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Can Intellectual Property Rights Protection Generate Brain Gain from International Migration?

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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 better absorbed under sound IPR institutions. IPRs thus work as a moderating factor to overcome brain drain by creating the conditions to better absorb potential gains from migration. Using a panel dataset of emerging and developing countries, we establish a positive correlation between emigration and innovation when IPRs are sufficiently strong.

J.E.L. Classification: O30; F22; J24.

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

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1 Introduction

The recent surge in the outward transfer of the 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 about 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, little formal research in the economic literature directly examines 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 bridging two phenomena that nurture innovation, namely intellectual property right (IPR) protection and migration, and exploring their interaction in determining innovation performance.[3] The key question we aim to answer is whether an appropriate level of IPR protection in the sending country could help transform the brain drain caused by migration into a brain gain. 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 better absorbed in countries with sound IPR institutions.

The roles of IPRs and migration as means of technology diffusion have generally been studied in isolation from each other.[4] In particular, the interrelationships between migration and IPR policy in determining innovation are yet to be explored. 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 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 the literature by shedding light on how IPR protection in the sending country may influence the effect of migration on innovation there.

The conceptual framework we adopt argues that although emigration can initially result in the

[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)."

[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 & Kuhn (2011).

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 extent to which this superior knowledge can be absorbed in the home country depends on its IPR environment. A strong level of IPR protection in the sending country increases the magnitude of potential benefits from migration, making it more likely for the gains to outweigh the negative effects of brain drain on innovation, thus facilitating a potential net brain gain.

Using a sample of emerging and developing economies, 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 the South 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 with the index of IPR protection as measured by Park (2008). Our findings show that the impact of emigration on innovation is positive in the presence of strong IPR protection. Hence, IPRs have a role in promoting the beneficial effects of the diaspora channel of knowledge, confirming the main conclusions of our conceptual framework.

Our results are tested using a variety of robustness checks which 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 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. 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.

[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).

2 Conceptual Framework and Main Empirical Implications

In its lead article, 'The Magic of Diasporas', The Economist has suggested that diasporas can be an important factor in fostering development in their home economics (The Economist 2011). Diasporas help spread ideas by fostering trust through kinship 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 may be related to the IPR regime in the sending country, and how the latter can transform brain drain into brain gain. More precisely, 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.

The immediate consequences of migration can be summarized into the well-known brain drain effect. The underlying assumption here is that South-North migration also provides migrants with an opportunity to learn superior skills and more up-to-date technologies than what is available in their home country. The knowledge acquired abroad can in turn flow back to the country of origin, increasing the skills of the remaining workers engaged in innovation activities. Diasporas can therefore play a key role here in stimulating innovation in their home countries. This can happen through different channels. The most obvious channel is the physical return of the brains. An example of such phenomenon can be explained by the domination of China's technology industry by return (sea turtle) migrants. A less direct channel is the recirculation of knowledge back to the country of origin. A good illustrative case is 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 by encouraging the return (or use) of newly learned information and skills to their home economy (Kerr, 2008).

The protection of IPRs comes into the picture by enhancing the probability that an inventor can exercise monopoly power by obtaining a patent in the market for his invention. A strong IPR regime hence increases returns from skills and create stimulus for innovation. Several forces are in play here. First, an increase in IPR protection renders skilled occupations more attractive, causing a flow of domestic workers into the innovation sector. Although this may increase the absolute number of inventors *per se*, the productivity of each worker may be decreasing with the size of the innovation sector. On the one hand, research productivity declines as less talented workers become researchers and reduce the average productivity of the team (Eaton and Kortum, 1999). On the other hand, managerial time can be a constraint when a given amount of attention needs to be allocated among researchers (Helpman, et al., 2009). Finally, a better IPR environment can also limit innovators' migration incentives and hence reduce prospective gains from diaspora knowledge networks.

The crux of the argument is that diaspora networks may generate positive knowledge flows, but only to the extent that there is enough absorptive capacity in the home country. Once migration is set off, IPR protection 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 stronger IPRs encourage 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 for various explanations for brain gain, namely human capital incentives (Bein et al., 2001), return migration (Mayer 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 instigate 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 net brain gain is the outcome of migration if the magnitude of this skill upgrading is large enough to outweigh the direct negative effects of an outflow of skills on innovation.

A simple theoretical framework to illustrate the concept is presented in the Appendix.[6] The main testable implications of this framework is that although emigration and IPR protection can themselves slow down domestic innovation, IPRs allow the materialization of potential gains from migration. A sufficiently strong level of IPR protection in the origin country may therefore transform brain drain in a net brain gain.

