Intellectual Property Rights, Diasporas, and Domestic Innovation

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Abstract

This paper studies the interaction between international migration and intellectual property rights (IPR) in determining innovation performance of developing countries. Although emigration may directly cause brain drain, it generates a flow of knowledge acquired by emigrants abroad back to their home countries, which could be exploited under sound IPR institutions. IPRs can thus stimulate domestic innovation by creating the right environment to absorb potential gains from international migration. Using a panel dataset of emerging and developing countries, we show that emigration has a favorable effect on strengthening the link between IPR protection and innovation by making a new source of knowledge available to domestic innovators. We test our results through instrumental variable methods using information on geography, cultural distance and institutions.

Keywords: Intellectual property rights; International migration; Innovation; Knowledge flows; Brain drain; Diaspora

JEL classification: O30; F22; J24

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1. Introduction

The recent surge in the outward transfer of human capital has made emigration a key concern for the developing world (Docquier and Rapoport, 2012). This process has given origin to a rich debate on the threats and opportunities that skilled emigration may pose to the sending countries. The traditional literature on migration and brain drain presents mechanisms through which skilled emigration could be detrimental to growth.[1] A growing number of contributions, however, have introduced channels through which emigration may foster development and create brain gain. These include incentives for education attainment through migration prospects (Mountford, 1997; Beine et al., 2001, 2008; Stark et al., 2007), return migration of better trained managers and entrepreneurs (Mayr and Peri, 2009; Dustmann et al., 2011), and access to foreign-produced knowledge by means of cross-border diaspora networks (Kerr, 2008; Agrawal et al., 2011).

There is little doubt today about the contribution of emigration in creating potential gains for the home economy.[2] Nevertheless, there is little formal research on the role of home country institutions in moderating a link between the knowledge absorbed by emigrants abroad and innovation in their home countries. This study seeks to fill this gap by exploring the interaction between intellectual property right (IPR) protection and migration in determining innovation performance in emerging and developing countries (EDCs).[3] The key question we aim to answer is whether an appropriate level of IPR protection in the sending country could stimulate domestic innovation by creating the right environment to exploit superior knowledge acquired through migration to more advanced economies. In sum, we argue that although emigration may directly result in a brain drain, it also generates a flow of ideas and inventions back to the sending country, which could be absorbed in countries with sound IPR institutions.

The roles of IPRs and migration as means of technology diffusion have generally been studied in isolation of each other.[4] Among the vast literature on IPRs, Chen and Puttinan (2005) and Parello (2008) are perhaps most closely related to our work, as they specifically focus on domestic skill accumulation and

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[1] See e.g. Berry and Soligo (1969), Bhagwati and Hamada (1974) and Miyagiwa (1991).

[2] Referring to Agrawal et al. (2011), *The Economist* (2009) writes: "[...] a scientific diaspora gives countries of origin a leg-up in terms of access to the latest research, mitigating some of the problems of a 'brain drain'. And given that the same scientist is going to be more productive in America than in a developing country because of better facilities and more resources, immigration may help overall innovation (some of the benefits of which may flow back to firms in poorer countries)." See also 'The Magic of Diasporas' in *The Economist* (2011).

[3] When dealing with technology transfer and innovation in the developing world, intellectual property rights protection is certainly a crucial institution to consider (Maskus, 2000).

[4] Only two theoretical contributions to our knowledge have looked at both in the same context, namely Mondal and Gupta (2008) and McAusland and Kuhn (2011).

innovation. While the former positively relates IPR protection to innovation, the latter finds it ineffective for innovation in less-developed countries. On migration, Williams (2007) and Oettl and Agrawal (2008) focus on the externalities of international migration to emphasize their role in knowledge and technology transfer. Our work contributes to this literature by shedding light on how migration may influence the effect of IPR protection on innovation in the sending country.

The conceptual framework we adopt argues that although emigration can initially result in the loss of domestically available skills, it also instigates a channel through which more advanced knowledge acquired by emigrants abroad can flow back to the developing world. This can for instance be made possible through the remote mobilization of intellectuals and professionals abroad and their connection to scientific, technological, and cultural programs at home.[5] We first argue in line with Agrawal et al. (2011) that the capacity of innovators who remain in their origin countries is related to their access to valuable technological knowledge that is partially accumulated abroad (i.e., brain banks). We then claim that the diaspora knowledge partially makes up for the lacking innovation capacity in the home country that can be utilized under a sound IPR regime. In other words, migration increases the magnitude of potential benefits from IPR protection in terms of innovation in developing economies.

Using a sample of emerging and developing countries, we perform an empirical analysis to investigate the joint impact of emigration and IPR protection in the sending country on innovation there. The sample we use is a panel of 34 low-income countries ranging from 1995 to 2006. We measure innovation activities in EDCs through the number of resident patent grants, with data taken from WIPO (World Intellectual Property Organization). We use this information together with extensive original data on migration stocks and the index of IPR protection as measured by Park (2008). Our findings show that emigration has a favorable effect on strengthening the link between IPR protection and innovation by making a new source of knowledge available to domestic innovators. Hence, benefits of IPRs can be better seized in the presence of diaspora knowledge networks, confirming the main conclusions of our conceptual framework.

Our results are tested using a variety of robustness checks that are also able to address a potential omitted variable bias. Indeed, in the presence of omitted variables, the causal mechanism we highlight may not necessarily be the driver of our correlations. In particular, there can be a host of unobserved factors, which may trigger emigration and are at the same time correlated with innovation. For instance, countries

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[5] Student/scholarly networks, local associations of skilled expatriates, short-term consultancies by high-skilled expatriots in their country of origins, and other unestablished intellectual/scientific diaspora networks are a few examples of such networks (Meyer and Brown, 1999).

with superior innovation capabilities could be better able to send migrants to more advanced countries. Although we provide a variety of controls, among which trade and FDI tend to play an important role, we certainly cannot exclude the possibility that some key factors remain unobserved. We address these concerns via a first difference as well as an instrumental variables approach. Our instrumental variables estimates use information on geography, cultural distance and institutions. These methods allow us to validate the importance of IPRs in transforming skills learned from abroad by emigrants and transferred back to their home country into successful innovations.

In the remainder of the paper, we introduce the conceptual framework and main empirical implications in Sections 2, conduct the empirical exercise in Section 3, and conclude in Section 4.

2. Conceptual Framework and Main Empirical Implications

Diasporas help spread ideas by promoting trust through ethnic ties, speeding the flow of information, and through the return of better trained and more experienced migrants to their home countries. The conceptual framework presented in this section shows how this relates to the IPR regime in the sending country. We argue that IPR protection influences a country's potential for innovation by increasing the absorptive capacity in the country of origin, thus enabling them to exploit the benefits that arise from cross-border diaspora networks.

Although the immediate consequence of skilled migration is a brain drain, migrants are provided with the opportunity to learn better skills and up-to-date technologies in more advanced countries. The knowledge acquired abroad can in turn flow back to the country of origin. This can happen through different channels. The most direct channel is the physical return of the brains, as is the case with the domination of China's technology industry by return migrants (sea turtles). A secondary route is the recirculation of knowledge back to the country of origin with a good illustrative example being the frequent interaction between Indian computer scientists in Bangalore and their counterparts in Silicon Valley. Both phenomena also implicitly involve access to foreign-produced knowledge through trade and investment activities of cross-border diaspora networks (Agrawal et al., 2011). In this way, skilled emigrants foster technology diffusion through the return of newly learned information and skills to their home economy (Kerr, 2008).

