Moving ideas across borders: Patents and FDI

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Abstract

This paper analyses the impact of multinationals’ innovative performance on their investment decisions abroad. We focus on a specific aspect of the innovative activity carried out by multinational firms: Their capacity to adapt their products to the requirements of the destination market measured by the number of patent applications. We develop a model which explains that firms may hedge transaction costs related to the customization of products in order to meet foreign quality standards. Migrants may reduce information frictions as they provide firms with knowledge that allows them to increase the perceived quality of their products at the host country. We focus on a very specific type of migrants: those who cross borders and patent and invention in their host county. Our preliminary results show that the interaction between patents and migrants inventors promote Greenfield FDI at both the intensive as well as the extensive margins. The positive impact of both patents and migrants is inhibited by a financial crisis in the host country. Our estimations also reveal the need to account by the high level of heterogeneity across sectors.

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1 Introduction

Multinational corporations accounts for the majority of innovation worldwide. By serving various markets, they often benefit from economies of scale, and have a stronger financial capacity to invest in innovation projects. They are in a better position than small and local firms to attract talent, acquire sophisticated equipment, adopt comprehensive technology management tools, and build innovation networks with suppliers, customers, strategic partners, universities, and public research institutes.

Firms invest in R&D and other related activities to develop and introduce product and process innovations. These investments in knowledge enhance the productivity of the firm and change its competitive position relative to that of other firms (Doraszelski and Jaumandreu, 2013). When a new product has successfully been introduced to the market, it creates new demand for the output of the innovating firm. Foreign-owned firms might reach higher sales when introducing new products because they can learn from experiences the multinational company has made in other countries (Dachs and Peters, 2014). Also, the introduction of new products generate more per-product revenue than the retired products did (Balasubramanian and Sivadasan, 2011). Innovations in product quality may not necessarily raise the quantity of output per unit input, but they can increase the product price and, therefore, the firm’s revenue (Syverson, 2011).

Many previous studies have found evidence supporting a positive impact of multinational firms on the innovative performance of both, their foreign subsidiaries (Guadalupe et al., 2012) as well as on domestic firms in the recipient economy (see
Alfaro, 2017 and Rojec and Knell, 2017 for recent surveys about FDI spillovers). However, to the best of our knowledge, little it is known about the impact of multi-
nationals’ innovation decisions on their own investments abroad.

Our paper highlights that multinational firms might be interested in improving the perception of their products in foreign markets. This can be done by shaping patentable ideas and transforming them into products. In fact, we can think of patents as a measure of the number of ideas in a product, which would make it more valuable. Thus, our analysis relies on patent data at the firm level as the increase in patenting reflects new products introduction (Balasubramanian and Sivadasan, 2011). The intuition is that a firm’s innovative activities affect the probability the firm develops new product of process innovations needed to adapt their products to foreign tastes and this influences the future path of firm profits and FDI.

A novel aspect incorporated in our analysis is the role played by migrants in facilitating the improvement in the quality of the products by easing their process of adaptation to local standards. We focus on a very specific type of migrants: inventors who cross borders. In other words, those inventors nationals from country i who patent an invention in their host country j. This migrants can help multinational firms to adapt better to consumer’s preferences and tastes in the host economy and thus customize their products to attend local needs. Thus, an increase in inventor migrants will reduce the fixed cost of FDI and will boost FDI. To the best of our knowledge, our study constitutes the first attempt to cover the link between patents, greenfield FDI and migrant inventors over a long period of time and for a wide number of countries and sectors. The rest of the paper is organized as follow. Section 2 shows
some stylized facts that help to motivate our analysis. Section 3 provides an overview of the relevant literature. Section 4 presents the model. Section 5 describes the data. Section 6 details the estimation procedure and the main results. Section 7 concludes.

2 Stylized facts

Three empirical regularities motivate our work. We start by looking at the relationship between FDI and patents at the country level and then we magnify this relationship at sector and firm level.

Fact 1. **Total world’s FDI and patents have similar time trends.**

The yearly trends of FDI and patents in Figure 1 show analogous evolution. Figure 1a depicts the pairwise evolution of the aggregate greenfield investment of Multinational Enterprises (MNE) in their new foreign affiliates (right hand y-axis) and the patent activity of those same MNEs (left hand y-axis). We can clearly appreciate how both capital investment and patenting activity peak in 2008 follows a collapse in 2009, in line with the trade collapse of the Great Recession. The evolution of new affiliates shown in figure 1b follows a similar path, with a sudden stop in year 2009.

[Figure 1 about here.]

Fact 2. **FDI and patents are correlated at country level.**

At the country-pair level, bilateral FDI and patents are significantly correlated, as shown in Figure 2. Each dot represent a a country-pair in a particular year of
our dataset. The top Figure 2a shows correlates the aggregate investment between country pairs with the patent activity of MNEs at the source country. The correlation is positive and significant as in the lower figure 2b, where we repeat the exercise with foreign affiliates. The scatter cloud has clear a growing trend, which clearly increases towards the upper quantiles.

[Figure 2 about here.]

**Fact 3.** *Sectors with high patenting activity have also high volumes of FDI.*

In Figure 3, we have ordered the sectors in terms of their average patenting activity. We have then used patenting order to represent FDI activity. The leading patenting sectors (Software & IT services, Automotive OEM, Communications and Industrial Machinery) in the Figure 3a rank above the average in terms of yearly FDI projects in the Figure 3b. The data represented in Figure 3 also reveals sectoral heterogeneity in terms of patents and FDI. Patents are highly concentrated in the Software & IT sector, while FDI activity seems to be more evenly distributed.

