International Collaboration: Experiences of Indian Scientists and Engineers after Returning from the United States

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Abstract[1]

This article presents findings on international research collaboration from a National Science Foundation-funded study with 83 faculty in science and engineering (S&E) who returned to India after studying and working in the United States. These faculty members were brought up in the Indian socio-cultural context, but they were professionalized in the scientific culture of Western academia. When they returned to India to take a faculty position, they knew collaborators in the US with desired skills, including their advisors. Yet, returned Indian migrant faculty face significant challenges in establishing successful international research collaboration with their American peers. Interestingly, this is not the case with collaborators from Europe and other parts of the world with whom they had little connection before moving to India. Findings show some inequities that exist between scientists and engineers in the US and India that pertain to resources and attitudes towards collaboration.

Keywords

core-periphery – Indian scientists & engineers – international collaboration – research collaboration – return migration

1   Introduction

In the past, developing countries were experiencing "brain drain" as their scientists and engineers relocated themselves for education and work to the United States and other developed countries (Varma 2007). With globalization—integration of economic, socio-cultural, technological, and political domains and circulation of people and knowledge across national borders aided by revolution in communication and information technologies—research in science and engineering (S&E) has expanded in many developing countries (National Science Board 2008). It has resulted in what can be best characterized as "brain circulation" as scientists and engineers from developing countries return home after education and work in the US and other developed countries (Varma and Kapur 2013). These returnees not only share their knowledge and expertise in building S&E capacity and infrastructures in their home countries, they also build international research collaboration with scientists and engineers abroad. Scientists and engineers in developing countries have been seeking international research collaboration as a way to build their S&E capacity (Duque et al. 2005), which is seen as essential to high quality research, innovation, and economic growth.

It has long been recognized that advances in S&E depend on the ability to work with the best scientists and engineers beyond national borders (Bush 1945; Frame and Carpenter 1979; Luukkonen et al. 1992). It is, therefore, no surprise that international research collaboration is growing in S&E fields (Bozeman et al. 2013). With the rise of the Internet, global boundaries have spanned, which has expanded the network of collaborating nations (Wagner 2005). For instance, a recent study found that the number of multiple-author scientific papers with collaborators from more than one country increased from 10 percent in 1990 to 25 percent in 2015. Furthermore, 58 more countries participated in international research in 2015 than in 1990 (Grabmeier 2017). It is proposed that with international research collaboration, a competitive edge in global innovation is maintained (Peters 2006). International activities are seen as enhancing one's productivity and access to funding (Bozeman and Corley 2004). In an increasingly globalized world, international research collaboration contributes to global agenda and global citizenship (Engels and Ruschenburg 2008; European Commission 2009). International research collaboration has become one of the key elements in doing academic science.

Yet, there is little agreement on the definition of international research collaboration in S&E. There are many ways international research collaboration is understood, namely international co-authorships, foreign exchange programs, intergovernmental agreements on scientific cooperation, scientific initiatives

of international organizations, international collaborative projects, and establishment of international, large-scale facilities (Ulnicane 2014). Typically, multiple authors with multiple international affiliations on published papers have been used as an indicator of international research collaboration (National Science Board 2018). Scholars employ bibliometrics and/or scientometrics techniques to analyze trends and differences in co-authorship among countries and geographical regions. Such counting, however, has been criticized, as it does not give correct scope of nature and extent of international research collaboration (Bozeman and Corley 2004; Sabharwal and Varma 2015). For instance, there are other forms of international collaboration that have no publication outputs, namely patents, innovations, mentoring, and student exchange programs.

Though international research collaboration is highly valued in academic science, it is seen as more complex than national research collaboration (Rosas and Camarinha-Matos 2009). There is a concern that international research collaboration may transfer critical knowledge and skills to another country in the era of global competitiveness; thus, all sides try to maintain their control on S&E projects. Funding process is unlikely to be similar in two countries, which adds inflexibility to support international research projects. Administration of such projects tends to be rather complex due to legal differences among various countries involved (Cozzens et al. 2011). Similarly, distributing costs and benefits in an equitable manner to various countries involved is a difficult task.

Most importantly, it is proposed that challenges in international research collaboration are compounded when the research team is comprised of individuals from different cultures, educational systems, histories, and with different language skills (Bagshaw et al. 2007; Kraus and Sultana 2008). To some extent, scientists and engineers are embedded in their national culture, that is, the set of norms, behaviors, beliefs, and customs that are prevalent in their country. Bourdieu (1977) has referred to this as 'habitus'—the physical embodiment of dispositions, ingrained habits and skills, and socialized norms that guide behavior and thinking. This habitus represents the way scientists and engineers in one country may differ in activities from those in other country.

