries. U.S.A, Germany & U.K being the top three collaborators of India (supporting the centre periphery model), yet when we look at other seven countries in top ten collaborating countries we find that it contains many developing countries of the periphery like Brazil, Russia, South Africa etc. (not supporting the centre periphery model). We reach similar conclusions when we analyse the top ten organisations collaborating with India in science and technology. However finally when we probe into the collaboration between India and Germany, we find that even after being 2nd top most collaborator of India, both countries are trying to increase their collaborations by taking various initiatives and tailor-making of policies. Here also we find that both countries have their own areas of specialisation and hence can avail various benefits by collaborating with each other.

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