Department of Economics and Statistics "Cognetti de Martiis"
Campus Luigi Einaudi, Lungo Dora Siena 100/A, 10153 Torino (Italy)
www.est.unito.it

Dipartimento Economia e Statistica Cognetti de Martiis

Working Paper Series

01/17

MIGRATION, COMMUNITIES-ON-THE-MOVE AND INTERNATIONAL INNOVATION NETWORKS: AN EMPIRICAL ANALYSIS OF SPANISH REGIONS

ANNA D'AMBROSIO, SANDRO MONTRESOR, MARIO DAVIDE PARRILLI and FRANCESCO QUATRARO

brick Bureau of Research on Innovation, Complexity and Knowledge

UNIVERSITÀ DEGLI STUDI DI TORINO

The Department of Economics and Statistics "Cognetti de Martiis" publishes research papers authored by members and guests of the Department and of its research centers. ISSN: 2039-4004

Migration, communities-on-the-move and international innovation networks:

An empirical analysis of Spanish regions

Anna D'Ambrosio[1,4]*, Sandro Montresor*[2]*, Mario Davide Parrilli*[3]*, Francesco Quatraro*[1,4]

December 2016

[1] *University of Turin, Department of Economics and Statistics "Cognetti de Martiis" (IT)*

[2] *Kore University of Enna (IT)*

[3] *Bournemouth University (UK)*

[4]*BRICK, Collegio Carlo Alberto (IT)*

Abstract

This paper investigates the impact of migration on innovation networks between regions and foreign countries. We posit that immigrants (emigrants) act as a transnational knowledge bridge between the host (home) regions and their origin (destination) countries, reinforcing their networking in innovation and facilitating their co-inventorship. We argue that the social capital of both the hosting and the moving communities reinforces such a bridging role, along with the already recognised effect of language commonality and migrants' human capital. By combining patent data with national data on residents and electors abroad, we apply a gravity model to the co-inventorship between Spanish provinces (NUTS3 regions) and a number of foreign countries, in different periods of the last decade. Both immigrants and emigrants are found to affect this kind of innovation networking. The social capital of both the moving and the hosting communities actually moderate this impact in a positive way. The effect of migration is stronger for more skilled migrants and with respect to non-Spanish speaking countries, pointing to a language-bridging role of migrants. Overall, individual and community aspects combine in accounting for the impact of migration on international innovation networks.

Key-words: Migrations; communities-on-the-move; international innovation networks; social capital.

JEL codes: R11; F22; O33.

Acknowledgements: The authors would like to thank Giovanni Campeol, Maria Litvinova, Ernest Miguelez, Andrè Rodriguez-Pose, Maria Luigia Segnana, and Paolo Zacchia, as well as the other participants to the 2016 AISRE conference (University of Ancona), the 2016 AQR workshop (University of Barcelona), the 2016 Conference of Italian Geographers (University of Turin), the 2016 lunch seminar of the University of Trento, for insightful comments and suggestions. The usual disclaimer applies.

1. Introduction

As regions are becoming increasingly more permeable to international flows of goods/services, capital and people, labour migration has come to intersect with the movement of communities and the scattering of populations across different countries, usually referred to as "diasporas" (Portes, 2000, Vertovec, 1999; Castles, 2002; Brubaker, 2006; Saxenian, 2006; Sonderegger and Taube, 2010). This has entailed novel implications, not only for the workforce composition, the skill and the wage profile of regions, but also for their production modes, their industrial structure and their entrepreneurial and innovation activities (e.g. Piore, 1986; Ottaviano and Peri, 2006; Peri and Sparber, 2008; Niebuhr, 2010; Lewis, 2013; De Arcangelis et al., 2013; Gagliardi, 2015).

In addressing these new aspects, an additional role of migration has been identified with respect to the "injection" ("expulsion") of (more or less skilled) labour in (from) regional economies, by contrasting the cultural and cognitive homogeneity of communities on the move, with their diversity with respect to the hosting ones. In this respect, migration flows and diasporas have been claimed to act as "information brokers" between the host and the home regions, working as a transnational knowledge link, which allow them to get different kinds of economic benefits, like those accruing from engaging in international trade and FDI (Rauch and Trinidade, 2002; Wagner et al., 2002; Peri and Requena-Silvente, 2010; Felbermayr et al., 2014).

The knowledge flows brought to local economies by migration have recently attracted more direct attention with respect to regional innovation patterns and performances. The analysis has so far concentrated on mapping and investigating the effects of international knowledge flows that are revealed by phenomena of cross-regional (and cross-country) patent citations, inventors' collaborations, and co-inventorships (Almeida and Kogut, 1999; Agrawal et al, 2006, 2008; Breschi and Lissoni, 2009, 2006a, 2006b; Quatraro and Breschi, 2016). Out of these phenomena, the present paper focuses on the international innovation networks that lead to cross-regional, foreign co-inventorships, through which regions can increase their innovation and economic performance (cfr. Broekel et al 2015; Miguelez and Moreno, 2015; 2013)). In particular, maintaining that these co-inventorships are the typical outcome of knowledge networks that, formally and/or informally, extend beyond the focal inventors, we investigate the extent to which they are affected by the stock of regional migrants and by the social capital that make of the hosting populations, and of the migrant ones, bridging communities. In so doing, we aim at extending the extant literature in at least two respects.

