University Industry Interaction in Global Innovation Networks The case of ICT GINs in India

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Abstract

One of the neglected dimensions of GINs with crucial bearing on innovation is the interaction between universities and Industries. The present paper, by making use of the primary data collected as part of INGINEUS survey, intends to contribute towards our understanding of the patterns and determinants university interaction by taking the case of ICT sector in India. The study finds important variation in the occurrence in university industry interaction across firms belonging to different organizational categories and regions. The study highlights significant institutional and policy deficit and callas for addressing these deficits such that Global Innovation Networks do not turn out to be Global Innovation Traps

1. Introduction: the analytical context

UNCTAD (2005) reported that by 2004 China had emerged as the most attractive location for R&D affiliates after the United States and the United Kingdom followed by India(6th position). The study also projected that the pace of R&D internationalization is likely to accelerate indicating an unprecedented rise in the emergence of Global innovation network on the one hand and greater participation of developing countries on the other. In a similar vein Cantwell (1995) observed that GINs have expanded the traditional high tech regions in the United States, the EU and Japan with new location in Asia especially in India and China are emerging as active participants. Drawing from these and other empirical evidences, both secondary and primary, Dieter Ernst (2009) argued that the emergence of Global Innovation Network (GIN hereafter) is real, and it is not merely something that can be expected to occur in the future. Similar view has also been held by scholars like (Athreyae and Prevezer 2008: Athukorala and Kohpaiboon2010 among others). This is in contrast to the prevalent view that this networks are still limited in number and mostly concentrated with big firms (OECD, 2008; 64) .

The emergence and spread of GINs according to Ernst (2009) poses new challenges and opportunities for the policy makers as well as the academia. In a sense, GINs could be viewed as a double edged sword both for the MNCs and the host counties. As far as the foreign firms are concerned, in the current context of globalization and heightened competitive pressures, they have many gains to be made from the globalization especially an enhancement of the rate of return on R&D investment. At the same time, there are also pains associated with R&D which is inherent in GINs like loss of control over the technology. The situation is summed up by Grimpe and Kaiser (2010); R&D outsourcing is certainly beneficial to innovation performance and that it may result in increased efficiency, reduced cost, or foster innovation by getting access to valuable resources not available internally. At the same time, it might lead to dilution of firms' resource base, deterioration of integrative capabilities as well as rise in cost coordination. From the perspective of developing countries there are a number of instances wherein the participation in GINs has been instrumental in domestic capability building. At the same time, in the absence of appropriate policy measures and institutional interventions GlNs could also turn out to be global innovation traps, or poisoned chalice to use the term used by Ernst (2009, *inter alia* on account of brain drain and focus on low end of the value chain.

It is often held that rising R&D costs, increasing risk and complexity associated with technology development activities along with shorter product life cycle, and intense competition in domestic and global markets have compelled firms to locate their R&D activities outside the borders of their home countries (Stembridge, 2007). Drawing on the OLI framework popularised by John Dunning, it has been argued that the internationalisation of R&D is the result of a complex interaction between the ownership advantages of MNCs and the location advantages of regions. Cantwell (1995) for example, predicts that in a globalised world, MNCs will relocate the R&D activities to exploit regions' differential advantage in production and in R&D. Such gains can arise through several channels: because of the lowering of the costs for routine R&D, the rationalization of human capital intensive activities and the growing ability of MNEs to source new types of skills, networks and the science base in emerging regions. Another set of scholars, by drawing insights from the resource based view of the firm, analyzed the implication of R&D globalization and argued that these activities could be important instrument to acquire external technological knowledge that is subsequently integrated into firm's own knowledge base. Other than resource based theory, scholars have also approached the problem from transaction cost economics and transaction value perspective that combines both resource based theory and transaction cost economics as a reasonably parsimonious theoretical approach to the idea of outsourcing as an alliance strategy (Mudambi and Tallman 2010)

While exploring the factors that induce firms to globalize innovative activities, earlier studies have identified a host of "centripetal forces" which induce the firms to centralize the R&D activities in the head quarters and the "centrifugal forces" that work towards the dispersion of R&D activities across different locations beyond the home country. The centripetal forces included the need to protect firm- specific technology as relocation of R&D that could lead to unwanted R&D leakage (Rugman, 1981). Patel and Pavitt (1991) argued that despite the increasing globalisation of business, technological activities of large firms tended to stay in their countries of origin. This has to be viewed against certain key features of major innovations like the tacit nature of technological knowledge, need for closer coordination in decision making in the face of uncertainty of innovation, the person-embeddedness of multidisciplinary scientific research, all of which necessitated the need for proximity to headquarters. Steele (1975) argued that, firm specific technical advantages tend to evolve from and mirror home market conditions and that the need to retain and strengthen such advantages necessitates continued close contact with the domestic market. This turns out to be vital factor leading to centralization of R&D. Another line of argument centered around the significance of scale economies in R&D and the difficulties in achieving minimum scale in case of decentralized laboratories[1]. Some of the pioneering studies also found the high cost of co-ordination and control (Vernon, 1974) as a centripetal force.

The centrifugal forces also include demand oriented factors that emanate from the need to be nearer to the exports market. Very often the establishment of R&D units in the host countries is preceded by exports at the initial stage and later setting up of sales subsidiary and finally the manufacturing facilities entirely based on the technology and other support from the parent company. However, very often the transfer of manufacturing technologies from the parent firm calls for substantial adaptation to suit the local market conditions. In such a context, firms resort to the setting up of local R&D units. Needless to say such R&D units oriented towards adaptive R&D are found to be in countries with large domestic market. There could also be cases where in government regulations reinforce the inducement to setting up of such R&D units. When it comes to supply side factors operating as centrifugal forces most important one appears to be the access to scientific and technological skill including scientific infrastructure that are available at more advantages terms than in the domestic market.

Nonetheless, the observed unprecedented increase in the pace at which GINs are being formed (UNCTAD 1995; Ernst 2011) indicates the presence of factors that undermines the centripetal

[1] Empirical evidence on the adverse effect of scale economies on internationalization however, remained in conclusive as reported in one of the earlier surveys by Granstrand et.al.(1997).

forces that reduces uncertainty as well as transaction and coordination costs. There are two important factors for this rebalancing and resultant increase in the mobility of knowledge as argued by (Albuquerque et al 2011). First one relates to the improvement in the information communication infrastructure and its extensions around the world and second ones relates to the liberalization of trade and investment policies that helped firms to exploit the benefit of technological change. To this we may add the emergence of new locations with complimentary capabilities, especially human capital, at lower cost especially in India and China. For instance, it has been shown that by 2010 China would have more science and engineering doctorates than United States (Freeman 2005; National Science Board 2008).

Though there are indications to suggest that disadvantages associated with centralization of R&D are often counter balanced by the advantages arising from centrifugal forces, GINs cannot be viewed as purely a benign phenomenon without any associated challenges. Exploiting the opportunities while addressing the challenges, however, calls for a deeper understanding of the complexities involved in this network *inter alia* in terms of the inducement mechanism and their outcomes

Growing number of studies that contributed immensely to our understanding on the inducing factors notwithstanding, the real dynamics involved in GINs still remain a black box. This has been to a great extent on account of the fact that GINs have been often considered as one of the stages in the evolution of global production network which has a longer history. To the extent that GINs *prima facie* are concerned with knowledge production in contrast to the focus on commodity production in global production network, the underlying dynamics as well as its outcomes are bound to be different both for the host countries and recipient countries.

The most striking character in global innovation network, with its significant bearing on knowledge production and diffusion, is the role of universities and research institutions. Scholars have highlighted the bearing of innovation capacity as critical for reaping the potential advantages of GINs and the studies on innovation in the National System of Innovation perspective have assigned a key role for universities and Public Research Institutions (PRIs). However, this issue has not received the attention of GINs scholars that it deserves. The literature on GINs, as Albuquerque et al (2011) argues, definitely displays awareness of the significant relationship between GINs and universities and research institutes, but this is typically implicit and largely unexplored. Albuquerque et.al (2011) based on a detailed critical survey of existing literature on GINs have come up with a broad analytical framework to approach the issue at hand (see Fig 1) and highlighted following seven main types of interactions, which necessarily go beyond GINs, both backwards and forwards:

1. Local firms interacting with local AND/OR foreign universities
2. Multinational corporations interacting only with their LOCAL
3. Multinational corporations interacting BOTH with their LOCAL (home-based) universities and foreign (host country) universities and
4. International consortia

It is not that all these forms of interactions will be present in all the GINs. The type of interaction that is found to exist is likely to be conditioned by a host of factors including the characteristics of both the universities and sectors/firms involved along with the institutional arrangements and policy environment, or the system of innovation in the host country and receiving country at the sectoral, regional and national level. Following Albuquerque et al (2011) the present study explores the global local linkage between universities/research institutions in India in the context of Global Innovation Network by taking the case of India's ICT sector. This study in the Indian context assumes immense policy relevance for more than one reason. To begin with, industry-university interaction in India remains almost an unexplored area. While, there are a few studies, with the possible exception of Joseph and Abraham (2010), all of them related either to a specific institution (Chandra, 2007 on IIT and Mashelkar, 1996 on NCL), specific region (Basant and Chandra, 2007) or a specific industry (D'Costa 2006 on software). More importantly, none of the studies have explored the interaction between universities and firms in the context of GINs while India is known to have emerged as an active participant in GINs. In such a context, any study on industry-university interaction neglecting the involvement of firms and universities in Global Innovation Network is likely to present only a partial picture. Therefore the present study intends to explore the issue at hand by taking the case ICT sector. The selection of ICT sector is guided by the fact that India's presence in GINs has been most notable in the sphere of Information Technology that accounted for almost 40 percent of foreign Direct Investment in R&D in India (TIFAC 2006).

The remainder of this paper is organized as follows: The second section introduces the database made use of in the study. The third section, presents the broad contours of interaction between the ICT firms within the country and abroad with universities and research institutions within and abroad-both the north and the south – and explored the underlying factors for the observed pattern of interaction. Section four presents insights from two case studies and the final section concludes with certain policy implications.

2. On the database

The paper is largely based on the INGINEUS survey and the case study of two firms in India. The survey was designed to be implemented to all IT firms in India. This was intended to be a census survey of all firms with an expectation of 30 percent response rate. The firms were chosen from the NASSCOM Directory of ICT firms. The NASSCOM Directory is released every year and covers all areas of software production and related industries such as IT Enabled Services. The 2009-10 Directory provides the information of 1287 firms in IT industry that accounts for about 95 per cent of ICT production in the country.

Prior to the field survey, a pilot survey was conducted with five firms in India the responses and our feedback was sent to the INGINEUS WP2 leaders for modification of the questions on this basis.

Initially a web based survey was implemented, but the yield was very low. Hence direct interviews were planned. For the face to face interviews, time and resource constraint did not permit us to cover the entire country. Instead, we chose cities/IT clusters that together represented nearly 93 percent of all firms according to the NASSCOM directory. A survey team was developed and face to face interviews were implemented in cities/ IT clusters selected for the survey. The survey was implemented in eight cities during the period March 1st to April 30th, 2010 ending up with a sample of 325 completed surveys representing a favourable response rate of 24 percent.

Table 1: Survey design

Cities chosen for survey	Number of Firms as per NASSCOM survey 2009-10	Number of firms surveyed Manually	percentage of firms surveyed manually
Bangalore	281	50	17.79
Delhi/Noida/Gurgaon	256	75	29.30
Mumbai	185	68	36.76
Pune	72	20	27.78
Chennai	147	39	26.53
Trivandrum	184	20	10.87
Hyderabad	107	25	23.36
Kochi	55	10	18.18
Manual Total	1287	307	23.85
Online Total		18	
All Total		325	

We have also utilized the RoKS survey data, conducted in 2007-08 on industry academia interaction by the Centre for Development studies to supplement the data gathered by the INGINEUS survey.

For the case study we identified three firms that had previously agreed upon through matching done by the INGINEUS case study consol. The identified firms were large firms, all three MNCs, two with head quarters in India and one with head quarters in the US. But all three firms had operations in mainland Europe. The case study interviews were conducted with high ranking representatives of the firms in India as per the TOR of various work packages.

3. International knowledge flows in the ICT sector in India

Ernst (2009) argues that absorptive capacity is critical for upgrading innovative capacity and the firms must increase R&D investment to avoid diminishing returns on network integration. Thus the new geography of knowledge cannot be left to market forces alone. In such a context, to explore the possibilities for exploiting various potential advantages of GINs we need to have an understanding of the present state of innovative capacity as evident from the R&D investment by firms in the ICT sector.

The INGINUES Survey showed that more than 60 percent of the firms in ICT sector are engaged in R&D activities. Moreover, it was the MNC headquarters in India that had the highest share of firms that undertook R&D. While more than 78 percent of the MNC headquarters are having in-house R&D units, it was 75 percent for the MNC subsidiaries. When it comes to stand alone firms, only 46 percent of them were found engaged in R&D activities (see table 2). The high share of MNCs, both head quarters and subsidiaries, in R&D activity suggest that the firm-specific characteristics in terms of organizational status do matter in R&D and being MNCs induces them to engage in R&D activity, while not so much for the stand alone firms.

Table 2: Existence of R&D activity in firms (%)

	Stand Alone	Subsidiary of MNCs	Head Quarter of MNCs	Total
R&D No	53.89	25.47	22	39.63
R&D yes	46.11	74.53	78	60.37
Total	100	100	100	100

Source: INGINEUS SUVEY

The evidence further tends to suggest that the low prevalence of R&D activities among the stand alone firms might set limits to their ability to take advantage of the potential benefits of GINs as compared to their foreign and local counterparts who appears to be well positioned (given the high R&D orientation) in the "global innovation race".

We also find significant inter-industry variation in the nature of R&D activities as per the evidence provided by the RoKs survey. RoKs survey, that covered six groups of industries, revealed that of the firms that invested in R&D 43.5 per cent undertook R&D in a regular and centralized manner. Whereas, for 48.5 per cent of firms R&D has been reported as occasional (see table 3). Coming to inter-industry variation, while 81 percent of the firms in chemicals (including pharma and biotech) reported R&D as a regular activity only 10 percent of the firms in textile and garments reported R&D as regular. In IT and electronics also a substantial share of firms (65 %) were found engaged in regular R&D. In machine tools, and other industries R&D was an occasional activity for majority o the firms. Thus it appears that firms operating in technologically more dynamic industries are likely to undertake R&D as a regular activity.