[Figure 3 about here.]

**Fact 4.** *Firms with high patenting activity have also high volumes of FDI.*

The last stylized fact is related to firm heterogeneity, showing that individual firms with high patenting activity are also FDI champions. Figure 4 shows the evolution in terms of patents and FDI affiliates of IBM, a leading IT firm. The trends depicted in this figure resemble greatly the world’s evolution of Figure 1, highlighting the relevance of individual firms on aggregate outcomes.
Fact 5. *Migrant inventors and FDI are correlated*

Our final fact is related with inventors who cross borders. Theses are migrants which patent an invention in the host country. Figure 5 shows that FDI and these migrants follow similar trends (Figure 5a). At the country-pair level, FDI and migrant inventors are positively correlated, as show in Figure 5b.

3 Background

Innovation is the main conduit through which globalization affects productivity (Gorodnichenko et al., 2015). The positive impact of technology improvement and investment in knowledge on firm’s productivity have been found by previous papers. R&D expenditures seem to play a key role in determining the differences across firms as well as the evolution of firm-level productivity over time (see and Aw et al., 2011). Innovations seem to be capturing factors with a persistent influence on productivity such as the absorption of techniques, modification of processes, uncertainties related to investment in physical capital and gains and losses due to changes in labour composition and management abilities (Doraszelski and Jaumandreu, 2013).

We focus on a specific aspect of the innovative activity carried of multinational firms: Their capacity to adapt their products to the requirements of the destination market. The customization of products is expected to increase firm’s revenues at
the destination market and FDI. Previous studies have reported a higher innovation output of foreign-owned firms (when compared with domestically own firms) in terms of sales from new products (Dachs and Peters, 2014). An increase in patenting reflects innovation, rather than simply more protection of existing knowledge (Coelli et al., 2016). The evidence obtained by Balasubramanian and Sivadasan (2011) supports a strong link between patenting and the introduction of new products. This evidence supports the use of patents as a meaningful proxy of firm-level innovation.

Multinational companies might develop new products by adapting their subsidiaries to local needs and practices. These organisations have and incentive to endow offshore affiliates with their knowledge as efficiently as possible (Keller and Yeaple, 2013). Thus, when setting up an affiliate in a foreign country, the multinational firm not only has to pay a fixed cost of opening a new plant but also it faces the costs of transferring its knowledge. “(…) The cost of transfer vary with the knowledge intensity and the destination market (…) Because not all knowledge can be codified, offshore production calls for communication between home country CEOs and affiliate managers”. According to these authors, disembodied knowledge transfer cost (direct communications) quantitatively accounts for much of the gravity in multinational activity. Communication is more costly in knowledge-intensive goods as industries with high R&D intensity production techniques are subject to rapid change and frequent communication needs between manager in the home country and the affiliate. In similar terms, Alfaro and Chen (2018) emphasize that information frictions play a relevant role in explaining the geographic patterns and gravity of FDI. Cristea (2015) found that a way through which multinational firms can reduce
costly information transfers between parent companies and their affiliates is by hiring skilled workers at the host country of the investment. The availability of talent in the foreign market reduces communications costs between the headquarters and the affiliates as talented workers are able to carry out production activities with very little supervision.

Therefore, information play a role in the process of adaptation of products to the destination markets. Our paper explores a different mechanism through which parent firms can reduce the costs of knowledge transfers to distant affiliates: inventors migrants can reduce the cost of entering foreign locations by facilitating the process of adapting their products to foreign markets. We hypothesize that these migrants have a strong understanding of customer behavior and may provide insights about the types of products that would face higher levels of demand. This type of knowledge helps firms to increase the perceived quality of their products at the host country. This constitutes a rather specific and novel channel with respect to those already analyzed in most previous studies, which have mainly emphasized the role of migrants in reducing the fixed costs of setting a plant by mitigating general information asymmetries regarding their origin and destination countries (see Buch et al. (2006); Burchardi et al. (2016); Cuadros et al. (2016); Javorcik et al. (2011), among others).

Migrants can also promote collaborations with innovators and business developers in host countries. In fact, international migration exposes a country to the creative ideas of different people and may result in more innovation (Ortega and Peri, 2014). However, migrants’ contribution to innovation activity is still rather limited and
confined largely to the US (see Grossmann, 2016; Hunt and Gauthier-Loiselle, 2010; Kerr, 2008). According to Foley and Kerr (2013), ethnic innovators play a significant role in facilitating the expansion of US multinationals in ethnic regions: Increases in the share of a firm’s innovation performed by investors of a particular ethnicity are associated with increases in the share of that firm’s affiliate activity related to that ethnicity. These authors emphasize the higher knowledge and experience of innovators from a certain ethnicity which are crucial for developing products and services targeted at customers in countries associated with that ethnicity.

The recent contribution by Miguelez (2016) calls for the need of multi-country studies about the influence of migration on innovation. This author explores the influence of diaspora networks on international technology cooperation. The results show a strong relationship between inventor diasporas and different forms of international co-patenting between developed and developing countries. Contrary to most previous migrations studies that used census-based migration data based on ethnic name to assign a migratory background (see, for example Foley and Kerr, 2013; Kerr, 2008), Miguelez’ study relies on direct information about the nationality of the inventors by exploiting inventors’ information listed in patent applications (see Miguelez and Fink (2013)). The results obtained indicate that a 10% increase in the investor diaspora abroad is associated with a 2.0-2.2% increase in international patent collaborations. These results are not particularly driven nor by the country attracting the largest number of migrant investors (that is, US) neither by particular diasporas such as Chinese or Indian investors.