3 Empirical Analysis

3.1 Data and Specification

Our empirical analysis uses a sample composed of emerging and developing countries (EDC) as classified by IMF (2010) to concentrate on the determinants of innovation in the South. 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.[7] Patent data are from the WIPO database. Our

[6] 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.

[7] 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.

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. To retrieve the emigration data for each origin country, we aggregate the bilateral migration data across countries of origin.[8] 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.[9] 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.[10]

To investigate whether a stronger IPR regime can enhance the possibility of brain gain from 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 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.[11] 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:

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

where i denotes the country and t each of the 5-year intervals.[12] The dependent variable $patents_t$ is our measure of innovation. The variable $emigr_{t-1}$ represents emigration and is taken with a

[8] 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.

[9] 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.

[10] See Trefler (2004).

[11] 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).

[12] 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.

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_t is the measure of IPR protection. The variable $emigr_{t-1}IPR_t$ 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_t and $gdppc_t$ 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).[13] We also add R&D expenditure, another proxy for a country's potential for innovation. Another relevant control is tertiary 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 control variables, see the Appendix.[14] Table 1 illustrates the summary statistics of the key variables of our analysis.

[TABLE 1 ABOUT HERE]

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 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]

[13] 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.

[14] 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.

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.[15] 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 shows 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).[16]

The key to our analysis is the sign and significance of the interaction term between migration and IPR protection. As we can see from the table, the interaction term reveals to be highly significant and positive. This suggests that IPR protection nurtures the diaspora channel of knowledge transfer originating from migration. It also implies that above a certain threshold IPR level migration can result in brain gain.

[FIGURE 1 ABOUT HERE]

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.[17] The coefficient of trade is positive and significant, 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 for 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

[15] 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.

[16] 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).

[17] 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.

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. The test reveals that our key variables are always jointly significant at 5% or 10% level. In our reference full specification (column (11)), in particular, the F-test is significant at 5%. In Figure 1 we show the partial regression plots for the effect of migration and of the interaction term between migration and IPRs on patent grants. The reference specification is our full specification.[18]

In the Appendix we report our sensitivity analyses, together with additional checks. Table A.1 presents the results of a balanced sample to check whether the findings of Table 1 are sensitive to the sample considered: the sample we use is that of our full specification in column (11). Table A.2 and Table A.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 use a dichotomous indictor using the average value of IPRs in EDC countries as a reference threshold (where "strong IPR" equals 1 if the country is above the average 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.

In Table A.4 we also propose a first check of our basic idea about the channel of knowledge flows. 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, we check the link between innovation in the origin and heterogeneity in the destination in terms of innovation capacity (measured by patent grants or R&D), trade, and FDI.[19] 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. Taking into account differences in destination countries hence confirms that the diaspora in more innovative destinations play a more important role in the transfer of skills and brain gain than trade or FDI. To conclude, these results can be viewed as a first check of the importance of diasporas in more innovative countries as the main channel of knowledge flow. Further investigations are performed in the following section.

[18] The sign of the change in patent grants is robust to removing the potential influential points (Jordan and Lithuania). The results are available upon request.

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

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), 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 addresses this issue through a first difference and an instrumental variable 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 effect 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.[20] 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. In all regressions both country fixed effects and time fixed effects are present. The findings in the table 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. It is worth pointing out that these specifications are quite demanding given that they are in difference and with country-specific effects. This may be the reason why some of the other relevant controls become weaker or lose significance; exceptions are patent stock and trade, which remain positive and significant, and tertiary education which gains significance. The joint F-test again confirms the joint significance of our key variables.

To investigate in detail whether and under what conditions migration induces a brain drain or a brain gain, we now explicitly consider the changes in the effect of emigration on innovation

[20] 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.

according to the level of IPRs. 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)).

[FIGURE 2 ABOUT HERE]

As the figure suggests, while under weak IPR protection the effect of migration on resident patents is negative and significant, this effect becomes positive and significant when IPRs are strong, confirming that emigration could foster innovation as long as the IPR regime is strong. Note however that even at the maximum protection level ($IPR_t = 5$) the positive effect of $\beta_3 IPR_t$ may not always fully compensate the unfavorable impact of migration through β_1. We can therefore not conclude that IPR protection always leads to brain gain, but can deduce from the results that it helps mitigate brain drain.