The protection of IPRs creates incentives to innovate by granting monopoly rights to inventors through a patent. A strong IPR regime hence increases returns from skills, creating stimulus for innovation and rendering skilled occupations more attractive. However, this does not necessarily translate into innovation in developing countries without access to more advanced foreign technologies.[6] Diaspora networks create this possibility by generating knowledge flows from their host to their home countries. Only then can IPRs instigate domestic innovation by creating the basic absorptive capacity needed in the home country. IPR protection therefore creates the conditions for an effective innovation sector, in terms of either industrial development or foreign direct investment prospects, and employs workers into skilled occupations that can benefit from diasporas. Our idea somewhat complements Chen and Puttinan (2005), who illustrate how a stronger IPR regime encourages a shift from the imitation of foreign technologies to domestic innovation in developing countries. Our analysis adds to this argument by showing how the mobility of workers makes it possible to learn foreign technologies and how a strong IPR regime in turn allows this knowledge to be put into use among a more qualified skill profile in the home labor market.

The strength of IPR institutions here works as a moderating factor to exploit gains from diaspora networks. The results obtained by stronger IPRs are compatible with various explanations for brain gain, namely human capital incentives (Beine et al., 2001), return migration (Mayr and Peri, 2009), and access to new knowledge through trade and FDI within diaspora networks (Agrawal et al., 2011). IPRs function as an intermediary channel to exploit gains from migration by encouraging investment in education and thereby human capital formation in the sending country. Better IPR protection also encourage return migration of workers who have obtained better skills abroad back to the innovation sector of their home country. They also trigger trade and investment by diasporas with their kins. Notwithstanding the channel in play, one can conclude that skilled migration generates technology diffusion when institutional development in the home country is sufficiently evolved to allow the absorption of knowledge flows through human capital development, return migration, or diaspora networks. A simple theoretical framework to illustrate this concept is presented in the Appendix.[7]

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[6] Although a flow of workers into the innovation sector may increase the number of inventors, Helpman, et al. (2010) argue that research productivity in the innovation sector may decline due to human capital complementarity as less talented workers become researchers and reduce the average productivity of the team or because of managerial time constraint when a fixed amount of time needs to be allocated to each worker.

[7] We refer the reader to the working paper version of this paper, Naghavi and Strozzi (2011), for a more complete version of the theoretical framework.

3. Empirical Analysis

3.1. Data and Specification

Our empirical analysis uses a sample of emerging and developing countries as classified by IMF (2010). The innovation measure we adopt is resident patent grants, i.e., the number of patents granted to the residents of each country from their local national patent office.[8] Patent data are from the WIPO database. Our migration measure is the gross migrant stock, which is retrieved from an original bilateral annual dataset which includes bilateral migration stocks and flows from 129 countries of the world into 27 OECD countries.[9] To retrieve the emigration data for each origin country, we aggregate the bilateral migration data across countries of origin. Intellectual property rights are measured through the Park (2008) index, which measures the strength of patent protection for each country in the dataset. The index is the unweighted sum of five separate scores: coverage, membership in international treaties, duration of protection, enforcement mechanisms, and restrictions.

Our reference dataset is an unbalanced panel including 34 EDC countries and covering the period from 1995 to 2006.[10] While patent and migration data are available yearly, the index of IPR protection is only available every five years. Taking into account the frequency of the IPR data, our dataset is composed of 5-year averages. This also allows us to wipe out the role of cyclical fluctuations in the data.[11]

To investigate whether a stronger IPR regime can mitigate the brain drain caused by migration, we focus on the interrelationship between migration and IPR protection. To this end, we study the determinants of home innovation using an empirical specification that consists of migration, IPR protection and their interaction as key variables.

The estimation strategy we adopt takes into account both the characteristics of our sample and the specificity of the WIPO patent data at country level. While in our sample there are no countries with

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[8] For the benefits of using patent statistics to measure innovation, see Griliches (1990). Along with input data such as research and development (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). In particular, we use patent grants as they can be considered a proxy for "successful" innovation and therefore a stronger measure of innovation compared to patent applications.

[9] The migration data have been collected by Mariola Pytlikova, who kindly provided us with the data (Pedersen et al., 2008; Pedersen and Pytlikova, 2008). See Appendix A.2 for details, which also provides further information regarding other data and sources used.

[10] The countries in the sample have been chosen based on data availability. The sample consists of the following 34 emerging and developing countries (EDC): Algeria, Argentina, Bangladesh, Brazil, Bulgaria, Chile, China, Colombia, Ecuador, Egypt, Guatemala, Honduras, Hungary, India, Iran, Jamaica, Jordan, Kenya, Lithuania, Madagascar, Malaysia, Mexico, Morocco, Pakistan, Peru, Philippines, Poland, Romania, Russia, Sri Lanka, Thailand, Turkey, Ukraine, and Vietnam.

[11] See Trefler (2004).

zero patents (see below on Table 1), it may very well be that for very poor countries a missing data on patents represents a zero: where the proportion of missing values is relevant, this could result in biased OLS estimates. However, since in our dataset missing observations comprise only 10% of the sample, this is not a crucial problem of our data.[12] Our choice is hence to perform our estimations using fixed effects regression methods at country level.

The baseline empirical specification we adopt is the following:

$$\begin{aligned} patents_{it} &= \beta_0 + \beta_1 emigr_{it-1} + \beta_2 IPR_{it} + \beta_3 emigr_{it-1} IPR_{it} + \\ &+ \gamma pop_{it} + \delta gdppc_{it} + \alpha_i + \eta_t + \varepsilon_{it}, \end{aligned}$$

where i denotes the country and t each of the 5-year intervals.[13] The dependent variable $patents_{it}$ is our measure of innovation. The variable $emigr_{it-1}$ represents emigration and is taken with a lag, to account for the time needed for the emigrants to acquire skills in the destination and for the knowledge to be transferred back and transformed into a patent in their home countries. IPR_{it} is the measure of IPR protection. The variable $emigr_{it-1}IPR_{it}$ is the interaction term between emigration and IPR protection. The cumulative effect of migration on innovation is then captured by adding β_1 and $\beta_3 IPR_t$, and varies with the level of IPR protection. pop_{it} and $gdppc_{it}$ are respectively population and GDP per capita, included to account for size effects. Finally, the α_i 's are time-invariant country-specific effects, the η_t's are period dummies, and ε_{it} is the error term.

Following the related literature, we complete the baseline specification by including a number of relevant controls. First, we add patent stock, which can be considered a proxy for a country's absorptive capacity and is expected to positively influence innovation (Hall et al., 2001).[14] We also add R&D expenditure, another proxy for a country's potential for innovation. Another relevant control is tertiary

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[12] More generally, it is worth pointing out that most missing values on WIPO patents data at country level should not represent zeros and are continuously being estimated and updated by WIPO (WIPO, 2008).

[13] The time intervals we use are 1995-99, 2000-04 and 2005-06. The last interval is only composed of two years since our sample ends in 2006. Data from 1990 till 1994 were used to construct the lagged data on emigration stocks for the interval 1995-99.