In addition, the hierarchical relationship between developed and developing countries is likely to create challenges between scientists and engineers from collaborating nations. The core-periphery theory (Amin 1974; Frank 1967; Wallerstein 1974) provides a spatial metaphor of unequal relationship between developed and developing countries in international research collaboration. This theory holds that the modern nation states exist within the framework of the world capitalist system, consisting of a core (i.e. industrialized

countries of North America and Western Europe) and a periphery (underdeveloped countries of Asia, Africa, and Latin America). It shows how the world capitalist system has passed through various stages of development, each corresponding to different kinds of relation between the core and periphery. It reasons that the development of the core and underdevelopment of the periphery is predominantly an outcome of the unequal exchange through which periphery is exploited by the core for its cheap labor and raw material. The periphery has experienced partial dependent development, which remains under the control of the core. Recently, some scholars have used this theory for the international scientific system (Choi 2012; Hwang 2008; Kim 2006; Schubert and Sooryamoorthy 2009). They have mostly used bibliometrics and/or scientometrics techniques to analyze international collaborations showing advantages to center rather than to periphery countries.

In this article, we study international research collaboration in S&E by Indian faculty who returned to India after studying and working in the US. We focus on this group of faculty because they have been professionally socialized in the same scientific culture of the American academia; in the US they learned how to carry out research, conduct experiments, scrutinize results, value their own research, shape research teams, present findings in conferences, publish papers in peer review journals, and collaborate with their peers. So, their habitus should not be a significant factor in international research collaboration. In the era of globalization, returned Indian scientists and engineers do not form a monolithic group; instead, they have been exposed to and interact with those belonging to a variety of national cultures.

Because the place (e.g., industry, government) where the research is carried out can shape collaborative activities, we control institutional structures by focusing on international research collaboration by returned Indian faculty with academics outside India. Since international co-authorship is a partial indicator of collaborative activities, we rely on returned Indian faculty to use their own definition or understanding of international research collaboration though we recognize that such self-reporting lacks operational exactness. Also, it assumes that the concept of international research collaboration is similarly understood by everyone, which may not be the case. For this article, we define international research collaboration as a process whereby scientists and engineers who have returned from the US to India collaborate across borders to produce scientific knowledge and applications that allow them to participate in professional relations in their birth country and the foreign country. We recognize that this definition lacks operationalization, but it is useful for this article as it takes international research collaboration as a matter of both formal and informal activities.

Though the literature on international research collaboration has grown, there are limited studies from the perspectives of scientists and engineers from developing countries. Existing studies on this topic are quantitative using data on international co-authorship and centers and trans-national networks to examine inequities between center and peripheral countries. This article relies on qualitative methodology, which is explained in the next section; the social context and complexities of international research collaboration are also taken under consideration.

2   Methodology: a Qualitative Approach

Data for this article come from a National Science Foundation (NSF)-funded qualitative study of the return migration of faculty from the US to India that was conducted in 2013. We interviewed Indian immigrant faculty who moved back to India after studying and/or working in the US. They were selected from research-intensive, higher-education institutions located in seven states/ union territories: Andhra Pradesh, Delhi, Karnataka, Maharashtra, Tamil Nadu, and West Bengal. This gave us a balanced geographic mix. A list of Indian faculty in S&E departments who returned from the US was compiled from their curriculum vitae or biographical information posted on the institutions' faculty directories. We randomly selected those who had worked a minimum of five years at a US institution to insure that they were more than visitors, and had the opportunity to become socialized into US science activities. Overall, our sample included 83 Indian immigrant faculty who were employed in 14 known institutions of higher education in India. In a qualitative study, subjects are studied in an in-depth manner; thus, their number cannot be much larger. The names of the subjects and institutions are not provided to comply with the Institutional Review Board's (IRB) requirements for anonymity.

A semi-structured interview guide was used to conduct in-depth interviews with them, which lasted anywhere from one to two hours. The interviews were recorded, transcribed, and entered into NVivo for analysis. To ensure trustworthiness of data and minimize researchers' bias, two independent coders coded the data. The codes were categorized by themes that allowed us to identify patterns within the entire text. Inter-coder reliability for each category was assessed using Cohen's Kappa statistic, and reliability was established between coder one and coder two. We had coefficients of 0.90 or greater as acceptable level of reliability. A phenomenological approach—the lived experiences of a concept or a phenomenon for several individuals—was employed to understand international research collaboration. Findings are reported with

interview excerpts to highlight the complexity of concepts and by frequency to show their strength. Six out of 40 questions asked pertained to the international research collaboration and thus formed the basis for this article.