First of all, by drawing on economic geography and combining it with recent local/regional studies on innovation systems (Autio, 1998, Cooke et al., 2004, Breschi and Lissoni, 2001, Paci and Usai, 2000, Tödtling and Trippl, 2005, Boschma, 2005), we extend the analysis of mobile skilled workers and inventors, and look at migration in broader terms, along the lines of this special issue. We argue that, even if with possibly lower levels of formal education and training, immigrants and emigrants can embody a tacit kind of knowledge and experience that can promote the exchange of more formal and codified knowledge between co-inventors. Second, by referring to the literature on diasporas and international knowledge diffusion (Agrawal et al, 2006, 2008; Miguelez, 2016), we also extend its analysis by investigating if social capital, as a crucial aspect for the community nature of the hosting and the migrant populations, can facilitate the impact of migration on cross-regional co-inventorship. We argue that such an impact can be positively moderated by a bridging kind of social capital and by a social kind of proximity, which can help local (foreign) inventors to counteract the physical distance to foreign (local) inventors.

By combining different sources of available data, we test these arguments with respect to the co-inventorship between Spanish provinces and an ample set of foreign countries over different periods of the last decade. In particular, we use a gravity model of knowledge flows quite standard in the literature (e.g. Maurseth and Verspagen, 2002; Paci and Usai, 2009; Picci, 2010), which we originally specify at the province-country dyadic level with respect to co-inventorships.

Results generally support our arguments, with the exception of that on language communality, as the impact of migration is stronger with respect to non-Spanish speaking countries. The implications of these results are discussed in Section 4, after having grounded our hypotheses in the literature, in Section 2, and presented the empirical application, in Section 3. Section 5 concludes.

2. Background literature and research hypotheses

In a recent stream of research, across regional and innovation studies, an important link has been ascertained between the innovation performance of regions and the mobility of skilled human capital and inventors towards local contexts (e.g. Faggian and McCann, 2006; Niebuhr, 2010; Trippl, 2013; Gagliardi, 2015). This mobility can actually favour inter-regional knowledge flows with a high innovation impact, like those revealed by cross-regional patent citations and co-inventorships (e.g. Maurseth and Verspagen, 2001; Paci and Usai, 2009; Quatraro and Usai, 2016). On the one hand, this mobility increases the spatial proximity among inventors and their face-to-face interaction, augmenting the chances of making mutual use of their innovative knowledge – as for patent citations – and of participating to common innovation networks – as for co-inventorships. On the other hand, the transaction costs associated to the mobility of inventors can be compensated by their non-spatial proximity, as guaranteed by their common belonging to the same disciplinary and/or professional network, and by their sharing common experience, mutual appreciation and trust (Thompson and Fox-Kean, 2005; Agrawal et al., 2006, 2011; Breschi and Lissoni, 2009; Singh, 2005).

When we focus on co-inventorships, and on the kind of knowledge exchange and innovation networking that they generally entail, and additional kind of mobility can affect their occurrence: that of immigrants and emigrants at large. Indeed, unlike patent citations and other kinds of knowledge flows, co-inventorships require the inventors to confront their learning routines and practices, exchange also tacit and procedural knowledge and, in so doing, access wider and nested networks and sub-networks (Montobbio and Sterzi, 2013; Quatraro and Usai, 2016), to which immigrants and emigrants can also take part.

Regional studies have hardly addressed this general impact of migration on knowledge flows in international co-inventors' networks. Yet, from our standpoint, migrants can play an important role as facilitators of these mechanisms of knowledge exchange, given their simultaneous involvement in both their home and the host country (Coe and Bunnell, 2003; Williams, 2007; Basch et al. 1994). In particular, drawing on the research about the drivers and obstacles of international co-inventorships (e.g. Picci, 2010; Montobbio and Sterzi, 2013; Miguelez, 2016), we argue that migrants contribute to their realization by lowering the communication and cultural barriers between inventors that hamper their occurrence. For instance, the migrant workers of a domestic firm can interact with the local entrepreneurs and help them getting familiar with the cultural approach to the economic and innovation activities of their home country, thus favouring a potential co-inventorship between local and foreign entrepreneurs, which would not have happened otherwise. In brief, this could increase the probability that local inventors co-invent with foreign inventors. More in general, the migrants' familiarity with the business climate and the socio-cultural context of both their home and their host countries may be an asset that local inventors can use to connect their innovative ideas with those of distant foreign inventors (D'Ambrosio, 2015).[1]

The previous arguments constitute the basis of our first research hypothesis, which is twofold, as we can specify them with respect to immigrants and emigrants:

H1.a) *Immigrants favour the occurrence of co-inventorship between their hosting regions and their countries of origin.*

H1.b) *Emigrants favour the occurrence of co-inventorship between their home regions and their destination countries.*

Using a different, but related angle, these two hypotheses can be also interpreted in terms of substitution between different kinds of proximity: an issue on which evolutionary economic geography has recently concentrated (Boschma, 2005; Ponds et al., 2007). In brief, even in absence of their own mobility, the geographical distance between regional and foreign inventors can be compensated by the spatial and social proximity between the former (the latter) and the immigrants (emigrants). Through this twofold proximity to local inventors, migrants can actually interact with them in such a way to transmit important procedural/tacit knowledge of their home country, which can be helpful for co-inventorships between geographically distant inventive partners.

