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Innovating in the periphery: The impact of local and foreign inventor mobility on the value of Indian patents☆

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A B S T R A C T

We examine the impact of local and foreign labor mobility in India by modeling one regional and one global network, each of which captures the inter-organizational mobility of inventors. Our analysis of the regional network shows that, within India, the productivity of inventors does not improve when they move from foreign to Indian organizations. In the global network, we find that Indian organizations remain located in the periphery as a result of employing a small number of inventors from foreign organizations. However, in the instances when inventors are hired from foreign organizations, they are able to produce patents with a higher impact in comparison to inventors hired from other Indian organizations. Furthermore, when the inventors are hired from abroad, the impact of their patents is even higher in comparison. The implications of these findings for innovation and policy in the emerging economy context are discussed.

1. Introduction

Individuals generate stocks of knowledge, capabilities and skills from their prior work experiences. When people move between organizations, a portion of their accumulated knowledge travels with them, which could then be beneficial to their new host organizations (Argote and Ingram, 2000; Arrow, 1962). This process, however, does not occur without certain obstacles, as the extent of knowledge transfer is affected by the specific attributes of the knowledge, the individual, and the organization. For example, it has been shown that it is difficult to transmit tacit knowledge between two organizations (Brown and Duguid, 1998; Grant, 1996; Nonaka, 1991; Polanyi, 1966), particularly if their knowledge bases differ substantially (Zahra and George, 2002). As such, the transfer of knowledge from one organization to another does not occur automatically (Kogut and Zander, 1993; Singh, 2005).

Previous research has indicated that some of the challenges associated with transferring tacit knowledge across organizational boundaries can be alleviated by close social relationships and face-to-face interactions (Agrawal et al., 2006; Breschi and Lissoni, 2009; Singh, 2005). These relationships can include inter-organizational collaborative ties, alliances, as well as hiring new labor, which has also been shown to facilitate the process of tapping into and building on external knowledge (Hoisl, 2007; Liu and Buck, 2007; Moen, 2005; Song et al., 2003). In this study, we extend the discussion on the effects of labor mobility to an emerging-economy context, specifically that of India. We examine the effects of two forms of labor mobility: mobility from co-located organizations and mobility from geographically distant organizations. For the purpose of this study, organizations include firms, universities and research institutions.

Examining the trend and the effect of labor mobility in emerging economies has important implications for managers and policy-makers alike. The rapid growth rate in R&D productivity, witnessed in a number of emerging economies in recent years, is a testament to their abilities to innovate, and yet there remains a technological gap separating many organizations headquartered in these locations from those of advanced economies (Furman and Hayes, 2004; Wright et al., 2005). If domestic organizations headquartered in emerging economies (henceforth referred to as domestic or Indian organizations for simplicity) employ foreign talent, and if in doing so knowledge is transferred from the foreign organizations, emerging economy firms may be able to acquire the knowledge and skills required to effectively compete with the countries in which the knowledge originated. While this can be a distinct advantage for emerging economies, for advanced nations it can potentially lead to a "hollowing out" of competences.

With the aid of patent data, this study explores two questions regarding labor mobility in India. The first examines three possible

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sources of new employees joining Indian organizations, namely: other Indian organizations, Indian subsidiaries of foreign organizations, and geographically distant foreign organizations. The second question examines how labor mobility from each of these three sources affects subsequent innovation by the hired employees when they join the Indian organizations. To address these issues, we model one regional and one global network, each of which captures the labor mobility trends to Indian organizations. The regional network specifically captures mobility ties between Indian organizations and subsidiaries of foreign organizations in India. The global network accounts for the possibility of newly hired employees from geographically distant foreign organizations (such as returnee entrepreneurs), and differs from the regional network in that it is constructed using *all* patents in the USPTO database, not just those issued to organizations located in India. In line with similar studies (e.g., Balconi et al., 2004; Fleming et al., 2007; Giuliani and Bell, 2005), we also use social network analysis to illustrate the patterns of inventor mobility and to examine its effect on innovation.

In so doing, this study makes a number of contributions to the current literature on international management. With a few exceptions (Filatotchev et al., 2011; Gorg and Strobl, 2005), most studies examining the effect of labor mobility have been in the context of advanced economies. Our focus on organizations in India will help extend existing empirical evidence, by examining whether labor mobility can also be an effective mechanism for improving innovation in emerging economies. Additionally, by studying intra- and inter-regional labor mobility concurrently, this study provides a deeper understanding of how the two mechanisms differ in terms of their impact on innovation by organizations in India. The study also makes a contribution to the literature relating to the internationalization strategies of MNCs. A major feature which continues to attract MNCs to large emerging economies, like India, is the availability of large pools of skilled, but low cost labor (Thursby and Thursby, 2006). Accordingly, the flow of labor from Indian organizations to subsidiaries of MNCs is inevitable. We extend these prior findings by examining whether or not Indian organizations can also attract employees from the co-located subsidiaries of foreign firms.

2. Theory and hypotheses

2.1. Labor mobility in India and the productivity of mobile inventors

A large body of literature has explored the occurrence and effects of labor mobility, both within and across regional boundaries. Much of the literature has found that while there are different methods by which employers source new employees, a large proportion of labor is hired through personal contacts or referrals (Autor, 2001; Granovetter, 1995). In accordance with the 'homophily principle', these personal contacts are more likely to occur between people that share similar traits such as a common language or culture (McPherson et al., 2001). Consequently, social ties and labor mobility are more likely to occur within rather than across regions (Almeida and Kogut, 1999; Breschi and Lissoni, 2009). This might also imply that domestic organizations and subsidiaries of foreign organizations that are co-located within an emerging economy will potentially share these ties.