A majority (75 percent) of the returnees were employed at public institutions, while the remaining worked at private institutions (25 percent). Close to half of the sample (44.2 percent) were under 40 years of age, while 30 percent of them were in the age groups ranging between 40-49, close to 20 percent belonged to the age group ranging from 50 to 59 and a mere 6.5 percent were 60 years and beyond. About one-third of the returnees were full professors (32 percent), approximately one-fifth were associate professors (22 percent), and almost half of them were assistant professors (46 percent). Nearly 55 percent of them were working in various engineering departments: aerospace, civil, computer, electrical, environmental, or mechanical, while the remaining worked in biology, chemistry, and physics departments. Almost all of them were married (96 percent) and about three-fourths (73 percent) had children. In the US, a large majority of the returnees were on temporary visas (82 percent) and the remaining had a permanent residency card, including one who was a US citizen. On average, these returnees spent 9.5 years in the US before they decided to leave, and were in India for more than five years post-return (average of 9.3 years). On average, these returnees had spent over 13 years in academia. An overwhelming majority of them were male (84 percent) in the sample; this study, therefore, does not take gender into consideration.

3   Findings

3.1   *International Collaboration*

We first sought to find out whether returnees were engaged in international collaboration. Their responses were categorized into four categories: (i) yes, included statements that conveyed returnees were involved in at least one international collaborative project at the time of the interview; (ii) past, included declarations that showed current returnees were not involved in an international collaborative project, but had been in at least one prior to the interview; (iii) no, included sentences that suggested returnees were neither engaged in an international collaborative project at the time of the interview nor had any plan to do so in the near future; and (iv) future, included records that transmitted returnees were not engaged in an international collaborative project, but had the desire to do so in the near future.

The majority of returnees (62 percent) were involved in international collaborative projects, with some others (16 percent) who had been involved in

such projects in the past. Some returnees (13 percent) were not involved in any international collaborative projects though a few (9 percent) indicated a general openness and willingness for it in the future. It appeared that their ability to collaborate internationally was hindered by limitations in time, funding, or a lack of compatible connections and collaborators. As one returnee said, "Right now I don't. And one of the reasons for that is that I wanted to build up myself in the field. Otherwise I will have to work with somebody and go in his field and pretty much do that." Another said, "There have been opportunities but we have not gone after those. The primary reason is that we are really out of whack because of the number of projects we can handle."

If returnees responded positively to international collaboration, we further explored how many such projects they were engaged with and with whom they were carrying them out. Almost one-third of returnees (28 percent) were involved in one international collaborative project and the rest had anywhere from two and more such projects. Typically, returnees had either two or three international collaborative projects, with eight percent of them involved in several projects. The locations that returnees collaborated internationally varied, but most tended to work either in Europe (generally or a combination of countries) or in the US. The predominance of countries within Europe was distinctive (37 percent), followed by the US (24 percent). Another 17 percent returnees were working on a project both in Europe and the US simultaneously. The remaining returnees mentioned projects all around the world located on three different continents. As one returnee said, "We have an Indo-UK project and now we are trying to get something done with Finland." Another said, "Currently I have one with the Netherlands." This returnee noted, "I have a small collaboration in Germany, but most of my projects are with people in the U.S."

Finally, we asked those returnees who had an international collaborative project what type of international activities they were carrying out. Their responses were categorized into two broad categories: (i) research, included statements that conveyed research-related activities, which included exchanging ideas, experiments, laboratory work, writing and publishing papers, writing and submitting grant proposals, and making presentations on findings; and (ii) exchange, comprised of sentences that showed exchanges of students and teachers between the programs.

The kind of collaboration that the returnees were engaged in varied. A large majority (67 percent) talked about international collaborative research projects with their foreign collaborators. As one returnee said, "I have a collaboration with a couple of professors in South Africa. That arose out of a meeting at an international conference and then we applied for a joined

funding which was funded, mostly a travel grant." Other echoed, "I have started a collaboration with a scientist in Bristol … We have a three-year research collaboration, so I visited Bristol last summer for some weeks, he came to [India] this summer."