Our second research hypothesis concerns the role of the social capital, of both the hosting and the moving communities, in the occurrence of cross-regional foreign co-inventorships. In particular, out of the two configurations identified in the literature (Putnam, 2000; Dekker and Uslaner, 2001; Adler and Kwon, 2002), referring to social capital that 'bonds' and 'bridges', similar and diverse people, within and across a certain network, respectively, it is the latter that reveals the most. Indeed, by definition, bonding refers to networks bringing "together people who are like one another in important respects", among which a common *ethnicity* is the most important (Putnam and Goss, 2002: 11), and thus sets it quite aside from our research context. On the other hand, bridging refers to "cooperative connections" and "inclusion" with respect to people "from different walks of life", especially in terms of country of origin and ethnicity (Schuller et al., 2000). Focusing on this last configuration, the

---

1 One could go even further and, following Saxenian (2006) and Parrilli (2012), argue that transnational co-inventorship ties are enabled by circular migration pathways, embodying tacit and non-scientific knowledge gained in different communities. As we will say, these patterns of circular migration will not be addressed in the empirical application, as we are only able to capture a rather simplistic dual origin-destination migration flow.

impact that immigrants can have on co-inventorship as from H1.a could be reinforced, on the one hand, by the social capital of the hosting community, leading to a higher socio-economic integration of immigrants in the focal region (Portes and Sensenbrenner, 1993; Putnam, 2000), on the other hand, by the social capital of the immigrant community itself, which presumably makes it more willing to convey and spread in the hosting region the cultural aspects of their home countries. For similar and symmetric reasons, we can argue that the impact of the regional emigrants on co-inventorship as from H.1b could be reinforced by the social capital of their destination community as well as by their own social capital, as a moving community.

On this basis, and referring to the bridging nature of social capital, we posit our second, twofold hypothesis:

H2.a) *The impact of immigrants on the occurrence of co-inventorship between their hosting regions and their countries of origin is positively moderated by: 1) the social capital of the hosting community; 2) the social capital of the immigrant community.*

H2.b) *The impact of emigrants on the occurrence of co-inventorship between their home regions and their destination countries is positively moderated by: 1) the social capital of the destination community; 2) the social capital of the emigrant community.*

Like in the case of HP1, also HP2 can be supported by referring to the compensation between different forms of proximity. In brief, the social capital of the hosting (moving) community adds to the spatial proximity between regional (foreign) inventors and immigrants (emigrants), a social kind of proximity that can help local (foreign) inventors to bridge the physical distance to foreign (local) inventors.

While Hp1 and HP2 are the two focal hypotheses of the paper, the analysis of migration for co-inventorship in international innovation networks should also consider other aspects, which have already been shown to have a role in the literature. This is particularly the case of the language commonality between migrants and recipient countries, and of the human capital hold by migrants in terms of education and qualification. Drawing on and extending the literature on migration and international trade (e.g. Peri and Requena-Silvente, 2010; Felbermayr et al., 2014), with respect to language commonality, and the literature on inventors and skilled labour mobility, with respect to human capital (Faggian and McCann, 2006; Niebuhr, 2010; Trippl, 2013; Gagliardi, 2015), we claim that each of these two aspects should positively moderate the impact that immigrants and emigrants have on cross-regional foreign co-inventorship, as from H1.a and H1.b, respectively.

3. Empirical application

Our empirical application refers to 50, out of the 52 administrative provinces (NUTS3 regions) of Spain (excluding Ceuta and Melilla), with respect to 73 countries worldwide (see Table A2.1 in Appendix 2), for a total of 3,650 dyads. These are observed over the periods 1998-2011, for the analysis of immigrants, and 2006-2011, for that of emigrants and of both together.

The choice of Spain is first of all one of relevance. As shown by previous studies, Spanish provinces, invested by fast growing and regionally heterogeneous migration phenomena (Instituto Nacional de Estadística, INE[2]), benefit from significant immigrants' and emigrants' network effects with foreign countries, whose positive impact has been found especially in terms of international trade linkages (e.g. Peri and Requena, 2010; D'Ambrosio and Montresor, 2016). The choice has also been data-driven, as official Spanish data-sources on residents and voters – for the measurement of immigrants and emigrants – could be easily accessed and linked with the OECD REGPAT database – for measuring co-inventorships – with the European Value Survey and the World Value Survey – for measuring social capital at the country level – as well as with other Spanish data on other socio-economic variables – INE for GDP per capita, and the Ivie Study for social capital at the Spanish provincial level (see Appendix 1 for details on the data-sources).

3.2 Model and variables

The model we use to test our research hypotheses is a gravity model for the analysis of knowledge flows widely used in the extant literature (Maurseth and Verspagen, 2002; Paci and Usai, 2009; Picci, 2010; Maggioni et al, 2011; Montobbio and Sterzi, 2013; Cappelli and Montobbio, 2013). Consistently with its logic, we retain that the exchange of knowledge entailed by a co-inventorship between a focal region, *i*, and a foreign country, *j*, is hindered by the geographical and non-geographical (in particular, cognitive, cultural and technological) distance among the relative inventors (Criscuolo and Verspagen, 2008; Picci, 2010,

---

2 Evolution of the foreign population in Spain since 1998. http://web.archive.org/web/20070929140743/http://www.ine.es/inebase/cgi/axi?AXIS_PATH=/inebase/temas/t20/e245/p08/l0/&FILE_AXIS=04001.px&CGI_DEFAULT=/inebase/temas/cgi.opt&COMANDO=SELECCION&CGI_URL=/inebase/cgi/

Montobbio and Sterzi, 2013), and “attracted” by their respective “masses” of knowledge, for example in terms of R&D, absorptive capacity, and human capital (Montobbio and Sterzi, 2013). More precisely, following the literature on the pro-trade effects of migrants, in order to test their knowledge-bridging role, we include migrants between each province-country dyad among the factors that reduce the bilateral costs between them.