The policy implications of our analysis are relevant due to the potential effects
of the recent rise of economic protectionism. “The global innovation model long embraced by leading multinationals, one based on the free flow of information, money, and talent across borders, is at risk (… ) The policies inspired by economic nationalism may prove self-defeating, in part by disrupting R&D activities for the new products and services that will generate the jobs, growth, and wealth of the future” (Jaruzelski et al., 2017).

4 The model

Setup

Consider a world with $J$ small-open economies. In each of these countries, two final goods are produced, denoted by $A$ and $B$. Consumers derive utility for the consumption of these two goods. Preferences across these two goods are described by the following Cobb-Douglas utility function

$$U_j = X_{A_j}^\mu X_{B_j}^{1-\mu}$$

where $\mu$, $1 - \mu$ represents respectively, the importance of these two goods in the utility function and are assumed to be common across countries. The good $B$ is an homogenous good while the good $A$ is a differentiated good. More precisely, the good $A$ is composed of a continuum of varieties $\omega \epsilon \Omega$, and the preferences across different varieties are represented by means of the standard CES utility function,
\[ X_j = \left[ \int_{\omega \in \Omega} (q_j(\omega)x_j(\omega))^{\frac{\sigma-1}{\sigma}} d\omega \right]^\frac{\sigma}{\sigma-1}, \sigma > 1 \]

where \( x_j(\omega) \) denotes the consumption of variety \( \omega \), in country \( j \) and \( q_j(\omega) > 1 \) its the perceived quality of variety \( \omega \) in country \( j \). \( \sigma > 1 \) controls for the elasticity of substitution across different varieties.

Solving for the utility maximization problem that households face, we have that each household dedicates a fixed proportion of their income to spend in each of the composite goods, i.e.

\[ X_{A_j} = \mu R_j, \quad X_{B_j} = (1 - \mu) R_j \]

The demand for each variety is given by

\[ x_j(\omega) = (q_j(\omega))^{\sigma-1} \frac{\mu R_j}{P_j} \left( \frac{p_j(\omega)}{P_j} \right)^{-\sigma}, \quad (1) \]

where \( p_j \) is the price charged for the variety \( \omega \) in country \( j \) and \( P_j \) the CES adjusted-quality aggregate price index associated to \( X_j \), \( P_j = \left[ \int_{\omega \in \Omega} (p_j(\omega)/q_j(\omega))^{1-\sigma} d\omega \right]^{1/(1-\sigma)} \).

**Production and Investment in Quality.**

Producing final goods require both capital and labour. Firms in each sector produce using a Cobb-Douglas technology using the following production function:
\[ x_A(\omega) = \varphi \left( \frac{K}{\gamma} \right)^\gamma \left( \frac{L}{1 - \gamma} \right)^{1 - \gamma} \]

where \( \varphi \) is the firms’ TFP and common in the literature on firm heterogeneity, let us assume that it is obtained at the moment of firms’ entry and it is constant over time, \( x_A(\omega) \) is the total quantity produced of variety \( \omega \), and \( K \) and \( L \) are respectively the capital and labour used in production and \( \gamma \) represents the importance of physical capital in the production of each variety.

The homogenous good is produced in perfect competition using a constant returns to scale technology that is linear in labour. Let denote \( \varphi_{ Bj} = (\varepsilon_j)^{-1} \), the productivity of country \( j \) in the homogeneous good. Assuming that this good is freely traded and considering that this good is the numeraire for each country then the price will be equal to one. The latter implies that wages in each country are given by \( w_j = \varepsilon_j \).

Each firm, when entering, draws their productivity from a common productivity distribution which follows a Pareto functional form. More precisely, we have that

\[ \Pr(\varphi \leq \varphi_0) = 1 - (\varphi_0)^{-\kappa}, \varphi_0 \geq 1, \kappa > \sigma - 1 \]

In order to serve each market, the firm faces a fixed operational cost of \( f_{ij} \) units of capital and a variable trade cost (an iceberg transportation cost \( \tau_{ij} \)). When the firm is serving its own domestic market the firm does not incur in any trade costs \( \tau_{ii} = 1 \).

Firms can also invest in the consumer’s perceived quality at each destination market. This investment in quality is materialized in physical changes of the product which makes the product uniquely differentiated from one country to another and
therefore can be patented. More precisely the perceived quality of each product depends on the number of ideas the firm creates to get the product close to their customer’s needs. The mapping of ideas into quality is described by the following functional form:

\[ q_j(\omega)^{\sigma - 1} = (z_j(\omega))^\alpha, \ 0 < \alpha < 1 \]

where \( z_j(\omega) \), represents the number of specific ideas applied to the variety \( \omega \) in destination \( j \). Note that, for simplicity, we consider that ideas are destination specific.\(^1\) We assume that there are decreasing returns to scale associated to the application of ideas for a product in a specific destination. Ideas are produced using a technology described by the following cost function

\[ C(z) = \frac{w_i}{\theta_{ij}} z_j \varphi^{\sigma - 1} \]

where, \( w_i \) denotes the wage in the country of origin \( i \) . Note that the technology is linear in labour, the unique production factor. The number of workers needed to produce an idea, depends negatively on \( \theta_{ij} \), that represents the productivity of the workers in the country of origin \( i \) in making ideas applicable to the destination country \( j \) and it is increasing in the productivity of the firm \( \varphi^{\sigma - 1} \). The workers’ productivity \( \theta_{ij} \) will depend on the cultural distance between the country of origin of the workers \( i \) and the destination country \( j \).