It should be noted that not all international research projects were formal with funding, organizational support, task structure, and well-established relationships wherein a set project is completed. Some returnees discussed informal international collaborative relationships with colleagues and institutions, but the terms on which these informal relationships were based were not entirely certain. It appeared that informal collaboration involved general communication and an active attempt to remain open to the potential for a new collaborative project. As one returnee said, "We have couple of informal collaborations where we discuss things on and off … They are not funded projects. They are just something that we are exploring. So that is going a bit slower in the sense that whenever we find time we do some work on it." Another conveyed, "I am doing some international collaborations in terms of idea. We do not have a written formal collaboration." It seems that returnees stay in contact with colleagues in order to remain open to future collaborative projects.

Remaining returnees (33 percent) mentioned exchange programs established between them and their collaborators' institutions, which allowed them and/or their students to travel between the institutions to teach and learn. Some of them termed their ability to collaborate internationally in reference to their institution, which had a working partnership with another institution outside of India, and set up a network of communication and exchange, wherein the returnee could send students and receive students to and from this institution, work there as a visiting professor, and work with their colleagues at the international institution. As one returnee said, "I taught there for one semester and got some experience of what they were doing. And we expect that in future again." Another said, "In one of our classes, we actually had student teams formed. Some students in a team were from [India] and some were from [outside India]. We worked on the design exercise." This returnee explained, "We do have a lot of international visitors here, with whom we get to interact and something does come up." A few returnees worked with organizations, which allowed them to participate in work for that organization across multiple international areas with different people. As one returnee said, "My institute has two joint centers. One is with [X], and the other is with [Y]. The total funding for three years is about $500,000, and that funding is only for the exchange visits of faculty, students, post docs and workshops."

3.2   *Challenges in International Collaboration*

We asked all returnees, including those who did not have any international collaborative projects, to describe major challenges in collaborating internationally. First, their responses were categorized into two general categories: (i) yes, included statements that showed various challenges, which emerge in international collaborative projects; and (ii) no, composed of sentences that there were no significant challenges in collaborating internationally at the time of interview. Second, the yes category was differentiated further based on the types of challenges, which are outlined later.

A small number of returnees (16 percent) stated that they do not actually have any issues collaborating internationally, and it is relatively easy to do so. They believed that if a fair international collaborative project that is mutually beneficial can be negotiated, then there would not be any issue. As one returnee said, "Academically, it is fantastic to collaborate with people outside. I have never had problems because the terms are very clear, what my expertise is and what they are expecting from me." Another echoed, "I don't think there are any challenges as such that I can think of. If you have some ideas, concrete ideas, you discuss it with proper person and chances are they will be picked up."

The large majority of returnees (84 percent), however, discussed various challenges they face in carrying out international collaborative projects. Almost all returnees gave more than one response; however, their responses were coded only once in the first category, which was viewed as a primary category. It should be noted that there was a feeling that having an international student or faculty exchange program is a lot easier to deal with, and does not have as many challenges toward being successful as international collaborative research. Returnees outlined the following challenges in international collaboration.

3.2.1   Finding Suitable Collaborators

This category included statements that indicated the major challenge was finding appropriate international collaborators with whom the fit was intellectually rewarding, fair in division of work and distribution of rewards, and there was mutual respect for national and socio-economic differences. Over one-third of returnees (33 percent) stated that the greatest difficulty in collaborating internationally was finding suitable collaborators or a project that would benefit them. According to them, if these connections could be found, or if a project that is mutually beneficial could be agreed upon, then there may not be an issue in collaborating internationally. As one returnee said,

"You have to find the right match. The challenges that exist in collaborating internationally are somewhat same as in collaborating inside India. It has to be a match of two minds and if that happens it can work anywhere." Another indicated, "The problem with international collaboration is that the credit has to be appropriately shared. So you have to find people who are reasonable in that regard, which is not easy." There was a preference towards working with familiar contacts that were already established. Since these people returned from the US, they thought it would be easier to collaborate with their American peers. However, some noticed that comparatively there is growing collaborations with Europeans with whom they have little connection; but, not with Americans with whom they have had a long connection since they were US-trained, and published papers with their advisors and other faculty members. As one returnee said, "Americans should be willing to collaborate with Indians like Europeans do. There are many programs between India and Europe, but not between India and U.S." Another explained, "Two weeks ago a fellow from Ireland was here and made a strategic decision to start collaboration with us Indians. Before that I met a French group and before that a Swiss group. I have no idea what is driving this. I see it more from Europe, but less from the U.S." Commenting on international students, this returnee declared, "We have a lot of European students in India, but you will hardly find American students here." A few returnees went to the extent of saying that Americans are unwilling to collaborate with Indians. This returnee generalized, "Americans only see India as a reservoir of good students and nothing more."