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 (IV1) exploits information on the determinants of migration used in the gravity literature to derive a measure of predicted emigration stocks.[21] 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:

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

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

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

either of them 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.[22] We add to this a measure of past bilateral migration stock from i to j in 1960, $migr_{ij1960}$, [23] 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.[24] 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 results of our gravity regressions are shown in Table A.5 of the Appendix. We present six different gravity models and we experiment with all of them in our instrumental variables (2SLS) estimations.

We also employ a secondary instrument for migration (IV2), 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.[25] 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.[26] We further categorize far countries into those that share a common language with the origin and those that do not.[27] 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 relevant information from our bilateral annual dataset, we first aggregate the data across origin countries and then collapse them in 5-year averages.

Tables 4 and 5 report the results using our two sets of instrumental variables. Although migration stock (MS) is the only potential endogenous variable in our empirical specification, it also appears in the interaction term (MS*IPR). We hence use IV1 or IV2 as an instrument for MS and interact it with the IPR protection index to provide an instrument for the interaction term. The empirical analysis with the chosen instruments is presented as 2SLS regressions using our reference full specification.

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

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

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

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

[26] 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.

[27] 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.

Table 4 presents the results obtained using the IV1 instruments derived from the six gravity models in Table A.5. Each column of Table 4 corresponds to a column in the table in the Appendix.[28] 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.

[TABLE 4 ABOUT HERE]

Table A.6 of the Appendix includes our findings obtained with IV2 instruments using different measures of distance and language proximity across countries.[29] 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 under IV2 confirm our core results, we lean more towards the results of the IV1 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 protection is negative and significant and the interaction term between migration and IPR protection is positive and significant. In addition, the impact of migration on innovation reveals to be positive and significant under higher levels of IPR protection.

4 Conclusion

This paper sheds light on the joint role of institutions and migration in promoting growth and contributes to the rich debate about the brain drain/brain gain effects of emigration. We ask the question whether political instruments such as IPR protection can be used to generate a win-win scenario out of emigration. Our analysis shows that IPR protection can make this possible by fostering diaspora knowledge networks. We highlight a process of knowledge transfer from developed to developing countries that is independent of trade and FDI and that mainly relies on people's movement, by focusing on the potential relationship between knowledge absorbed by emigrants abroad and innovation in their home countries.

We explore the link between international migration and innovation capacity in migrants' countries of origin using a sample of emerging and developing countries and show that the impact of emigration on innovation is positive in the presence of strong IPR protection. We argue that although skilled emigration out of a developing country may directly result in the well-known concept

[28] E.g. column (1) in Table 4 uses the predicted migration stock from the gravity model of column (1) in Table A.5.

[29] 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).

of brain drain, it can also cause an indirect brain gain effect, the extent of which depends on the level of IPR protection in the country of origin. Our conceptual framework draws upon the realistic assumption that emigration may trigger the flow of knowledge between skilled emigrants and natives. In the presence of a strong IPR regime, gains in human capital made possible through the diaspora channel are more likely to outweigh the direct drain of skills caused by emigration.

These results highlight the role of IPR protection in promoting the beneficial effects of international migration. One should however 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.

A Appendix

A.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 (1) shows the returns to the unskilled, the skilled who remain in their home country, and the migrants, respectively:

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

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:

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

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.

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 (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.

A.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 (2013a). Data on historical immigration stock comes from Özden et al. (2011).

A.3 The Channel of Knowledge Flow

We here propose a measure of the channel 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 A.4 reports the role of each potential channel of knowledge flow on resident patent grants.

A.4 Tables

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Table 1 – Summary Statistics

	Obs	Mean	Std. Dev.	Min	Max
Resident Patent Grants	122	1053.395	3664.058	1.750	22891
Resident Patent Grants (Stock)	112	5062.069	16124.69	4.645	106329.6
Emigration Stock	135	792644.1	1488538	1050	1.12e+07
IPRs Protection	102	3.040	0.851	1.080	4.540
Population	129	92179.34	241364.3	1344.823	1307370
GDP Per Capita	128	8.504	0.782	6.694	9.759
R&D	109	0.482	0.321	0.017	1.375
Tertiary Education	122	0.290	0.193	0.020	0.760
Government Spending	132	0.714	0.193	0.079	0.971
Trade	127	0.803	0.404	0.166	2.117
FDI	135	0.036	0.033	0.000	0.198

Note: The summary statistics are calculated with reference to the time interval under consideration (1995-2006). The variables are in their original format except GDP Per Capita (in logs) and population (in thousands). All the variables are represented in 5-year averages.