\(^1\)A more extended version of the model may allow for some ideas to be destination specific while some other may be transferred to other destinations upon a cost. This analysis introduces a little bit more of complexity but we presume it does not have implications for the main results of the paper.
Finally, we are going to assume that the number of workers needed to produce ideas which improve the quality of the product increase with the complexity of the product, considering that the complexity is proxied by the productivity of the firm. This resembles earlier semi-endogenous growth models (Jones, 1995), where as the economy was moving to the technology frontier the cost of doing R&D increases. The implication of this assumption is that the investment in quality will not depend on the productivity of the firm, with all firms investing in the same degree of quality. Relaxing this assumption in this model, in which all firms invest in quality may not generate further interesting qualitative results.

The firm’s problem

Firms choose prices and the investment in quality by maximizing profits. Since the investment in quality is an R&D investment, following a long-tradition in industrial organisation, we assume that firms undertake their investment decision in quality first, and then they decide how much to produce and what price to charge for the product in each market.

The model is solved by backward induction. To solve for the firms’ optimal quality we need to find the firms’ cost function. Solving the standard firms’ cost minimization problem (See appendix for details), we have that the optimal cost function is given by:

$$ C(x, \varphi) = w_i \gamma \frac{r^{1-\gamma} x(\omega)}{\varphi} $$

It is important to notice that the cost function as long as the revenue function is separable across destinations and this allows us to solve for the optimal quality choice.
separately for each destination. Solving the standard firms’ maximization problem we have that:

\[ p_j = \frac{\sigma}{\sigma-1} \frac{w^*_j r^{1-\gamma} r_j}{\phi} \]

Substituting in the demand function and rearranging terms we obtain that the firms’ variable profit for each destination for a given quality level, which is given by:

\[
\pi_{vij}(\varphi) = p_{ij} x_{ij} - C(x_{ij}, \varphi) = (\tau_{ij})^{1-\sigma} B_{ij} (\varphi q_j)^{\sigma-1}
\]

where \( B_{ij} = \left( \frac{(\sigma-1)}{\sigma w^*_j r^{1-\gamma}} \right)^{\sigma-1} \left( \frac{1 - \mu R_i}{\phi^{\sigma-1}} \right) \) is constant from the point of view of the firm. Then the firm’s operating profits for a given quality level are given by:

\[
\pi_{oij}(\varphi) = (\tau_{ij})^{1-\sigma} B_{ij} (\varphi q_j)^{\sigma-1} - r f_{ij}
\]

Now we turn to the decision to the firms’ quality decision for each destination market. Firms’ solve the following maximization problem:

\[
\max (\tau_{ij})^{1-\sigma} B_{ij} (\varphi q_j)^{\sigma-1} - \frac{w_i}{\theta_{ij}} z_{ij} \phi^{\sigma-1} - r f_{ij}
\]

s.t. \( q_j(\omega)^{\sigma-1} = (z_j(\omega))^{\alpha} \)

This gives us the optimal quality decision

\[
q_j(\omega)^{\sigma-1} = \left( \frac{\alpha (\tau_{ij})^{1-\sigma} B_{ij} \theta_{ij}}{\varepsilon_i} \right)^{\frac{\alpha}{\sigma-\alpha}}
\]

Note that the firms’ investment on quality depends on the extent of the market.
and other variables determining the demand of the firm, \( B_{ij} \), the transportation costs \( \tau_{ij} \), the cost of labour \( w_i = \varepsilon_i \), the degree of decreasing returns associated with knowledge accumulation, \( \alpha \), and above all, the productivity of the workers in creating knowledge associated with market \( j, \theta_{ij} \). The more productive the workers are the larger will be the investment in quality to that specific destination. Note also that ceteris paribus firms will tend to invest more in the quality of their products in the domestic market. This is due to two mechanisms, the first one is the fact that sales are larger in the domestic market compared to the foreign market, since transportation costs makes our good more expensive into the foreign markets. Any improvement in quality, therefore yields higher profits in the domestic market. The second one, is through the variable \( \theta_{ij} \). If \( \theta_{ij} \) is related to cultural distance, as specified above, then native workers will have the largest productivity in creating ideas for their own domestic market. This largest productivity translates into a smaller cost in improving quality in the domestic market.

Note that the firms’ operating profits, once the investment in quality is made become

\[
\pi'_{o ij}(\varphi) = B_{ij} (\tau_{ij})^{1-\sigma} (\varphi q_j)^{\sigma-1} \frac{\varepsilon_i}{\theta_j} z_j \varphi^{\sigma-1} - r f_{ij} =
\]

\[
((\tau_{ij})^{1-\sigma} B_{ij})^{\frac{1}{1-\sigma}} \alpha^{\frac{\alpha}{1-\sigma}} (1 - \alpha) \left( \frac{\theta_{ij}}{w_i} \right)^{\frac{-\alpha}{1-\sigma}} \varphi^{\sigma-1} - r f_{ij}
\]

Three observations are worthy to be mentioned. First that, common to all Melitz (2003) models, the variable profits of serving any market, are proportional to a
measure of firms’ productivity $\varphi^{\sigma-1}$. A threshold level of productivity $\varphi^*_{ij}$ can be established such that firms with productivity $\varphi \geq \varphi^*_{ij}$ can serve the market $j$. Second, that, the operating profits of serving the exporting market are smaller than those ones in the domestic market. This is due to two main effects a direct effect that works through the increase in the cost of serving the market induced by transportation costs and an indirect and magnifying effect that works through the impact of transportation costs on quality. Note that under certain conditions, $\varphi^*_{ij} > \varphi^*_i$, where $\varphi^*_i$ the survival productivity threshold (domestic firms serving market $i$).