3.2.2   Distance

This category included statements that indicated the greatest challenge returnees faced in collaborating internationally was the geographical distance and difficulty in communication and travel due to distance. For one-quarter of returnees (26 percent), physical distance between India and foreign countries was a major challenge in collaborating internationally. This distance often restricted communication (especially when dealing with different time zones), ability to travel to collaborate, and the general ease of facilitating a successful collaborative environment. As one returnee said, "The main challenge is distance. It matters that you are living far away and not sitting across the table. So you have to rely on phone calls or emails, which are not really an efficient way to collaborate." The other narrated, "Although it is very easy to plan that you will collaborate together, different time zones here and there do become an impairment." These returnees acknowledged that information technology and communication tools have greatly reduced issues in collaborating internationally. While such technology does not entirely remove the challenge of

distance, it at least reduces its magnitude, and makes it easier to collaborate in spite of distance. Several returnees referenced Skype and emails as their primary mode of communication with collaborators. As one returnee said, "I have a few collaborators with whom I interact on Skype. The technology has helped, but meeting and spending half a day with your collaborators cannot be supplanted by a Skype conversation." Another said, "Skype meetings help to some extent … but students do not get full exposure to high quality research with Skype." There was a general preference toward collaborating face-to-face where distance is not an issue, which reduces issues in communication and workflow. Some returnees, however, pointed out perpetual problems in getting a US visa; interestingly, no one mentioned a visa to be an issue when collaborating with non-Americans. As one returnee said, "It is very difficult to get an American visa. There is a disconnect between how welcoming the university is and how welcoming the U.S. embassy is." Another responded, "The primary hassle is that the visa regime is oppressive and down right crazy … If any policy maker in the U.S. is thinking about encouraging collaboration specifically with India, they need to rethink how they are handling the visa particularly with researchers." This one showed his anger, "The U.S. should stop treating scientists like criminals when it comes to visas."

3.2.3   Funding

This category is comprised of statements that showed issues with securing or finding grants to support returnees' projects as a hindrance in collaborating internationally. For some returnees (19 percent) funding has to be sustainable and useful toward fostering an international presence and maintaining international collaborative relationships. As one returnee said, "One would be the funding. You know just how are you going to work it all out, for travel, for stay, and those sort of things." Several returnees believed that American institutions value international collaborations theoretically, but hesitate in financially supporting activities to sustain them. It seems US institutions of higher education do not have internal financial support for international collaborations; they mostly encourage seeking external funding for them, which was an additional challenge. As one returnee said, "Indo-U.S. formal structures and funding options are not that many. It is a pity, given the number of Indian faculty and scientists who have gotten their advanced degrees in the United States." Another stated, "What is sustainable is that if a U.S. agency sponsors part of the process." Some returnees mentioned that funding from the European Union or European countries was relatively easy to come by for international collaborations. This returnee contrasted the American funding scenario with Europeans, "There are a lot of funding options with Germany, for example,

but how many Indian scientists have gotten their degree in Germany, not very many. Compare this to the United States, where many Indians have gotten their degrees and there is little funding." Some returnees also complained of restrictions in funding for non-Indians. It appeared that India is restrictive on what funding they provide to foreign entities. This leaves little incentive for foreign collaborators to work with returnees. As one returnee said, "I can apply for an EU [European Union] grant with a foreign collaborator ... but no foreign citizen can apply for an Indian grant. Therefore, a foreign researcher has very little to gain from me."

3.2.4   Execution

This category included statements that showed some differences in carrying out research-related activities, namely focus, national identity, and gender issues as a challenge in collaborating internationally. For some returnees (15 percent) the differences in both the scope and method of scientific activities were a hindrance toward collaborating internationally. They often used the US as a point of reference, stating that their focus and conduct for research was too different in comparison to India that made it difficult to successfully establish a collaborative project that is mutually beneficial. For some, the work they were doing was India-centric, which tended not to appeal to Americans. As one returnee said, "My field is very application oriented to India. So it is difficult to have the U.S. universities to work on which is entirely India specific." Interestingly, European collaborators appeared to be interested in what can be termed either as a global or an Indian problem. Other returnees discussed non-scientific factors with their American peers as a challenge in conducting international collaborative work. One returnee declared, "In my opinion, international collaborations are still not perfectly bilateral." National and gender identities, which did not appear significant in other questions, were at forefront. A few returnees remarked that their ethnicity was actually detrimental toward collaborating internationally. As one returnee with reference to US said, "Very tough to manage. One of the reasons is that they live in their own little islands with a big fat ego ... with the subtle power they enjoy, it becomes extremely hard to overcome that." Another said, "You do not see white Americans collaborating with Indians. You see Indians in India collaborating with Indians in the U.S. These Indians will collaborate no matter what. For international collaboration to grow, Americans have to collaborate with Indians. Color of skin prevents such collaborations." Female returnees discussed the difficulty in fostering a fair and respectful collaborative relationship due to their gender in comparison to their male colleagues. As one said, "I am very little, nobody notices me, and I am completely dismissed professionally being a woman."