For domestic organizations, hiring new talent from the subsidiaries of foreign organizations is attractive for several reasons. Firstly, from a transaction-cost perspective, the cost of hiring from the locality is lower (Angel, 1991; Krugman, 1995; Marshall, 1920). Secondly, hiring new employees from captive subsidiaries can generate opportunities for domestic organizations to catch up technologically by leveraging foreign knowledge. For example, Song et al. (2001) found that employees in South Korea and Taiwan who were previously employed by US firms, often build on knowledge that was developed in the US, thereby contributing to the reduction of the technological gap between the countries. Hence, there is also an incentive for domestic firms to build on the foreign knowledge that exists in the captive subsidiaries.

Contrary to the arguments suggesting that there are fundamental drivers causing labor to move from foreign to domestic organizations, there are a number of reasons for doubting the existence of this underlying trend. One factor which could deter mobility between foreign and domestic organizations is the difference between each of their objectives and specializations: if these diverge too greatly, there may be little benefit from hiring new talent from foreign organizations. For example, a primary objective of many subsidiaries of multinational corporations (MNCs) in India is to adapt home-country technologies to suit the local context (Prahalad and Lieberthal, 1998) – an objective which differs from those of many domestic organizations who would like to stretch their products to be competitive with global standards. For similar reasons, different types of organizations in India vary in the extent to which they hire foreign talent. Universities and research institutions have different incentives toward innovation relative to private firms, and may therefore search for potential employees from different labor pools. For example, consider the case of the Council of Scientific and Industrial Research (CSIR), an Indian state-owned entity. Like many other state-owned entities, employee salaries at CSIR are heavily regulated (Choudhury and Khanna, 2009), which may not appeal to employees in foreign organizations where salaries are generally more market-driven.

Taken together, these arguments suggest that labor mobility from foreign organizations to Indian organizations should not occur in abundance. When they do occur, however, it is likely that they will lead to the creation of high-impact innovations. The knowledge required for continuous innovation is unlikely to exist within the boundaries of a single organization; but it is rather dispersed across multiple organizations. Thus, an organization's ability to access external knowledge is a process that is indispensable for its innovative performance (Mansfield, 1988). For emerging economy organizations, accessing external knowledge, through labor mobility or otherwise, is expected to have greater implications because these organizations typically have smaller stocks of knowledge due, in part, to their younger experiences with innovation and R&D (Filatotchev et al., 2011).

Apart from the creation of a conduit through which foreign knowledge can flow into emerging economy organizations, there is a second reason to expect that hiring new inventors from foreign organizations would increase the impact of patents developed. In a study which utilized patent data, Hoisl (2007), who measured the impact of patents produced by mobile inventors, found that inventors become more productive after the move; a result that is at least partially driven by better employer–employee matches (Topel and Ward, 1992). In the context of developing economies, Gorg and Strobl (2005), who study the influence of intra-regional mobility from subsidiaries of foreign MNCs to local firms, show that Ghanaian firms, whose owners previously worked at an MNC within the same industry as the new firm, were more productive as a result of the knowledge that they brought with them. A similar effect is expected in the Indian context, therefore:

Hypothesis 1. The impact of patents produced by mobile inventors hired from foreign organizations is higher after they move to the Indian organization.

2.2. Global labor mobility, and the productivity of distant and local hires

Apart from hiring from within regional boundaries, Indian organizations can also tap into foreign knowledge by hiring employees from geographically distant foreign firms. However, for several reasons, we expect that Indian organizations will be located within the *periphery* of the global network, such that the rate at which they employ labor from globally distant organizations will remain low. A recent survey by the OECD (2009) indicated that increases in inter-regional mobility are geographically widespread. Nevertheless, certain factors attract skilled labor to some regions as opposed to others. For example, most OECD countries (particularly, the United States, Canada, Australia and France) have experienced a high degree of incoming skilled labor (OECD, 2009), due to the fact that advanced economies benefit from more established labor and capital markets (Bresnahan and Gambardella, 2004). It is therefore unsurprising that global mobility trends would exhibit heterogeneity, given that the labor force is attracted to some regions more than others. As a result, the global mobility network is expected to contain dense regions, hereafter *core* regions, and sparse regions, hereafter *the periphery*.

A number of studies that have modeled regional networks highlight the attributes of organizations and individuals that reside in the core versus those that reside in the periphery. Core positions are often associated with enhanced creativity (Cattani and Ferriani, 2008), as well as higher absorptive capacities (Giuliani and Bell, 2005) and innovative output (Cantner and Graf, 2006). Although measured in the context of regional networks, these attributes resonate with those held by the core of the global network. For example, in modeling the international co-authorship network, Wagner and Leydesdorff (2005) found that countries that are more scientifically advanced reside in the core, while less scientifically advanced countries reside in the periphery. Other global networks depicting trade, commodity exchange, and other relationships have corroborated this trend (e.g. Fagiolo et al., 2009; Nemeth and Smith, 1985; Reyes et al., 2008; Snyder and Kick, 1979). Following these findings, we conjecture that there is a higher likelihood that skilled labor will move to and between regions in advanced economies, and therefore organizations in these economies will be in denser regions of the global mobility network than emerging economy organizations.