Note that the workers’ research productivity for ideas targeted to a specific destination $j$ becomes crucial in this productivity threshold. The larger this productivity is, the larger will be productivity threshold needed for survival.

**Introducing FDI**

Consider now the possibility that firms can invest in Foreign Direct Investment ($FDI$). In order to establish a plant there, firms need to invest in creating a new plant there for which they need to bear a cost of $f_{ij}$ units of capital. We are going to assume that, despite all the recent literature on offshoring $R&D$ activities, the improvement in the quality of the products are always done in the headquarters. 2.

Our paper is focused on the potential role played by destination specific R&D

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2In this version of the model we assume this for simplicity. However, during the last years there has been an increasing trend in outsourcing R&D activities. Although we are conscious about the implications of this, note that our results, regarding the importance of home country cultural distance on Foreign Direct Investment, will still hold as long as some of the investment in R&D activities are done in the headquarters.
activities on promoting foreign direct investment and the potential role of migration in these activities. In order to proceed, let us first assume a mapping between workers’ productivity in ideas and geographical distance. While $\theta_{ij}$ will capture more cultural rather than geographical distance we could firstly approximate the former by the latter, since on average countries which are closer to each other share a common culture compared to countries which are far from each other. Let us assume that the productivity of local workers $\theta_{ij}$ is inversely related to the transportation costs (i.e. distance) between both countries:

$$\theta_{ij} = \Delta_{ij} (\tau_{ij})^{-\beta}$$

where $\beta$ controls for the elasticity of workers’ productivity in the research sector to geographical distance (i.e. transportation costs), and $\Delta_{ij}$ captures other variables related to cultural distance and not account by geographical distance (i.e. having a common language, having a common border, being one country the ex-colony of the other etc..). Note that if the firm decides to invest in FDI, in country $j$ the operating profits in country $j$ will be given by:

$$\left(B_j\right)^{\frac{1}{1-\alpha}} \alpha^{\frac{\alpha}{1-\alpha}} \left(1 - \alpha\right) \left(\frac{\theta_{ij}}{\xi_i}\right)^{\frac{\alpha}{1-\alpha}} \varphi^{\sigma-1 - r_j f_Ij}$$

where notice that $B_j = \left(\frac{w_i}{w_j}\right) \gamma B_{ij}$. The latter implies that the benefits of undertaking FDI are given by
\[
\left( \frac{\varepsilon_i}{\varepsilon_j} \right)^{\frac{1}{1-\alpha}} - (\tau_{ij})^{\frac{1}{\alpha}} \right) (B_{ij})^{\frac{1}{1-\alpha}} \alpha \beta^\alpha (1 - \alpha) \left( \frac{\Delta_{ij}(\tau_{ij})^{-\beta}}{\varepsilon_i^\alpha} \right)^{\frac{\sigma}{1-\alpha}} \varphi^{\sigma-1} \geq r(f_{ij} - f_{Xij})
\]

Note that the left hand side of the previous equation, which represents the operating profits of undertaking FDI as opposed to exports is increasing in the productivity of the firm. As in Helpman, Melitz and Yeaple (2004) the higher the productivity of the firm, the higher the volume of sales in the destination country and the higher the profits of building a plant in the foreign country (since the saving in transportation costs overcomes easier the fixed cost of creating a new plant). This implies that there exists a productivity threshold level \( \varphi_{Ij} \) such that the firm will undertake FDI if and only if \( \varphi \geq \varphi_{Ij} \). The condition defining this productivity threshold comes from the previous expression at equality, that is:

\[
\left( \frac{\varepsilon_i}{\varepsilon_j} \right)^{\frac{1}{1-\alpha}} - (\tau_{ij})^{\frac{1}{\alpha}} \right) (B_{ij})^{\frac{1}{1-\alpha}} \alpha \beta^\alpha (1 - \alpha) \left( \frac{\Delta_{ij}(\tau_{ij})^{-\beta}}{\varepsilon_i^\alpha} \right)^{\frac{\sigma}{1-\alpha}} \varphi^{\sigma-1} = r(f_{ij} - f_{Xij})
\]

Note that the proportion of firms doing FDI within an industry increases will increase with the extent of the market \( B_{ij} \) and will decrease the larger the difference in fixed costs are (the extent to which firms benefit from concentration). These results are standard in the traditional proximity concentration trade-off involving the decision of the firm to do horizontal FDI. However we have two new predictions brought by our theory regarding the firm’s decision to build a plant in the foreign market. First, there is an inverse relationship between cultural distance and horizontal FDI.
More cultural distant countries implies a larger cost of adapting the product to local tastes. This implies that firms will invest less in adapting the product to those destinations. The latter implies that the firm’s sales will be low in these destinations and this will lead to less internationalisation. Second, by relating cultural distance with geographical distance, the model predicts an ambiguous relationship between geographical distance and FDI. This is just a combination of two different forces at work regarding geographical distance: Distant markets are more expensive to be served through exports. This promotes the creation of a plant in the destination market to save in transportation costs (Proximity mechanism). However, the cost of adapting the product to more distant markets is larger. The latter implies that firms tend to invest less in more distant markets (ceteris paribus) and so they tend to be less competitive in distant markets. As with cultural distance this force will work against internationalisation since the volume of sales to that particular destination will not cover the fixed costs of neither building a plant in the foreign country nor serving the foreign country via exports. The net effect is in principle ambiguous although under certain conditions the result found in the traditional horizontal FDI model will prevail. In any case, in this model the impact of distance on promoting FDI is attenuated by the presence of the quality improvement decision.