3.2.5   Bureaucracy

This category consisted of sentences that indicated general institutional or bureaucratic limitations restricting with whom and how faculty can collaborate internationally. A few returnees (7 percent) stated that the Indian bureaucratic system restricted international collaboration. They complained that dealing with paperwork and the bureaucratic system is extremely complex and a huge deterrent for collaborating internationally. As one returnee said, "Paperwork is so extensive just to hold a workshop here and invite outside individuals. The paperwork is killing." Another gave this example, "We submitted a proposal to Indo-UK program in October 2011 which got funded in July 2012. However, the money could not be touched until approval by the Indian ministry. So there was another 6 months delay, all because of Indian bureaucratic issue." There was an acknowledgement that the bureaucratic system is becoming more open to international collaboration, but progress generally was slow.

3.3   *Improving International Collaboration*

We asked all returnees to suggest what can be done to improve international collaborations between Indian and American scientists and engineers. We limited ourselves to the US because of our focus on US-returned Indian scientists and engineers. Their responses were first categorized into three categories: (i) aid, included various suggestions that would lead to better international collaborative relationships between the two countries; (ii) satisfaction, included statements that showed non-existence of challenges and approval of existing opportunities between the two countries; and (iii) impossible, comprised of sentences that implied international collaborative efforts with the US were difficult to improve, and not worth their efforts.

Some returnees (14 percent) stated that the state of international collaboration between the US and India was good, and actually praised the system, giving little to no notes of improvement. The general sentiment was "International collaboration with the U.S. is fine … there is no need to do any thing special." It should be noted that these returnees were mostly referring to exchange programs between India and the US. Several spoke favorably of the high standard of the US education system where Indian exchange students could enhance their studies and experiences. As one returnee said, "Students regularly go to the U.S. institutions to get education and some training … They get degrees, they do internships … all sponsored by the host."

Interestingly, some returnees (12 percent) did not see a way to improve collaborative effort with the US. This was mostly due to the physical distance

between the two countries that affected international collaboration, as well as the rigid US immigration system. Physical distance could not be improved through more funding or better programs. As one returnee explained, "We are definitely far apart in space ... Geographically, India is closer to France, Germany and all those places, so, it makes it easier to collaborate with them." A few returnees felt it was hopeless to collaborate with Americans due to immigration issues. As one returnee said, "We all hear stories that faculty and students have applied for conferences in the U.S. but by the time the visa cleared, either the conference had started or the flight had gone. So this actually builds up a wall which dissuades us to even try."

A large majority of returnees (74 percent), however, made various suggestions, which were likely to improve international collaborations between India and the US. Almost all returnees gave more than one response, which were coded only once in the first primary category. Returnees made the following four suggestions.

3.3.1   More Funding

Most returnees (37 percent) felt that more funding was needed to aid international collaborations between Indian and American scientists and engineers. Many acknowledged the existence of funding, but also stated that the funding was often not enough, and only covered a small portion of the collaborative project, namely travel. Several compared the US with other European countries, which provided more money for collaborative projects in comparison, and thus were seen to be more successful in their collaboration efforts. As one returnee explained, "If we want to leverage those links, then it takes more than what is available right now. UK puts in more money, Australia puts in more money ... We have little links with these countries. But, they are putting in more funds for collaborations than the U.S." Many returnees also acknowledged the need for more funding for travel, especially since the US was far away from India, thus more expensive. As one returnee said, "One difficulty is that travelling to Europe or Japan is more advantageous and easier for an Indian because of the amount of travel money. Travelling to the U.S. costs more." Overall, returnees believed that there should be more grants looking to support international collaborative projects.