If hiring foreign talent improves the quality of innovation produced by Indian organizations, then improving their position in the global network such that they become located closer to the core would therefore be advantageous. Subsidiaries of foreign organizations located in India have an advantage over single-location domestic firms because they are able to tap into globally dispersed knowledge with greater ease (e.g., Bartlett and Ghoshal, 1989; Frost et al., 2002; Kogut and Zander, 1993; Nobel and Birkinshaw, 1998). In other words, knowledge that is embedded in these subsidiaries is likely to be more diverse relative to neighboring, domestic organizations. Thus, hiring labor from local subsidiaries could create a conduit for the transfer of knowledge that is heterogeneous, creating richer possibilities for producing novel innovations (Cummings, 2004; Reagans and Zuckerman, 2001; Rodan and Galunic, 2004). The discussion thus far suggests that, all else being equal, the patents produced by new hires from subsidiaries of foreign organizations would be higher than those produced by new hires from other Indian organizations.

Hypothesis 2. After joining the Indian organization, the impact of patents produced by inventors should be higher when they are hired from subsidiaries of foreign organizations than when they are hired from Indian organizations.

Following the same logic, it is also likely that the impact of patents produced by new hires from foreign organizations located abroad would be higher. Countries differ in terms of their resources, national innovation systems and their comparative advantages (Cantwell, 1989; Alcácer and Chung, 2011). Therefore, new hires from abroad may also bring into their new organizations knowledge that is distinctive. However, there is likely to be a difference between the impact of patents produced by new hires from foreign organizations located in India and those from abroad. When a foreign organization first enters into a new country, it faces a liability of foreignness that prevents it from attaining perfect embeddedness. Cultural, institutional, and economic differences between the new host country and the home are only some of the challenges that such firms face overseas (Ghemawat, 2001). These obstacles can be minimized if the captive subsidiary becomes more similar to the domestic organizations in its locality (Zaheer, 1995). In comparison, foreign organizations located abroad are likely to differ more substantially from domestic organizations. Consequently, the likelihood of obtaining heterogeneous knowledge increases when an organization creates a tie across geographic boundaries (Boschma, 2005; Phene et al., 2006). Thus, by hiring an inventor from abroad, the diversity of the receiving organization's knowledge stock is enhanced more than when the new hire is from a co-located organization; this can facilitate technological exploration and create richer opportunities for combining knowledge (Rosenkopf and Nerkar, 2001). These factors have been found to positively influence the generation of high impact innovations (Katila and Ahuja, 2002; Phene et al., 2006; Rosenkopf and Nerkar, 2001; Sampson, 2007), and therefore we expect that:

Hypothesis 3. After joining the Indian organization, the impact of patents produced by inventors should be higher when they are hired from geographically distant foreign organizations than when they are hired from co-located foreign organizations.

3. Data and methods

3.1. Sample

Our analysis is based on successful patent applications made by organizations in India and which are registered with the United States Patent and Trademark Office (USPTO). In accordance with our database, successful patent applications are deemed to be those which were granted by 2008. In line with a number of different studies, including those examining patenting trends in emerging economies, we rely on USPTO patents since important inventions that are expected to have a global impact are likely to seek protection in the US (Mahmood and Singh, 2003). The patent data spans the 20-year period between 1985 and 2004. While a longer timeframe might have been favorable, we limit our dataset to 2004 because after this period there was a decrease in the annual frequency of patent applications due to the time-lag between patents' application and issue dates. Further, only patents assigned to organizations are considered in our analysis because this study examines the patterns of inter-organizational labor mobility. Thus, our sample does not contain patents applied for by individual inventors not affiliated with organizations at the time of application.

We were able to identify 3555 patents assigned to 567 organizations. These organizations consist of 134 Indian firms whose respective corporate headquarters are in India, 36 Indian universities and research organizations, 315 subsidiaries of foreign firms and 82 foreign universities and research organizations. As with similar studies (e.g., Criscuolo, 2009; Frost and Zhou, 2005; Stolpe, 2002), we define a patent as being assigned to an Indian subsidiary of a foreign firm if the firm's headquarters is not in India and if at

least one inventor had an Indian address at the time of its application. In a like manner, a patent developed by a foreign university or research organization is one in which at least one inventor had an Indian address.

The sample consists of patents across a wide range of technological categories. While USPTO patent data in its original form does not describe the technological category of a patent, this can be inferred using the three-digit technological class that is listed on each patent. We calculate the technological category for each patent in our sample following the methods employed by Hall et al. (2001).[1] This variable can take one of 6 values related to a broad range of technological categories, namely: Computers and Communications, Drugs and Medical, Electrical and Electronics, Chemical, Mechanical and Others. Using the same method, we include a second variable that provides a finer description of the technological specification of a patent; namely, the technological subcategory, which is a two-digit integer that we use to construct the mobility networks.

3.2. The inventor mobility networks

The network of inventor mobility is assembled following methods analogous to other studies that have used patent data for this purpose (Agrawal et al., 2006; Almeida and Kogut, 1999; Hoisl, 2007). First, we develop and use a name-matching algorithm to identify unique inventors. Unique inventors are those that satisfy the following two criteria: (i) the inventor's name that appears in two patents consists of the same the first name, last name and middle initial, when available; (ii) the technological subcategories of the two records are the same. Patents whose listed inventors did not provide a full first and last name were disregarded in order to reduce false positive errors.

After all unique inventors are identified; each instance in which an inventor's name appears on two patents assigned to two different organizations is flagged as a mobile tie. This method constructs a two-mode network, defined as a network that is guided by two events – in this case, organizations and inventors. A tie exists between an organization and an inventor if the inventor was listed on a patent that is assigned to that organization. As the level of our analysis is the organization, the two-mode network is transformed to a one-mode network consisting of only organizations. The date of tie formation between the two organizations is taken as the application date of the mobile inventor's first patent at the new organization; this is because it most closely resembles the date when the inventor moved. Moreover, the network generated is a directed network, where mobility ties point toward the organization in which the inventor patented in later. In order to avoid left-censoring the data on mobile inventors who patent at their new organization during or after 1985, we record all patent applications during a 10-year period preceding our main time period, from 1975 to 1984. Therefore, if a mobile inventor patented in one organization in 1975 and patented in a second in 1985, this mobility tie would be recorded in our dataset.