We are interested in deriving the gravity for FDI under the presence of country-specific innovation. By foreign direct investment, as traditional in the literature we consider the investment made in foreign capital by a firm in the home country. This can come from two sources: The investment made by each firm which has already established a company there (The intensive margin) and the investment made in
fixed costs by new multinational firms (the extensive margin). Note that conditional on having established a plant there, the value of the firm’s investment in foreign assets is given by

\[ r \gamma \left( \frac{w_j}{r} \right)^{1-\gamma} \frac{x_j(\omega)}{\varphi} = \gamma \frac{\sigma - 1}{\sigma} \alpha \frac{\alpha}{1-\alpha} B_{ij}^{\frac{1}{1-\alpha}} \left( \frac{\Delta_{ij}}{w_i} \right)^{\frac{\alpha}{1-\alpha}} \varphi^{\sigma-1}, i f \varphi \geq \varphi_{ij} \]

\[ 0 \quad \text{otherwise} \quad (2) \]

Note that the investment in foreign capital is decreasing in cultural distance which determines the productivity of the home workers in the research sector. The previous equation cannot be directly estimated because \( B_{ij} \) is an equilibrium variable and therefore endogenous.

Following Chaney (2008), it can be shown that \( B_{ij} = Z (Y_j)^\lambda \). Substituting this information in the previous equation and rearranging terms implies that:

\[ r_j K_j(\varphi) = \gamma \frac{\sigma - 1}{\sigma} Z (Y_j)^\lambda (q_j)^{\sigma-1} \varphi^{\sigma-1} \]

5 Data

The data used in this study is standard in FDI gravity literature and similar to previous studies (see for instance Myburgh and Paniagua, 2016, Cuadros et al., 2016 or Costa-Campi et al., 2018). The Financial Times Ltd. cross-border investment monitor (FDIMarkets, 2013) is the source of the FDI dataset. Patent data came

\[^{3}\text{Available on request}\]
from the Patstat. We matched the FDI and patent activity from 1450 firms in 19 activity sectors during 2003-2012. In total, 145 countries hosted investments from firms from 34 different countries.

Data for migrant inventors come from Fink and Miguelez (2013): Inventors nationals from country i residing in country j. Contrary to previous studies that determine the probable ethnicity of migrants by their names (see Foley and Kerr, 2013), Miguelez and Fink (2013) use direct information about the nationality of the inventors listed in patent applications.

The variable of interest, patents, was constructed aggregating the patent applications of all individual firms that invested in a particular country per sector and year. By doing this, we assume the non-rivaly of patents and therefore firms are able to use all their inventions in all investment destinations.

6 Results

In the next set of tables, we test our model with the estimation procedure developed with Larch et al. (2017), which takes care of popular biases in gravity estimates. All results control for time-varying multilateral resistance by adding the interaction of home and host dummies with year. The estimates include a full set of country-pair fixed effects to control for unobservable heterogeneity at the country pair level. This specification greatly reduces the type of control variables, which have to be time-varying at the country pair level in order to prevent co-linearity with the fixed effects.
Country-level results

We start by presenting country level-results in Table 1. The first two columns estimate the total investment flows in levels measured in million USD. Focusing on our variable of interest, increasing 1% the patenting volume of investing firms, increases by 0.05% the investment volumes between country pairs. In the second column, we examine the effect of credit constraints as moderator of this relationship. The results suggest, that those countries with systemic banking crisis, as defined by Laeven and Valencia (2012), reduces drastically the effect of patenting activity. In fact, the effects of patents are not statistically significant in the event of severe credit restriction at the host. However, this effect is not persistent when the crisis originates in the source country.

The two last columns of Table 1 report the result for the extensive margin. The estimates of patents are positive and significant to the 1% level. In average, a marginal increase in the patents at home, increase the number of foreign affiliates in 0.02%. Again, this result is annulled by a systemic banking crisis in the host country.

[Table 1 about here.]

Sector-level results

Sectoral results are reported in Table 2. In addition to time-varying country (home and host) effects and country-pair fixed effects, we added sector fixed effects to control for heterogeneity at the sector level. When we do so, the effects of patents on the intensive margin increase in magnitude as compared with the country level
results of Table 1. The estimates suggest that increasing patents by 1%, increases
the FDI volume flows in a particular sector of two country pairs by 0.13% on average.
The effect of patents on the extensive margin reported in the second column has also
a larger effect than at the country level, albeit lower in magnitude than the intensive
margin. This would suggest that the effect of patents is more intense in the volume
of FDI projects than on their number.

[Table 2 about here.]

In table 3 we presents the estimates of patents sector by sector. We can appreciate
how the results of the previous table captures and controls the heterogeneity across
sectors that was intuited in the styled facts on patents and FDI by sector. Patents
have a positive and significant effect on several sectors in both margins. However,
there are seven sectors on which patents has no significant effect (on the intesive
margin). There are four sectors (business services, consumer electronics, plastics and
semiconductors) where we appreciate a negative effects of patents on the intensive
margin and from these only the first two have a negative effect of patent activity on
the extensive margin as well. These sectors seem to be at odds with the rest sectors
where we appreciate a positive effect of patents (Automotive Components & OEM,
Chemicals, Communications, Electronic Components, Industrial Machinery, Medical
Devices, Metals, Rubber and Software). A plausible explanation for these reusults
might lie in the protection of intellectual property through industrial secrets rather
than patenting in these specific industries.