Table 3: Nature of R&D activities in firms

	Regular & centralized	Regular & decentralized	Regular	Occasional & centralized	Occasional & decentralized	Occasional	Total
Pharma, Chemical & Biotech	67.3	13.5	80.8	7.7	11.5	19.2	100
IT and Electronics	48.1	16.5	64.6	7.6	27.9	35.4	100
Automobile	48.6	8.6	57.1	20.0	22.9	42.9	100
Textile& Garments	10.0	0.0	10.0	5.0	85.0	90.0	100
Machine tools	39.7	4.8	44.4	30.2	25.4	55.6	100
Others	41.9	4.3	46.2	17.1	36.8	53.8	100
Total	43.5	8.0	51.6	15.0	33.4	48.5	100

Source: RoKS survey

3.1 Scale and pattern of interaction

Of the 324 firms that were surveyed, majority of the firms (53%) reported that they had some form of interaction with universities (local or foreign) or public funded research institutes in India. Among the firms, about 47 percent stated that they had interacted with local universities or Research Institutes (RIs hereafter). About 31 percent of the firms interacted with foreign universities or RIs whereas 24 percent of the firms had interacted with both foreign and local universities. This represents a moderately high level of interaction between universities and firms in India's ICT sector.

The above aggregate picture conceals more than what is revealed. The table also indicates that there are significant differences across different organizational categories in terms of their interaction with universities and research institutes. What is striking is the higher level of interaction observed in case of MNC head quarters as compared to the MNC subsidiaries and stand alone companies regardless of the type of interaction. While 84 percent of the MNC head quarters are found interacting with any university or research institutes, among their foreign counter parts only 55 per cent are found interacting and the corresponding percentage in case of standalone firms is found lower (42.%). The difference becomes all the more striking when it

comes to interaction with local universities wherein the observed percentages are 74 per cent, 46 per cent and 39 per cent respectively in case of MNC head quarters, MNC subsidiaries and stand alone firms. The same pattern is observed with respect to their interaction with foreign universities or with both local and foreign universities wherein the stand alone companies record much lower level of interaction (see table 4).

Table 4: Firms that reported any form of university industry interaction during the last 3 years that was important for an innovation for them

firm type	Any University RI	Any Local University RI	Any Foreign University RI	Both Local and Foreign Unviersity_RI
stand alone firms	42.51	39.52	19.76	16.77
MNC subsidiaries	55.66	46.23	36.79	27.36
Indian MNCs	84	74	54	44
Total	53.25	47.06	30.65	24.46
Total Number	172	152	99	79

Source: INGINEUS Primary Survey 2009-10

Given that these interactions were for the purpose of innovation, as is evident from the survey, Indian MNCs and foreign MNCs are utilizing the resources from public sources such as universities and research institutes much more intensively as compared to the stand alone firms indicating the bearing of firm characteristics in university industry interaction.

3.2 Sectoral and regional patterns

Apart from firm characteristics, the sector specificities also appear to influence the interaction between universities and industry. From the data obtained from the RoKS survey it is evident that the occurrence of interaction with universities varies significantly across industries. While the firms operating in the modern knowledge intensive industries such as Pharmaceuticals, Biotechnology, Chemicals and Information Technology reported a relatively higher level of interaction their counterparts in low technology industries like textiles reported hardly any interaction. (Table 5)[2].

[2] Here it may be noted that the reported occurrence of interaction in RoKS survey in general has been lower than what has been observed in the INGINEUS survey. This discrepancy may be due to the difference in the way in which the questions were posed. The RoKS survey explored the "current status" of university industry collaboration of the firm, while the INGINEUS survey reported "any episode of university interaction during the last three years". Thus one is a cross sectional picture of interaction, while the other may be interpreted as a stock of such interactions during the past three years.

Table 5: Occurrence of interaction (collaboration) with universities/PRIs

Sector	collaboration	no collaboration	Total
Chemical, Pharma and Biotech	23.44	76.56	100
Information Technology and Electronics	20.22	79.78	100
Automobile and parts	5.36	94.64	100
Textile and garments	0	100	100
Machine tools	11.76	88.24	100
Others	5.13	94.87	100
Total	11.33	88.67	100

RoKS Survey 2008

There seems to be substantial regional variation in the incidence of university industry interaction indicating that regional innovation system does matter. While in Bangalore, 94 percent of the firms reported having interaction with universities, and in Delhi it was 77 percent, in Mumbai it was as low as 13 percent. In other regions like Pune , Trivandrum and Hyderabad it was moderate. The incidence of interaction with foreign universities was relatively less compared to local universities in most regions. In Bangalore while the share of firms that interacted with the local universities/RIs were 90 percent, only 40 percent of the firms interacted with foreign firms (table 6). Similarly, in Delhi while 71 percent of the firms interacted with local universities and Research institutes, only 49 percent of the firms interacted with foreign universities. In Mumbai, where the overall interaction levels were very weak there were no instances of interaction with foreign universities. As noted by earlier studies, the centers like Bangalore and Delhi are characterized by relatively more vibrant regional innovation system with the presence a number of leading pubic funded research institutes, leading public sector units and universities which in turn acted as an inducement factor for the clustering of ICT firms for foreign and local (Kumar and Joseph 2005). Here it needs to be noted that the observed pattern with respect to Mumbai is an aberration and against the commonly observed trend

Table 6: Regional variation in the number of firms that reported any form of interaction with university & RIs during the during the last 3 years that was important for an innovation.

City		Any interaction	Local interaction	Foreign interaction	Total No. of Firms
BANGALORE	Number	46	44	20	49
	Percentage	93.88	89.8	40.82	100
CHENNAI	Number	22	22	11	41
	Percentage	53.66	53.66	26.83	100
COCHIN	Number	8	8	8	10
	Percentage	80	80	80	100
HYDERABAD	Number	12	8	10	27
	Percentage	44.44	29.63	37.04	100
MUMBAI	Number	9	9	0	71
	Percentage	12.68	12.68	0	100

DELHI/NOIDA/GURGA	Number	59	54	37	76
	Percentage	77.63	71.05	48.68	100
PUNE	Number	4	2	2	20
	Percentage	20	10	10	100
TRIVANDRUM	Number	7	0	7	20
	Percentage	35	0	35	100
Total	Number	167	147	95	314
	Percentage	53.18	46.82	30.25	100

Source: INGINEUS Primary Survey 2009-10

However, in smaller cities such as Trivandrum, Pune and Cochin, even though their overall interaction levels are relatively less, their foreign interaction seems to be as high as compared to interaction with local universities. This difference in interaction patterns based on city size probably indicates the lack of availability of knowledge and information base at the local level universities and research institutes compared to the ones at the larger cities and the weak regional innovation system.

3.4 Interaction with local vs. foreign universities

The interaction of the firms with the local universities was more with universities in the region than with universities away from the region (table 7). Moreover, the interaction with universities in the local region as well as with universities at the national level were much higher for the MNC headquartered in India, compared to other types of the firms. Interestingly, there is not much difference in the share of stand alone or MNC subsidiaries that interact with regional or national universities.

Table 7: Firm interaction with Local Universities

	With universities in the local region			**with universities in the country other than regional**		
Firm type	No interaction	Any interaction	Total	No interaction	Any interaction	Total
Stand alone	75.45	24.55	100	82.63	17.37	100
MNC subsidiaries	73.58	26.42	100	81.13	18.87	100
MNC head quarters	52	48	100	70	30	100
Total	71.21	28.79	100	80.19	19.81	100

Source: INGINEUS Primary Survey 2009-10

In terms of institutional interlinkages across countries, the most important aspect to note is the very poor levels of interaction of Indian firms across all the countries. Collaboration was found highest with North American universities and RIs. This needs to be seen in terms of the fact that North America accounted for highest share of IT export from India. Of the 314 firms that reported their location, 38 firms (12.1%) had interaction with North American universities (see table 8). The next largest occurrence of interaction was with South American firms. This could perhaps be seen in the context of various initiatives towards greater integration between India and MERCUSUL (especially Brazil) after the New Delhi declaration at the instance of the President of Brazil in 2004. West European universities and RIs came to only a distant third interacting with Indian firms in almost all regions across the country. This in turn underscores the relevance of recent initiatives being undertaken to promote greater integration between EU and India. In fact while Bangalore and Chennai has their university interaction largely originating from the North America, in case of Hyderabad and Delhi the main university interactions came from South America. Finally interaction of Indian firms with Asian economies was found only marginal underlying the need for institutional interventions and policy measures to promote such interaction, especially in a context wherein India's foreign policy provide for south-south cooperation and new century is often termed as Asia's century, is vital.

The observed nature of interactions is such that most interactions with foreign universities were very formal in nature. Of the 99 firms that reported any foreign university linkages, 62 of them had formal linkages. Only nine firms reported explicitly that they had informal linkages with the universities in foreign countries. The rest of the firms did not respond on their status of formality.

Table 8: Number of firms that reported any form of foreign university industry interaction during the last 3 years that was important for an innovation for them-By RegionX country

		State	**Rest of country**	**North America**	**South America**	**West Europe**	**C&E Europe**	**Africa**	**Jap_ Aus Assia**	**Rest of Asia**	**Total No. of Firms**
BANGALORE	No.	0	0	**12**	2	**3**	3	0	2	3	49
	%	0	0	**24.49**	4.08	**6.12**	6.12	0	4.08	6.12	100
CHENNAI	No.	0	0	**7**	**6**	2	1	0	0	3	41
	%	0	0	**17.07**	**14.63**	4.88	2.44	0	0	7.32	100
COCHIN	No.	0	0	1	2	**6**	4	0	0	0	10
	%	0	0	10	20	**60**	40	0	0	0	100
HYDERABAD	No.	0	1	2	**7**	0	**2**	0	0	0	27
	%	0	3.7	7.41	**25.93**	0	**7.41**	0	0	0	100
MUMBAI	No.	0	0	0	0	0	0	0	0	0	71
	%	0	0	0	0	0	0	0	0	0	100
DELHI/ NOIDA/ GURGA	No.	0	1	12	**13**	5	1	2	8	2	76
	%	0	1.32	15.79	**17.11**	6.58	1.32	2.63	10.53	2.63	100
PUNE	No.	0	0	1	0	1	0	0	0	0	20
	%	0	0	5	0	5	0	0	0	0	100
TRIVANDRUM	No.	0	0	3	1	2	4	1	0	0	20

	%	0	0	15	5	10	20	5	0	0	100
Total	No.	0	2	38	31	19	15	3	10	8	314
	%	0	0.64	12.1	9.87	6.05	4.78	0.96	3.18	2.55	100

Source: INGINEUS Primary Survey 2009-10

of their relationship. The degree of formal interaction with foreign universities in suggestive of rigid, inflexible and structured forms of interaction that is typical of developing country patterns of interaction with universities. The literature talks of such interactions of formal type not being fruitful to the extent of informal interactions that lead to flexible and multiple forms of benefits.

The observed pattern of university interaction also corresponds largely to their export markets of these firms. The largest number of firms interacts with North American universities and they also have their largest export market in North America. The second largest market seems to be the South America, and correspondingly, University interaction in South America also seems to be relatively high compared to other regions. Similar is the case with W Europe and other regions as well. This suggests that interactions with universities are marked with local market for their products. However, we do not know what purpose these interactions serve. Theory talks about interactions for local product adaptation, understanding the local market and also getting skilled workforce from their respective markets.

3.5 Own R&D vs. university industry interaction

While the traditional literature on innovation highlighted the role of R&D, studies on innovation systems, conceptualizing innovation as an evolutionary process involving interaction between different agents involved in the generation and diffusion of knowledge, consider interaction between universities and firms as an important factor in innovation. In the literature there is a line of argument that the university research is a substitute for firm R&D and that one might expect firms with higher absorptive capacity to rely less on universities (Thursby and Thursby 2003). Here research by universities and public laboratories are considered as a substitute for in-house R&D by firms.

However evidence from the INGINEUS survey presented in table 9 tends to suggest that there is a high degree of association between university industry interaction and the firm's R&D activity. Both the activities seem to occur together in a large number of firms. Nearly 70 percent of the firms stated that they undertake R&D activity and have some form of interaction with the universities/Public research institutions. While this was the average among all firms, there were some differences across organizational types. Among the stand alone firms and MNC subsidiaries more that 60 percent of the firms were found engaged in in-house R&D activity and also interacting with universities (table 9). But for the MNC head quarters more than 95 percent of the firms were found undertaking R&D activity and interacting with the universities. These patterns suggest that university research in general acts as a complement to the industry's own

Table 9: Incidence of R&D activity and university industry interactions among firms

	No interaction	Any interaction	Total
Stand Alone			
No R&D	73.33	26.67	100
Did R&D	38.96	61.04	100
MNC subsidiaries			
No R&D	74.07	25.93	100
Did R&D	34.18	65.82	100
MNC head quarters			
No R&D	54.55	45.45	100
Did R&D	5.13	94.87	100
All firms			
No R&D	72.09	27.91	100
Did R&D	30.26	69.74	100

Source: INGINEUS SURVEY

research efforts, rather than being a substitute to own R&D efforts. Further, we have already seen that the prevalence of R&D is high among the MNC head quarters and MNC subsidiaries and they interact more intensively with the university system. This tends to support the view that MNCs search for such locations that are capable of offering the complementary capabilities (Ernst 2000 and Ernst and Lundvall 2000). But the observed trend with respect to the stand alone firms regarding their interaction with universities is not very encouraging especially when viewed along with the evidence from table1 to the effect that prevalence of R&D activity among the stand alone forms extremely low as compared to their counterparts. The preliminary evidence therefore, further reinforces our argument that the innovative behavior of large segment of firms operating in the India ICT sector are not attuned to equip them to reap the potential benefits of GINs in the context of global innovation race. At the same time, we also observe interaction with universities is not an agenda of a large proportion of firms. To be more specific, over 72 per cent of the firms not engaged in R&D and about 30 per cent of those undertaking R&D are not having any interaction. As already noted, the interaction is much lower with that of foreign universities. To the extent that various studies have highlighted the role of such interaction in innovation, we now explore the underlying factors.