[14] To derive the patent stock series, we use the perpetual inventory method (Coe and Helpman, 2005). The 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 as follows: $PS_{i,t_0} = P_{i,t_0}/(g+d)$, where g is the average growth rate of patent flow (Griliches, 1979). We assume a depreciation 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 from the 1990s.

education, to capture the ability to absorb new knowledge. Government spending is added to measure the degree of economic freedom. Finally, trade and FDI are included in light of a rich literature on North-South trade and FDI as determinants of innovation in low-income countries. For details on the sources of the variables, see the Appendix.[15] Table 1 illustrates the summary statistics of the key variables of our analysis.

[TABLE 1 ABOUT HERE]

Table 1: Summary Statistics

				First differences	
	Obs	Mean	Std. Dev.	Mean	Std. Dev.
Resident Patent Grants	122	4.369	2.156	0.130	0.758
Patent Stock	112	5.992	2.214	0.302	0.493
Emigration Stock	135	12.558	1.718	0.379	0.478
IPR	102	3.040	0.851	0.594	0.619
Population	129	17.028	1.499	0.043	0.056
GDP p.c.	128	8.504	0.782	0.124	0.171
R&D	109	0.482	0.321	0.045	0.129
Tertiary Education	122	0.290	0.193	0.051	0.068
Government Spending	132	0.714	0.193	-0.003	0.074
Trade	127	0.803	0.404	0.066	0.168
FDI	135	0.036	0.033	0.013	0.024

Note: The summary statistics are calculated with reference to the time interval under consideration (1995-2006). The first three columns of the table refer to the original variables we consider in our sample, while the last two columns report mean and standard deviation of their first differences. Residents Patents, Resident Patent Stock, Emigration stock, Population and GDP per capita are in logarithms; R&D, Tertiary Education, Trade and FDI are represented in shares; IPR is the Park's index of IPR protection and lies between 0 and 5. All the variables are taken in 5-year averages.

3.2. Results

Table 2 presents our results with resident patent grants as dependent variable. The migration variable is gross emigration stocks. We initially consider three specifications where we explore the role of migration and IPRs, first separately and then together (columns (1)-(3)), always including the two controls for size effects (population and GDP per capita). As we can see from the table, in these specifications the coefficients on the variables of interest are not statistically significant. The coefficients of the size controls are positive and significant, as expected. Column (4) is our baseline specification and explores the joint

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[15] In our empirical specifications the following variables are taken in logs: patent grants, patent stock, emigration stock, population, and GDP per capita. The rest of the variables (IPR protection, tertiary education, government spending, trade, FDI) are taken using their original values.

role of our three main variables of interest: emigration, IPR protection, and their interaction. The findings show that taken together our three main variables of interest are highly significant.

[TABLE 2 ABOUT HERE]

In line with the vast literature discussed in the introduction, the negative and significant coefficient of emigration suggests that migration by itself could induce brain drain.[16] At the same time, the negative and significant effect of IPRs resembles previous empirical findings by Qian (2007) that IPR protection by itself does not stimulate domestic innovation in developing countries with low educational attainment. It is also in accordance with Madsen et al. (2010), who show imitation to be a much more important means of gaining access to essential technologies in developing countries. Lerner (2009) also finds that IPRs increase foreign rather than domestic patenting in a country and thus the capturing of national patent monopoly rights mainly by foreign firms (Lanjouw and Cockburn, 2001).[17]

The key to our analysis is the sign and significance of the interaction term between migration and IPR protection. Our baseline specification in column (4) shows that the interaction term is highly significant and positive. This suggests that IPR protection becomes more strongly correlated with domestic innovation in the presence of the diaspora channel of knowledge transfer that originates from migration.

Columns (5) to (10) in turn add the controls to our baseline specification: patent stock, R&D expenditure, education, government spending, trade and FDI. As the results demonstrate, the coefficients of our three main variables of interest always remain significant with the same sign as in the baseline specification: migration and IPR protection are negative, and the interaction term is positive and significant. The results also show that patent stock, trade and FDI have a significant role as 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 more effective when the ability to absorb new knowledge is high.[18] The coefficient of trade is positive and significant,

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[16] We are aware of the limitations of the data we use, which only allows to capture total migration from developing countries. However, the fact that migration to the OECD area in the 1990s has been increasingly composed of high-skilled immigrants from the South (Docquier and Rapoport, 2012) should reinforce the interpretation of our results and thereby help mitigate related concerns.

[17] IPR protection also negatively affects patenting by delaying spillovers in sequential innovation (Scotchmer and Green, 2000), creating wasteful attempts to invent around the patent (Jaffe and Lerner, 2004), and promoting costly disputes and excessive litigation (Bessen and Meurer, 2009).

[18] In line with Cohen and Levinthal (1990), absorptive capacity is the capacity to adopt new technologies and to create new inventions. Essential to this concept is the idea that the stock of knowledge accumulated through adoption or invention enhances the capacity to absorb external ideas and to create valuable inventions. In this sense, patent stock, which represents the stock of knowledge accumulated through inventions, can have a positive effect on innovation.

Table 2: The Impact of Emigration and IPR Protection on Innovation. Fixed Effects

Dependent variable: $patents_{it}$

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Emigration Stock	-0.161		-0.181	-0.883**	-1.148***	-0.458	-0.794**	-0.798*	-0.842**	-0.671*	-0.847***
	(0.187)		(0.259)	(0.393)	(0.271)	(0.281)	(0.353)	(0.400)	(0.380)	(0.392)	(0.266)
IPR		-0.309	-0.319	-3.167**	-2.755**	-2.149**	-3.004***	-3.061**	-3.578***	-2.346*	-2.174**
		(0.264)	(0.270)	(1.254)	(1.034)	(0.930)	(1.094)	(1.245)	(1.167)	(1.199)	(0.954)
Emigr. Stock*IPR				0.219**	0.200**	0.165**	0.206**	0.206**	0.251***	0.162*	0.160**
				(0.098)	(0.075)	(0.070)	(0.086)	(0.098)	(0.088)	(0.094)	(0.069)
Population	5.263*	6.102**	5.645*	6.116**	1.540	8.784***	7.336***	5.813**	8.263***	5.233**	2.897**
	(2.740)	(2.775)	(2.816)	(2.394)	(2.042)	(2.226)	(1.321)	(2.221)	(1.987)	(2.371)	(1.360)
GDP p.c.	2.955*	2.950	3.023*	2.547*	0.146	3.453***	3.950***	2.675*	3.061***	2.482*	0.931
	(1.515)	(1.784)	(1.769)	(1.485)	(1.007)	(1.201)	(1.191)	(1.345)	(1.076)	(1.434)	(0.693)
Patent Stock					0.982***						0.836***
					(0.188)						(0.206)
R&D						0.143					
						(0.885)					
Tertiary Education							-0.917				
							(1.183)				
Government Spending								-1.648			
								(1.507)			
Trade									2.092**		1.588**
									(0.788)		(0.755)
FDI										-5.376***	-6.050***
										(1.441)	(1.988)
Constant	-109.154*	-126.795**	-117.027*	-112.087**	-14.498	-174.323***	-146.770***	-107.549**	-156.858***	-98.819*	-49.590*
	(57.102)	(61.549)	(61.799)	(51.691)	(41.117)	(49.704)	(31.659)	(47.335)	(41.594)	(50.498)	(26.202)
Country Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj. R-squared	0.116	0.124	0.120	0.201	0.524	0.318	0.273	0.212	0.300	0.221	0.600
F test main var. (p value)	0.393	0.251	0.489	0.060	0.001	0.086	0.034	0.053	0.017	0.184	0.022
Observations	116	93	93	93	86	76	87	93	91	93	84
Number of Groups	43	34	34	34	31	31	34	34	34	34	31

Note: The dependent variable $patents_{it}$ is the logarithm of the number of patents granted to the residents of each country from their local national patent office. Observations are at 5-year intervals. Emigration stock is lagged by one period. IPR protection is measured by the Park (2008) index (0-5 scale, 0=weak, 5=strong). All regressions include country and time fixed effects. Standardized 'beta' coefficients are reported with their standard errors in brackets, adjusted for clustering at the country level. ***, ** and * indicate significance at the 1, 5 and 10 percent levels, respectively. Patent stock, emigration stock, population and GDP per capita are also in logarithms.

highlighting the expected importance of trade in fostering innovation. The coefficient of FDI is instead negative and significant. This 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). R&D appears instead insignificant in our results but its positive sign is intuitive and follows the main predictions of the relevant literature: the more efforts are devoted to R&D, the greater is a country's potential for innovation. Tertiary education appears to be insignificant, while 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. Government spending is also insignificant here; its negative sign 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).