3.3.2   Less Red Tape

Almost one-third of returnees (29 percent) indicated that in order to improve collaboration between the US and India, administration in both countries needed to become lot more flexible and cooperative than what it is now. It is interesting to note that for the American side, these returnees referred to the obstacles created by the US immigration service; whereas, for the Indian

side, obstacles were at the institutional level. Returnees suggested that the US needs to have better immigration policies for visiting scholars from developing countries. As one returnee said, "U.S. can do a lot more ... It is such a pain to get a U.S. visa that everybody just hates it. You are waiting and waiting and not knowing until the end whether you will get the visa ... Such things need to change if U.S. wants to encourage cross pollination." Another declared, "Please, release the restrictions on foreign travel from scholars." Overall, returnees believed that US institutions were fairly open in spite of difficulty with US immigration. The same sentiment was not there when it came to Indian institutions. Some returnees suggested that the Indian educational institutions ought to become more open to accepting visiting researchers from the US. Similarly, they felt there should be less paperwork to make international programs more efficient. One returnee said, "If I want to get an American scholar, I have to get a lot of approvals from Indian officials, but this is not the case in the U.S." Another said, "We are given a lot of money in India for international work, but not the freedom to use it ... So, restrictions to use the money should be lifted." In general, these interviewees seemed to express a need to have a more open system, which would allow for international collaboration without navigating bureaucratic systems that tend to slow the process of collaboration and deter potential collaborators.

3.3.3   Outlook Changes

Over one-fourth of returnees (24 percent) indicated that US scientists and engineers needed to change their attitude towards collaborating with Indians. There was a general feeling that the benefits for collaboration were one-sided and the workload was not always evenly distributed. A few returnees felt that some of the programs in the US were a bit insulting towards Indians wherein Americans underestimated their abilities. This returnee expressed his resentment, "In general it is almost impossible to work with 99.9 percent of Americans. These people are very good, very smart, but so are we ... But, they have big ego." Another gave an example, "From [X university], we got a proposal to have exchange visiting faculty ... It was about how they would teach us everything they know and we would have to get two faculty to go there who would sit in classes for four months, come back and teach the rest of us." In other words, a better collaborative relationship between India and the US needs to be established where both sides feel the terms are equal.

3.3.4   Additional Programs

A few returnees (10 percent) felt that more collaborative programs and opportunities ought to be established between the US and India, which are mutually beneficial to both sides. Further, these programs should be sustainable and

long-lasting, and take shape in a stronger alliance as opposed to temporary collaborative projects. There was a recognition that the US is rich in resources and technology and has better infrastructure compared to India; however, India was seen as rich in qualified human power compared to the US. Thus, having more visiting faculty programs would benefit both countries. While some returnees praised the ability for Indian students to study in the US, they were not so optimistic when it came to faculty and post-doctoral fellows. As one returnee said, "There are more exchange faculty programs between India and Europe than with the U.S.... I think NSF (National Science Foundation) does not have such schemes, if they do, there are not many."

4   Discussion

Typically studies use joint publications as a valid marker for international research collaboration (e.g. National Science Board 2018). There is a preference for publication data because published papers tend to include the names and affiliations of the authors so the country of authors can be indexed. The results of this study, however, show that international collaboration is not limited to joint publications. International collaboration between scientists and engineers in India and elsewhere resulted in research projects and exchange programs, which involved multiple activities such as publishing papers, making presentations in conferences, writing grant proposals, taking visiting faculty positions, having an exchange of students, and developing technologies. In addition, international collaboration ranged from having discussion with colleagues (informal) to active engagement in research and exchange activities (formal). In addition, findings in this study showed that Indian returnees are rather cosmopolitan (Bozeman and Corley 2004) as they not only work with people in India, but are open to collaborators from any geographic location. Such forms of collaborations are fostering scientific ties between scientists and engineers situated in India and in other countries.

In a study on India's research output and collaboration conducted by Thomson Reuters characterized India as a "sleeping giant" that seems to be waking up (Adams et al. 2009). For instance, in 1981, India published 14,000 papers in the Thomson Reuters database, which rose only to 16,500 by 1998. Since then, there has been major growth in publications; India published 30,000 papers in 2007, which is an 80-percent increase in just nine years. The Thomson report, therefore, suggests that Europe and the US ought to become partners with India rather than just being observers. In 2016, India produced 110,320 peer-reviewed S&E publications (National Science Board 2018). Findings from this

article suggest that international collaboration with European countries, rather than with the US, is on the rise. Challenges in international collaboration were grouped into five distinct categories, namely finding suitable collaborators, distance, funding, execution, and bureaucracy. International collaboration was more with Europe than with the US. Similarly, suggestions to improve international collaboration centered mostly on what needs to be done on the American side. Though international collaborations is seen as resulting in positive outcomes in the US, it appears that American colleagues are not taking full advantage of this opportunity with Indian colleagues. This is ironic since these returnees were trained in the US, and thus have similar professional ethics and work styles. They build networks with peers while in the US, and carried these ties with them upon return to India. In contrast, they had little initial connection with European colleagues, but are now increasingly collaborating with them. It should be noted that we did not cross-check returnees perspectives with their American and European colleagues to find out the reasons behind their relative insularity and attraction with India, respectively.