3.6 Behind the low level of University-Industry Interaction

Lower level of interaction that firms have with the universities and research centers, especially with those from abroad, by and large reflects on the firms' internationalization strategies. Most firms did not outsource the functions of the firms to other firms. Rather the delegation of functions seems to be among the subsidiaries of the same firm. The functions of the firm were still centralized, though there was some delegation with regards to technology and process development to subsidiaries in the developed countries. More than 73 percent of the firms stated that technology and process development was internal to the firm (table 10)

Table 10: Performance of various functions of the firm and internationalization

	Firm type	**By your unit in your location**	**subsidiaries of firm in developed country**	**subsidiaries of firm in developing country**	**Outsourced to partner in your country**	**Outsourced to a partner outside your country in a developed location**	**Outsourced to a partner outside your country in a developing location**
Product development	SA	0.0	12.6	4.2	0.0	1.2	0.6
	MNCSUB	0.0	20.8	21.7	2.8	2.8	1.9
	MNCHQ	0.0	20.0	42.0	4.0	2.0	0.0
	TOTAL	0.0	16.4	15.8	1.6	1.9	0.9
Technology and process development	SA	82.0	10.2	3.6	0.0	0.0	0.0
	MNCSUB	69.8	22.6	17.0	0.9	0.9	0.0
	MNCHQ	54.0	36.0	24.0	2.0	2.0	0.0
	TOTAL	73.7	18.3	11.2	0.6	0.6	0.0

Only 18 percent had subsidiaries of the firm in developed country and 11 percent of the firms had process development being delegated to subsidiaries in developing countries. Even then most technology development was firm specific and internally generated. Thus viewed the old model of global production networks still characterizes the GINS wherein firms' functions are distributed mostly among their own subsidiaries and the partnerships with other agents either in the developing or the developed countries is remaining weak. While this could be seen as an indication of the premature nature of innovation systems in developing countries, it is in tune with the findings of Pavitt and Patel (1991) that innovative activities among the largest firms in the world were among the least internationalized of their functions.

Why global knowledge collaboration has not taken root among firms in India? Majority of the firms (55%) perceived that finding relevant knowledge across the globe was a serious or moderate barrier for such collaborations to develop, of which 23% reported this as a serious barrier (table 11). As seen earlier, stand alone firms do not make attempts to internationalize their knowledge sources; hence they may not find the issue as a serious barer. Among the MNC subsidiaries in India 24 per cent reported finding knowledge of relevance as serious barrier. It was the MNCs head quartered in India that found operational knowledge collaboration for innovation very difficult. More than 42 percent of the firms felt that it was an extreme or serious barrier. The MNCs emerging from developing country locations such as India, seem to find partners either among other firms or from universities/research institutes.

Table 11: Factors that represent a challenge or a barrier to international innovation collaboration

	Firm Type	Extreme/ Serious Barrier	Extreme barrier	Serious barrier	Moderate barrier	Small barrier	Not a barrier at all	Total
Finding relevant new knowledge across the globe	SA	16.8	7.74	9.03	34.84	26.45	21.94	100
	MNC sub	23.6	5.66	17.92	26.42	33.96	16.04	100
	MNC HQ	42.0	6	36	34	12	12	100
	Total	23.2	6.75	16.4	31.83	26.69	18.33	100

With respect to the institutional arrangements to promote internationalization of innovation nearly 70 percent of the firms felt that public funded centers of innovation and internationalization carried a negative attitude towards internationalization efforts of the firm (table 12). While this is true in case of all types of firms, a much larger share of the MNC from India (82 percent) felt that public support or innovation was very negative. This was true in case of public support and incentives, international exposure to universities, and training of labour force for internationalization. In all of these factors of internationalization, the firms largely felt that the role of these institutions were negative and did not encourage internationalization. Thus the state policies and institutions are yet to fully appreciate the potential benefits and initiate proactive measures to support internationalization of firm's innovative activities. Yet another factor that came out from the survey related to the availability of labour force required for internationalization. This finding assumes added importance in a context wherein it is generally believed that India provides an abundant supply of skilled manpower that facilitates India's participation. Whereas, argued in work package 6; India needs to travel a long distance to accomplish this perception into reality and the present situation is one wherein there is intense competition for the available labour force between different players in GINs.

Table 12: Factors influencing the internationalisation of innovation activities

		Highly negative	Moderately negative	Moderately positive	Highly positive	Factor not experienced	Total
Practical support from centres for the internationalisation of innovation	SA	22.08	40.26	3.25	4.55	29.87	100
	MNC sub	37.86	33.98	12.62	2.91	12.62	100
	MNC HQ	34	48	2	4	12	100
	Total	29.32	39.41	6.19	3.91	21.17	100
Public incentives and economic support available for internationalising	SA	28.1	30.72	9.8	1.96	29.41	100
	MNC sub	36.89	35.92	8.74	3.88	14.56	100
	MNC HQ	46	34	6	2	12	100
	Total	33.99	33.01	8.82	2.61	21.57	100

The international contacts and international exposure of universities, university and public research	SA	23.68	38.82	6.58	3.29	27.63	100
	MNC sub	39.81	33.01	8.74	3.88	14.56	100
	MNC HQ	36	42	4	2	16	100
	Total	31.15	37.38	6.89	3.28	21.31	100
Labour force training specific to the needs of the internationalisation	SA	31.58	37.5	7.89	1.97	21.05	100
	MNC sub	45.63	29.13	8.74	2.91	13.59	100
	MNC HQ	50	28	10	2	10	100
	Total	39.34	33.11	8.52	2.3	16.72	100

4. Interaction of MNCs and their subsidiaries in IT sector with universities and public research institutes: two case studies

The case studies of two MNCs one with head quarters in India and other with head quarters in the U S are presented in this section to throw further insights on the issue subjected to discussion in the previous section using data gathered through the primary.

4.1 Case 1: Integration with universities as a conduit for ensuring skill supply

Firm A is an MNC with headquarter in India, is one of the largest ICT firms in India, with a very high export intensity (export as a proportion of sales) higher than 90 percent. The firm began with customized services during the early stages and gradually moved up towards consultancy and product development and the traditional demand for its services and products come from the US market. However, the market is being increasingly being diversified to Europe and in the recent years, especially after the financial crisis, there has been a trend towards increased domestic market orientation. The firm focused mainly on customized services in its early stages, but now gradually moving to products as well.

This firm considers its clients and suppliers as the main sources of knowledge for innovation. The firm follows a much closed model for knowledge seeking. The firm does not seek interactions with other agencies in R&D, be it competitor companies or universities. The firm, which is now internationalizing its operations, has a history of acquiring foreign firms for knowledge of foreign markets and soft skills that are required to operate in foreign markets. The firm has two R&D centres, one in India, the other in another developing country and there is a close constant interaction between employees of the firm and their R&D centres. These interactions, which are essentially internal to the firm are spurred usually by the specificities of the customer's demand. Thus it may be stated that this firm's innovation is demand driven. To illustrate, on the sources of knowledge for innovation the interviewee stated that

> "We basically start looking at the problems that our customers are facing, issues with services and those reports and our in-house knowledge tries to solve the problems."

However, this is not to say that there is no interaction with the universities or research centers. The most common form of interaction with the academic world was through student recruitment to the firm. This firm has an elaborate network of student placements every year in the firm, recruiting annually a few thousand employees from all over the country. The interviewee stated that from repeated placement programmes for many years they recognized that there was a vast gap between the students' knowledge pool and the industry's skill requirements. This had led to the establishment of an educational intervention programme by the firm in select colleges across the country, wherein the senior members of the firm would join hands with the locally available faculty in training students to be better industry-ready. In some cases, the firm had been successful in bringing about changes in the university/college syllabus such that the regular taught programmes reflect the industry skill requirements by the industry.

To conclude it appears that this firm represents the case typical of university industry interaction in an immature innovation system. The firm does not see universities as partners in research or innovation rather its internal sources are the core sources of innovation along with the feedback from customers and suppliers. While the firm interacts with the universities, the basic objective is to influence the teaching and training in such way that the products from the university system is industry ready to enhance its international competitiveness by reducing the cost involved in training. Such cost reduction appears especially important given the high export orientation of the firms. This needs to be seen in the present context wherein the firm is forced to invest heavily in training by establishing a massive training facility with a capacity of 20,000 per annum, much more than any non affiliating university in India.

4.2 Case 2: Interaction with universities as a means of market creation

Firm B is the Indian subsidiary of a MNC with headquarters in U.S., a global market leader in networking and telecommunication. This firm was founded in 1984 by a small group of computer scientists and produced the first router in 1986. Over the years the firm emerged as the worldwide leader in networking. In 2010 the company has its presence in 165 countries with 550 offices and around 30 manufacturing sites and employed 72,600 with a sales turnover of US $ 44 billion.

Being a company operating in a high tech industry with relatively shorter product cycle under highly competitive conditions, it has been providing top priority for innovation. The R&D

expenditure as a proportion of sales by the firm has been maintained consistently at two digit level even during the period of economic crisis indicates the high priority to research and development attached by the company. Innovation in CISCO is not perceived as technological innovation alone but also as business innovation (capturing the current transitions at societal level and create cooperation with partners and competitors to grow). The firm, for example, is involved in the creation of smart cities (in particular in emerging markets like China, India, Mexico where the main societal transitions are going on, for example, for education or healthy issues). The role of innovation as is evident from statements in various annual reports. To illustrate;

> In our opinion, the key to long-term success in the high-technology industry is ongoing strategic investment and innovation, and we intend to continue to take good business risks. Our innovation strategy requires a unique combination of internal development, partnerships, and acquisitions. In our opinion, for companies to lead in the technology industry they must be able to do all three" (annual Report 2005)

The company is a typical case of open innovation within a global network. Apart from being highly R&D intensive, the firms' innovation strategy is reflected in the strong internal network between the head quarter and 550 offices, 30 manufacturing sites spread across 165 countries. Apart from alliances the firm also actively pursued since late 1980s a strategy of acquiring new companies with competence in niche areas from both developed and developing countries to strengthen its technological competence. So far the company has acquired 140 companies of which 14 of them were since 2008.

The firm first came to India in 1995 to establish a representative office to provide data communications solutions to various customers.3 In 1999, the firm established a Global Engineering Development Center in Bangalore with an investment of US$20 million to develop and test Cisco IOS(R) software, network management software, application specific integrated circuits (ASICs), and other technologies like ATM (asynchronous transmission mode) and VOIP (voice over internet protocol).4 This Center was in addition to the joint development centers established in partnership with Wipro Technologies and Infosys Technologies in Bangalore; HCL Technologies in Chennai, and Zensar Technologies in Pune. For Cisco, like for everybody else, India was, beside from being a market, a source of "engineering and talent" to develop its networking products.

The Globalisation Centre in Bengaluru, established December 2006, serves as a "mirror site" to many headquarters functions including R&D, IT, sales and customer support, and finance and is termed as the Eastern Headquarter. The 12.5 hour time difference between San Jose and India allowed the firm to be run 12 hours out of India and 12 hours in India. It provides every other function as part of a global team, participating in global work. In the words of Chief Technology

[3] Unless otherwise mentioned, this section draws on an interview with Susheela Venkataraman, Managing Director, Internet Business Solutions Group, Bangalore, 30 July 2010.
[4] http://newsroom.cisco.com/dlls/fspnisapi997f.html

Officer Padmasree Warrier, "The Globalization Center in Bangalore is not a center for India [the] market, it is a center for global markets."5

Being a truly innovative, global and networked firm, the strategy of building and sustaining technological competence by the firm involves networking not only within the firm and other firms, suppliers and customers but also the other knowledge generating organizations like universities around the world. It collaborates with universities worldwide both for educational purpose (e.g. special graduated programmes) and also for innovation purpose. The main collaborations are in US and in India.

A major programme is Global Talent Acceleration Programme (GTAP) established in different countries. Networking Academy aims to provide a consistently enriching learning experience by partnering with public and private institutions such as schools, universities, businesses, nonprofits, and government organizations to develop and deliver innovative ICT courses, improve the effectiveness and accessibility of the program, increase access to education and career opportunities, and help ensure that students and instructors have the resources they need to accomplish their goals. These initiatives are equally helpful in creating new markets and expanding the existing ones.

In India, though there are many instances of interaction with academic institutions like the Indian Institute of Science Bangalore a full-fledged and formal linkages with institutions are yet to take place. Hiring of course continues to be the major form of interaction with the academic institutions. There is a small focus now growing in India towards research interactions as well but mostly informal in nature. The initiative for such interactions comes from both the firm and the institutes. The subsidiary in India has some highly knowledgeable persons who have joined from the academia and they are the ones who usually established linkage with the academic circles. Also its personnel participate in research seminars, workshops, conferences in the various academic institutions. But of course the firm also has a purely research programme that is linked with these academic research institutions. In addition interactions also takes place in the form of internship for students approximately 150 to 200 or even more in some years.

The case study of a highly innovative and globally integrated firm clearly indicates that innovation as a process is increasingly been considered as an interactive process wherein collaboration with users, suppliers and other knowledge generating entities like universities (both within an outside the countries) is as important, if not more, than in house R&D activities. The firm under study explicitly states three key elements in the innovation strategy; they are internal development, partnership and acquisitions. The firm has also been establishing a global network for promoting skilled manpower especially in the core area of its concern; that networking. In addition, the firm has been developing strategic alliances, even with competing firms, and local governments apart from their conscious effort to acquire firms with skills set in niche areas. The key question is to what extent the policy environment and institutional arrangements within developing countries like India and China are capable of harnessing the presence of such firms for making their innovation system more vibrant. The answer to the above issue, going by the

[5] http://www.forbes.com/2010/01/26/forbes-india-padmasree-warrior-cto-cisco-tech-with-business.html

evidence from India, appears to be not very encouraging. While the firm believes in interactive learning and collaboration with universities no formal arrangements exist until now in India. At the same time there are various initiatives that are oriented more towards market creation and expansion as compared to promoting innovation.

5. Concluding observations

Viewed from the perspective promoting innovation, both in the developing and developed countries, the most pertinent characteristics of GINs is the process of interaction between universities and research institutions that is inherent in most GINs. While the literature on GINs acknowledged the significance of the interface between universities and industries in GIN formation, our understanding of the underlying process and its implications at best remains rudimentary. Such a knowledge deficit, needless to say, seems to have undermined the ability of both developed and developing countries to design relevant policies. In this context, the present study, by making use of the data gathered through a primary survey of India's ICT firms explored the interaction between ICT firms within the country and abroad with universities and research institutions within and abroad- both the north and the south – and highlighted the underlying factors.