In column (11) we finally put all the significant variables together in the same regression: this is our reference full specification. As we can see from the table, also in this case our key variables are significant and of the correct predicted sign. The role of our key variables is also highlighted by the results of the F-test for the joint significance of their coefficients, which we present throughout Table 2. In our reference full specification, the F-test is significant at 5%. In the top panel of Figure 1 we show the partial regression plots for the interaction term between migration and IPRs on patent grants for our reference full specification.[19]

[FIGURE 1 ABOUT HERE]

In the online Appendix we report our sensitivity analyses, together with additional checks. Table OA.1 presents the results of a balanced sample to check whether the findings of Table 2 are sensitive to the sample considered: the sample we use is that of our full specification in column (11). Tables OA.2 and OA.3 use alternative functional forms for IPRs. In the former table we use the logarithm of IPRs to explore whether an increment in the IPR index has different effects according to the starting degree of IPR protection. In the latter we build a dichotomous indictor using the average value of IPRs in EDC countries as the reference threshold (where "strong IPR" equals 1 if the country is above the average

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[19] The role of outliers is investigated by eliminating the observations with studentized residuals that exceed +2.5 or -2.5 in our baseline regression. This drops a total of four observations from the sample. Our main findings are unchanged. Results are available upon request.

value in a particular year and 0 otherwise). This allow us to single out the extent to which the effect of a change in emigration is greater for nations with strong IPRs than those with weak IPRs. As we can see from the tables, our key findings remain the same in all cases.[20]

In Tables OA.4 and OA.5 we also propose a first check of our basic idea about the channel of knowledge flow. Since we claim that emigrants promote innovation in their home countries if their host countries have a high potential for innovation, we need to rule out the possibility that knowledge transfer originates from other channels such as trade between the two countries or FDI. Along these lines, in Table OA.4 we explore the role of two interaction terms, one including trade and migration and the other FDI and migration. Both variables are estimated together with our main interaction term (Emigr. Stock*IPR). In all cases their coefficient is insignificant, while our key interaction remains positive and significant. In Table OA.5 we also check the link between innovation in the origin and indexes of heterogeneity in the destination in terms of innovation capacity (measured by patent grants or R&D), trade, and FDI.[21] When the index is built on innovation-related characteristics of the host country, the results are positive and significant (more for R&D expenditure than for patent intensity). GDP per capita in the destination, trade and FDI instead do not seem to play a role in transferring knowledge between emigrants and residents in their home country. The results confirm the importance of IPRs at home and diasporas in more innovative destinations as a channel of technology transfer, combining the mechanisms of knowledge flow explored in the context of multinationals by Branstetter et al. (2006) and Foley and Kerr (2013).

3.3. Robustness Checks

In this section, we present some key robustness checks of our results. We deal in particular with the potential endogeneity of one of our main variables of interest, namely emigration stock. While reverse causality is unlikely to be responsible for the relationship between patents at home and lagged total emigration stock, the omitted variable bias can be a major source of endogeneity in our context. In particular, patent grants, IPRs and emigration may be jointly influenced by omitted variables. For example, developing countries that adopt a technology focus (such as China and India) could be more likely than others to strengthen their IPRs, invest in education (potentially leading to more emigration),

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[20] We also run additional sensitivity checks. We investigate the monotonicity of the relationship between patents, IPR and migration adding a squared IPR term to the regression. We also construct an alternative IPR dummy variable with the reference group being the bottom categories of the IPR index (i.e. with a value less than 2). The results remain the same and are available upon request.

[21] The details for the construction of these indexes are given in Appendix A.3.

and invest in technology development in ways that increase patenting. Therefore, we cannot necessarily infer a causal link between emigration and patents and cannot conclude that strengthening IPRs fosters innovation via more effective knowledge that flows back from the diaspora. In what follows we address this issue through a first difference and an instrumental variables approach.

3.3.1. First Differences

Together with fixed effects and a proper configuration of the control variables, the first difference technique can help mitigate some of the concerns related to omitted variables. While the fixed effects (within) estimator is derived by subtracting the time-average model from the original model, the first difference estimator is obtained by subtracting the model lagged by one period from the original model. In other words, the first difference model removes the time-invariant individual components by first-differencing the data. The relative efficiency of the first difference estimator with respect to the fixed effects estimator depends on the properties of the error term. In particular, the first difference estimator requires weaker exogeneity assumptions, and it is usually preferred if the errors are serially correlated.[22] Our first difference estimates are presented in the regressions of Table 3.

[TABLE 3 ABOUT HERE]

The specifications in the table replicate those of Table 2, starting from the specification that includes our three main variables of interest. The findings confirm the robustness of our previous results: the coefficient of our key variables of interest (migration, IPR and the interaction term) have the same sign as before and remain significant. The joint F-test again confirms the joint significance of our key variables. The bottom panel of Figure 1 illustrates the partial regression plots for the interaction term between migration and IPRs in our full specification for the first difference analysis. While these results are in line with our fixed effects estimates, it is worth pointing out that they are derived from a small set of countries and here are measured over only two periods. To further investigate the effect of migration on brain drain, we proceed by considering the changes in the effect of emigration on innovation according to the IPR regime in the sending country. Figure 2 illustrates the marginal effect of emigration on resident patent grants for different levels of IPR protection, together with its 95% confidence interval. The reference specification is the full specification of Table 3 (column (11)).

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[22] Indeed, while the fixed effects estimator assumes that the error terms are serially uncorrelated, the first difference estimator only assumes that the first differences in the errors are uncorrelated.