We model the global mobility network using the same method. In this case, mobility between all organizations with USPTO patent data is included. However, since this process is computationally intensive, we model the global network during the time period: 1985–2004. As with the regional network, we record all patent applications during a 10-year period preceding 1985 in order to avoid left-censoring the data. The global network contained approximately 177,000 inter-organizational ties, of which 115 ties were to 58 Indian organizations.

3.3. Variable definitions and model specification for the regional network

We examine the impact of labor mobility by operationalizing the variable *impact*, which is a count of the forward citations that a patent receives during the five-year period after it is granted. Patent forward citations have been widely used as a proxy for the technological impact and the market-value of inventions (Trajtenberg, 1990; Hall et al., 2005). We use a five-year window to count forward citations because it has been shown that patents accumulate the most citations during this time-frame (Hall et al., 2001) and, more importantly, to control for the differences in the number of citations that older versus younger patents accumulate. Specifically, it is likely for older patents to be cited more often, as they have a longer exposure time to accumulate citations than more recent patents. This can be adjusted by using a fixed window within which forward citations are observed (e.g., Fleming and Sorenson, 2004). As a robustness check, we also use a six-year window and our main results remain consistent.

The model we use to examine the impact of labor mobility shares similarities with those used by Hoisl (2009). After identifying all mobile inventors, we isolate all the patents that were developed by these inventors at both their previous organization as well as their new one. We use unpaired student *t*-tests to test the difference in the mean impact of the patents produced by inventors before and after they move to their new organizations. The effects of six different mobility ties are inspected: mobility to Indian firms from Indian firms, from Indian universities and research organizations, and from subsidiaries of foreign firms; and mobility to Indian universities and research organizations from Indian firms, from Indian universities and research organizations, and from subsidiaries of foreign firms. While we would have liked to examine the effect of labor mobility from foreign universities and research organizations, there was not sufficient data to do so, as will be highlighted when interpreting the mobility network (Section 4.1).

3.4. Variable definitions and model specification for the global network

To assess whether or not Indian organizations exist in the core of the global network, we construct a variable *coreness*, which measures the degree to which each organization is located in a dense regional network. The degree of *coreness* of an organization is measured as the largest integer *c*, where the weighted sum of the incoming ties of all its neighbors has a value that is greater than or equal to *c*.[2] This variable is extracted from the network created during each three-year window between 1995 and 2004. As such, it calculates the cumulative ties formed during each three-year window, and the highest core value that an organization achieves during that time.

Next, following the methods by Song et al. (2003), we examine how different mobility ties influence the innovative activity of Indian organizations. We identified 87 mobile inventors who successfully applied for 276 patents at their new, Indian organizations between 1995 and 2004. The dependent variable in this case is *impact*, which is measured as a function of forward citations as described in Section 3.3. Since the dependent variable is a count, we use a Poisson regression for the analysis (Hausman et al., 1984).

[1] The technological class to technological category and technological subcategory cross walk is available on: http://www.nber.org/patents/.

[2] We used the matlab_bgl package to extract the core numbers of the vertices. This is available on: http://www.stanford.edu/~dgleich/programs/matlab_bgl/.

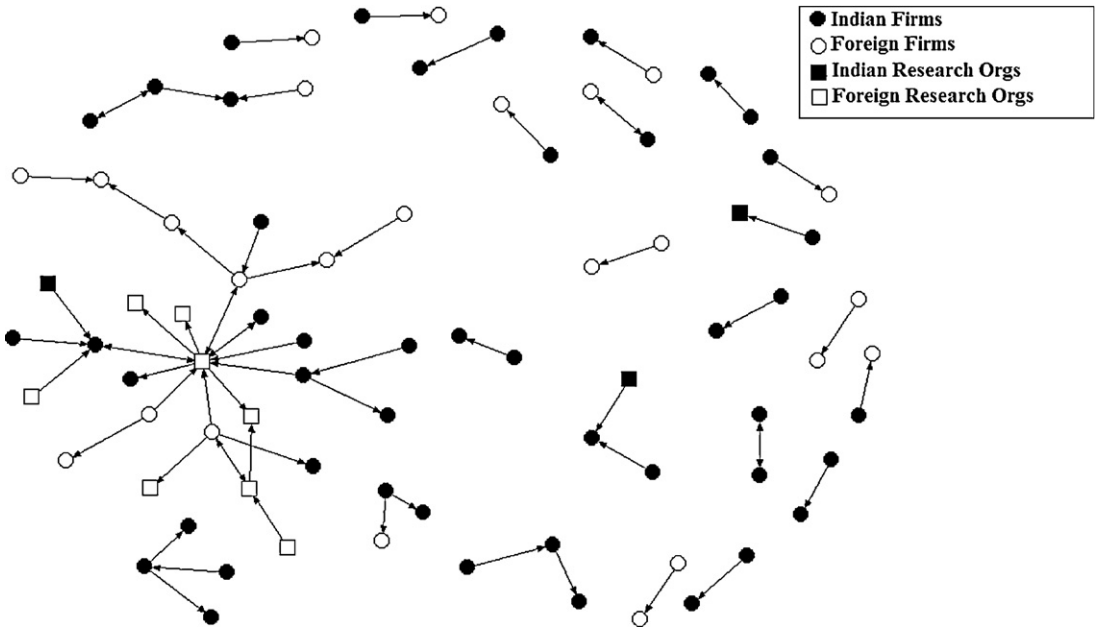

Fig. 1. Mobility network in India during the period 1984–2004.