The study found that the interaction with the universities is highest in case of MNC head quartered in India as compared to the subsidiaries of MNCs and stand alone companies indicating that the Indian MNCs and foreign MNCs are utilizing the resources universities and research institutes much more intensively as compared to the stand alone firms. The interaction with universities in the local region as well as with universities at the national level were found to be higher for the MNC headquartered in India, compared to other types of the firms. Collaboration was found highest with North American universities and research institutes. This needs to be seen in terms of the fact that North America accounted for highest share of IT export from India. While there are indications of growing interaction with universities in the South and Indian MNCs, that with the European firms is found much lower calling for the immediate attention of policy makers.

Apart from firm characteristics, the sector specificities also appear to influence the interaction between universities and industry. While the firms operating in the modern knowledge intensive industries such as Pharmaceuticals, Biotechnology, Chemicals and Information Technology reported a relatively higher level of interaction their counterparts in low technology industries like textiles reported hardly any interaction at all. There seems to be substantial regional variation in the incidence of university industry interaction indicating that regional innovation system does matter.

The evidence also suggests the low prevalence of R&D activities among the stand alone firms as compared to their MNC counterparts. To the extent that there is high association between firms' inhouse R&D and interaction with universities the observed behavior of standalone companies tends to suggest that they are poorly positioned to take advantage of the potential benefits of GINs as compared to their foreign and local counterparts who appears to be well positioned (given the high R&D orientation) in the "global innovation race".

The study provides some insights on why global knowledge collaboration has not taken root among firms in India? Majority of the firms perceived that finding relevant knowledge across the globe was a serious or moderate barrier for such collaborations to develop. With respect to the institutional arrangements to promote internationalization of innovation, majority of the firms felt that public funded centers of innovation and internationalization carried a negative attitude towards internationalization efforts of the firms. Thus the state policies and institutions are yet to fully appreciate the potential benefits and initiate proactive measures to support internationalization of firm's innovative activities. Yet another factor that came out from the study related to the availability of labour force required for internationalization. This finding assumes added importance in a context wherein it is generally believed that India provides an abundant supply of skilled manpower that facilitates India's participation.

The case study of two MNCs, one based in India and other abroad, tends to suggest that while interaction with universities does exist, its major focus is not on promoting innovation. The nature of university interaction by the MNC based in India tends to suggest that the underlying objective of fostering interaction with universities at present is to ensure that graduates from the universities are industry ready such that the cost of in-house training is reduced. In case of the MNC based abroad, interaction with the university has the major objective of generating new markets and expanding the market for the existing products. If the finding of the present study is any indication there is an urgent need for appropriate policy measures and institutional interventions such that Global Innovation Networks do not become Global Innovation Traps.

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Intellectual Property Rights, Migration and Diaspora

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Intellectual Property Rights, Migration, and Diaspora*

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Abstract

In this paper we study theoretically and empirically the role of the interaction between skilled migration and intellectual property rights (IPRs) protection in determining innovation in developing countries (South). We show that although emigration from the South may directly result in the well-known concept of brain drain, it also causes a brain gain effect, the extent of which depends on the level of IPRs protection in the sending country. We argue this to come from a diaspora channel through which the knowledge acquired by emigrants abroad can flow back to the South and enhance the skills of the remaining workers there. By increasing the size of the innovation sector and the skill-intensity of emigration, IPRs protection makes it more likely for diaspora gains to dominate, thus facilitating a potential net brain gain. Our main theoretical insights are then tested empirically using a panel dataset of emerging and developing countries. The findings reveal a positive correlation between emigration and innovation in the presence of strong IPRs protection.

J.E.L. Classification: O34; F22; O33; J24; J61.

Keywords: Intellectual property rights; Migration; Technology transfer; Brain gain; Diaspora.

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1 Introduction

International trade and foreign direct investment (FDI) have often been identified as the main determinants of innovation and growth in developing countries (South) (Saggi, 2002; Keller, 2004). While the significance of trade and FDI has been confirmed by a two- and three-fold increase in their ratio with respect to world output during the 1990s, high-skill migration to developed countries (North) has witnessed an even faster increase (Docquier and Rapoport, 2010). The resulting surge in the outward transfer of the human capital embedded in migrants has created controversial debates about the threats and opportunities that skilled emigration may pose to the South. On the one hand, the traditional literature on migration and brain drain presents mechanisms through which skilled emigration could be detrimental to growth.[1] On the other hand, a growing branch of contributions argues that skilled emigration need not harm the South and may even increase the potential for development.

The so-called brain gain effect derives from an incentive channel that works through the increased expected returns to education brought about by migration prospects (Mountford, 1997; Stark et al. 2007; Beine et al., 2001, 2008).[2] An additional channel is return migration, which can induce innovation through the knowledge embodied in migrants returning from more advanced economies (Domingues Dos Santos and Postel-Vinay, 2003; Mayr and Peri, 2009; Dustmann et al. 2011). Finally, cross-border diaspora networks among skilled emigrants and natives may also promote access to foreign-produced-knowledge and foster innovation by encouraging trade, investments and the recirculation of information back into the sending countries (Agrawal et al., 2008; Kerr, 2008).[3] Research in other disciplines such as Meyer (2001) suggests such informal networks to be crucial in turning brain drain into a net brain gain. Despite a large number of studies on diaspora networks, however, little formal research in the economic literature directly examines the potential link between the knowledge absorbed by emigrants abroad and innovation in their home countries.[4]

[1] Seminal works are those of Berry and Soligo (1969), Bhagwati and Hamada (1974) and Miyagiwa (1991). For a recent complete survey of the literature on brain drain and development, see Docquier and Rapoport (2010).

[2] The possibilities of such gains from emigration were first referred to by Bhagwati and Rodrigues (1975).

[3] Student/scholarly networks, local associations of skilled expatriates, short-term consultancies by high-skilled expatriots in their country of origins, and other not established intellectual/scientific diaspora networks are a few examples of such networks (Meyer and Brown, 1999).

[4] Williams (2007) and Oettl and Agrawal (2008) focus on the externalities of international migration to emphasize

What are the consequences of skilled emigration for innovation in developing countries? Do diaspora networks play a role in this process? In this paper we explore how emigration from the South affects innovation activities in the home (sending) country. In particular, we investigate the existence of a channel through which the knowledge learned by emigrants after interacting with higher skills in the North can flow back to the South.[5] We refer to this channel as "intellectual diaspora", that is, the remote mobilization of intellectuals and professionals abroad and their connection to scientific, technological and cultural programs at home. We also examine the role of intellectual property rights (IPRs) protection in the South by exploring how IPRs interact with emigration in determining innovation performance. The key question we aim to answer is whether an appropriate level of IPRs protection could help transforming the brain drain caused by skilled emigration into a brain gain. In sum, we argue that although emigration may directly result into a brain drain, it also causes a brain gain affect, the extent of which depends on the strength of IPRs protection.

The role of IPRs protection in any study that involves innovation and the developing world is crucial. However, while the trade-off faced by an emerging economy between imitation and the provision of incentives for domestic innovation through IPRs are clear (Maskus, 2000), the inter-relationships between skilled migration and IPRs policy in determining innovation remain to be explored. Our work fills this gap and contributes to the above mentioned strand of research by capturing the diaspora dimension of migration and discovering how IPRs protection in the sending country may influence the effect of skilled migration on innovation there.[6] On this basis, we shed light on the net impact of emigration on innovation and show whether a strong IPRs regime at home can eventually turn the initial brain drain into a brain gain.

Our theoretical framework is a standard occupational choice model in which emigration reduces effective innovation activities due to the loss of the most skilled (the *extensive margin*). Migration

their role in knowledge and technology transfer. More recently, Beine et al. (2011) show the influence of diasporas on the evolution of migration flows and their composition in terms of skills.

[5] In this framework the capacity of innovation of the Southern innovators which remain in their origin countries is related to their access to valuable technological knowledge partially accumulated abroad (i.e. brain banks). On this issue, see Agrawal et al. (2008).

[6] Among the vast literature on intellectual property rights, Chen and Puttinan (2005) and Parello (2008) are perhaps most closely related to our work, as they specifically focus on domestic skill accumulation and innovation. While the former relates positively IPRs protection to innovation, the latter deems it to be ineffective for innovation in less developed countries.

however also opens a diaspora channel, through which the knowledge acquired abroad can flow back into the innovation sector in the home economy and enhance the skills of the remaining workers there (the *intensive margin*). To investigate whether the beneficial effects of diaspora could outweigh the direct negative effects of the flow of skilled workers, we look at the size and the average skills of the innovation sector. While a strong level of IPRs protection directly increases the magnitude of gains from diaspora by raising the returns to skills and expanding the innovation sector (thus causing the diaspora effect to fall on a larger range of workers actively using their skills in the economy), it also endogenously increases the skill composition of the emigrants (thus leading to an increase in the quality of skills learned and transmitted back home). As a consequence, a strong level of IPRs protection in the sending country makes it more likely for diaspora gains to outweigh the negative effects of brain drain on innovation, thus facilitating a potential net brain gain.[7]

Using a sample of emerging and developing economies, we then show that the joint impact of migration and IPRs protection on innovation is positive in the presence of strong IPRs protection. The dataset we adopt is a panel of low-income countries ranging from 1995 to 2006. We measure innovation activities in the South by the number of patents granted to citizens of emerging and developing countries (EDC) with data taken from WIPO (World Intellectual Property Organization). We use this information together with extensive original data on migration flows and stocks derived from national statistical offices and with the index of IPRs protection as measured by Park (2008). By conducting an empirical investigation focused on emerging and developing countries, our work also contributes to the missing world of empirical analysis on innovation and development in the South.[8]

In the remainder of the paper, we introduce the theory in section 2, the empirical exercise in section 3, and conclude in section 4.

[7] These results are in contrast to the theoretical conclusion obtained in McAusland and Kuhn (2011), who claim IPRs to be an obstacle to the international flow of brains. While their study is to our knowledge the first contribution which explicitly investigates the link between IPRs and brain circulation, it does not take into account any channels through which the skills acquired abroad can be transferred back into the country of origin.

[8] Indeed, while innovation has been deemed central to economic take-off, catch-up, and development in low-income countries, research on innovation tends to neglect developing countries, leaving a large gap in economic literature (Lorentzen and Mohamed, 2010).

2 The Model

2.1 Basic Framework

Suppose there are two regions: a developing economy referred to as the South, and an alternative North with better economic opportunities and employment possibilities, where skills and wages are higher by assumption. As the focus of our study is the Southern market, we concentrate our analysis on goods invented, produced and consumed locally in the South.[9] Consumers have the following utility function:

$$U_i = C_i = \left[\int_0^N c_j^{\alpha} di \right]^{\frac{1}{\alpha}}, \tag{1}$$

where individual consumption C_i is divided between a continuum of N invented goods subscripted by $j \in (0, N)$, and $\alpha \in (0, 1)$ represents the inverse measure of product differentiation.

There are two sectors in the economy, a production and an innovation sector. Labor is the only factor of production and innovation, and is mobile between sectors. Workers are spread over a continuum of skills $z \in [0, \infty)$, distributed with density $g(z)$ and cumulative distribution $G(z)$. We normalize the mass of workers to one. While production does not require skills, a worker i with skills z_i in the innovation sector has productivity h_i such that

$$h_i(z) = z_i + Z, \tag{2}$$

where z_i represents own skill endowment and Z (defined below) is spillovers of knowledge learned by emigrants abroad through what we call the "diaspora" channel.

The timing of the model is as follows. Nature reveals the IPRs regime exogenous to our model. Emigration takes place in period 0, activating the diaspora channel. Innovation is then carried out in the first period, and production occurs in the second.

The core of our analysis deals with the events that occur in period 0. We first study the implica-

[9] To single out the impact of migration from South to North on local innovation, we abstract from trade-related issues. For s study of the trade and migration in an occupational choice model see Iranzo and Peri (2009). While their study is not innovation-related, Davis and Naghavi (2010) explore the effects of trade and offshoring on innovation and growth in a similar but dynamic occupational choice setting.

tions of the IPR regime, which determines the size of the innovation sector and the skill composition of migration. We then look at the impact of emigration on innovation, measured by average skills to represent effective innovation activities in that sector, given the IPR regime in the South.

Emigration in period 0 is modelled as a movement of labor from the South to the North at a cost F, which allows only the highest skilled to move. Potential diaspora is then realized by means of skilled emigrants transferring their newly acquired knowledge back to the South. We define the positive externalities from diaspora networks as

$$Z = b\tilde{\zeta}, \tag{3}$$

where the average skills endowment of those who migrate to the North is $\tilde{\zeta} > 0$. Parameter $b \geq 0$ measures the intensity of diasporas, which is influenced by factors such as the level of academic and professional interactions and the amount of skills learned in the North, or the successful transmission of knowledge to and the absorptive capacity of the South. Note that $b = 0$ implies no international knowledge transfer, $b = 1$ the return of only original (pre-migration) skills of emigrants, and $b > 1$ the diffusion of their improved skills to the South.

In period 1, N goods are invented. Each good needs ρ units of skills. Total amount of human capital in the economy can be written as

$$H(z) = \int_{z_1}^{\infty} h_i g(z) dz, \tag{4}$$

where z_1 represents the skills of a threshold worker indifferent between working in the production or the innovation sector. The total number of goods available for consumption are

$$N = N(z) = H(z)/\rho. \tag{5}$$

In order to work in the innovation sector, each worker must go through training at a cost e, which is paid in the second period. Effective wage (wage per unit of skill) for the high-skilled in the innovation sector is equal to ω_H and is paid in period 2, giving each individual with skills z_i a wage equivalent to $z_i \omega_H$.

In period 2, the production sector absorbs all workers who have not worked in the innovation sector in the first period. The production function is CRS in labor and has productivity equal to one, so that there is a one to one relationship between output and labor, $n_j = l_j$. Individual wage is identical for all workers in this sector and equals ω_L.