Table 3: The Impact of Emigration and IPR Protection on Innovation. First Differences

Dependent variable: $patents_{it}$								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Emigration Stock	-0.737*	-1.103***	-0.451	-0.565	-0.691	-0.731*	-0.700*	-1.001***
	(0.393)	(0.305)	(0.461)	(0.367)	(0.410)	(0.363)	(0.400)	(0.316)
IPR	-3.202**	-3.368***	-2.369	-2.808**	-3.093**	-3.245***	-2.969**	-3.105***
	(1.232)	(0.982)	(1.415)	(1.130)	(1.248)	(1.146)	(1.241)	(0.975)
Emigr. Stock*IPR	0.235**	0.256***	0.187*	0.207**	0.226**	0.240***	0.218**	0.236***
	(0.094)	(0.068)	(0.105)	(0.086)	(0.095)	(0.087)	(0.094)	(0.068)
Population	5.049**	1.387	7.949***	4.952**	4.740**	6.331***	4.429*	2.645
	(2.218)	(2.033)	(2.830)	(1.860)	(2.226)	(2.017)	(2.178)	(1.697)
GDP p.c.	1.952	0.306	3.161*	2.966**	2.072	2.368**	1.962	1.032
	(1.304)	(0.955)	(1.604)	(1.129)	(1.241)	(1.112)	(1.257)	(0.886)
Patent Stock		0.929***						0.780***
		(0.219)						(0.250)
R&D			-0.171					
			(1.265)					
Tertiary Education				-1.999				
				(1.450)				
Government Spending					-0.968			
					(1.577)			
Trade						1.784**		1.704*
						(0.866)		(0.899)
FDI							-3.675*	-3.112
							(2.086)	(2.611)
Constant	-0.298	-0.065	-0.702*	-0.400	-0.300	-0.618**	-0.232	-0.348
	(0.322)	(0.282)	(0.359)	(0.317)	(0.312)	(0.291)	(0.326)	(0.265)
Adj. R-squared	0.083	0.307	0.090	0.139	0.073	0.147	0.084	0.360
F test main var. (p value)	0.086	0.001	0.206	0.074	0.104	0.054	0.129	0.006
Observations	57	53	44	51	57	55	57	51
Number of groups	32	29	26	29	32	31	32	28

Note: The dependent variable $patents_{it}$ is the logarithm of the number of patents granted to the residents of each country from their local national patent office. Observations are at 5-year intervals. Emigration stock is lagged by one period. Estimated effects are based on within-country variation (averaged over at most 32 countries) over two periods. IPR protection is measured by the Park (2008) index (0-5 scale, 0=weak, 5=strong). Standardized 'beta' coefficients are reported with their standard errors in brackets, adjusted for clustering at the country level. ***, ** and * indicate significance at the 1, 5 and 10 percent levels, respectively. Patent stock, emigration stock, population and GDP per capita are also in logarithms.

[FIGURE 2 ABOUT HERE]

As the figure suggests, while under weak IPR protection migration has a strong negative effect on resident patents, IPR protection mitigates this effect by using the knowledge acquired by diasporas to foster innovation. Note however that even at the maximum protection level ($IPR_t = 5$) the positive effect of $\beta_3 IPR_t$ may not fully compensate the unfavorable impact of migration through β_1.

3.3.2. Instrumental Variables

We next employ an instrumental variable approach (2SLS) to help alleviate endogeneity concerns regarding one of our main variables of interest, migration stock. Although the fixed effects as well as the first differences specifications in the previous estimations address the issue of omitted variable bias, further exercises that account for time-variant omitted factors are needed to provide more compelling evidence of a genuine link between emigration, IPRs, and domestic innovation.

The first step is to find a suitable instrument for emigration that is correlated with emigration but not directly with the endogenous variable, patent grants. We adopt two types of instruments that we believe satisfy this requirement.

In the spirit of Frankel and Romer (1999), our main instrument for migration (IV$grav$) exploits information on the determinants of migration used in the gravity literature to derive a measure of predicted emigration stocks.[23] Bilateral migration is generally determined by various economic, political, cultural and geographic factors. Since the focus of our framework is on innovation and IPRs, we cannot use the full set of bilateral variables as in standard gravity models. In particular, we cannot use economic and institutional factors as this could create an endogeneity problem with our two main variables of interest, i.e. migration and IPRs. We hence specify the following gravity model for migration:

$$\begin{aligned} migr_{ijt} \quad = \quad & a_0 pop_{it} + a_1 pop_{jt} + a_2 area_{it} + a_3 area_{jt} + a_4 dist_{ij} + a_5 border_{ij} + a_6 landlocked_{ij} \\ & + a_7 comlang\_off_{ij} + a_8 comlang\_def_{ij} + a_9 colony_{ij} + a_{10} migr_{ij1960} + bX_{ij} d_{ij} + x_t + e_{ijt} \end{aligned}$$

where $migr_{ijt}$ is the migration stock from origin country i to destination country j in year t, pop_{it} , pop_{jt}, $area_{it}$ and $area_{jt}$ are the population and the area of i and j, $dist_{ij}$ is distance between i and j, $border_{ij}$ and $landlocked_{ij}$ are dummies indicating whether i and j share a common border or if either of them

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[23] See e.g. Spilimbergo (2009), Mayda (2010), Beine et al. (2013), Alesina et al. (2013), and Ortega and Peri (2014).

is a landlocked country, $comlang\_off_{ij}$ and $comlang\_def_{ij}$ are dummies denoting whether i and j share a common official primary language or a *de facto* language that is spoken by at least 9 percent of the population in both i and j, and $colony_{ij}$ is a dummy to capture colonial past between i and j.[24] We add to this a measure of past bilateral migration stock from i to j in 1960, $migr_{ij1960}$, [25] and a set of interactions $X_{ij}d_{ij}$ between the vector of geographical variables X_{ij} $(dist_{ij}, pop_{it}$, pop_{jt}, $area_{it}$, $area_{jt})$ and each dummy d_{ij} ($border_{ij}$, $landlocked_{ij}$, $comlang\_off_{ij}$, $comlang\_def_{ij}$). Finally, x_t is a year fixed effect and e_{ijt} is the error term.[26] Once we have estimated the gravity regressions using the information from our staring bilateral annual dataset, we aggregate them across origin countries to obtain the predicted migration stocks for each country. We then collapse the predicted stocks in five-year averages. The gravity regressions are shown in Panel B of Table A.1 in Appendix A.4. We present six gravity models that differ with respect to the sets of interaction terms that have been included. We consider in particular the interactions between each of the chosen dummies (Border, Colony, Official Language, De Facto Language and Landlocked) and the vector X of geographical variables (Distance, Population Destination, Population Origin, Area Destination, Area Origin).

The first-stage results of our instrumental variables analysis are shown in Panel A of Table A.1. Each column uses the fitted emigration stock derived from the six gravity models in Panel B of the same table. Although emigration stock (ES) is the only potential endogenous variable in our empirical specification, it also appears in the interaction term (ES*IPR). We hence use IV$grav$ as an instrument for ES and interact it with the IPR protection index to provide an instrument for the interaction term. Our first stage results show that the fitted emigration stocks are good predictors for migration and for the interaction term.

Table 4 presents the results obtained using the IV$grav$-type instruments derived from the six gravity models in Panel B Table A.1 (e.g. column (1) in Table 4 uses the predicted migration stock from the gravity model of column (1) in Panel B of Table A.1). The 2SLS regressions with the chosen instruments use our reference full specification. As the results show, our main variables of interest remain significant and with the correct sign also when the potential endogeneity of migration is taken into account. Moreover, the tests on the performance of the first stage regressions are all significant and show that our instruments are valid. The results show that the OLS estimates slightly overestimate the 2SLS estimates, as expected.

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[24] Data has been taken from CEPII, see Head et al. (2010).

[25] We use historical data on 1960 immigration stock constructed by Özden et al. (2011).

[26] We also define additional gravity models that only consist of the key geographical variables together with destination and origin, or just destination fixed effects.