Coming to the variables, the *dependent* one is the log of the number of patent co-inventorships (plus 1, in order not to lose zeros), in turn obtained by counting all patent applications where at least one inventor resides in a Spanish province and one abroad. Standard fractional counting procedures for multiple inventors are adopted, as well as standard reference is made to the priority year of the patent application.

As for the *independent* variables, following the literature on gravity models with panel data (e.g. Head and Mayer, 2014; De Benedictis and Taglioni, 2011; Baldwin and Taglioni, 2007), we mainly account for the “masses” of the involved pairs through time-varying fixed effects.[3] More specifically, on the one hand, we include time-varying, country-level dummies, ψ_{jt}, which proxy for the mass factors that typically attract knowledge in countries, like their aggregate R&D efforts, stock of patents, quality of the educational system, as well as their GDP, along with their variations. On the other hand, we do the same to proxy provincial knowledge attractors but, in order to avoid problems of model saturation with time-varying, province (NUTS3)-level dummies (Bratti et al. 2014), we rather include a set of them at the (NUTS2) region (*r*) level, φ_{rt}. Being provinces our focal units of analysis, however, we add to these fixed effects, two variables that account for the province-specific capacity to attract knowledge, that is, the lagged log of the provinces’ GDP and of their stock of patent applications (drawn from the INE web-site). In absence of more reliable disaggregated data, these can actually be taken as proxies of the provinces’ absorptive capacity (R&D data are not available at this level) and of their human inventive capital, respectively.[4]

3 On the advantages of including fixed effects rather than specific attractor variables, mainly in capturing the average amount of knowledge each node exchanges each year with the whole world, see for instance Anderson and Van Wincoop (2003), Baldwin and Taglioni (2007), and Head and Mayer (2014).

4 We also run our regressions substituting the stocks of patents with the stock of inventors, obtaining similar results, available from the authors on request.

As to distance-related regressors, we include the great-circle distance in km between each province and the capital city of each partner country and, to account for factors other than geographical proximity, which could influence the bilateral costs of exchanging knowledge – like, for instance, the similarity of the technological portfolio across pairs - we add a bilateral fixed effect χ_{rj} at the country j-NUTS2 region r level.

In the previously defined standard setting of gravity variables, we then plug our focal ones and consider the log of the stock (plus 1) of immigrants from country j to province i, and of the stock of emigrants from province i to country j, at time t - 1. Indeed, as both our hypotheses refer to the role of migrants as part of networks, consolidated stocks appear more adequate than variable flows to capture their actual size and to proxy their nature of communities (Rauch and Trinidade, 2002).

With all of the previous positions, our econometric model is the following:

$$\ln(1 + Co\text{-}inventorship_{jit}) = \psi_{jt} + \varphi_{rt} + \chi_{rj} +$$
$$+ \beta_1 * \ln(GDP_{it-1}) + \beta_2 * \ln(1 + Patent\_Stock_{it-1}) +$$
$$+ \beta_3 * \ln(1 + Immigrants_{jit-1}) + \beta_4 * \ln(1 + Emigrants_{ijt-1}) + \beta_5 * \ln(Distance_{ij}) + \varepsilon_{jit} \quad (1)$$

In order to test our first research hypotheses (H1.a and H1.b), we run different specifications of model (1). We first focus on immigrants, and fully exploit the length of our panel (1998-2011). We then look at emigrants, as it this shrinks the length of the panel to 5 years only (2006-2011). Finally, we include both immigrant and emigrant stocks, comparing their effects over the period 2006-2011.

As for the second set of hypotheses, the first part of H.2a is tested by augmenting model (1) with the inclusion of a variable of social capital for province i, at time t ($Social\_Capital\_Host_{it}$) obtained from the Ivie Study (see Appendix 1). While this measurement does not distinguish between bridging and bonding social capital, it refers to elements (e.g. the connectivity of social networks and inequality) that in principle could pertain to both, and which can thus inform us, though not exclusively, about the role of bridging, on which we have built up our hypothesis. More precisely, H2.a1 is tested by interacting the stock of immigrants from country j to province i, with two social capital related dummies, capturing the provinces that score more and less than the year-median in terms of social capital, that is, *Social_Capital_Host_H* and *Social_Capital_Host_L*, respectively. H.2a1 can be deemed confirmed if the former moderates the impact of immigrants on co-inventorship more than the latter, if not even uniquely.