2.2 Patents and Consumption

We use the basic framework in Saint-Paul (2003, 2004) as our benchmark, modelling IPR protection as the probability that an innovator can obtain monopoly power over his invention.[10] The probability of being granted a patent is q, which captures the degree of IPR protection.[11] The price of a non-patented good is equal to its marginal cost normalized to one, which also gives us wages in the production sector $p_L = \omega_L = 1$. Otherwise, if a patent is granted, a firm charges monopoly price $p_M = \mu$, which is a mark-up over marginal cost

$$\mu = 1/\alpha. \tag{6}$$

Next, consumption is divided between patented and non-patented goods, c_P and c_N respectively. Consumers allocate their income y (net of training costs) between the two types of goods by maximizing (1) or equivalently

$$\underset{c_N, c_P}{Max} \quad Nqc_P^\alpha + N(1-q)c_N^\alpha, \tag{7}$$

under the budget constraint

$$y = Nq\mu c_P + N(1-q)c_N. \tag{8}$$

[10] Saint Paul (2004) uses this setting to explore the implications of IPR and redistribution on occupational choice and welfare.

[11] Grossman and Lai (2004) also model patent protection in a similar manner.

The solution to the above maximization problem is:

$$c_N = \frac{y}{\psi}, c_P = \frac{y}{\psi}\mu^{\frac{1}{(\alpha-1)}}, \tag{9}$$

where

$$\psi = N(1-q) + Nq\mu^{\frac{\alpha}{(\alpha-1)}} \tag{10}$$

captures the love of variety effect as $\partial\psi/\partial N > 0$, and the disutility caused by monopoly pricing as $\partial\psi/\partial q < 0$.

Using (1), (7), (9) and (10), aggregate consumption index is therefore

$$C = \frac{y}{\psi^{\frac{(\alpha-1)}{\alpha}}} = \frac{y}{P},$$

where $P = \psi^{\frac{(\alpha-1)}{\alpha}}$ is the aggregate price index.

The value of a patent, which is equal to monopoly profit, is equal to

$$\pi = (\mu - 1)\frac{Y\mu^{\frac{1}{(\alpha-1)}}}{\psi}, \tag{11}$$

where Y is aggregate income (net of training cost). In the above expression, the first term on the RHS is the mark-up while the second is total demand for the patented good.

Under a competitive labor market, expected profit from inventing a new good must equal to its cost in terms of skills so that

$$q\pi = \rho\omega_H.$$

This gives

$$\omega_H = q(\mu - 1)Y\mu^{\frac{1}{(\alpha-1)}}/\psi\rho. \tag{12}$$

As we are interested in the direct effect of strengthening IPR protection (which corresponds to an increase in q) on employment in the innovation sector, we partially differentiate (12) with respect to

q to get

$$\frac{\delta\omega_H}{\delta q} = \frac{(\mu-1)Y\mu^{\frac{1}{(\alpha-1)}} + \rho N(1-\mu^{\frac{\alpha}{(\alpha-1)}})}{\psi^2\rho^2} > 0. \tag{13}$$

Recalling that $\mu > 1$ and $\alpha < 1$, the sign of the derivative in (13) reveals that stronger patent protection increases effective wages in the innovation sector. Notice that this has no effect on the skills of each individual worker and only changes average skills by increasing the returns to working in the innovation sector, hence expanding its size. While the size of the innovation sector is given by equation (4), the average level of skills in the South is denoted by

$$\tilde{z} = \frac{1}{1-G(z_1)}\int_{z_1}^{\infty} z dg(z). \tag{14}$$

Differentiating (14) with respect to z_1 reflects the basic results from the occupational choice model of Roy (1951). Since $\frac{\delta\tilde{z}}{\delta z_1} < 0$, the entry of less skilled workers in the innovation sector reduces average skills there.

2.3 Innovation and Migration

A worker with skill level z_i can either work in the innovation sector and earn $\omega_H z_i - e$ or become a production worker with wage $\omega_L = 1$, choosing the option that generates a higher income. Therefore, given $\omega_H > 1$, a worker chooses to work in the innovation sector if[12]

$$\omega_H z_i - e > 1 \Rightarrow z_1 = \frac{1+e}{\omega_H}. \tag{15}$$

Lemma 1 *The threshold skill level z_1, which determines the equilibrium allocation of workers between the production and the innovation sector, is decreasing in effective wages ω_H as $\frac{\delta z_1}{\delta\omega_H} = -\frac{1+e}{\omega_H} < 0$: higher effective skilled wages in the South shift workers from the production to the innovation sector.*

[12] Using z_i instead of h_i from (2) to find the threshold in (15) follows from the assumption that a worker does not take into account potential spillovers of knowledge learned by emigrants abroad, when choosing his occupation or deciding whether or not to migrate. This assumption avoids the anticipation of potential benefits from diaspora and free-riding on migration by others.

A worker migrates to the North if his gains from doing so net migration costs exceed what he would earn in the innovation sector at home:

$$\omega_M z_i - e - F > \omega_H z_2 - e \Rightarrow z_2 = \frac{F}{\omega_M - \omega_H}, \tag{16}$$

where we assume an exogenous effective wage in the innovation sector of the North higher than that in the South: $\omega_M > \omega_H$.

Lemma 2 *The threshold skill level z_2, which distinguishes emigrants from non-emigrants, is increasing in effective wages ω_H as $\frac{\delta z_2}{\delta \omega_H} = \frac{F}{(\omega_M - \omega_H)^2} > 0$: higher effective skilled wages in the South discourages emigration to the North.*

Observing (15) and (16) together reveals the size of the innovation sector. It is derived from the brain drain effect which relates to migration of the highly skilled population (lower z_2) and from the effect of the movement of workers from the production to the innovation sector as a result of stronger IPRs (lower z_1). Higher moving costs F deter emigration and preserve the size of the innovation sector; higher training costs to work in the innovation sector e decrease the size by preventing the low skilled from entering the innovation sector; higher prospective wages abroad ω_M encourage the flow of skills away from the country, while higher wages in the innovation sector at home ω_H attract workers from the production sector and reduce skilled emigration.

Finally, stronger IPR protection discourages emigration by the lower end of skilled workers. Defining

$$\tilde{\zeta} = \frac{1}{1 - G(z_2)} \int_{z_2}^{\infty} z dg(z) \tag{17}$$

as the average skill composition of migrants, stronger IPRs increase the *skill intensity* of migration by limiting the migrants to those with highest skills, as $\partial\tilde{\zeta}/\partial z_2 > 0$.[13]

Lemma 3 *Given Lemma 2 along with the definition of $\tilde{\zeta}$ in (17), $\partial\tilde{\zeta}/\partial z_2 > 0$ implies that a higher in z_2 increases the skill intensity of migration as long as the number of migrants is greater than zero,*

[13] Total skills of emigrants increases as more workers move to the North, while their average skills fall since every new migrating worker is endowed with lower initial skills ($\partial\tilde{\zeta}/\partial z_2 > 0$).

i.e. $z_2 < \infty \Rightarrow G(z_2) < 1$.

2.4 Equilibrium

The economy is in equilibrium when the allocation of workers across sectors is compatible with the labor and product market clearing conditions. Recall that the total number of workers in the production sector in terms of the threshold skill level z_1 is

$$L = L(z_1) = \int_0^{z_1} g(z)dz = G(z_1), \tag{18}$$

and that total skills in the innovation sector in terms of z_1 and z_2 are expressed by

$$H(z) = H(z_1, z_2) = \int_{z_1}^{z_2} h_i g(z)dz. \tag{19}$$

Market clearing implies that total output net training cost Y is equal to total factor income:[14]

$$Y = \omega_H H(z_1, z_2) + L(z_1). \tag{20}$$

This equilibrium condition can equivalently be written through the labor market clearing condition

$$L(z_1) = [N(1-q)]\frac{Y}{\psi} + Nq\frac{Y\mu^{\frac{1}{(\alpha-1)}}}{\psi}, \tag{21}$$

where the first and the second term on the RHS derive from total consumer demand for the non-patented and patented goods respectively.

[FIGURE 1 ABOUT HERE]

We can close the model by using equations (5), (10), (12), and (20) to solve for the equilibrium

[14] In what follows, we assume training costs e to be embedded in Y, which simplifies the notation but does not influence the results.

effective wage in terms of z_1 and z_2:

$$\omega_H = \omega_H(z_1, z_2) = \frac{q(\mu - 1)\mu^{\frac{1}{(\alpha-1)}} L(z_1)}{\rho + H(z_1, z_2)[1 - q(1 - \mu^{\frac{\alpha}{(\alpha-1)}})]}. \tag{22}$$

The following two-equations system allows us to calculate the dynamics of z_1 and z_2:

$$\begin{aligned} z_1\omega_H(z_1, z_2) &= 1 + e, \\ z_2\omega_H(z_1, z_2) &= \omega_M z_2 - F. \end{aligned} \tag{23}$$

Equilibrium effective wage $\omega_H(z_1, z_2)$ and the conditions in (23) can be interpreted as follows. We saw from (12) that an increase in the level of IPR protection raises the effective wage associated with one unit of skill. As the wage of the worker with skills z_1 in the innovation sector net of training cost is always equal to unity, an increase in q is always followed by a fall in z_1, as $\partial L(z_1)/\partial z_1 > 0$ in the numerator and $\partial H(z_1, z_2)/\partial z_1 < 0$ in the denominator work to keep the wage of the new (lower skilled) threshold worker net training cost equal to unity.

In addition, rewriting equilibrium conditions in (23) as

$$\begin{aligned} z_1 q(\mu - 1)\mu^{\frac{1}{(\alpha-1)}} L(z_1) &= (1 + e)\left\{\rho + H(z_1, z_2)[1 - q(1 - \mu^{\frac{\alpha}{(\alpha-1)}})]\right\}, \\ z_2 q(\mu - 1)\mu^{\frac{1}{(\alpha-1)}} L(z_1) &= (\omega_M z_2 - F)\ \left\{\rho + H(z_1, z_2)[1 - q(1 - \mu^{\frac{\alpha}{(\alpha-1)}})]\right\}, \end{aligned} \tag{24}$$

we can easily see that thresholds z_1 and z_2 must move in opposite directions, i.e. $\partial z_2/\partial z_1 < 0$. This is so because the LHS of (24) is strictly increasing in z_1, while the RHS is decreasing in z_1 through $H(z_1, z_2)$. Migration threshold z_2 must therefore increase to reestablish equilibrium as $\partial H(z_1, z_2)/\partial z_2 > 0$.[15]

Redefining averages skills from (14) after adding threshold z_1 to account for migration, we have

$$\tilde{z} = \frac{1}{G(z_2) - G(z_1)} \int_{z_1}^{z_2} z dg(z). \tag{25}$$

[15] See Appendix for a formal proof and the derivation of the total derivatives.

Differentiating (25) with respect to z_1 and z_2 gives $\frac{\delta \tilde{z}}{\delta z_1} < 0$ and $\frac{\delta \tilde{z}}{\delta z_2} > 0$.

Lemma 4 *Given (25) along with Lemmas 1-2, a rise in per unit wages of the skilled in the South lowers average skills* $\tilde{z}$ *(*$\frac{\delta \tilde{z}}{\delta \omega_H} < 0$*) if* $\left|\frac{\delta z_1}{\delta \omega_H}\right| > \left|\frac{\delta z_2}{\delta \omega_H}\right|$*, and increases it if the opposite holds.*

We can conclude that an increase in the IPR protection level q shifts workers from the production to the innovation sector, increasing the size of the latter and lowering average skills in the South. However, Lemma 4 shows that IPR protection does not only imply an expansion of the innovation sector by lowering z_1, but also via increasing z_2 as $\partial z_2/\partial z_1 < 0$. This reduced migration works against the negative impact of IPRs on average skills in the innovation sector, and at the same time increases the skill composition of the emigrants $\tilde{\zeta}$ from Lemma 3. The impact of IPR enforcement on the home economy is illustrated in Figure 1.

Proposition 5 *A stronger level of IPR protection in the South (higher q) increases the returns to working in the innovation sector* ω_H *and therefore (1) expands the size of the innovation sector from both ends of the spectrum (*$\frac{dz_2}{dz_1} < 0$*) by reducing* z_1 *(*$\frac{dz_1}{dq} < 0$*) and raising* z_2 *(*$\frac{dz_2}{dq} > 0$*); (2) increases the skill intensity of migration by increasing* $\tilde{\zeta}$ *through a larger* z_2*.*

Proof. *See (13), (24), (17), and the Appendix.* ■

We now turn to analyze the conditions under which skilled emigration could promote innovation in the South. In particular, we study how emigration changes the level of skills in the South, and how the magnitude of this effect is determined by the IPRs regime. We then explore when the beneficial effects of cross-border diaspora are likely to outweigh the negative brain drain effect of emigration on innovation and transform it into brain gain.[16]

2.5 Intellectual Property Rights and Diaspora

In order to measure the net effect of migration on innovation in the South, we must weight the magnitude of the negative brain drain effect against gains brought about by the diaspora channel.

[16] The brain gain channel which we refer to has a different interpretation from that of the relevant literature. While the literature on brain gain and development highlights that the brain gain channel is realized through an increase in the incentives for human capital formation in the sending countries, in our framework the brain gain channel is realized through an increase in the size and average skill level of the innovation sector of the origin country. Both interpretations, however, lead to the same conclusion: under certain conditions, skilled emigration could be beneficial for growth in the sending countries.

Brain drain can be summarized as the direct loss of skills embedded in workers who migrate abroad, i.e. *the extensive margin*. This is in other words the amount of skills initially available prior to migration minus the base skills of the remaining workers post-migration:

$$BD = \int_{z_1}^{\infty} zg(z)dz - \int_{z_1}^{z_2} zg(z)dz = \int_{z_2}^{\infty} zg(z)dz. \tag{26}$$

[FIGURE 2 ABOUT HERE]

Next, we rewrite the aggregate supply of skills as

$$H(z_1, z_2) = \int_{z_1}^{z_2} (z + Z)g(z)dz = \int_{z_1}^{z_2} (z + b\tilde{\zeta})g(z)dz = \int_{z_1}^{z_2} zg(z)dz + b\int_{z_1}^{z_2} \tilde{\zeta}g(z)dz, \tag{27}$$

The first term on the RHS represents the amount of skill workers in the innovation sector are originally endowed with, and the second term the aggregate diaspora effect on the same workers still residing in the South, i.e. *the intensive margin*.[17] Such potential gains from diaspora are illustrated in Figure 2. The second term on the RHS of (27) denotes the virtual return of upgraded skills through diaspora and can be rewritten to define brain gain as

$$BG = b\int_{z_1}^{z_2} \tilde{\zeta}g(z)dz = b\tilde{\zeta}\int_{z_1}^{z_2} g(z)dz = b\tilde{\zeta}[G(z_2) - G(z_1)] = b\frac{G(z_2) - G(z_1)}{1 - G(z_2)}\int_{z_2}^{\infty} zdg(z), \tag{28}$$

where $[G(z_2) - G(z_1)]$ represents the size of the innovation sector, which is then multiplied by the diaspora term $b\tilde{\zeta}$ to account for the total effect of the latter on innovation in the home economy. Recall that an improvement of the IPR regime increases returns to skills (working in the innovation sector) by increasing effective wages ω_H. This results in an expansion of the innovation sector by reducing z_1 and increasing z_2. The RHS of equation (28) reveals that protecting IPRs increases the number of workers in the innovation sector that can benefit from diaspora by enlarging $[G(z_2) - G(z_1)]$, and by enhancing the level of skills $\tilde{\zeta}$ that can be transferred back to the home country. This phenomenon is depicted in Figure 3.