[TABLE 4 ABOUT HERE]

We also employ a secondary instrument for migration (IVlaw), which exploits information on a key institutional feature associated with migration costs, i.e. the stringency of entry laws in destination countries. The idea here is to use the information regarding exogenous shocks to emigration that emerge as a result of immigration policy changes in destination countries.[27] To select the relevant entry laws for each origin country, we use information on geographical distance and cultural similarity between the origin and the destination. We first use our bilateral dataset to distinguish between near and far destinations by observing whether they lie within or outside a 3000 km distance from the origin.[28] We further categorize far countries into those that share a common language with the origin and those that do not.[29] The aim is to capture the fact that those who emigrate to countries far from their homeland are more inclined to go to places that share a common language, compensating for costs associated with geographical distance. Finally, we collect the entry laws relevant for each country of origin, considering as relevant the entry laws of all near countries, plus those of far countries that share a common language. Once we have collected the information from our bilateral annual dataset, we first aggregate the data across origin countries and then collapse them in 5-year averages.

Table OA.6 of the Appendix includes our findings obtained with IVlaw instruments using different measures of distance and language proximity across countries.[30] It can be seen from the table that all our variables continue to be significant with the predicted sign. However, the results on the performance of first stage regressions appear less satisfactory. In addition, the number of observations used is much lower than that in our reference sample. As a consequence, although the sign and the significance of the coefficients using IVlaw confirm our core results, we lean more towards the IV$grav$ estimates and consider them as our primary check for the endogeneity of the migration variable.

To summarize, in all the empirical specifications and robustness checks we perform, the effects of our three main variables of interest on patents are largely robust: migration is negative and significant, IPR

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[27] We use data on immigration policies that regulate the entry of immigrants in destination countries from Ortega and Peri (2013). We use an ordinal proxy from 1 to 3 with a higher value indicating more lenient entry laws.

[28] The classification is based on differentiating between short-haul and medium/long-haul flight destinations. A widely agreed defintion for a short-haul flight is a flight under 3000 km. See, for example, ”Short/medium-haul widebody airliner market 2013”, www.flightglobal.com.

[29] Note that if countries share a common border, destination countries are classified as ”near” also if the distance among countries is more than 3000 km. This is for example the case of Mexico and the United States.

[30] As an indicator of distance, columns (1)-(2) use the geodesic distance across countries, whereas columns (3)-(4) use the distance between capitals. Columns (1) and (3) use the measure of common language taken from CEPII, whereas columns (2) and (4) use a dummy for linguistic similarity from Adsera and Pytlikova (2012).

TABLE 4: THE IMPACT OF EMIGRATION AND IPR PROTECTION ON INNOVATION. INSTRUMENTAL VARIABLES (2SLS) WITH IV$grav$

Dependent variable: $patents_{it}$						
	(1)	(2)	(3)	(4)	(5)	(6)
	IV1	IV2	IV3	IV4	IV5	IV6
Emigration Stock	-0.627**	-0.609**	-0.706***	-0.627**	-0.620**	-0.612**
	(0.262)	(0.265)	(0.240)	(0.263)	(0.268)	(0.266)
IPR	-2.133**	-2.076*	-2.425**	-2.148**	-2.094*	-2.094**
	(1.046)	(1.074)	(0.977)	(1.061)	(1.078)	(1.060)
Emigr. Stock*IPR	0.158**	0.154**	0.180**	0.159**	0.155**	0.155**
	(0.0762)	(0.078)	(0.071)	(0.078)	(0.079)	(0.077)
Population	3.686***	3.682***	3.754***	3.704***	3.664***	3.692***
	(1.209)	(1.213)	(1.225)	(1.213)	(1.220)	(1.203)
GDP p.c.	0.953	0.962	0.909	0.951	0.958	0.959
	(0.641)	(0.638)	(0.663)	(0.641)	(0.636)	(0.638)
Patent Stock	0.807***	0.807***	0.806***	0.806***	0.808***	0.807***
	(0.207)	(0.207)	(0.210)	(0.208)	(0.207)	(0.207)
Trade	1.726**	1.723**	1.748**	1.730**	1.721**	1.725**
	(0.707)	(0.709)	(0.698)	(0.708)	(0.709)	(0.709)
FDI	-6.438***	-6.511***	-6.080***	-6.425***	-6.480***	-6.492***
	(2.084)	(2.088)	(2.128)	(2.097)	(2.082)	(2.082)
Country Effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Effects	Yes	Yes	Yes	Yes	Yes	Yes
Adj. R-squared	0.307	0.306	0.306	0.306	0.307	0.306
Angrist-Pisckhe F test for ES	18.65	18.66	18.06	18.11	18.69	17.25
Kleibergen-Paap F test	18.90	21.81	18.42	16.89	16.46	16.72
Anderson-Rubin Wald test	5.316	4.938	8.107	5.419	4.911	4.919
Observations	83	83	83	83	83	83
Number of groups	30	30	30	30	30	30
SY 10% max IV size	7.03	7.03	7.03	7.03	7.03	7.03
SY 25% max IV size	3.63	3.63	3.63	3.63	3.63	3.63

Note: The dependent variable $patents_{it}$ is the logarithm of the number of patents granted to the residents of each country from their local national patent office. Emigration stock and the its interaction with IPR protection are instrumented using IV$grav$, i.e. a measure of predicted emigration stock using the six different gravity models from Panel B of Table A.1 (IV1-IV6). All regressions include country and time fixed effects. Observations are at 5-year intervals. Standardized 'beta' coefficients are reported with their standard errors in brackets, adjusted for clustering at the country level. ***, ** and * indicate significance at the 1, 5 and 10 percent levels, respectively. Patent stock, emigration stock, population and GDP per capita are also in logarithms. The Angrist-Pisckhe F test for ES reports the first-stage F statistics for test of weak identification of our endogenous regressor, Emigration Stock (ES). The Kleibergen-Paap F test is the Kleibergen-Paap rk Wald F statistic and performs a weak identification test for our endogenous regressors when standard errors are clustered. Its critical values are 7.03 and 3.63 for a rejection rate of 10% and 25%, respectively (Stock and Yogo, 2005), as shown in rows SY 10% and SY 25%. The Anderson-Rubin Wald test reports a test for the joint significance of the endogenous regressors in the structural equation and is distributed as a chi-squared with degrees of freedom equal to the number of excluded instruments. The first stage estimates of the 2SLS regressions are presented in Panel A of Table A.1. Emigration stock is lagged by one period. IPR protection is measured by the Park (2008) index (0-5 scale, 0=weak, 5=strong).

protection is negative and significant and the interaction term between migration and IPR protection is positive and significant.

4. Conclusion

This paper sheds light on the joint role of institutions and migration in promoting innovation and contributes to the rich debates about the suitability of IPR protection and the brain drain effects of emigration in developing countries. We ask the question whether political instruments such as IPR protection can generate a win-win scenario out of emigration. Our analysis shows that IPR protection can be beneficial for innovation by exploiting the resources of knowledge made available through diaspora networks. We highlight a process of knowledge transfer from the developed to the developing world independent of trade and FDI that mainly relies on the movement of labor. The focus of the analysis is on the potential relationship between knowledge absorbed by emigrants abroad and the efficacy of IPRs in promoting innovation in their home countries.

Our conceptual framework assumes that emigration may trigger the flow of knowledge between skilled emigrants and natives. Using a sample of emerging and developing countries, we explore the link between international migration and innovation capacity in migrants' countries of origin and show that IPR protection works as a moderating factor between the two. We argue that migration helps provide the missing source of knowledge required for IPR protection to stimulate domestic innovation in developing countries. Although skilled emigration out of a developing country may directly result in the well-known concept of brain drain, it can be supportive for innovation in the country of origin, depending on the strength of IPR institutions.