Table 2 - The Impact of Emigration and IPRs Protection on Resident Patent Grants – Fixed Effects

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Emigr. Stock$_{-1}$	-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)
Emig. St.$_{-1}$*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 Ed.							-0.917				
							(1.183)				
Gov. Spend.								-1.648			
								(1.507)			
Trade									2.092**		1.588**
									(0.788)		(0.755)
FDI										-5.376***	-6.050***
										(1.441)	(1.988)
Constant	-108.261*	-125.965**	-116.356*	-111.525**	-14.498	-172.799***	-145.690***	-107.023**	-156.858***	-98.383*	-49.155*
	(56.565)	(60.937)	(61.138)	(51.172)	(41.117)	(49.238)	(31.421)	(46.898)	(41.594)	(49.993)	(25.930)
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
F test main var. (p)				0.060	0.001	0.086	0.034	0.053	0.017	0.184	0.022
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
Observations	116	93	93	93	86	76	87	93	91	93	84
Number of groups	43	34	34	34	31	31	34	34	34	31	31

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

Table 3 - The Impact of Emigration and IPRs Protection on Resident Patent Grants – First Differences

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Emigr. Stock$_{-1}$	-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)
Emig. St.$_{-1}$*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 Ed.				-1.999				
				(1.450)				
Gov. Spend.					-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)
Country Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
F test main var. (p)	0.086	0.001	0.206	0.074	0.104	0.054	0.129	0.006
Adj. R-squared	0.083	0.307	0.090	0.139	0.073	0.147	0.084	0.360
Observations	57	53	44	51	57	55	57	51
Number of groups	32	29	26	29	32	31	32	28

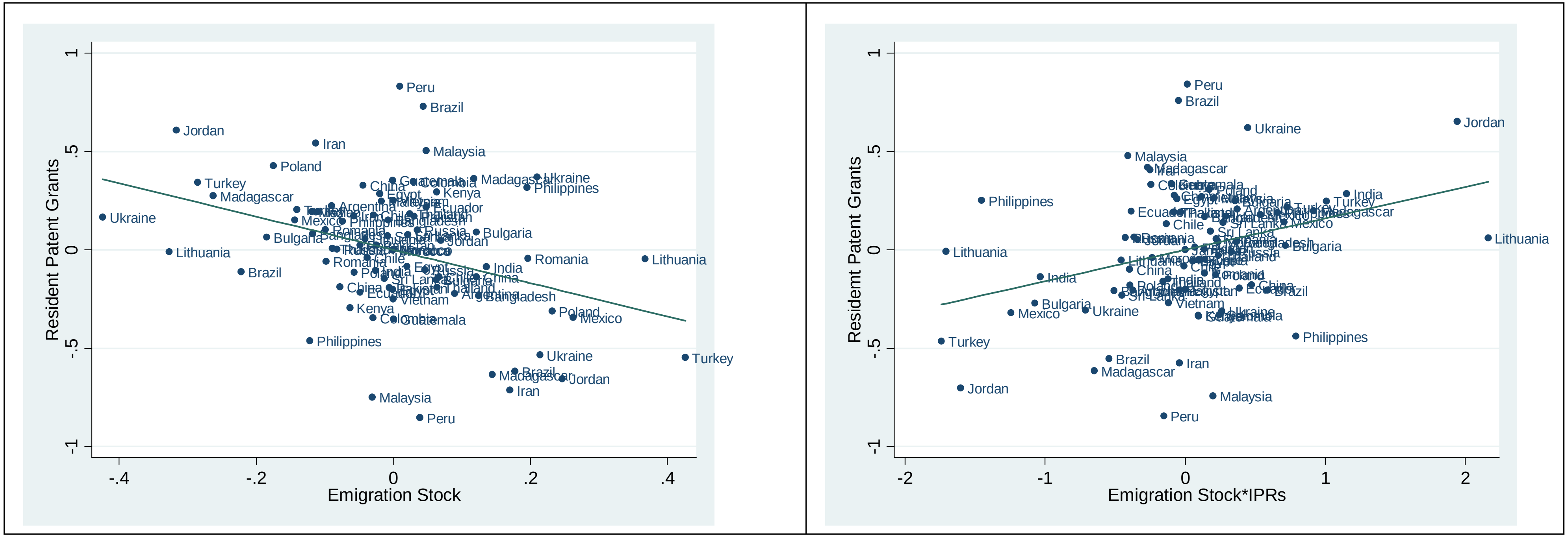
Note: Robust standard errors in parentheses, clustered at country level. * significant at 10%; ** significant at 5%; *** significant at 1%. The dependent variable is resident patent grants. Patent grants, patent stock, emigration stock, population and GDP per capita are in logarithms.