Each successful patent that the mobile inventor files after the move is considered to be an observation; thus, the level of analysis is the patent. For each observation, we indicate whether the inventor was hired from a local Indian firm, a local foreign firm or a geographically distant foreign firm. Additionally, in a similar way to Song et al. (2003), other independent variables corresponding to each observation are included in order to control for the characteristics of the focal patent, the hired inventor, the hiring organization, and the organization that the inventor was hired from. The independent variables are as follows:

From Foreign. To measure how foreign hires influence the impact of a patent, we use the dummy variable *From Foreign*, which takes a value of 1 if an inventor was hired from a foreign organization and takes a value of 0 otherwise. An inventor is considered to be from a foreign organization if the organization is not headquartered in India.

From Abroad. In order to distinguish between foreign hires from India and foreign hires from abroad, we include a second dummy variable which takes a value of 1 if the hired inventor was from an organization not headquartered in India and did not have an Indian address during the time when the last patent from the previous organization was filed, and takes a value of 0 otherwise. Note that *From Foreign* always takes a value of 1 when *From Foreign Abroad* = 1. Thus, *From Abroad* measures the marginal impact of hiring an inventor from a geographically distant foreign organization.

Team Size. Controlling for the number of inventors that are listed on a patent is important because the quantity and diversity of combined knowledge and skills is likely enhanced in larger teams (Singh, 2008; Singh and Fleming, 2010). In turn, this could influence the impact of a patent.

International Collaboration. Previous research has found that patents that are developed by teams of inventors from dispersed regions and countries have a superior impact (Singh, 2008), and it also helps inventors yield value through integrating knowledge that is globally dispersed (Lahiri, 2010). Thus, it is an important variable to include as a control. *International Collaboration* is calculated by considering the countries of the inventors on a focal patent. If their addresses were not all in the same country at the time the patent was filed, the variable takes a value of 1; otherwise, the variable takes a value of 0.

We control for the technological capabilities of the organization that the mobile inventor was hired from, as well as the hiring organization, as they can both have a direct impact on the quality of patents produced by the inventor. In line with Song et al. (2003), we count the number of successful patents applied for during the five-year window that precedes the date when the focal patent was filed to calculate the *Previous Organization's Patent Stock* and the *Hiring Organization's Patent Stock*. Similarly, we also include the variable *Inventor's Patent Stock*, to control for the capabilities of the mobile inventor, which is calculated by counting the number of patents that were filed by that inventor during the past five years.

Indian Firm. To distinguish between Indian organizations and Indian universities and research institutes, we use a dummy variable *Indian Firm*, which takes a value of 1 if the hiring organization is an Indian firm, and a value of 0 if the hiring organization is an Indian university or research institute.

Technology Dummy. Since patenting propensities vary across technological categories (Hall et al., 2005), we include dummy variables to overcome any differences that may exist. Six technological categories are possible, as indicated in Section 3.1.

4. Results 1: The regional mobility network

4.1. Labor mobility trends

The methods detailed in Section 3.2 are used to generate Fig. 1, modeled using UCINET 6.0 (Borgatti et al., 2002). The figure illustrates the mobility of inventors between the 81 organizations that compose the regional network formed between 1985 and 2004. The different organizations are coded by shape and color, as defined in the legend. As shown, only 14.28% of the organizations that patent in India are contained in this network; thus, inter-organizational inventor mobility only occurs between a small number of the innovating organizations. The network is also very sparse, with only 65 inter-organizational ties[3] joining

[3] The network shows a total of 65 distinct ties between the 81 organizations. However, the total number of mobile inventors in the regional network is 91, as it is possible for an organization to hire multiple inventors from the same

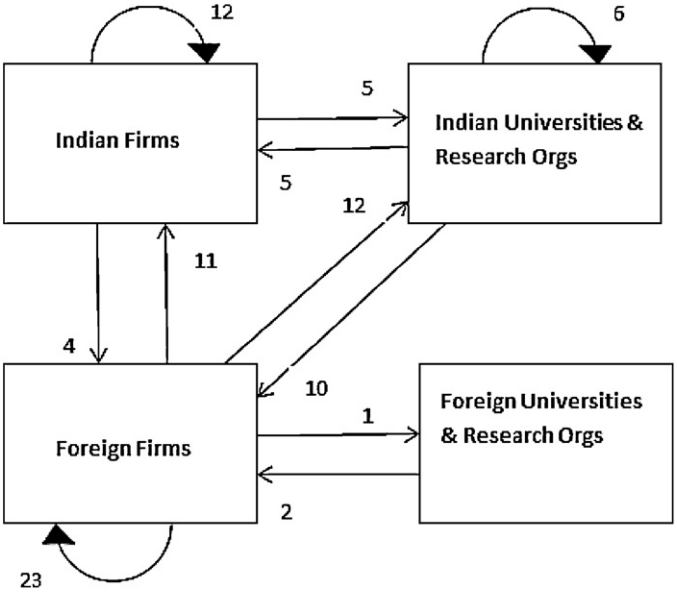

Fig. 2. Number of mobility ties between categories of organizations.

the 81 organizations in the network. Fig. 1 also shows that the type of organization with the most presence is Indian organizations. Approximately 22% of the Indian universities and research organizations[4] and 18% of the Indian firms are in this regional network. In contrast, only 15% and 3.6% of the foreign firms and foreign universities and research institutions are in the network. This suggests that inventors are less likely to move to and from foreign organizations, in comparison Indian organizations.