While these results highlight the role of IPR protection in promoting the beneficial effects of international migration, one should be cautious in interpreting and/or generalizing the results of such macro-level analyses. For instance, there may be other policies being adjusted alongside the IPR regime, which could contribute towards capacity building and potential for development. Acknowledging the limitations inherent to the interpretations that can be deduced from our framework, our research has aimed to highlight the importance of the interplay between international migration and IPRs in the global flow of knowledge and to lay a foundation for further research and data collection on these premises.

AppendixA. Appendix

AppendixA.1. A Simple Theory

To pin down the idea that the strength of IPR institutions can exploit the gains from diaspora networks, we take a simplified version of Ohnsorge and Trefler (2007) model of heterogeneous workers and introduce in it an innovation sector, migration and IPR protection. Suppose a developing country, where individuals are endowed with a minimum level of human capital normalized to 1, and are heterogeneous in their learning ability z_i. Each individual lives two periods. In the first period, they all work and earn wages normalized 1, but can also pay e to invest in education. This allows them to earn a wage $1 + z_i$ according to their innate ability. Those who forego education continue to earn 1. The lack of an adequate IPR regime reduces returns to their skills by lowering their ability to retain monopoly profits for their inventions: $0 \leq \gamma \leq 1$ represents an inverse measure of IPR protection where $\gamma = 0$ denotes full protection and maximum profits, and $\gamma = 1$ indicates no protection with perfect competition driving profits to zero. Migration provides inventors with the opportunity to move to advanced countries where IPRs are fully enforced. This allows them to earn maximum returns to their inventions z_i, but entails a migration cost m. The population therefore decides whether or not to invest in education in the first period, and faces the option to emigrate in the second. Equation (A.1) shows the returns to the unskilled, the skilled who remain in their home country, and the migrants, respectively:

$$\begin{aligned} v_{00} &= 1 + 1, \\ v_{10} &= 1 - e + 1 + z_i(1 - \gamma), \\ v_{11} &= 1 - e + 1 + z_i - m. \end{aligned} \tag{A.1}$$

The first binary subscript stands for education and the second for migration.

The setting creates a continuum of agents assorted according to their capabilities with two thresholds, z_1 and z_2, representing the agents who are indifferent about obtaining education and migrating, respectively:

$$\begin{aligned} z_1 &= e/(1 - \gamma), \\ z_2 &= m/\gamma. \end{aligned} \tag{A.2}$$

Agents with ability $z_i < z_1$ do not invest in education, those with $z_1 < z_i < z_2$ invest in education but stay home, and the highest skilled $z_i > z_2$ also migrate. An improvement of the IPR regime (reducing γ) shrinks the size of the population in the first and the third zone (uneducated and migrants), whereas those in the middle who are capable of producing domestic inventions increases. On the contrary, a weak recognition of IPRs in the home country deters investment in education while inducing the more skilled educated segment to emigrate. The positive relationship between IPRs and the number of potential inventors is in line with evidence plotted in Figure A.1, which shows a strong positive and significant correlation (0.6423*) between the IPR regime and tertiary education for the countries in our sample.

[FIGURE A.1 ABOUT HERE]

Consider two exogenously given levels of IPR protection: weak (γ_W) and strong (γ_S), where $0 < \gamma_S < \gamma_W < 1$. A strong IPR regime results in a lower (higher) value of z_1 (z_2), increasing the middle range consisting of the educated population in the home country, $z_1 < z_i < z_2$. An increase in emigration can be shown through a marginal reduction in migration costs m. It follows from (A.2) that a lower m induces migration by shifting the threshold z_2 to the left. This creates an immediate brain drain effect through a depletion of skills of the potential inventors who leave the country. However, migration facilitates access to foreign information and technologies, which can eventually flow back through diaspora channels described above. This effect is larger, the more human capital is actively employed in the country of origin who can utilize the knowledge, i.e. the larger is the middle region $z_1 < z_i < z_2$, which is the case under a strong IPR regime, γ_S.

AppendixA.2. Data Description and Sources

Patents

We use resident patent grants, which are patents granted in each country to its residents by the local national patent office. The data are annual and the source is WIPO (2011). The data version we use is that of January 2011 and the series we retrieved is ”Patent grants by patent office, broken down by resident and non-resident (1883-2009)”. Patent stock series are calculated using the perpetual inventory method and a 15% depreciation rate. For details on this method, see the main text.

Migration

As migration measure, we use stocks of emigrants abroad. The data are annual. Emigration stocks are derived by summing the available bilateral immigration stocks by country of origin into 27 OECD countries. The original bilateral migration dataset collects information from different statistical offices of the world, supplemented by published OECD statistics from “Trends in International Migration” publications and Eurostat data. For a more comprehensive description of earlier versions of this dataset, see Pedersen et al. (2008) and Pedersen and Pytlikova (2008).

Intellectual Property Rights

The source is Park (2008). The available data cover 123 countries over the period from 1960 to 2005 in five-year intervals. Given the focus of our study, we selected a 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

The additional controls (GDP, population, R&D, education, government spending, trade and FDI) are from the World Bank (2009), IMF (2010), and the United Nations. All data have an annual frequency. The education variable is measured by enrollment in tertiary education in Barro and Lee (2010). Geographical data used in the gravity model are from CEPII as described in Head et al. (2010). Data on entry laws are from Ortega and Peri (2013). Data on historical immigration stock comes from Özden et al. (2011).

AppendixA.3. The Channel of Knowledge Flow

We here propose a measure of the channel of knowledge flow across countries, which takes into account the characteristics of the destination countries. The measure is a variant of Spilimbergo (2009). While Spilimbergo argues that foreign-trained individuals promote democracy in their home countries if they study in democratic countries, we here claim that emigrants promote innovation in their home countries if their host countries have a high potential for innovation.

To capture the heterogeneity among destination countries, we construct an index composed of a weighted average of the potential channels of knowledge, with the weights given by the share of emigrants from each origin in each destination over total emigration stock from the origin. The Knowledge Channel Index (KCI) of type k for each origin country i is defined as:

$$KCI_{ikt} = \sum_{j} \frac{m_{ijt}}{M_{it}} I_{jkt},$$

where i is the origin country, j is destination country and t denotes time. m_{ij} is the bilateral emigration stock from country i to country j, M_i is total emigration stock from country i, and I_{kj} is the relevant index of knowledge flow of type k from country j. By construction, the KCI lies between 0 and 1. To build each of the k-type indexes of knowledge flow we adopt the following measures: the total number of patents granted to the residents of each destination country over total population, R&D expenditure in destination, GDP per capita in the destination and the value of bilateral trade and FDI between j and i. Table OA.5 in the online appendix reports the role of each potential channel of knowledge flow on resident patent grants. Comparing the results in columns (1)-(2) with columns (4)-(5) confirms our hypothesis that innovation potential in the host country of migrants here plays a more important role than alternative channels of knowledge transfer such as bilateral trade and FDI.