Table 4 - The Impact of Emigration and IPRs Protection on Resident Patent Grants – Instrumental Variables (2SLS) with IV1

	(1)	(2)	(3)	(4)	(5)	(6)
Emigr. $Stock_{-1}$	-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)
Emig. St_{-1}*IPR	0.158**	0.154**	0.180**	0.159**	0.155**	0.155**
	(0.076)	(0.078)	(0.071)	(0.078)	(0.079)	(0.077)
Population	0.953	0.962	0.909	0.951	0.958	0.959
	(0.641)	(0.638)	(0.663)	(0.641)	(0.636)	(0.638)
GDP p.c.	3.686***	3.682***	3.754***	3.704***	3.664***	3.692***
	(1.209)	(1.213)	(1.225)	(1.213)	(1.220)	(1.203)
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)
Constant						
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 MS	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	5.32	4.94	8.11	5.42	4.91	4.92
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

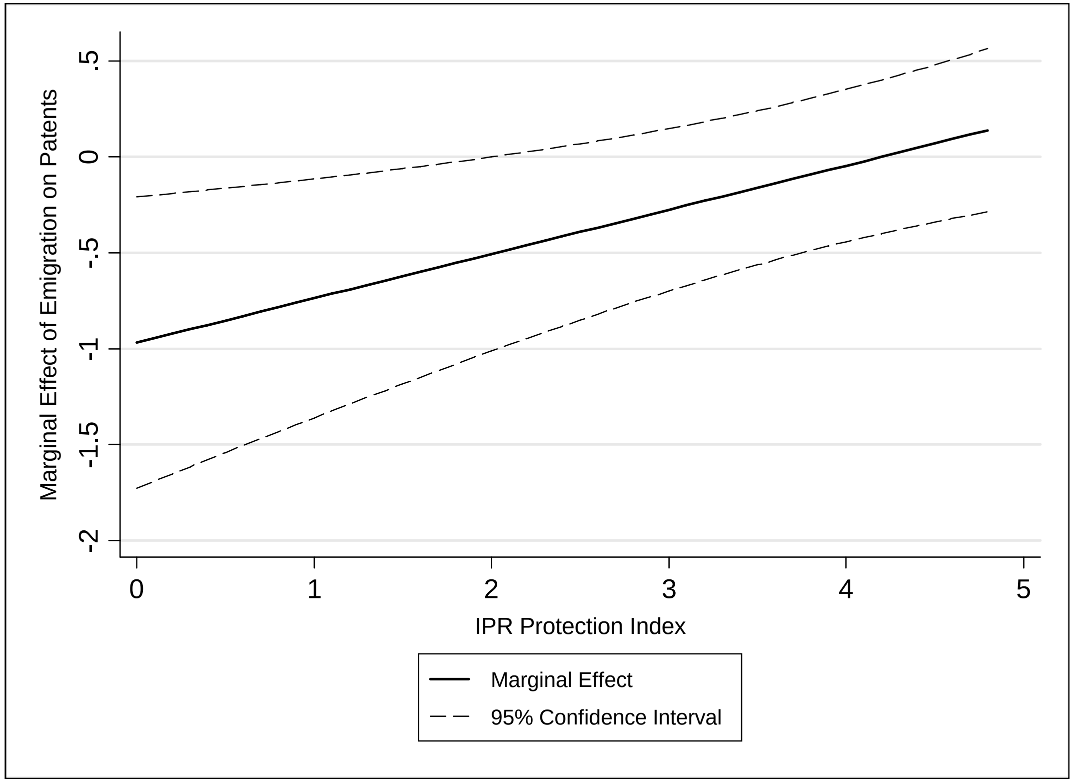
Note: Robust standard errors in parentheses, clustered at country level. * significant at 10%; ** significant at 5%; *** significant at 1%. The dependent variable is resident patent grants. Patent grants, patent stock, emigration stock, population and GDP per capita are in logarithms.

Figure 1 – Partial-regression Plots for Emigration and the Interaction between Emigration and IPR Protection



Note: The reference specification for the above partial-regression plots is the specification in column (11) in Table 2, which corresponds to our reference full specification.

Figure 2 – Marginal Effect of Emigration on Resident Patent Grants According to the IPR Level



Note: The reference specification for the above partial-regression plots is the specification in column (11) in Table 3, which corresponds to our reference full specification in first differences.