In order to gain a clearer understanding of the patterns of inventor mobility within India, we summarize the regional network. Fig. 2 depicts the mobility trends between the different types of organizations by indicating the number of times that inventors move between groups of organizations. The results show that, in both Indian and foreign organizations, the largest quantity of ties occur within the same categories. For example, 23 inventors move from Indian subsidiaries of foreign firms to other Indian subsidiaries of foreign firms, whereas only 11 move from these firms to Indian firms. However, this trend does not hold for Indian universities and research organizations, where more inventors leave their current organization to join Indian and foreign firms than those that move to other entities in the same category. Interestingly, although there are many more Indian firms than Indian universities and research organizations in our sample, a similar number of inventors leave the foreign firms to join both. This trend is largely due to CSIR, an Indian state-owned entity, which is responsible for approximately 92% of the mobility ties from foreign firms to Indian universities and research institutes.

The fewest ties occur between foreign universities and research organizations. A number of different causal explanations for this phenomenon are possible; for example, our study might have underestimated the number of universities as a result of the fact that, in universities more than in firms, patents tend to be assigned to the inventor rather than to the organization (Crespi et al., 2007). In such cases, while an academic inventor may have moved from one university to another, where patents are owned by inventors, they would not have registered in our sample. Another additional factor that may have distinguished the mobility trends of the foreign versus the Indian universities and research organizations is that the latter tend to be more inclined to recruit locally than internationally. Hence, while such foreign organizations may have academic inventors in India, the majority of their recruits are more likely to come from the country from which they originate.

4.2. Intra-regional labor mobility and the impact of patents

Next, we formally test the first hypothesis, which compares the impact of patents developed by mobile inventors before and after they are hired by a new organization, as measured by the forward citations that these patents accumulate during a five-year window. The results of the unpaired *t*-test, described in Section 3.3, are presented in Table 1. Although Hypothesis 1 discusses mobility to Indian organizations from foreign organizations, we also include the effect of mobility from other organizations in India for comparison. The results show that when Indian firms hire inventors, the impact of patents they produce before they move does not statistically differ from the impact of patents produced at their new firms. This holds true whether the mobile inventor is hired from a foreign firm, an Indian university or research organization, or another Indian firm.

The second set of results examines the impact of mobility on innovation in Indian research organizations and universities. Mobility from Indian organizations does not have a significant effect on the impact of patents produced by the inventors after they are hired. However, when inventors are hired from foreign firms, the patents they produce after the move have a significantly lower value for *impact* ($p < 0.05$).

Overall, the results indicate that the impact of patents produced by inventors from Indian and foreign organizations in India does not improve after the move. When inventors move from foreign firms to Indian universities and research organizations, the average impact of the patent decreases after the move. Thus, Hypothesis 1 is rejected. A number of factors can contribute to these differences, such as whether or not the technological specialization of the hiring firm matches that of the mobile inventor, the overall quality of the R&D team that the mobile inventor joins, and their ability to coordinate tasks with one another. These questions are beyond the scope of this study, but could be of interest for subsequent studies wishing to build on the results we present. To verify the consistency of our results, two robustness checks implemented. First, we implemented a Mann–Whitney test on the same sample, which is a non-parametric test that is analogous to the unpaired *t*-test. Second, we implemented a paired *t*-test; where each pair represented (respectively) the last patent that was developed by the inventor in the former organization and the first patent that was developed at the new organization. The results of these tests remained consistent with our main results.

5. Results 2: Indian organizations in the global mobility network

5.1. Indian organizations in the periphery of the global network

In Section 2.2, we posited that Indian organizations would be located in the periphery of the global network. In order to ascertain where these organizations are located in the global network, we calculate the *Coreness* score of each organization and use percentile-rank analysis to identify where, in relation to other organizations, the average value of *Coreness* of all Indian organizations lies. In accordance with Fagiolo et al. (2009) and Reyes et al. (2008),

organization. Fig. 2 shows the number of mobile inventors between the different types of organizations.

[4] There is only a single instance of an inventor moving to an Indian university: Indian Institute of Technology. Therefore, although universities and research organizations fall under a single category, the remaining mobility ties are to Indian research organizations.

Table 1
Impact of patents by inventors before and after they join a new Indian organization.

From	Pre-move impact	Post-move impact	Difference
	Mobility to Indian firms		
Indian firms	3.07	1.59	−1.48
Indian research orgs	0.86	0.46	−0.4
Foreign firms	3.61	1.25	−2.36
	Mobility to Indian research organizations		
Indian firms	1	0.63	−0.37
Indian research orgs	1.63	1	0.63
Foreign firms	2.10	0.24	−1.86**

** Significant at $p < .05$.

a group of organizations is considered in the core if their average *Coreness* scores lies between the 95th and the 100th percentile. The results of this analysis, which are provided in Table 2, indicate that for all three-year time periods between 1995 and 2004, the average *Coreness* of Indian organizations that were located in the global network's largest component was below the 60th percentile, rendering them in the periphery of the global network. Moreover, the median *Coreness* score of Indian organizations located in components other than the largest component was zero. We therefore infer that organizations in other components are also in the periphery.