Because of data availability, testing the second part of H.2a is more difficult and inevitably less accurate. In particular, in order to have a comprehensive and time-variant indicator of the social capital of the immigrant communities, we had to assign to them the level of social capital that the European and the World Value Survey recognise to their country of origin (see Appendix 1). By assuming that immigrants embody and bring with them the social capital of their own country, we entail that, for example, the immigrated Turkish of Valencia have the same social capital of the Turkish immigrated in Madrid, being that the social capital of Turkey. Although with this strong assumption, the Survey enables us to explicitly refer to a bridging configuration of social capital (looking at the country share of respondents declaring to volunteer in "bridging" associations), $Social\_Capital\_Im_j$, and to build up two dummies, distinguishing immigrant communities (countries) that score high, *Social_Capital_Im_H*, and low, *Social_Capital_Im_L*, with respect to it. Similarly to H.2a.1, also H.2a.2 is confirmed if the former moderates the impact of immigrants on co-inventorship more than the latter, if not even uniquely.

Data availability turns out even more limiting in testing for H.2b.1. On the one hand, still by relying on Value Survey data, we are forced to equate the social capital of a destination community with that of the relative country: for example, the social capital of any destination Turkish community of Spanish emigrants is assumed to be equal to that of Turkey. In so doing, a $Social\_Capital\_Dest_j$ variable can be built up similarly to *Social_Capital_Im*, and the two correspondent dummies, *Social_Capital_Em_H*, and *Social_Capital_Em_L*, interacted with the stock of emigrants from province i to country j. H.2b.1 is thus confirmed if the former moderation is higher than the latter, if not even uniquely significant.

Finally, the test of H.2b.2 would require measuring the social capital of a community emigrating from province i to country j, which is not available either. As a second-best solution, we assume that such a community brings with it the social capital of the province from which it emigrates, as is measured by $Social\_Capital\_Host_{it}$. Accordingly, we test for H.2b.2 by interacting the stock of emigrants at stake with *Social_Capital_Host_H* and *Social_Capital_Host_L*, and retained it confirmed if the former moderates the impact of emigrants on co-inventorship more than the latter, if not even uniquely.

A moderating procedure is also followed to investigate the role of language commonality, by interacting both the immigrant and the emigrant stocks with a dummy (*Spanish*), equal to 1 if the partner country of the considered pairs is Spanish-speaking (either as an official language or because Spanish is currently spoken) and 0 otherwise – and with its complement to one. The same is done with respect to the role of human capital, for which reliable data – from the OECD-DIOC database (see Appendix 1) – are only available for immigrants to Spain. Accordingly, such a stock is interacted with a dummy variable (*Qualified*), which takes value 1 if the immigrant population is comparatively qualified (the ratio between ISCED 3-6 codes and ISCED 0-2 exceeds the median) and zero otherwise – and with its complement to one.[5]

In Appendix 2, Table A2.2 reports the summary statistics of our variables, and Table A2.3 the correlation matrix, from which collinearity problems appear excludable, as VIF testes (available on request) actually confirm.

The nature of the variables defined above should of course be carefully retained in choosing an appropriate strategy to estimate model (1). In particular, the count nature of our dependent, which is also quite zero-inflated, requires special care. As we argue more extensively in Appendix 3, a Poisson Maximum Likelihood Estimator (PPML) might seem the most suitable choice for that, but only apparently. Indeed, following Head and Mayer (2014), OLS turn out to be more accurate in terms of elasticity and will be thus followed in the benchmark estimates, reporting the PPML ones in Appendix 4 as a robustness check.

4. Results

We begin our analysis from the base-line specification of the model, with no interacting terms. Starting with the stock of immigrants (1998-2010), in columns (1) and (2) of Table 1, the "mass-attractor" variables at the province level (GDP and stock of patents) have the expected significant and positive effect on knowledge flows. Still in line with expectations, the coefficient of the distance variable is significant and negative, thus supporting the choice of the gravity model for our analysis.

Insert Table 1 around here

5 The information about the average immigrants' qualification is not available for Cyprus, Estonia, Kazakstan, Latvia, Madagascar, Malta, Malaysia, Netherlands, Serbia, Uzbekistan in the version at our current disposal, which reduces the observations to a maximum of 42,700 when the high-qualification variable is included.

The fit of the model (R-squared and AIC statistics) increases when including the stock of immigrants (from column (1) to (2)), confirming their relevance too. The coefficient is significant and positive, supporting our hypothesis H1.a about their role in bridging co-inventors in innovation-based knowledge. Increasing the immigrant population by 10% would increase the count of co-invention ties by approximately 0.3%, adding more than 10 new ties.

Looking at the stock of emigrants (2006-2010), also H.1b gets confirmed. In Table 1, adding emigrants to the baseline (from column (3) to column (4)) still improves the model fit, and the coefficient is significantly positive, with an elasticity of nearly 0.5%. Emigrants do also affect the occurrence of co-inventorship between their home province and their destination country, and when they are both retained (column (5)), to a larger extent than immigrants affect the co-inventorship between their host province and their home country: the elasticity is actually more than 0.3% higher. This might be explained by the relative high degree of education of the Spanish population migrating to the rest of Europe (e.g. UK, Germany and France) vis-à-vis the migrant population reaching the Spanish provinces from Northern Africa and Latin America. Overall, we find support of the fact that international innovation networks could actually be wider than usually retained by looking at the relationship between inventors and at their mobility. Indeed, migration networks at large could intersect with inventors-networks and even affect their co-inventorship outcome.