Table A.1 - The Impact of Emigration and IPRs Protection on Resident Patent Grants –Fixed Effects (Balanced Sample)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Emigr. Stock$_{-1}$	-0.218		-0.285	-0.936**	-1.062***	-0.626**	-0.950**	-0.919**	-1.005**	-0.737*	-0.847***
	(0.292)		(0.291)	(0.402)	(0.285)	(0.258)	(0.374)	(0.437)	(0.380)	(0.412)	(0.266)
IPR		-0.302	-0.327	-2.968**	-2.666**	-2.323**	-3.089***	-2.955**	-3.562***	-2.224*	-2.174**
		(0.275)	(0.285)	(1.280)	(1.062)	(0.905)	(1.100)	(1.297)	(1.135)	(1.266)	(0.954)
Emig. St.$_{-1}$*IPR				0.203**	0.193**	0.172**	0.211**	0.201*	0.248***	0.151	0.160**
				(0.098)	(0.077)	(0.066)	(0.084)	(0.100)	(0.085)	(0.097)	(0.069)
Population	5.748**	7.228***	6.240**	6.585***	2.929*	5.964***	7.081***	6.525***	7.163***	5.900***	2.897**
	(2.653)	(2.452)	(2.463)	(1.891)	(1.661)	(1.632)	(1.384)	(1.929)	(1.942)	(1.773)	(1.360)
GDP p.c.	3.893***	4.093***	4.134***	3.620***	0.966	2.567**	4.111***	3.608***	3.106***	3.614***	0.931
	(1.285)	(1.448)	(1.440)	(1.198)	(0.773)	(1.010)	(1.162)	(1.204)	(1.024)	(1.093)	(0.693)
Patent Stock					0.948***						0.836***
					(0.196)						(0.206)
R&D						1.231					
						(0.746)					
Tertiary Ed.							-0.307				
							(1.180)				
Gov. Spend.								-0.278			
								(1.432)			
Trade									2.388***		1.588**
									(0.779)		(0.755)
FDI										-4.878***	-6.050***
										(1.377)	(1.988)
Constant	-127.072**	-157.390***	-135.472**	-129.722***	-46.932	-114.636***	-141.514***	-128.529***	-136.482***	-120.160***	-49.155*
	(55.116)	(53.373)	(52.736)	(40.891)	(32.153)	(37.516)	(32.457)	(41.492)	(40.997)	(36.873)	(25.930)
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	0.142	0.174	0.179	0.256	0.554	0.358	0.285	0.247	0.338	0.273	0.600
Observations	84	84	84	84	84	69	79	84	84	84	84
Number of groups	31	31	31	31	31	27	31	31	31	31	31

Note: All regressions are performed with the same balanced sample. The reference sample is that of specification of column (11) in Table 1, i.e. our reference full specification. Robust standard errors in parentheses, clustered at country level. * significant at 10%; ** significant at 5%; *** significant at 1%. The dependent variable is resident patent grants. Patent grants, patent stock, emigration stock, population and GDP per capita are in logarithms.

Table A.2 - The Impact of Emigration and IPRs Protection on Resident Patent Grants – Fixed Effects (Balanced Sample – IPRs in logs)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Emigr. $Stock_{-1}$	-0.218		-0.242	-0.841**	-0.997***	-0.659**	-0.863***	-0.834**	-0.872***	-0.701**	-0.816***
	(0.292)		(0.268)	(0.314)	(0.201)	(0.254)	(0.295)	(0.360)	(0.295)	(0.340)	(0.218)
IPR		-0.897	-0.913	-7.789***	-7.121***	-7.208**	-8.153***	-7.769***	-9.008***	-6.236**	-5.960***
		(0.694)	(0.701)	(2.676)	(2.016)	(2.727)	(2.261)	(2.755)	(2.245)	(2.868)	(1.990)
Emig. St_{-1}*IPR				0.543**	0.518***	0.530**	0.570***	0.540**	0.637***	0.434*	0.440***
				(0.212)	(0.149)	(0.196)	(0.183)	(0.221)	(0.178)	(0.225)	(0.148)
Population	5.748**	8.007***	7.148***	7.668***	3.756**	6.351***	8.473***	7.652***	8.265***	6.878***	3.546**
	(2.653)	(2.473)	(2.385)	(1.935)	(1.829)	(1.354)	(1.402)	(1.963)	(2.008)	(1.892)	(1.565)
GDP p.c.	3.893***	4.273***	4.301***	3.733***	1.075	2.427**	4.189***	3.731***	3.250***	3.696***	1.005
	(1.285)	(1.412)	(1.399)	(1.155)	(0.722)	(0.983)	(1.129)	(1.165)	(1.001)	(1.082)	(0.680)
Patent Stock					0.938***						0.834***
					(0.201)						(0.209)
R&D						1.280*					
						(0.686)					
Tertiary Ed.							0.105				
							(1.158)				
Gov. Spend.								-0.095			
								(1.364)			
Trade									2.310***		1.509**
									(0.812)		(0.722)
FDI										-4.113***	-5.378**
										(1.295)	(2.146)
Constant	-127.072**	-171.905***	-153.865***	-150.219***	-63.209*	-119.813***	-168.082***	-149.927***	-157.724***	-137.840***	-61.561**
	(55.116)	(53.006)	(50.811)	(39.929)	(34.457)	(31.446)	(31.757)	(40.414)	(40.897)	(37.749)	(29.496)
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	0.142	0.193	0.194	0.280	0.575	0.370	0.308	0.271	0.358	0.289	0.612
Observations	84	84	84	84	84	69	79	84	84	84	84
Number of groups	31	31	31	31	31	27	31	31	31	31	31