International collaboration is seen as an increasingly important outcome of globalization. In scholarly literature, it is seen to work best when the collaborating units have common research interests, complimentary skills, adequate financial and research resources, and a conducive research environment. The key factors that emerged as inhibitors of successful international collaborations with Indian scientists and engineers are: compatibility between researchers, geographic distance, level and sources of funding, type of research, and bureaucratic hurdles. Distance from the core (i.e. distance geographic distance between India and the US) is often enough to place even competent researchers on the periphery (Schubert and Sooryamoorthy 2009). Returnees in this study highlighted the challenges with unequal treatment in collaborations specifically with US scholars—Indian scholars are often perceived as consumers of knowledge produced by the US, and hence Indo-centric research generated by the scientific community in India is not seen as part of the core scientific knowledge—thus creating a hierarchy of sorts (Hwang 2008). It is interesting to note that the ties established by Indian returnees while in the US have not fully diffused into future collaborations—these scientists and engineers feel a part of the periphery while once probably belonging to the core. Thus, the physical movement of individuals away from the core can take away the networks established and move them to the periphery. Future research can study the movement of migrants in S&E and its impact on their placement in the scientific world system.

Furthermore, Indian-returned scientists and engineers emphasized the imbalance in collaborations with the US, wherein the core views Indians

(periphery) as purely a reservoir of talent by attracting the best students to the US, furthering the production and centrality of knowledge, thus strengthening the core. It should be noted that foreign Indian students are overwhelmingly present in S&E in US institutions of higher education (National Science Board 2016). The collaborations between the core and periphery are anything but equal and are characterized by geopolitical inequities in reputation, accumulation, and distribution of scientific knowledge, a phenomenon rightly labeled by Hwang (2008) as "multilayered center-periphery relationships." The differential of power thus created by the knowledge accumulation and creation by the core is resented by some returnees who viewed some in the US scientific community as egotistical and self-centered, further highlighting the challenges that arise in cross-cultural and international collaborations. While most returnees specified challenges with Indo-US collaborations, the ties were stronger with European and other nation scholars. However, nations closer to India physically and having positive attitudes, witnessed stronger and successful collaborations. Overall, most returnees agreed that international collaborations were useful and improved the quality and relevance of Indian research, thus contributing to the development of the Indian innovation system.

In addition to cross-checking responses of returnees with their American and European colleagues, there are some limitations in this study. We did not find out how international collaborations were established, which would have shown relevant factors such as common research interests, scientific competencies, visibility of researchers' work, and understanding of scientific quality. Also, it would have shown whether scientific outputs in journals, proceedings or conferences were good avenues in identifying potential collaborators. We did not examine the perceptions of returned academics on the quality and relevance of international research projects. We assumed international collaboration involved a mix of scientific, institutional and social motives. Also, we assumed the process of establishing international collaborations moved from informal to formal. Future studies can address these limitations by understanding the various forms and structures of international collaborations.

5   Conclusion

The current study highlights the challenges faced in international collaborations by academics trained and educated in the US and now working in premier academic institutions in India. The study is based on in-depth interviews with 83 return migrants who after receiving their doctoral degrees and working in the US for at least five years are currently employed in science and

engineering institutions of higher education in India. The key findings provide credence to the center-periphery model that explains why individuals working in countries like India are marginalized and on the periphery of international scientific collaborations. Future research can separate formal and informal collaborations, and can quantify the various kinds of collaboration via a survey or analysis of curriculum vitae of academics. Furthermore, conducting a longitudinal analysis of return migrants and tracking their collaboration patterns over time will provide greater insights into the impact reverse migration has on collaboration. The results of this qualitative study, nevertheless, provide us with a window into factors that either hinder or aid successful international collaborations. Policy efforts can thus begin to focus on ways to promote cross-national collaborations across nations that are considered at the core of innovation with those that lie on the periphery, but have much to contribute.

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