[17] Note that emigrants are excluded when summing up local skills in the South.

[FIGURE 3 ABOUT HERE]

To see whether the brain gain effects caused by a diaspora channel could dominate the physical escape of skills caused by brain drain we must calculate the net effect of migration on total human capital in the sending country and test whether

$$\begin{aligned} BD - BG &\gtrless 0 \\ \int_{z_2}^{\infty} zg(z)dz - b\frac{G(z_2) - G(z_1)}{1 - G(z_2)}\int_{z_2}^{\infty} zdg(z) &\gtrless 0 \\ b\frac{G(z_2) - G(z_1)}{1 - G(z_2)} &\equiv \Phi \gtrless 1. \end{aligned} \tag{29}$$

As seen above, the term $\Phi \equiv b\frac{G(z_2)-G(z_1)}{1-G(z_2)}$ can take a value greater or less than one. Brain gains through diaspora dominate when $\Phi > 1$, which is more likely for high levels of IPR protection because $\frac{\partial z_1}{\partial q} < 0 \Rightarrow G'(z_1) > 0 \Rightarrow \frac{\partial \Phi}{\partial z_1} < 0$ and $\frac{\partial z_2}{\partial q} > 0 \Rightarrow G'(z_2) > 0 \Rightarrow \frac{\partial \Phi}{\partial z_2} > 0$. As a result, IPRs indirectly promote brain gains by increasing the size of the innovation sector and the quality of diaspora, even if it could directly reduce average skills in the innovation sector (see Lemma 4).

Proposition 6 *Given proposition* 1 *and equation (29), gains from diaspora could outweigh the direct loss of skills caused by migration if the IPR regime in the South is sufficiently strong, so that* $b\frac{G(z_2)-G(z_1)}{1-G(z_2)} \equiv \Phi > 1$ *holds. This is so because 1. diasporas from the North reach out a larger number of workers who use their skills in the innovation sector:* $\frac{\partial[G(z_2)-G(z_1)]}{\partial q} > 0$*; 2. the average skills of migrants* $\tilde{\zeta}$ *and hence the quality of skills acquired abroad and transmitted back is higher:* $\frac{\partial[\frac{1}{1-G(z_2)}]}{\partial q} > 0$.

Proof. *See equation (29), Proposition 1, and Lemmas 3-4.* ■

2.6 Summary and Main Empirical Implications

In our theoretical model we investigate under what circumstances skilled emigration may be beneficial for development. We show that this occurs in the presence of a strong IPR regime, which may turn a brain drain into a brain gain.

In our framework a country's potential for innovation is influenced both by the size and average skill level of the innovation sector and by the average skill level of migrants. An increase in the size and average skill level of the innovation sector, as well as an increase in the average skill level of migrants, increase the absorptive capacity of the country where migration originates from, thus leading to stronger beneficial effects of cross-border diaspora networks. These beneficial effects are larger the bigger is the innovation sector, which occurs under strong patent protection.

The mechanism at work is as follows. Emigration has two effects. On the one hand, it decreases the average skills of the innovation sector $\tilde{z}$ since the implied loss of the most skilled induces a lower z_2 (*the extensive margin*). On the other hand, it increases the skills of the remaining workers in the innovation sector because of the diaspora channel (*the intensive margin*). This latter effect occurs through $\tilde{\zeta}$, which enhances the skills of all remaining individuals in the innovation sector as long as $b > 0$. The IPR regime also affects innovation in two ways. On the one hand, it affects the size of the innovation sector. On the other hand, it endogenously influences the skill composition of the emigrants. Indeed, an increase in IPRs protection enhances the attractiveness of working in the innovation sector, by thus increasing its size from both ends of the spectrum: it causes a move of the low skilled workers from the production to the innovation sector (i.e. z_1 falls) and it reduces emigration (i.e. z_2 rises). With a larger innovation sector, the potential for absorption of the newly acquired skills from the North ($b\tilde{\zeta}$) is higher, as the diaspora effect falls on a larger range of workers (i.e. a larger $H(z)$). At the same time, a reduction in the number of emigrants (i.e. a larger z_2) leads to a increase in their average skills $\tilde{\zeta}$, and hence to an increase in the quality of the skills that can be sent back to the original country.

This line of reasoning leads to the conclusion that the gains in human capital from diaspora are more likely to outweigh the direct drain of skills caused by emigration under a stronger IPRs regime. The main testable implications of our model are the following:

1. Abstracting from IPRs protection, skilled emigration is harmful for the origin country's potential for development, leading only to brain drain.

2. In the presence of IPRs protection, skilled emigration could be beneficial for innovation. This

occurs when the level of IPRs protection in the origin country is sufficiently strong. In such a case, the IPRs regime may help transform a brain drain in a net brain gain.

3 Empirical Analysis

3.1 Specification and Data

To investigate whether in the presence of emigration brain gains are more likely to prevail under stronger IPR regimes, we explicitly focus on the interrelationships between migration and IPRs protection. To this end, we study the determinants of innovation with the help of an empirical specification which introduces at the same time the following key variables: migration, intellectual property rights protection and the interaction between migration and IPRs protection.

The empirical analysis focuses on a sample composed by emerging and developing countries as classified by IMF (2010). We make this choice because our theoretical analysis specifically concentrates on the determinants of innovation in developing countries. The dataset is an unbalanced panel including 42 countries and covering the time interval from 1995 to 2006. The unit of analysis is a country-year. The specification we adopt is the following:

$$y_{it} = \beta_0 + \beta_1 x_{1it-k} + \beta_2 x_{2it} + \beta_3 x_{1it-k} x_{2it} + \boldsymbol{\gamma} \mathbf{Z}_{it} + \alpha_i + \varepsilon_{it}$$

where i denotes country and t denotes year. The dependent variable y is innovation, x_1 is emigration, x_2 is IPRs protection and $x_1 x_2$ is the joint impact of migration and IPRs. $\mathbf{Z}$ is a vector of m control variables, the α_i's are country-specific characteristics and ε is the error term. The cumulative effect of migration on innovation is then captured by β_1 and $\beta_3 x_{2it}$, by thus varying with the level of IPRs protection.

Our innovation measure is resident patent grants, i.e. the patent granted in each country to its residents by the national office of that country.[18] Patent data are from the WIPO database. Our

[18] On the benefits of using patent statistics to measure innovation, see Griliches (1990). Along with input data such as R&D expenditures and the human capital employed in research, patents have become the most common measure of innovation output (Hall et al. 2001) and of knowledge spillovers (Mancusi 2008).

migration measure is the flow of migrants out of each country and is taken with k lags, to take into account of both the time needed for the emigrants to interact with the people remaining in the sending countries and the time needed to make a patent granted. An additional migration measure is migrant stocks, which we mainly use in our robustness checks. The data on emigration flows and stocks are retrieved by aggregating original bilateral yearly data on immigrant flows and stocks by country of origin into 27 receiving OECD countries.[19] Intellectual property rights are measured through the Park (2008) index of IPR protection. Following the relevant literature, we also consider the following controls: population, GDP per capita, R&D expenditure, patent stock, trade, FDI, government spending and education. Population and GDP per capita are included in all regressions to take into account of size effects. R&D is considered as a measure for a country's potential for innovation. Patent stock is considered as a proxy for a country's absorptive capacity (Hall et al., 2001).[20] The education measure is tertiary education and is considered as an additional proxy for the ability to absorb new knowledge. Trade and FDI are included to take into consideration the conclusions of the rich literature on North-South trade and FDI as determinants of innovation in low-income countries. Finally, government spending is considered as a proxy for economic freedom.

For all details about our data and sources, see Appendix A.1. Table 1 illustrates the summary statistics of the sample of countries included in our baseline specification, i.e. column (1) of Table 2.

[TABLE 1 ABOUT HERE]

3.2 Results

Table 2 presents our regression results using resident patent grants as dependent variable. We initially consider a baseline specification with all the three main variables of interest (migration, IPRs

[19] Although for our analysis it would have been ideal to use data on skilled emigration, detailed statistics on the skill composition of emigrants by origin countries are available only for the two most recent census years (1990 and 2000) or, at maximum, every 5-years (from 1975 till 2000), but only with reference to the six major receiving OECD countries. For details about emigration data by skill levels, see Beine et al. (2010) and Defoort (2008).

[20] To derive the patent stock series we use the perpetual inventory method (Coe and Helpman, 2005). Patent stock (PS) of country i at time t is $PS_{i,t} = PS_{i,t-1}(1-d) + P_{i,t-1}$, where d is the depreciation rate and P is patent flow. The initial value of patent stock (i.e. at time t_0) is expressed by: $PS_{i,t_0} = P_{i,t_0}/(g+d)$, where g is the average growth rate of patent flow (Griliches, 1980). We assume a depretiation rate of 15% (Hall et al., 2001) and take g as the average growth rate of patents in the first decade of available and reliable data of the patent series, i.e. starting from year 1990. As specified in the Appendix, the patent series start from 1985. However, consistent and complete data are only available form the 1990s.

and the interaction between emigration and IPRs) and the key controls for size effects (population and GDP per capita). The migration variable is emigration flows and it is lagged five years to account for the time needed for social and business interactions to take place and for the time needed to have a patent granted.[21] All estimations include country and time effects and are performed using fixed-effects regression methods. All variables are expressed in logarithms except those indicating shares.

[TABLE 2 ABOUT HERE]

Column (1) in Table 2 shows that all the three main variables of interest are highly significant. The negative and significant coefficient of emigration suggests that migration by itself could induce brain drain. At the same time, there is a negative and significant effect of IPRs on patents, suggesting that IPRs protection by itself doesn't increase domestic innovation in developing countries (Qin, 2007). This effect could also be due to the fact that in the presence of a low degree of IPRs protection there could be a higher propensity to innovate through imitation. In such a framework, the stronger are IPRs, the lower is the potential for innovation. The interaction term between migration and IPRs protection reveals to be highly significant and positive. This suggests that IPRs protection helps the diaspora channel of knowledge originated by migration. This also means that above a certain threshold level of IPRs protection migration induces brain gain, thus mirroring the conclusion we derive in our theoretical model. To investigate in detail whether and under what conditions migration induces a brain drain or a brain gain, we explicitly consider the effect of migration on innovation as long as the level of IPRs protection varies. Figure 4 illustrates the joint impact of migration and IPRs on patents for our baseline specification. The figure shows the marginal effect of emigration on resident patents as long as the IPR protection index increases, together with its 95% confidence interval. As the figure suggests, while in correspondence to low levels of IPRs protection the effect of migration on resident patents is negative and significant, at high levels of IPRs protection migration has a positive and significant effect on innovation. This confirms that IPRs could help diaspora, as long as the IPRs regime is strong. As specified above, this is in line with the predictions of our

[21] Since our sample begins in 1995, the first observation of the lagged migration variable dates back to 1990.

theoretical model (see condition (29)).[22]

[FIGURE 4 ABOUT HERE]

In column (1) of Table 2 our two main size controls (population and GDP per capita) are positive and significant as expected. Columns (2) to (7) in turn add to the baseline specification our remaining controls: patents stock, R&D expenditure, government spending, trade, FDI and education. The results show that patent stock, R&D expenditure and government spending are significant determinants of innovation. The positive sign of patent stock suggests that innovation is stronger in the presence of a higher level of absorptive capacity: this implicitly confirms that the diaspora channel of knowledge is effective when the ability to absorb new knowledge is high. The positive sign of R&D is intuitive and follows the main predictions of the relevant literature: the more efforts are devoted to R&D, the bigger is a country's potential for innovation. The negative sign of government spending could be explained by the fact that a low share of government spending appears to be positively related to the degree of economic freedom as measured by the country's reliance on personal choice and markets (Gwartney and Lawson, 2000). Trade is positive as expected, but not significant. This suggests that international technology transfer is not necessarily due to trade and at the same time it reinforces our view that migration plays an important role in innovation. The negative and significant sign of FDI could be explained by the fact that inward FDI has a negative effect on the productivity of local domestic firms through the existence of negative externalities (Aitken and Harrison, 1999) and/or that foreign entrants often displace local firms to less-innovative market segments (see e.g. Cantwell, 1989). Finally, tertiary education appears to be not significant in this framework: its negative sign could be due to the fact that highly educated people in developing countries may prefer to apply for patents in more advanced economies.[23] Even after controlling for the extent of human capital, the effects of our three main variables of interest remain significant.

[22] It is important to point out that, even if we could interpret this result as the interaction between IPRs and diaspora, there could be other explanations of why IPRs foster innovation. For example, since skilled emigration increases the returns to skills, the country of origin may have a higher incentive to invest in education. The presence of a higher degree of IPRs protection could then make this incentive even stronger, thus generating a higher potential for innovation. This interpretation is in line with the traditional explanation of brain gain.

[23] Although tertiary education has here a non-significant coefficient, we also find that primary education affects positively and significantly the number of patents granted. The results are available upon request. We do not present the results with primary education as we believe tertiary education to be more relevant in a study of the determinants of innovation.

Columns (8) adds to the baseline specification all the controls at the same time. As the results show, the coefficients of our three main variables of interest still remain significant and of the same sign as in the baseline specification: migration is negative and significant, IPRs protection is negative and significant and the interaction term between migration and IPRs protection is positive and significant.[24]

To test the robustness of our main results we run the same regressions of Table 2 using emigration stocks instead of flows. The results are shown in Table 3 and are all in line with previous results. We also test an alternative measure of innovation, using as dependent variable resident patent applications instead of resident patent grants. The results are shown in Table 4 and are in line with previous results.