Note: All regressions are performed with the same balanced sample. The reference sample is that of specification of column (11) in Table 1, i.e. our reference full specification. Robust standard errors in parentheses, clustered at country level. * significant at 10%; ** significant at 5%; *** significant at 1%. The dependent variable is resident patent grants. IPRs, Patent grants, patent stock, emigration stock, population and GDP per capita are in logarithms.

Table A.3 - The Impact of Emigration and IPRs Protection on Resident Patent Grants – Fixed Effects (Balanced Sample – Dichotomous IPR Indicator)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Emigr. Stock$_{-1}$	-0.804**	-0.939***	-0.467*	-0.783**	-0.813**	-0.767**	-0.650**	-0.713**
	(0.317)	(0.256)	(0.268)	(0.323)	(0.352)	(0.336)	(0.301)	(0.264)
IPR	-8.335***	-7.278***	-6.352*	-8.250***	-8.346***	-8.602***	-6.339***	-5.200**
	(2.694)	(2.584)	(3.485)	(2.500)	(2.720)	(2.716)	(2.304)	(2.314)
Emig. St.$_{-1}$*IPR	0.641***	0.567***	0.483*	0.637***	0.643***	0.665***	0.494***	0.416**
	(0.205)	(0.198)	(0.258)	(0.189)	(0.207)	(0.206)	(0.175)	(0.176)
Population	6.748***	3.013	6.374***	6.676***	6.781***	7.092***	5.752***	2.476
	(1.763)	(2.180)	(1.847)	(1.964)	(1.795)	(2.057)	(1.439)	(1.634)
GDP p.c.	3.548***	0.870	2.438**	3.993***	3.553***	3.162***	3.418***	0.710
	(0.906)	(0.917)	(1.057)	(0.851)	(0.923)	(0.828)	(0.794)	(0.860)
Patent Stock		0.963***						0.860***
		(0.208)						(0.212)
R&D			1.096					
			(0.692)					
Tertiary Ed.				-0.884				
				(1.658)				
Gov. Spend.					0.169			
					(1.289)			
Trade						1.886**		1.412*
						(0.921)		(0.700)
FDI							-6.065***	-7.261***
							(1.738)	(2.055)
Constant	-134.225***	-50.013	-124.066***	-136.935***	-134.855***	-138.888***	-117.440***	-42.374
	(36.418)	(45.360)	(39.451)	(39.292)	(37.068)	(42.039)	(28.837)	(34.685)
Country Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj. R-squared	0.306	0.601	0.411	0.341	0.307	0.360	0.346	0.657
Observations	84	84	69	79	84	84	84	84
Number of groups	31	31	27	31	31	31	31	31

Note: All regressions are performed with the same balanced sample. The reference sample is that of specification of column (11) in Table 1, i.e. our reference full specification. Robust standard errors in parentheses, clustered at country level. * significant at 10%; ** significant at 5%; *** significant at 1%. The dependent variable is resident patent grants. IPRs, Patent grants, patent stock, emigration stock, population and GDP per capita are in logarithms. Dichotomous IPR variable has been created using the mean level over EDC countries.