Insert Table 2 around here

Table 2 reports the results of the estimates obtained by including province-level measures of social capital (Column 1) as well as its relevant interactions. Although by impairing their order of presentation in Section 2, these can be used to test our hypotheses about the moderating role that the (bridging) social capital of the hosting community and of the emigrating one have with respect to the co-inventorship impact of the immigrants (H.2a.1) and of the emigrants (H.2b.2), respectively.[6]

6 It is worthwhile noticing that, as with respect to Table 1, the effect of immigration on co-inventorship changes significantly before and after 2006, that is, across the burst of the financial crisis. To get clearer insights on this issue, in a set of unreported regressions (available upon request), we have split our sample and studied the effects of immigration on patent co-inventorships before and after 2006. The results confirm that the pre-2006 effect is quite large (close to 0.06) and significant, while the post-2006 effect is smaller and, when included jointly with emigration, even insignificant. This is in line with a closer approach to generic immigration (i.e. unskilled) in times of recession (i.e. higher fear of employment displacement, among others).

Starting with the hosting community (columns (1) and (2) for 1998-2011), let us observe that its social capital does not impact on co-inventorship, when its interaction with the stock of immigrants is *not* considered (column (1)). Its role with respect to the international innovation networks at stake seems to be somehow conditioned by its "application" to immigration flows, supporting our argument. Indeed, when the stock of immigrants is interacted with *Social_Capital_Host_H* and *Social_Capital_Host_L* (column (2)), the variable *Social_Capital_Host* becomes significant and negative[7], but more than compensated by the positive coefficients of the interaction themselves[8]. . More importantly, the moderation of the social capital at stake is twice as large in provinces with high social capital with respect to low ones, thus confirming our H.2a.1.

The argument about the conditioning role of immigration for the impact of social capital gets confirmed when we refer to the shorter period, 2006-2011 (column (3)), for which we have emigration data, and extends to emigration itself (column (4)) and to their joint consideration too (column (5)). In all of these specifications ((3), (4), and (5)), omitting its interaction with the stock of migrants, makes social capital irrelevant for co-inventorship, thus confirming that its bridging nature could actually be the one that reveals for its occurrence. With respect to the same period, H.2a.1 about the social capital of the hosting community for immigration gets also confirmed (column (6)).

When we look at the social capital of the emigrant community, though with the limitations we could capture it (see Section 2.3), our H.2b.2 appears confirmed, both when emigration is considered alone (column (7)) and along with immigration (column (8)). In both cases, with the usual caveat about the negative sign of *Social_Capital_Host*, the interactions between the

---

7 The result that the main effect of social capital in these specifications is negative and significant could be interpreted in two opposing ways: as a substitution of transnational coinventorships with domestic coinventorships, or as a reduction of coinventorships in absolute terms. Unfortunately, with the current structure of our data, we cannot test which interpretation is more suitable.

8 The net effect obviously depends on the values of both *Social_Capital_Host* and *ln(1+Immi)*Social_Capital_Host_H* (as well as *Social_Capital_Host_L*). For instance, by log social capital values of 2.7, a value which is above the median in all years, the main effect of social capital would be -0.087. The average log of immigrant stocks in high social capital provinces is 3.12. Plugging this value in our equation, and multiplying it by the dummy *Social_Capital_Host_H*, which in this case is equal to 1, we get 0,099, which offsets the negative effect. Because our main interest is on the differential effect of immigrants in high and low social capital provinces, we have not included a standard continuous interaction term, with a view to improve the readability of the results. Also, for the same reason, ln(1+Immi) and ln(1+Emi) appear only in interaction with *Social_Capital_Host_H and Social_Capital_Host_L*. A more standard interaction specification yields similar results and is available upon request.

stock of emigrants and *Social_Capital_Host_H* and *Social_Capital_Host_L* are both significant and positive, and again the former is twice as larger than the latter. As expected, possibly by picking up the social capital of their departing province, emigrants become more bridging with their destination communities and make the co-inventorship impact of their information-broker role (as from H.1b) more effective.[9] Overall, these results indicate that social capital is an asset (especially when it is of a bridging nature) as a means to promote, and possibly "export", openness to new cultures, integration and collaboration through knowledge flows leading to prospective innovation.

Table 3 augments the base-line model (1) by including social capital measurements at the country-level. As we said, we associate them to the immigrant and to the destination communities, in order to test for their social capital in moderating the co-inventorship impact of immigration and emigration, respectively. Once more, although by impairing the original order of their illustration in Section 2, using these data allows us to test for H.2a.2 and H.2b.1

Insert Table 3 around here

Starting with the social capital of the immigrant community, our H.2a.2 gets confirmed with respect to the 1982-2010 period (column (1)). Indeed, as the interaction between immigrants and *Social_Capital_Im_H* is the only significant one, it seems like the knowledge bridging role of immigrants for the sake of co-inventorship is entirely to be attributed to those marked by a high level of bridging social capital. This result seems to justify the interpretation for which it is openness and bridging social capital that drives the possibility to integrate new and relevant tacit knowledge that (may) boost innovation processes in the host country.