[TABLE 3 ABOUT HERE]

[TABLE 4 ABOUT HERE]

To sum up, in all the specifications we consider the effects of our three main variables of interest on patents are the same: migration is negative and significant, IPRs protection is negative and significant and the interaction term between migration and IPR protection is positive and significant. Furthermore, the joint impact of migration and IPRs reveals to be positive in correspondence to stronger IPRs protection. These results shed light on the role of IPRs protection in promoting the beneficial effects of the diaspora channel of knowledge, thus confirming the main insights of our theoretical model. Although our results are derived with reference to total migration, it is however possible to extend the main conclusions of the analysis in terms of skilled migration. This is due to the fact that starting from the 1990s migration to the OECD area has been increasingly composed by high skilled immigrants who have increasingly originated from developing countries (Douquier and Rappoport, 2010).

[24] To check whether the effect of emigration on innovation is due to capital independently from knowledge transfers, we also investigated the role of remittances. In our specifications, remittances are not significant.

4 Conclusions

In this paper we have explored the link between cross-border diaspora networks and the capacity of innovation of a country where emigration originates from. The perspective we adopt is that of a developing country. We argue that although skilled emigration out of a developing country may directly result in the well-known concept of brain drain, it can also cause an indirect brain gain affect, the extent of which depends on the level of intellectual property rights protection. The paper conducts a joint theoretical and empirical analysis of this issue.

The theoretical model relates a country's potential for innovation to the size and average skills of its innovation sector, as well as to the average skills of migrants. Our framework draws upon the realistic assumption that emigration may originate cross-border diaspora networks between skilled emigrants and natives. It turns out in the presence of a strong IPRs regime the gains in human capital deriving from the diaspora channel of knowledge are more likely to outweigh the direct drain of skills caused by emigration. As a consequence, when patents are sufficiently protected, informal networks of emigrants and people remaining at home are crucial in turning a brain drain into a brain gain. The main conclusions of our theoretical analysis are then tested in our empirical investigation. Using a sample of EDC economies, we show that the joint impact of migration and IPRs protection on innovation is positive when IPRs protection is stronger, thus confirming our main theoretical insights.

This paper sheds light on the joint role of institutions and migration in promoting growth, by thus contributing to the debate about the brain drain/brain gain effects of emigration. In particular, we explicitly model a process of transfer of knowledge from the developed to the developing countries which is independent of trade and FDI and which mainly relies on people's movement. In addition, the paper fills a gap in the rich literature on diaspora networks, by directly focussing on the potential relationship between knowledge absorbed by emigrants abroad and growth in their home countries.

A Appendix

A.1 Data Description and Sources

Patents

We use two series of patent data: resident patent grants and resident patent applications. Resident patent grants are patents granted in each country to its residents by the local national patent office. Resident patent applications are patent applications by residents of each country to the local national patent office. The data are annual and start in 1985. The source is WIPO (2010). Patent stock series are calculated using the perpetual inventory method and a 15% depreciation rate. For details on this method, see the text.

Migration

We use two series of migration data: emigration flows out of each country and stocks of emigrants abroad. The data are annual. Emigration flows and stocks are derived by summing up available bilateral immigration flows and stocks by country of origin into 27 OECD countries. The original bilateral migration dataset has been kindly provided by Mariola Pytlikova and collects information from different statistical offices of the world, supplemented by published OECD statistics from "Trends in International Migration" publications and Eurostat data. In total, the original dataset contains annual information on immigration flows and stocks in 27 OECD countries from 95 countries of the world for the period 1985-2006. For a more comprehensive description of earlier versions of the same dataset, see Pedersen et al. (2008) and Pedersen and Pytlikova (2008). To construct our data on emigration flows and stocks, the original data were purged of evident outliers and missing data for bilateral flows and stocks for which there was sufficient non-missing years were interpolated.

Intellectual Property Rights

The source is Park (2008). The data represent an index of the strength of patent protection for each of the countries of the dataset. The index is the unweighted sum of five separate scores for: coverage; membership in international treaties; duration of protection; enforcement mechanisms; and restrictions. Available data cover 123 countries for the period from 1960 till 2005, in five-year intervals. Given the focus of our study, we selected the sample of data starting in 1995. For the missing values in each of the five-year intervals, we impute the index of patent protection which is defined for the starting year of the corresponding time interval.

Additional Controls

All additional controls (GDP, population, R&D, government spending, trade, FDI and education) are from World Bank (2009) and United Nations. All data have an annual frequency. The education variable is measured by enrollment in tertiary education

A.2 Proof of Proposition 1

We have a system of 2 equations:

$$\begin{aligned} \omega_H z_1 - 1 - e &= 0 \\ \overbrace{\frac{q(\mu-1)\mu^{\frac{1}{(\alpha-1)}} L(z_1)}{\rho + H(z_1,z_2)[1-q(1-\mu^{\frac{\alpha}{(\alpha-1)}})]}}^{\omega_H} z_1 - 1 - e &= 0 \end{aligned} \tag{A}$$

$$\begin{aligned} \omega_M z_2 - \omega_H z_2 - F &= 0 \\ \omega_M z_2 - \overbrace{\frac{q(\mu-1)\mu^{\frac{1}{(\alpha-1)}} L(z_1)}{\rho + H(z_1,z_2)[1-q(1-\mu^{\frac{\alpha}{(\alpha-1)}})]}}^{\omega_H} z_2 - F &= 0 \end{aligned} \tag{A}$$

given

$$\frac{\partial L(z_1)}{\partial z_1} > 0, \frac{\partial H(z_1,z_2)}{\partial z_1} < 0, \frac{\partial H(z_1,z_2)}{\partial z_2} > 0$$

which implies

$$\frac{\partial \omega_H}{\partial q} > 0, \frac{\partial \omega_H}{\partial z_1} > 0, \frac{\partial \omega_H}{\partial z_2} < 0. \tag{A}$$

We would like to establish whether

$$\frac{dz_1}{dq} \gtrless 0, \frac{dz_2}{dq} \gtrless 0, \frac{dz_2}{dz_1} \gtrless 0.$$

Considering ω_H as a function of z_1, z_2, and q, we have the two conditions given by two functions $\Gamma_i(z_1, z_2, q) = 0$, for $i = 1, 2$:

$$\begin{cases} \Gamma_1(z_1, z_2, q) = -z_1\omega_H(z_1, z_2, q) + 1 + e = 0 \\ \\ \Gamma_2(z_1, z_2, q) = z_2\omega_H(z_1, z_2, q) + F - z_2\omega_M = 0 \end{cases} .$$

Subsequently, we calculate the total differentials $d\Gamma_1$ and $d\Gamma_2$ and we equate them:

$$d\Gamma_1 = d\Gamma_2 \Longleftrightarrow \frac{\partial \Gamma_1}{\partial z_1}dz_1 + \frac{\partial \Gamma_1}{\partial z_2}dz_2 + \frac{\partial \Gamma_1}{\partial q}dq = \frac{\partial \Gamma_2}{\partial z_1}dz_1 + \frac{\partial \Gamma_2}{\partial z_2}dz_2 + \frac{\partial \Gamma_2}{\partial q}dq,$$

then we consider the plane $(z_1,\ q)$ to evaluate the slope of the function $z_1(q)$, so we impose $dz_2 = 0$, and after calculating the first order partial derivatives we obtain:

$$-\left(\omega_H(\cdot) + z_1\frac{\partial \omega_H}{\partial z_1}\right)dz_1 - z_1\frac{\partial \omega_H}{\partial q}dq = z_2\frac{\partial \omega_H}{\partial z_1}dz_1 + z_2\frac{\partial \omega_H}{\partial q}dq.$$

Subsequently, we collect terms and identify the ratio of differentials:

$$\frac{dz_1}{dq} = -\frac{(z_1 + z_2)\dfrac{\partial \omega_H}{\partial q}}{\omega_H(\cdot) + (z_1 + z_2)\dfrac{\partial \omega_H}{\partial z_1}}. \tag{30}$$

From the investigation of (30) we can deduce that:

$$\frac{dz_1}{dq} < 0 \text{ as } \omega_H(\cdot) + (z_1 + z_2)\frac{\partial \omega_H}{\partial z_1} > 0.$$

We can repeat the same procedure by setting $dz_1 = 0$ in the relation $d\Gamma_1 = d\Gamma_2$ in order to accomplish a relation between the differentials dz_2 and dq:

$$-z_1\frac{\partial \omega_H}{\partial z_2}dz_2 - z_1\frac{\partial \omega_H}{\partial q}dq = \left(\omega_H(\cdot) + z_2\frac{\partial \omega_H}{\partial z_2}\right)dz_2 + z_2\frac{\partial \omega_H}{\partial q}dq - \omega_M dz_2.$$

The slope will amount to:

$$\frac{dz_2}{dq} = -\frac{(z_1+z_2)\dfrac{\partial \omega_H}{\partial q}}{\omega_H(\cdot) - \omega_M + (z_2+z_1)\dfrac{\partial \omega_H}{\partial z_2}} \tag{31}$$

(31) has a form which is analogous to (30), so that we can carry out a similar investigation:

$$\frac{dz_2}{dq} > 0 \text{ as } \omega_H - \omega_M + (z_2 - z_1)\frac{\partial \omega_H}{\partial z_2} < 0.$$

Finally, to derive the sign of $\dfrac{dz_2}{dz_1}$, we divide (31) by (30) to obtain

$$\begin{aligned} \frac{dz_2/dq}{dz_1/dq} &= \frac{dz_2}{dz_1} = \left(\frac{(z_1+z_2)\dfrac{\partial \omega_H}{\partial q}}{\omega_H(\cdot) - \omega_M + (z_2+z_1)\dfrac{\partial \omega_H}{\partial z_2}} \right) \left(\frac{\omega_H(\cdot) + (z_1 - z_2)\dfrac{\partial \omega_H}{\partial z_1}}{(z_1+z_2)\dfrac{\partial \omega_H}{\partial q}} \right) \\ &= \frac{\omega_H(\cdot) + (z_1+z_2)\dfrac{\partial \omega_H}{\partial z_1}}{\omega_H(\cdot) - \omega_M + (z_2+z_1)\dfrac{\partial \omega_H}{\partial z_2}}. \end{aligned} \tag{32}$$

Using the same argument as for (30) and (31), we can deduce from (32) that

$$\frac{dz_2}{dz_1} < 0$$

because given (A), both the numerator of (32) is positive, while the denominator is negative.

We have therefore proved that

$$\frac{dz_1}{dq} < 0, \frac{dz_2}{dq} > 0, \frac{dz_2}{dz_1} < 0.$$

That is, stronger IPR protection expands the size of the innovation sector from both sides of the spectrum of skills by decreasing z_1 and increasing z_2. Furthermore, thresholds z_1 and z_2 always move in the opposite direction.