Table 3 presents the temporal variations in the positions of organizations in the global network, where Column 1 represents the three-year time periods between 1995 and 2004, Column 2 represents the size of the network, which is the total number of organizations with at least one mobility tie, Column 3 shows the number of Indian organizations in the network which hired new inventors, and Columns 4–6 show the number of Indian organizations, foreign organizations in India and foreign organizations from abroad that the focal Indian organizations (Column 3) hired inventors from. The results indicate that, over time, there is an overall growth in the total number of organizations, as well as the number of Indian organizations in the global mobility network. Additionally, over time, Indian organizations begin to hire more inventors from both Indian organizations and from foreign organizations in India and abroad. However, the majority of foreign hires come from organizations in India rather than geographically distant organizations. These statistics rationalize why Indian organizations exist in the periphery of the global, labor mobility network. Since other Indian organizations are also located in the periphery, hiring more inventors from them will not improve the *Coreness* score of the Indian organizations. However, if they begin to employ more foreign hires, particularly from abroad and from organizations located closer to the core of the network, there is a likelihood that their network positions would improve.

5.2. Foreign and local labor mobility and the impact of patents

In this subsection, we examine whether or not Indian organizations can benefit from improving their position in the global network by increasing the number of hires from geographically distant foreign firms, or if local hires have a greater impact. The results of the negative binomial regression models are displayed in Table 4. Column 1 shows that inventors hired from geographically distant organizations produce patents with a higher *impact* than those hired from either local or foreign organizations in India. According to the coefficient on *From Abroad* in this column, the impact of patents produced by inventors that are hired from abroad are expected to be 1.78 ($p < 0.1$) times higher than that of inventors that are hired from within India.

In Column 2, we introduce the variable *From Foreign*, which includes hires from foreign organizations in India and abroad. The coefficient, which is also positive, indicates that inventors hired from foreign organizations (whether these are located in India or abroad) produce patents with a higher impact than patents produced by inventors that move from other Indian organizations. Specifically, the coefficient on *From Foreign* in this column suggests that the *impact* of patents produced by inventors that are hired from foreign organizations, regardless of their location, are expected to be 1.81 times higher ($p < 0.1$). This result supports Hypothesis 2, which states that the impact of patents produced by inventors hired from foreign organizations should be higher than the impact of patents produced by inventors hired from Indian organizations.

An interesting conclusion can be drawn by comparing the results in this table to those from Table 2, where we found that the impact of the patents by inventors did not change when they moved from foreign firms to Indian firms, and decreased when they moved to Indian universities and research organizations. This could suggest that the inventors from foreign firms do not become more productive when they join the Indian firms, but rather, that the impact

Table 2
Core-periphery analysis of the global network's largest component (LC).

Time period	All organizations in LC		Indian organizations in LC	
	Maximum core	Mean core	Mean core	Percentile
1995–1997	3	0.61	0	<50th
1996–1998	4	0.61	0.75	<50th
1997–1999	6	0.63	0.40	50th–55th
1998–2000	7	0.64	0.44	50th–55th
1999–2001	8	0.66	0.67	50th–55th
2000–2002	10	0.68	0.95	50th–55th
2001–2003	11	0.61	0.78	55th–60th
2002–2004	12	0.61	0.73	55th–60th

Table 3
Temporal variations of key network statistics.

Time period	Network size	Number of Indian organizations in network	Number of local ties from Indian organizations	Number of local ties from foreign organizations	Number of foreign ties from abroad
1995–1997	9371	8	1	7	2
1996–1998	12,240	9	3	10	5
1997–1999	15,678	14	8	14	8
1998–2000	19,582	16	8	18	10
1999–2001	24,109	27	17	19	13
2000–2002	28,566	32	15	25	12
2001–2003	31,861	40	21	24	16
2002–2004	32,992	31	13	21	12

of their patents are generally higher, and it is not compromised after the move. Furthermore, although the impact of patents by these inventors decreases after they join Indian universities and research organizations, this type of mobility tie is still expected to yield a higher patent impact in comparison to ties from Indian organizations.

Column 3 is the full model which includes both variables: *From Foreign* and *From Abroad.* The inclusion of both simultaneously allows us to examine the marginal impact of a patent produced by an inventor that is hired from an overseas organization. The coefficient on *From Abroad* remains positive and significant ($p < 0.1$) indicating that foreign hires from abroad are expected to produce patents which have an impact that is greater than that produced by inventors hired from both Indian organizations and foreign organizations in India. This result corroborates Hypothesis 3.

6. Discussion and conclusions

Emerging economies are traditionally viewed as regions that are more likely to adopt advanced economy innovations rather than engender novel innovations. However, today, many emerging economies, like India and China, have become important, global contributors of innovation (Govindarajan and Ramamurti, 2011). Nevertheless, there still persists a technological gap that renders many firms from these locations lagging behind firms which originate from the advanced economies (Furman and Hayes, 2004; Wright et al., 2005). Previous literature has discussed several methods that can help firms learn from, and therefore catch-up with one another; one of which is labor mobility, which has been shown to promote the flow of knowledge across organizational boundaries (Almeida and Kogut, 1999; Song et al., 2003; Saxenian, 1994). In this study, we extend the discussion on labor mobility and inter-firm knowledge transfer to the case of an emerging economy, India, in order to explore if it can also be a viable method for promoting innovation in this context. Specifically, we examine how new inventors that are hired from foreign organizations affect the quality of patents that are developed by Indian organizations.

There are two ways in which Indian organizations can hire new employees from foreign organizations. The first is by hiring them from co-located subsidiaries of foreign firms. Since the mid-1980s, a growing number of MNCs, headquartered in technologically advanced countries, have established R&D subsidiaries in India (UNCTAD, 2005). Although, over time, these subsidiaries are expected to share certain characteristics with the Indian organizations, they also exit as part of a global network, and are therefore likely to have access to foreign knowledge (e.g., Bartlett and Ghoshal, 1989; Frost et al., 2002; Kogut and Zander, 1993; Nobel and Birkinshaw, 1998). Thus, local hires from these subsidiaries can potentially provide Indian organizations with an opportunity to tap into foreign knowledge. Secondly, Indian organizations can also directly hire new inventors from abroad. In order to account for both sources, we model and analyze two networks, a regional network which depicts inventor mobility from co-located firms, and a global network, which also encapsulates geographically distant hires.