H.2a.2 is also confirmed with respect to the later sub-period (column (2)), as well as when emigration is considered along with immigration in the same temporal window (column (4)), though the effect is mitigated. When the destination communities (countries) are considered, although with the limitations we have been able to do it, the interaction with the stock of emigrants directed to them appears larger and only significant for those destination communities whose social capital is higher (column (3)) – *Social_Capital_Emi_H* – also when the stock of immigrants is retained (column (4)) . Our H.2b.1 is thus also supported,

---

9 It should be noted that, in the specification with both immigrants and emigrants (column (8)), H.2a.1 is not supported anymore, confirming the stronger role of emigration for the innovation networking at stake that we identified in Table 1, and suggesting that social capital might be more relevant as a feature of the emigrating community than as a feature of the hosting community. .

confirming in outward terms the magnifying role, with respect to the co-inventorship impact of migration, of the social capital of the hosting community, which we already detected in inward terms (H.2a.1).

Overall, an important result emerges from the test of our second set of hypotheses. The positive effect of immigration and emigration on knowledge flows in international innovation networks is, not only augmented, but even activated by higher levels of social capital in both the hosting and the migrant communities. This provide us with a strong economic case for promoting a bridging social culture towards migration, for example by promoting bridging kind of associations, which could entail an important innovation premium.[10]

Before concluding our analysis, let us turn to the moderation role that we expected from language commonality and human capital. As for the fomer, the results of Table 4 contradict our expectations.

Insert Table 4 around here

The positive effect of migration stocks is mainly observed for immigrants from countries speaking languages other than Spanish, confirming a commonly observed result in the literature on the pro-trade effects of immigration (Girma and Yu, 2002; Dunlevy, 2006). Notice that this does not rule out that knowledge flows are promoted by language commonality: as this effect is absorbed by the bilateral effects. Hence, the coefficient at stake is the specific *coeteris paribus* effect of *immigration* from Spanish-speaking countries on knowledge flows in international innovation networks. Because of language commonality, the barriers to knowledge flows are lower and immigrants are somehow not necessary to their bridging. Instead, their contribution is positive when it comes to facilitating knowledge flows with non-Spanish speaking countries, as in this case it is actually bridging (language) barriers to exchanging information with their home countries.

Finally, as expected, Table 5 shows that higher education actually reinforces the impact of immigrants on the innovation-based knowledge flows at stake. This result is of course not surprising. While migration at large can serve to help co-inventorship, even irrespectively

---

10 The case where the log of social capital equals zero and the effect of immigration or emigration is strictly negative is actually theoretical, considering that, by the way the social capital variable is constructed, this would imply that the level of social capital in that year is exactly equal to its level in 1983, a case that is not realized in our data. The cases where the volume of social capital is less than in 1983 amount to a 1.15% of the total. They refer to the first two years of our panel, 1998 and 1999 in five provinces: Ourense, Pontevedra, Zamora, Albacete, Caceres and Cordoba.

from its level of education and qualification, a high level of human capital reveals anyhow helpful to make their occurrence more probable.

Insert Table 5 around here

In concluding, let us observe that, as illustrated in Appendix 4, the previous set of results appear quite robust when a different estimator (i.e. PPML) is used, and when a more stringent account of fixed effects is incorporated in the analysis.

5. Conclusions

This paper has adopted a gravity model to study whether migrants can promote co-inventors' networks for the exchange of technological knowledge between regions and foreign countries. Our results, presented along with a large set of robustness checks and heterogeneity analyses, robustly show some important insights.

First of all, both immigrants and emigrants play a role in opening up the local system to co-inventions and, thus, to new knowledge flows relevant for innovation. Though we cannot definitely rule out endogeneity, our results are robust to different estimation methods and to very demanding specifications including large sets of effects. In most cases, the quantitative dimension of the effect is non-negligible. We argued that the underlying mechanism could be a network effect, so that our results actually enrich the findings of a branch of the international trade literature arguing that such an effect exists and promotes trade and FDI. Even if the outcome is different, this literature assumes the underlying mechanism to be exactly the one that we propose (e.g., Gould, 1994; Rauch and Trinidade, 2002). Assuming that our argument holds and that the positive effect of migrants on co-inventorships can be attributed to migrants' network effect, though, co-invention ties are probably among the networks whose creation relies less on social factors: qualification, technological proximity and specialization are more likely to play a role here. One could argue, then, that coinventorship networks are among the least responsive to the facilitation effect of migrants. Having detected a robust effect of migrants even in this *a priori* unfavourable case,and having showed the importance of social and linguistic factors besides qualification, we are inclined to conclude that our results could generalize to other kinds of social networks beyond co-invention networks. If these rely more on social networks, migrants' effect may actually be larger. Also, the implications of these effects for regions may be more far-reaching: within the same co-invention networks, less codified knowledge flows not captured in co-inventorships are also likely to occur. These, in turn, may lead to less radical, non-patented innovation.

Secondly, our results also support a strong economic case for promoting the social integration of immigrants though the promotion of a bridging kind of social capital. Indeed, both from the side of the host economy and from the side of the communities-on-the-move, social capital is found to magnify the knowledge bridging effect of immigrants and emigrants on co-inventorship, suggesting that, in connection with the mobility of people, it promotes tacit knowledge transfers and increases the local system's absorptive capacity. Social capital here, particularly in the form of bridging social capital, matters as a mediating factor to promote effective knowledge flows between immigrants and their countries of origin (and their scientists/inventors), with the host societies (and their scientists/inventors). This is a particularly relevant result, which helps confirm more conceptual and qualitative approaches to the impact of social capital of communities-on-the-move on the economic development of recipient countries (Sassen, 1988; Portes, 1995; Parrilli, 2012).