[Table 3 about here.]
Migration

In the next set of tables, we use migration as a control of flows of ideas between country pairs. The cost of adapting ideas to foreign markets might be alleviated by migrants. We use inventor migrants from Fink and Miguelez (2013). As expected, the results reported in 4 show that labor migrants have a positive and significant effect on both FDI margins. However, the magnitude of the effect is higher in the intensive margin. To test the moderating role of migrants in the effect of firm’s patent in FDI, we included the interaction between migrant inventors and patents. The interaction was found to be positive and significant in the intensive margin of FDI. This means that the effect of patents on FDI increases in the number of migrants. In other words, those country pairs with higher migrant inventors flows, the effect of patents on FDI is also higher.

[Table 4 about here.]

In Table 5 we tested the same specification with non-inventor migrants. Here, the interaction was non-significant, suggesting that the moderation effect of migrants is circumscribed to inventors.

[Table 5 about here.]

The investor dataset (Fink and Miguelez, 2013) allows us to distinguish between four types of migrant inventors: corporate, mechanical engineers, electrical engineers and chemists. We have mapped these inventors with the FDI activity sectors and regressed the effect of patents and migration for each sector. The results are reported
in Table 6. We can see how the individual sectoral results are in line with the previous aggregate results. However, we appreciate some notable exceptions in Automotive OEM, communications and pharmaceuticals. Like before, these results might be related to the protection of intellectual property through industrial secrets rather than patenting.

[Table 6 about here.]

**Sensitivity analysis**

We use an alternative measure of patents by taking the ratio of patents at origin and destination. Our results in Table (7) capture the positive effect predicted by the model. Particularly, patents are significant and positive for Non-resident patents and Resident in origin and Non-Resident in destination. However, when we measure patent distance measured as the ratio of patents filed by residents, this is not significant.

[Table 7 about here.]

Table (8) introduces a different migration measure: the stock of labour migrants. As expected, we find a positive result in line with previous work in this literature. Focusing on first three columns, where we add migration to patents, the effect of patents is absorbed by migrants. In column three we introduce the interaction between patent distance and migration. As we showed previously, patents and migrants interacted when migrants are also inventors.
In this specification, patent distance is significantly positive, although the idea flows in terms of patents seems independent from idea flows in terms of people. In the last three columns repeats the same exercise with patents filed by non-residents. We observe the same pattern as in the intensive margin.

[Table 8 about here.]

7 Conclusions

This paper shows that innovations, measured by patent activity of multinational firms at the source country, have a positive and significant effect on their Greenfield FDI at both the extensive as well as the intensive margins. This positive impact is mediated by a systemic banking crisis in the host country of investment. Our estimates also reveal the key role played by migrant inventors in reducing the costs of adapting products to foreign markets, enhancing in this way the impact of patents on FDI. The empirical analysis also reveals the importance of controlling for sectorial heterogeneity and the differential impact of patents across sectors and activities. We develop a model to explain the mechanisms through which these effects might operate. A relevant policy implication emerges from our analysis: Talent flows are at risk due to recent discretionary policies.

References


Table 1: Results: Country level evidence

<table>
<thead>
<tr>
<th></th>
<th>Intensive margin</th>
<th>Extensive margin</th>
</tr>
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<td>BIT</td>
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<td>-0.757**</td>
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<tr>
<td></td>
<td>(0.32)</td>
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<tr>
<td>FTA</td>
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<td>0.787***</td>
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<tr>
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<td>(0.15)</td>
</tr>
<tr>
<td>Patents</td>
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<td>0.045***</td>
</tr>
<tr>
<td></td>
<td>(0.01)</td>
<td>(0.02)</td>
</tr>
<tr>
<td>PatentsXcrisis (Host)</td>
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<td>-0.018*</td>
</tr>
<tr>
<td></td>
<td>(0.02)</td>
<td>(0.01)</td>
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<tr>
<td>PatentsXcrisis (Home)</td>
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<td>0.909</td>
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<td>Yes</td>
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<tr>
<td>Host*Year FE</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Country-pair FE</td>
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<td>Yes</td>
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Robust standard errors in parentheses, clustered by country pair

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Table 2: Results: Sector level evidence

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</tr>
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<td>(0.10)</td>
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<tr>
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<td>(12.97)</td>
<td>(0.17)</td>
</tr>
<tr>
<td>Patents</td>
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<td>0.055***</td>
</tr>
<tr>
<td></td>
<td>(0.02)</td>
<td>(0.01)</td>
</tr>
</tbody>
</table>

Observations 10511 10511

$R^2$ 0.989 0.992

Home*Year FE Yes Yes
Host*Year FE Yes Yes
Country-pair FE Yes Yes
Sector FE Yes Yes

Robust standard errors in parentheses, clustered by country pair

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Table 3: Results sector by sector