As a first step, we analyzed the regional network. Our results indicated that only 14.28% of organizations with patents developed in India were involved in the regional network. Given the sparseness of the regional network, it is unlikely for spillovers that are driven by inventor mobility be a dominant phenomenon in India (Almeida and Kogut, 1999). Furthermore, only 15% of the subsidiaries of foreign firms were in the regional network and, from these firms, Indian organizations hired a total of 23 inventors. Thus, knowledge flows from subsidiaries of foreign

Table 4
Regression estimates of patent impact produced by inventors hired by Indian organizations.

	Dependent variable: *Impact*		
	Column 1	Column 2	Column 3
From Foreign		0.594* (0.161)	0.425** (0.176)
From Abroad	0.575* (0.140)		0.410* (0.153)
Team Size	0.0634* (0.0153)	0.0800* (0.0146)	0.0685* (0.0154)
International Collaboration	−0.0914 (0.177)	−0.0988 (0.174)	−0.142 (0.176)
Previous Org's Patent Stock (/100)	0.0182* (0.0052)	0.0126** (0.0051)	0.0157* (0.0052)
Hiring Org's Patent Stock (/100)	−0.174* (0.0662)	−0.197* (0.0664)	−0.177* (0.0663)
Inventor's Patent Stock	0.0190* (0.0068)	0.0190* (0.0069)	0.0197* (0.0069)
Indian Firm	0.551* (0.211)	0.541** (0.212)	0.557* (0.211)
Technology Dummies	*Included*	*Included*	*Included*
Constant	−1.498* (0.263)	−1.718* (0.284)	−1.760* (0.286)
Observations	276	276	276
Log Likelihood	−478.0	−478.6	−475.0

Note: Standard errors in parentheses.
* $p < 0.1$.
** $p < .05$.

firms to Indian organizations that are guided by inventor mobility do not occur in abundance.

Next, we use the intra-regional network to examine how inventor mobility to Indian organizations affects the performance of the hired inventors. Our results reveal that when inventors move from foreign firms to Indian firms, the impact of the patents that these inventors produce does not statistically differ ($p > 0.1$). However, when inventors from foreign firms are hired by Indian research organizations, the impact of the patents produced in the post-move period decreases significantly ($p < 0.05$). Differentiating between the pre-move and post-move performance of inventors is an important question that helps to delineate the instances when labor mobility could improve the innovative performance of Indian organizations. Our results shed light on this inquiry by suggesting that the productivity of inventors is not compromised when they join Indian firms.

In the second part of our analysis, we examine the positions of Indian organizations in the global network. Our findings indicate that even fewer inventors are hired from geographically distant foreign firms in comparison to co-located foreign firms, which renders Indian organizations in the periphery of the global network. Yet, there are certain advantages of hiring from these foreign firms. The results of the full regression model suggest that the impact of patents developed by mobile inventors hired from foreign firms is approximately 53% ($p < 0.05$) higher than patents developed by inventors that are hired from other Indian organizations. Furthermore, the impact of patents developed by inventors hired from geographically distant foreign firms is 51% ($p < 0.1$) higher than those developed by mobile inventors from co-located foreign firms. In terms of their patenting performance, these results indicate that Indian firms can benefit from hiring inventors from foreign firms that are located in India and abroad.

6.1. Limitations

There are some limitations that could implicate the results produced in this study. Mobile inventors may have not been captured by the data if they have not patented within the time frame of the study, if they patented with other agencies, or if their names differed on two patents. Consequently, some organizations may have not been included in the analysis. Similarly, the number of universities in our study may have been underestimated because, in universities more than in firms, the patents may have been assigned to the inventor and not the organization (Crespi et al., 2007), and this dataset only includes organizations. Moreover, although a name-matching algorithm was devised to account for the ambiguity of inventor names, the algorithm may have created false positives that could lead to inflated mobility ties. While these limitations do not affect the theoretical framework of the study, they should be kept in mind while interpreting the empirical results.

Two other limitations are noteworthy. Firstly, although we include firm-level controls in the regression model, in our discussions we group all Indian firms and all Indian organizations. Since distinct entities may differ in their capabilities and strategies,[5] future research may wish to investigate the implications of such differences on the effects of labor mobility. An example, and possible avenue for further research, would be to compare the effects of mobility on multinational corporations that are headquartered in India versus single-location firms. Second, the vast majority of inventors that are hired by Indian organizations are from the US and other advanced nations; however, some inventors may be employed from other emerging nations. While these inventors are still likely to bring knowledge that is diverse into the Indian organizations, exploring the difference in the quality of innovations produced by mobile inventors from emerging and advanced economies is another possible avenue for future research.

6.2. Conclusion

The results of our study have important implications for policymakers and managers. Spillovers from foreign organizations – including subsidiaries of foreign firms – to local firms have raised fears about a loss of competitive advantage for technologically advanced nations, whereby countries which were once adopters of Western technologies (like India) would then be able to use that knowledge to compete with them. The results of this study assuage some of this concern. What we were able to show is that, since labor mobility between foreign and local organizations is an infrequent occurrence, the portion of knowledge spillovers that could occur through this route should also be scarce (Almeida and Kogut, 1999). However, when these mobility ties do occur, Indian firms do benefit, since inventors that are hired from foreign firms are able to produce more valuable patents than if inventors were hired from other Indian organizations.

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