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FIGURES

Figure 1: Stronger IPR enforcement

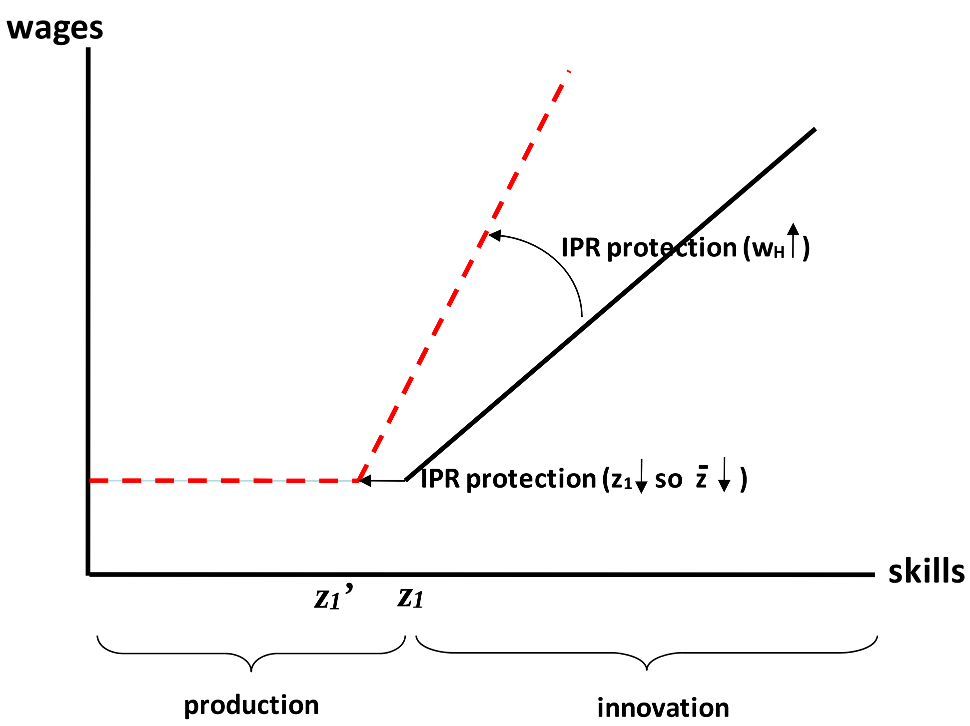


Figure 2: Diaspora Gains

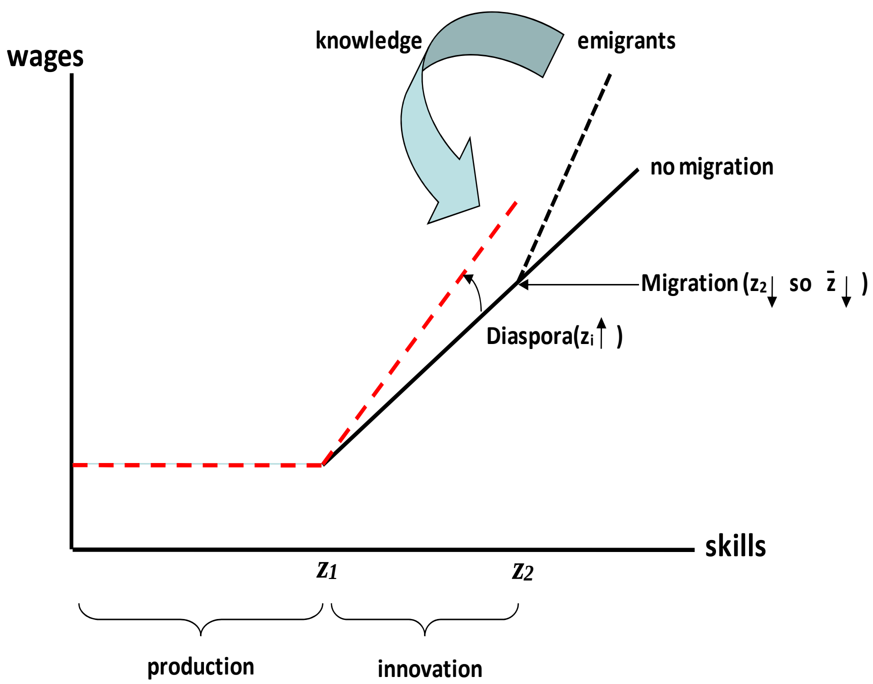


Figure 3: The Impact of IPRs on Diaspora

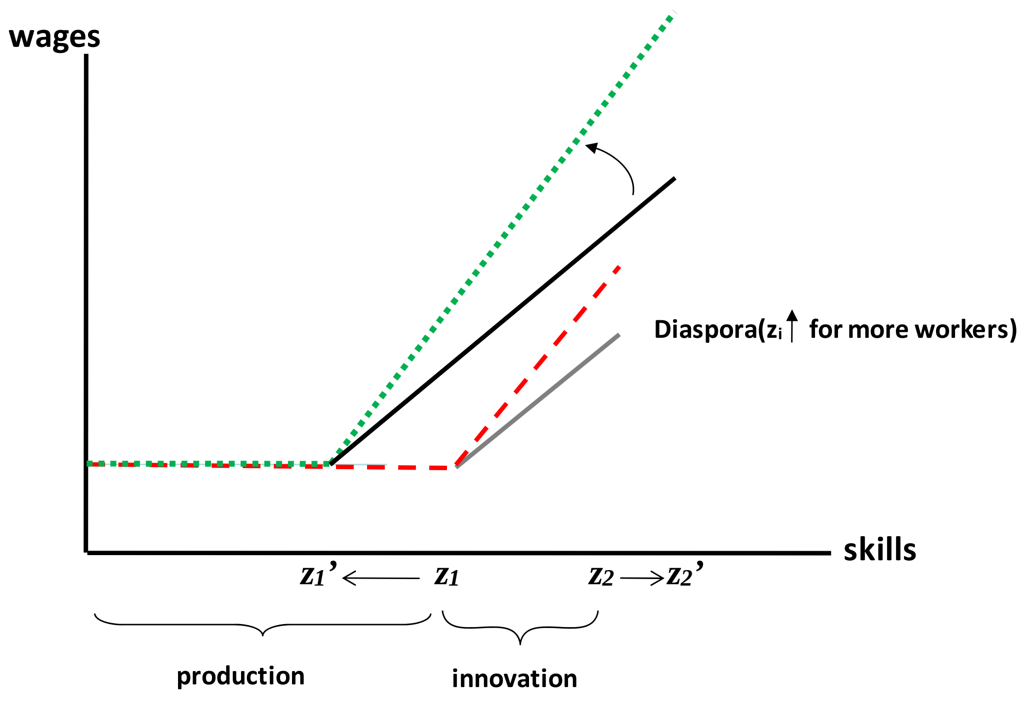
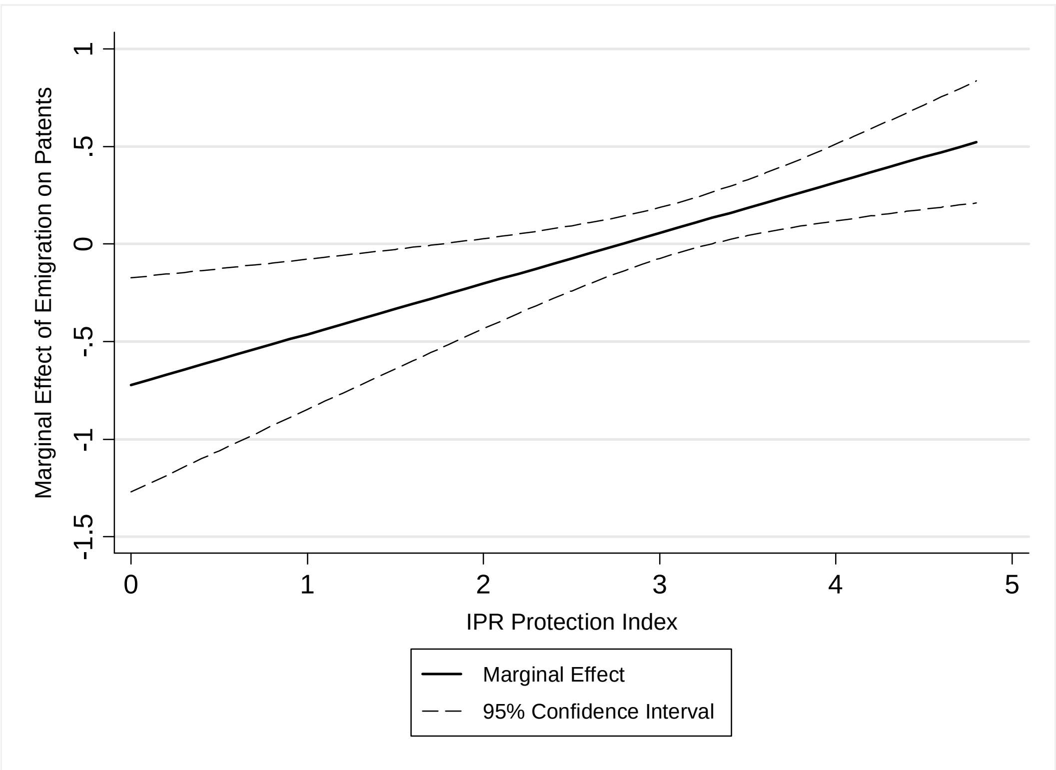


Figure 4: The Joint Impact of Migration and IPRs Protection on Innovation



TABLES

Table 1. Summary Statistics: EDC Countries

Variable	Obs	Mean	Std. Dev.	Min	Max
Residet Patent Grants	333	1319.673	4133.72	1	25644
Resident Patent Applications	321	3037.498	10980.59	1	122318
Emigration Flows	333	51756.21	79360.79	102	949784
Emigration Stocks	333	785784.9	1368585	1616	9259122
IPRs Protection	333	2.922	0.888433	1.08	4.54
Population	333	1.30E+08	2.89E+08	2480000	1.31E+09
GDP per cap.	333	6275.925	3932.163	358.0147	17660.82
Patent Stock (Grants)	318	8156.633	21520.57	3.196	141631
Patent Stock (Applications)	314	14426.78	35388.96	1.849	264736.9
R&D Expenditure	211	0.536	0.312	0.0549	1.417071
Government Spending	326	0.748	0.179	0.029	0.992
Trade	329	70.689	39.720	14.933	220.407
FDI	332	2.995	3.073	-0.1	23.7
Tertiary Education	271	26.576	17.939	0	76

Table 2. The Impact of Migration Flows and IPRs on Patent Grants: EDC Countries. Fixed Effects

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Emigration Flow (lag)	-0.722**	-0.695***	-0.758***	-0.737**	-0.703**	-0.694**	-0.686**	-0.624***
	(0.280)	(0.218)	(0.218)	(0.290)	(0.283)	(0.272)	(0.274)	(0.197)
IPRs Protection	-3.045***	-2.243**	-2.085***	-2.990***	-3.045***	-2.888***	-3.001***	-1.673***
	(0.924)	(0.859)	(0.676)	(0.929)	(0.921)	(0.909)	(0.872)	(0.561)
Emig. Flow (lag)*IPRs	0.259***	0.201**	0.198***	0.252***	0.260***	0.249***	0.254***	0.156***
	(0.0871)	(0.0772)	(0.0617)	(0.0882)	(0.0867)	(0.0853)	(0.0844)	(0.0546)
Population	6.009***	4.246***	8.005***	4.996***	6.601***	5.340***	5.632***	3.173**
	(1.769)	(1.354)	(1.629)	(1.680)	(1.757)	(1.922)	(1.235)	(1.335)
GDP Per Capita	2.550**	1.935**	1.647	2.524**	2.796***	2.414**	3.434***	0.294
	(1.021)	(0.796)	(0.972)	(1.015)	(0.966)	(1.012)	(1.005)	(1.154)
Patent Stock		0.459**						0.318*
		(0.187)						(0.162)
R&D Expenditure			1.290**					1.737***
			(0.618)					(0.504)
Government Spending				-0.528**				-0.197
				(0.198)				(0.136)
Trade					0.00417			0.00192
					(0.00573)			(0.00393)
FDI						-0.0269*		-0.0478**
						(0.0144)		(0.0184)
Tertiary Education							-0.0149	-0.0103
							(0.0129)	(0.0119)
Constant	-114.6***	-81.36***	-143.0***	-96.59***	-126.9***	-101.9**	-115.5***	-49.33
	(35.99)	(27.16)	(35.71)	(34.06)	(35.42)	(38.43)	(25.45)	(30.45)
Observations	333	318	211	326	329	332	271	166
R-squared	0.227	0.331	0.406	0.243	0.238	0.232	0.268	0.522
Time Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of groups	42	35	31	41	42	42	42	28

Note: Robust t statistics in parentheses, clustered at country level. * significant at 10%; ** significant at 5%; *** significant at 1%. Patents, emigration, population and GDP per capita are in logarithms. The dependent variable is resident patent grants. Patents, emigration, population and GDP per capita are in logarithms.

Table 3. The Impact of Migration Stocks and IPRs on Patent Grants: EDC Countries. Fixed Effects

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Emigration Stock (lag)	-0.625**	-0.885***	-0.552**	-0.678**	-0.602**	-0.599**	-0.606**	-0.553**
	(0.294)	(0.209)	(0.242)	(0.278)	(0.297)	(0.286)	(0.275)	(0.205)
IPRs Protection	-2.996***	-3.074***	-2.301**	-3.026***	-2.970***	-2.819***	-2.966***	-2.255***
	(1.020)	(0.782)	(0.840)	(0.979)	(1.022)	(0.996)	(0.952)	(0.730)
Emig. Stock (lag)*IPRs	0.207**	0.225***	0.179***	0.207***	0.206**	0.197**	0.205***	0.170***
	(0.0773)	(0.0551)	(0.0626)	(0.0746)	(0.0771)	(0.0760)	(0.0748)	(0.0489)
Population	5.962***	3.672***	7.331***	4.674**	6.588***	5.297**	4.967***	2.356
	(1.924)	(1.150)	(1.910)	(1.808)	(1.944)	(2.082)	(1.348)	(1.410)
GDP Per Capita	2.793**	1.883**	1.608*	2.760**	3.015**	2.655**	3.664***	0.176
	(1.165)	(0.756)	(0.935)	(1.106)	(1.137)	(1.148)	(1.138)	(1.100)
Patent Stock		0.522***						0.273
		(0.172)						(0.198)
R&D Expenditure			1.319**					1.876***
			(0.618)					(0.515)
Government Spending				-0.552**				-0.158
				(0.210)				(0.124)
Trade					0.00520			0.00386
					(0.00586)			(0.00356)
FDI						-0.0245*		-0.0473**
						(0.0138)		(0.0184)
Tertiary Education							-0.0223	-0.0166
							(0.0140)	(0.0111)
Constant	-115.3***	-66.90***	-131.3***	-91.89**	-127.8***	-102.9**	-105.0***	-32.80
	(40.78)	(24.40)	(40.75)	(38.09)	(40.84)	(43.05)	(29.80)	(33.25)
Observations	333	318	211	326	329	332	271	166
R-squared	0.203	0.344	0.388	0.225	0.213	0.208	0.255	0.526
Time Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of groups	42	35	31	41	42	42	42	28

Note: Robust t statistics in parentheses, clustered at country level. * significant at 10%; ** significant at 5%; *** significant at 1%. Patents, emigration, population and GDP per capita are in logarithms. The dependent variable is resident patent grants. Patents, emigration, population and GDP per capita are in logarithms.

Table 4. The Impact of Migration Flows and IPRs on Patent Applications: EDC Countries. Fixed Effects

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Emigration Fl. (lag)	-0.569***	-0.596***	-0.737***	-0.566***	-0.552***	-0.560***	-0.527**	-0.694***
	(0.195)	(0.132)	(0.140)	(0.209)	(0.195)	(0.193)	(0.222)	(0.0715)
IPRs Protection	-1.662***	-1.589***	-2.081***	-1.624**	-1.663***	-1.619***	-1.536**	-1.957***
	(0.601)	(0.485)	(0.482)	(0.627)	(0.604)	(0.600)	(0.677)	(0.261)
Emig. Fl. (lag)*IPRs	0.162***	0.151***	0.199***	0.157**	0.163***	0.159***	0.156**	0.178***
	(0.0573)	(0.0429)	(0.0438)	(0.0597)	(0.0575)	(0.0569)	(0.0644)	(0.0240)
Population	3.690**	0.547	4.493***	3.336**	4.101***	3.397**	4.528***	0.960
	(1.383)	(1.002)	(1.325)	(1.427)	(1.365)	(1.415)	(1.223)	(1.107)
GDP Per Capita	1.081	0.410	0.737	1.062	1.186	1.011	1.387*	-0.655
	(0.774)	(0.445)	(0.748)	(0.762)	(0.749)	(0.765)	(0.821)	(0.426)
Patent Stock		0.701***						0.779***
		(0.100)						(0.130)
R&D Expenditure			0.993***					0.441*
			(0.357)					(0.250)
Governm. Spend.				-0.261				0.00675
				(0.192)				(0.107)
Trade					0.00497			0.00794*
					(0.00396)			(0.00458)
FDI						-0.0160		-0.0259***
						(0.0155)		(0.00930)
Tertiary Education							-0.000246	0.00542
							(0.00808)	(0.00423)
Constant	-62.65**	-6.307	-72.19**	-56.40*	-71.50**	-56.96*	-80.36***	-4.615
	(28.93)	(19.32)	(27.46)	(29.47)	(28.49)	(29.46)	(25.08)	(21.96)
Observations	410	390	238	402	405	409	323	189
R-squared	0.298	0.527	0.480	0.304	0.313	0.302	0.312	0.680
Time Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of groups	46	41	37	44	46	45	46	33

Note: Robust t statistics in parentheses, clustered at country level. * significant at 10%; ** significant at 5%; *** significant at 1%. Patents, emigration, population and GDP per capita are in logarithms. The dependent variable is resident patent applications. Patents, emigration, population and GDP per capita are in logarithms.