Table A.4 - The Channel of Knowledge Transfer

	(1)	(2)	(3)	(4)	(5)	(6)
IPR	-2.174**	0.040	0.009	-0.220	-0.025	-0.039
	(0.954)	(0.141)	(0.139)	(0.340)	(0.139)	(0.143)
Population	2.897**	3.360**	2.708**	1.448	3.263**	3.436***
	(1.360)	(1.260)	(1.325)	(5.552)	(1.206)	(1.126)
GDP p.c.	0.931	1.230*	1.094	4.093	1.203*	1.189*
	(0.693)	(0.685)	(0.736)	(3.176)	(0.696)	(0.695)
Patent Stock	0.836***	0.746***	0.781***	0.149	0.808***	0.808***
	(0.206)	(0.228)	(0.221)	(0.443)	(0.221)	(0.217)
Trade	1.588**	1.974**	1.823**	3.161***	1.671*	1.649*
	(0.755)	(0.844)	(0.852)	(0.945)	(0.908)	(0.846)
FDI	-6.050***	-9.844***	-9.165***	-8.183**	-9.065***	-8.776***
	(1.988)	(1.876)	(1.971)	(3.666)	(1.909)	(1.957)
Index: Dest. Patent Rate		2.481*				
		(1.254)				
Index: Dest. GDP p.c.			3.402			
			(2.130)			
Index: Dest. R&D				12.370***		
				(3.955)		
Index: Bilateral FDI					-0.973	
					(2.150)	
Index: Bilateral Trade						1.572
						(1.569)
Constant	-49.155*	-72.160***	-60.794**	-65.069	-69.353**	-72.327***
	(25.930)	(26.078)	(27.223)	(116.701)	(25.320)	(23.946)
Time Effects	Yes	Yes	Yes	Yes	Yes	Yes
Adj. R-squared	0.600	0.575	0.556	0.549	0.542	0.543
Observations	84	84	84	53	84	84
Number of groups	31	31	31	30	31	31

Note: Column (1) is our reference full specification of column (11) without the interaction term in Table 1. Column (2) uses the index of patent grants in destination country. Column (3) uses the index of GDP per capita in destination. Column (4) uses R&D in destination, column (5) uses bilateral FDI, column (6) uses imports and (7) uses bilateral trade. Robust standard errors in parentheses, clustered at country level. * significant at 10%; ** significant at 5%; *** significant at 1%. The dependent variable is resident patent grants.

Table A.5 – Gravity Model Results

	(1)	(2)	(3)	(4)	(5)	(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)
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
R-squared	0.677	0.678	0.681	0.679	0.679	0.678
Observations	29669	29669	29669	29669	29669	29669

Note: Robust standard errors in parentheses, clustered at country level. * significant at 10%; ** significant at 5%; *** significant at 1%. The dependent variable is bilateral migration stock. The included interaction terms are listed at the bottom of the table. Each row represents the set of interactions between the chosen dummy and the vector **X** of geographical variables (Distance, Population Destination, Population Origin, Area Destination, Area Origin).

Table A.6 - The Impact of Emigration and IPRs Protection on Resident Patent Grants – Instrumental Variables (2SLS) with IV2

	(1)	(2)	(3)	(4)
Emigr. Stock$_{-1}$	-2.046***	-2.121***	-1.844***	-1.817***
	(0.486)	(0.576)	(0.562)	(0.596)
IPR	0.248*	0.262**	0.333**	0.262**
	(0.131)	(0.109)	(0.133)	(0.103)
Emig. St.$_{-1}$*IPR	-3.548**	-3.711**	-4.840***	-3.901***
	(1.776)	(1.465)	(1.818)	(1.399)
Population	0.944	1.161	-0.027	0.485
	(1.418)	(1.355)	(1.404)	(1.171)
GDP p.c.	4.130**	4.044**	5.141***	4.926***
	(1.959)	(1.873)	(1.716)	(1.474)
Patent Stock	0.752***	0.750***	0.924***	0.888***
	(0.251)	(0.263)	(0.267)	(0.249)
Trade	2.902***	2.693***	3.780***	3.707***
	(1.013)	(1.041)	(0.994)	(0.908)
FDI	-6.149**	-5.423*	-5.433*	-6.690**
	(2.947)	(3.278)	(3.280)	(3.216)
Constant				
Country Effects	Yes	Yes	Yes	Yes
Time Effects	Yes	Yes	Yes	Yes
Adj. R-squared	0.417	0.368	0.487	0.534
Angrist-Pisckhe F-test for MS	13.46	15.6	12.91	15.44
Kleibergen-Paap F test	2.165	1.246	1.759	1.218
Anderson Rubin Wald test	14.21	9.94	13.53	7.43
Observations	45	42	43	40
Number of groups	17	16	16	15
SY 10% max IV size	7.03	7.03	7.03	7.03
SY 25% max IV size	3.63	3.63	3.63	3.63

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