AppendixA.4. Appendix Table

[TABLE A.1 ABOUT HERE]

TABLE A.1: GRAVITY MODELS AND FIRST STAGE RESULTS FOR IV*grav*

	PANEL A											
	First Stage Results											
	IV 1		IV 2		IV 3		IV 4		IV 5		IV 6	
Dependent variables:	ES	ES*IPR	ES	ES*IPR	ES	ES*IPR	ES	ES*IPR	ES	ES*IPR	ES	ES*IPR
Fitted Emigr. Stock	1.253***	1.546	1.250***	1.459	1.247***	1.408	1.237***	1.321	1.251***	1.293	1.215***	1.373
	(0.268)	(1.089)	(0.269)	(1.142)	(0.273)	(1.109)	(0.271)	(1.089)	(0.270)	(1.060)	(0.274)	(1.113)
Fitted Emigr. Stock*IPR	0.0284	0.895***	0.029	0.888***	0.029	0.949***	0.029	0.969***	0.029	0.979***	0.026	0.897***
	(0.0213)	(0.116)	(0.021)	(0.121)	(0.023)	(0.127)	(0.024)	(0.111)	(0.024)	(0.103)	(0.022)	(0.114)
IPR	-0.347	1.788	-0.354	1.845	-0.354	1.174	-0.358	0.861	-0.357	0.749	-0.319	1.725
	(0.313)	(1.546)	(0.305)	(1.624)	(0.333)	(1.658)	(0.338)	(1.516)	(0.343)	(1.415)	(0.321)	(1.547)
GDP p.c.	-0.360	-3.127*	-0.406	-3.293*	-0.376	-3.273**	-0.345	-3.051**	-0.341	-3.624**	-0.360	-3.184*
	(0.443)	(1.583)	(0.440)	(1.654)	(0.451)	(1.509)	(0.443)	(1.434)	(0.448)	(1.436)	(0.450)	(1.596)
Population	-2.512***	-11.21***	-2.532***	-11.541***	-2.489***	-10.576***	-2.501***	-10.353***	-2.459***	-11.089***	-2.603***	-11.566***
	(0.759)	(2.472)	(0.754)	(2.517)	(0.765)	(2.584)	(0.758)	(2.329)	(0.752)	(2.303)	(0.778)	(2.523)
Patent Stock	0.0600	0.522	0.065	0.520	0.057	0.450	0.059	0.484	0.059	0.533*	0.063	0.543
	(0.0925)	(0.314)	(0.093)	(0.320)	(0.091)	(0.311)	(0.094)	(0.307)	(0.092)	(0.309)	(0.096)	(0.322)
Trade	-0.108	-1.835**	-0.128	-2.045**	-0.056	-1.699*	-0.102	-1.757**	-0.102	-1.818**	-0.105	-1.822**
	(0.290)	(0.836)	(0.292)	(0.917)	(0.279)	(0.854)	(0.297)	(0.859)	(0.289)	(0.885)	(0.299)	(0.854)
FDI	2.153	10.81	2.192	10.677	2.160	11.761	2.218	12.198	2.142	11.711*	2.223	11.118
	(1.696)	(6.932)	(1.692)	(6.976)	(1.724)	(7.130)	(1.743)	(7.383)	(1.702)	(6.867)	(1.744)	(7.044)
Country Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj. R-squared	0.805	0.992	0.807	0.991	0.804	0.992	0.803	0.992	0.806	0.992	0.798	0.992
Observations	83	83	83	83	83	83	83	83	83	83	83	83
Number of groups	30	30	30	30	30	30	30	30	30	30	30	30

Note: Each column in the table includes the first stage estimates using the fitted emigration stock obtained from the six gravity models in Panel B (IV1-IV6). For each first stage estimate the variables that have been instrumented are two: emigration stock (ES) and the interaction between emigration stock and IPR (ES*IPR). Emigration stock is lagged by one period. IPR protection is measured by the Park (2008) index (0-5 scale, 0=weak, 5=strong). All regressions include country and time fixed effects. Standardized 'beta' coefficients are reported with their standard errors in brackets, adjusted for clustering at the country level. ***, ** and * indicate significance at the 1, 5 and 10 percent levels, respectively.

TABLE A.1 [CONTINUED]

	PANEL B					
	Gravity Model Results					
Dependent variable: $migr_{ijt}$						
	IV 1	IV 2	IV 3	IV 4	IV 5	IV 6
Distance	-0.163***	-0.166***	-0.181***	-0.186***	-0.185***	-0.163***
	(0.046)	(0.046)	(0.046)	(0.048)	(0.048)	(0.056)
Population Origin	0.520***	0.531***	0.534***	0.514***	0.511***	0.518***
	(0.033)	(0.034)	(0.032)	(0.033)	(0.033)	(0.033)
Population Destination	0.343***	0.345***	0.337***	0.346***	0.345***	0.356***
	(0.030)	(0.032)	(0.030)	(0.031)	(0.031)	(0.030)
Area Origin	-0.132***	-0.133***	-0.126***	-0.100***	-0.097***	-0.141***
	(0.029)	(0.030)	(0.029)	(0.032)	(0.032)	(0.033)
Area Destination	0.168***	0.170***	0.180***	0.192***	0.173***	0.203***
	(0.025)	(0.025)	(0.025)	(0.028)	(0.027)	(0.028)
Border	0.313**	5.425**	0.345**	0.246	0.318*	0.287
	(0.158)	(2.355)	(0.153)	(0.167)	(0.167)	(0.192)
Colony	0.564**	0.568***	4.503**	0.589***	0.616***	0.600***
	(0.219)	(0.213)	(1.913)	(0.216)	(0.217)	(0.220)
Official Language	0.444***	0.395***	0.416***	2.882***	0.433***	0.468***
	(0.148)	(0.146)	(0.144)	(0.959)	(0.146)	(0.145)
De Facto Language	0.530***	0.575***	0.536***	0.554***	2.239*	0.491***
	(0.148)	(0.149)	(0.145)	(0.149)	(1.160)	(0.145)
Landlocked	-0.902***	-0.899***	-0.887***	-0.899***	-0.899***	0.189
	(0.075)	(0.075)	(0.075)	(0.075)	(0.075)	(0.798)
Past Migration	0.450***	0.450***	0.449***	0.445***	0.450***	0.443***
	(0.014)	(0.014)	(0.014)	(0.015)	(0.015)	(0.014)
Constant	-8.472***	-8.695***	-8.689***	-8.916***	-8.695***	-8.971***
	(0.638)	(0.661)	(0.636)	(0.666)	(0.654)	(0.642)
Time Effects	Yes	Yes	Yes	Yes	Yes	Yes
Border*X	No	Yes	No	No	No	No
Colony*X	No	No	Yes	No	No	No
Official Language*X	No	No	No	Yes	No	No
De Facto Language*X	No	No	No	No	Yes	No
Landlocked*X	No	No	No	No	No	Yes
Adj. R-squared	0.677	0.678	0.681	0.679	0.679	0.678
Observations	29669	29669	29669	29669	29669	29669
Number of groups	2002	2002	2002	2002	2002	2002

Note: The dependent variable $migr_{ijt}$ is the logarithm of bilateral migration stock from origin country i to destination country j in year t. All regressions include time fixed effects. Standardized 'beta' coefficients are reported with their standard errors in brackets, adjusted for clustering at the country level. ***, ** and * indicate significance at the 1, 5 and 10 percent levels, respectively. Each column includes a different set of interaction terms. The included interaction terms are listed in the rows at the bottom of the table. Each row represents the set of interactions between the chosen dummies (Border, Colony, Official Language, De Facto Language and Landlocked) and the vector X of geographical variables (Distance, Population Destination, Population Origin, Area Destination, Area Origin).

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