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<tr>
<th>Sector</th>
<th>Patent (Intensive margin)</th>
<th>Patent (Extensive margin)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automotive Components</td>
<td>0.186***</td>
<td>0.069***</td>
</tr>
<tr>
<td>Automotive OEM</td>
<td>0.158*</td>
<td>0.274***</td>
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<td>Business Machines</td>
<td>0.029</td>
<td>0.015</td>
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<td>Business Services</td>
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<td>-0.047***</td>
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<td>Chemicals</td>
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</tr>
<tr>
<td>Communications</td>
<td>0.046</td>
<td>0.079***</td>
</tr>
<tr>
<td>Consumer Electronics</td>
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</tr>
<tr>
<td>Electronic Components</td>
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<td>0.057**</td>
</tr>
<tr>
<td>Financial</td>
<td>-0.005</td>
<td>0.006</td>
</tr>
<tr>
<td>Food &amp; Tobacco</td>
<td>0.099</td>
<td>0.090</td>
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<td>Industrial Machinery</td>
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<td>0.035**</td>
</tr>
<tr>
<td>Medical Devices</td>
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<td>0.136*</td>
</tr>
<tr>
<td>Metals</td>
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<td>0.342***</td>
</tr>
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<td>Pharmaceuticals</td>
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<td>0.061</td>
</tr>
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<td>Plastics</td>
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<td>-0.008</td>
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<td>Rubber</td>
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<td>Semiconductors</td>
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<td>-0.047</td>
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<tr>
<td>Software</td>
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<td>0.027**</td>
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Notes: Control variables included but not reported
All estimates include a full set con country*year and country-pair FE

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
<table>
<thead>
<tr>
<th></th>
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<td>(3)</td>
<td>(4)</td>
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<tr>
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<td>0.045</td>
<td>0.058***</td>
<td>0.018</td>
</tr>
<tr>
<td></td>
<td>(0.03)</td>
<td>(0.05)</td>
<td>(0.01)</td>
<td>(0.03)</td>
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<tr>
<td>Inventor migrants</td>
<td>0.163**</td>
<td>0.082</td>
<td>0.092*</td>
<td>0.028</td>
</tr>
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<td></td>
<td>(0.07)</td>
<td>(0.08)</td>
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<tr>
<td>PatentsXInventors</td>
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<td></td>
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<td></td>
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<tr>
<td></td>
<td>(0.01)</td>
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<td>(0.01)</td>
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<td>4593</td>
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<td>0.991</td>
<td>0.995</td>
<td>0.995</td>
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<tr>
<td>Home*Year FE</td>
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<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Host*Year FE</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Country-pair FE</td>
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Robust standard errors in parentheses, clustered by country pair

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Table 5: Results: Total migrants and patents

<table>
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<tr>
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<tr>
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<td>Patents</td>
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<tr>
<td></td>
<td>(0.02)</td>
<td>(0.16)</td>
</tr>
<tr>
<td>Migrants</td>
<td>0.181**</td>
<td>0.191*</td>
</tr>
<tr>
<td></td>
<td>(0.08)</td>
<td>(0.11)</td>
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<tr>
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<td>$R^2$</td>
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<td>0.992</td>
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<tr>
<td>Home*Year FE</td>
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<td>Yes</td>
</tr>
<tr>
<td>Host*Year FE</td>
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<td>Yes</td>
</tr>
<tr>
<td>Country-pair FE</td>
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<td>Yes</td>
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</table>

Robust standard errors in parentheses, clustered by country pair

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Table 6: Results: Migration and patents sector by sector

<table>
<thead>
<tr>
<th>Migrant type</th>
<th>Sector</th>
<th>Intensive margin</th>
<th>Extensive margin</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Patents Migrants</td>
<td>Patents Migrants</td>
</tr>
<tr>
<td>Corporate</td>
<td>Financial</td>
<td>0.162*** 1.176***</td>
<td>0.055*** 0.356***</td>
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<tr>
<td>Mechanical engineers</td>
<td>Industrial Machinery</td>
<td>0.214*** 0.600**</td>
<td>0.024 0.175*</td>
</tr>
<tr>
<td></td>
<td>Automotive Components</td>
<td>0.322*** 0.296</td>
<td>0.161*** 0.320</td>
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<tr>
<td></td>
<td>Automotive OEM</td>
<td>-0.488** 0.376**</td>
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</tr>
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<td>Electrical engineers</td>
<td>Communications</td>
<td>-0.203*** 0.678</td>
<td>-0.076*** -0.342**</td>
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<tr>
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<td>Electronic Components</td>
<td>0.341*** 0.845***</td>
<td>0.059 0.575*</td>
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<td>Software</td>
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<td>Chemists</td>
<td>Chemicals</td>
<td>0.115*** -0.091</td>
<td>0.083*** -0.124**</td>
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<td>Pharmaceuticals</td>
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Notes: Control variables included but not reported
All estimates include a full set con country*year and country-pair FE
* p < 0.10, ** p < 0.05, *** p < 0.01
Table 7: Results: Country level evidence

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<td>Pat distance Residents</td>
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<td>Pat distance RES_o/NRES_d</td>
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<td>Host*Year FE</td>
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Robust standard errors in parentheses, clustered by country pair

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
### Table 8: Results: Country level evidence

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<tr>
<td>Labor migrants</td>
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Robust standard errors in parentheses, clustered by country pair

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Figure 1: Patents and FDI: trends

(a) Intensive margin

Notes: Greenfield FDI data comes from FDIMarkets and Patent data from Patstat
Figure 2: Patents vs FDI: country pair correlation

(a) Intensive margin

(b) Extensive margin

Notes: Greenfield FDI data comes from FDIMarkets and Patent data from Patstat
Figure 3: Patents and FDI: trends

(a) Patent per sector (yearly average)

(b) New affiliates per sector (yearly average)

Notes: Greenfield FDI data comes from FDIMarkets and Patent data from Patstat. Averages per sector and year, 2003-2012
Figure 4: IBM’s patents and FDI projects per year
Figure 5: Migrant inventors and FDI

(a) Trends

(b) Correlations

Notes: Greenfield FDI data comes from FDIMarkets and Patent data from Fink and Minguelez (2013)