Finally, our results confirmed the important role of human capital and role of global macroeconomic conditions affecting not only the magnitude, but also the composition of the immigrant population, leading to a substantial reduction in the growth rate of the immigrant population and in the magnitude of its effect from the pre- to the post-2006 period.

The implications of this study are straightforward. Social and innovation policies should be integrated as social objectives seem to reinforce innovation goals. Support to bridging types of associations and to language training both of immigrants and of natives to improve a local system competitiveness on the global innovation scene is, according to our results, not only going to promote social goals, but also the capacity of the local system to innovate. These recommendations accompany a more standard call to promote countercyclical policies attracting skilled immigration. Indeed, across specifications and estimation methods, and differently from the aggregate effect, the effect for highly qualified immigrants does not change significantly during the recession, and remains positive and significant. The focus on the recession was not a primary interest of the paper, but a consequence of data availability, hence the evidence is only initial. We could not test whether this result implies that highly skilled immigrants contribute to regional resilience, but such an implication would be consistent with our arguments and with our results and could be further investigated in extensions of this work.

References

Adler P. and Kwon S. (2002), Social capital: prospects for a new concept, *Academy of Management Review,* Vol.27, pp17-40.

Agrawal, A., D. Kapur, and J. McHale (2008) “How Do Spatial and Social Proximity Influence Knowledge Flows? Evidence from Patent Data” *Journal of Urban Economics*, 64, 258–269.

Agrawal, A., I. Cockburn, and J. McHale (2006), “Gone but Not Forgotten: Labor Flows, Knowledge Spillovers, and Enduring Social Capital,” *Journal of Economic Geography*, 6(5): 571-591.

Agrawal, Ajay, Devesh Kapur, John McHale, and Alex Oettl (2011) “Brain Drain or Brain Bank? The Impact of Skilled Emigration on Poor-Country Innovation,” Journal of Urban Economics, 69(1), 43-55.

Almeida, P., Kogut, B. (1999) Localization of knowledge and the mobility of engineers in regional networks. Management Science, 45: 905–917.

Anderson, J. and E. van Wincoop (2003). Gravity with gravitas: a solution to the border puzzle. American Economic Review 93, 170-92.

Autio, E. (1998) Evaluation of RTD in regional systems of innovation, European Planning Studies, 6 (1998), pp. 131–140

Baldwin, R. and D. Taglioni (2007). Gravity for dummies and dummies for gravity equations. NBER working paper series, Working Paper 12516, http://www.nber.org/papers/w12516.

Basch,L., Glick Schiller, N. and Szanton-Blanc, C. (1994). Nations unbound: Transnational projects and the deterritorialized nation-state. New York: Gordon and Breach.

Boschma, R. (2005). Proximity and innovation: A critical assessment. Regional Studies 39 (1), 61–74.

Bratti, M., De Benedictis, L. and Santoni, G. (2014). "On the pro-trade effects of immigrants," Review of World Economics (Weltwirtschaftliches Archiv), Springer; Institut für Weltwirtschaft (Kiel Institute for the World Economy), vol. 150(3), pages 557-594, August.

Breschi S. and, Lissoni F. (2006b) Knowledge networks from Patent data methodological issues and research targets. In: Henk F.M., Glänzel W., Schmoch U. (eds) Handbook of quantitative science and technology research. Springer, The Netherlands. Chesbrough, H. (2003b). The era of open innovation. Sloan Management Review, Summer, 35–41.

Breschi, S. and Lissoni F. (2009) “Mobility of skilled workers and coinvention networks: an anatomy of localized knowledge flows,” Journal of Economic Geography, 9, 439-468.

Breschi, S. and Lissoni, F. (2001) Knowledge Spillovers and Local Innovation Systems: A Critical Survey. Industrial and Corporate Change 10 (4): 975-1005 doi:10.1093/icc/10.4.975

Breschi, S. and Lissoni, F. (2006a) "Mobility of inventors and the geography of knowledge spillovers. New evidence on US data". KITeS Working Papers 184, KITeS, Centre for Knowledge, Internationalization and Technology Studies, Universita' Bocconi, Milano, Italy, revised Oct 2006.

Broekel, T., Brenner, T. and Buerger, M. (2015) "An Investigation of the Relation between Cooperation Intensity and the Innovative Success of German Regions". Spatial Economic Analysis 10 (1).

Brubaker, R. (2005) The "diaspora" diaspora, *Ethnic and Racial Studies*, 28(1)

Cappelli, R. and F. Montobbio (2013). European Integration and Knowledge Flows across European Regions. Technical report, Department Cognetti de Martiis Working Papers 201322.

Castles, S. (2002) "Migration and community formation under conditions of globalization." *International migration review* 36.4: 1143-1168.

Coe, N. and T. Bunnell (2003). Spatialising knowledge communities: Towards a conceptualisation of transnational innovation networks. *Global Networks* 3, 437–456.

Cooke, P. , Heidenreich, M., Braczyk, H.-J. (2004), *Regional Innovation Systems. The role of governance in a globalized world*, Second Edition, Routledge, London.

Criscuolo, P. and Verspagen, B., 2008. "Does it matter where patent citations come from? Inventor vs. examiner citations in European patents," *Research Policy*, 37(10), 1892-1908.

D'Ambrosio, A. (2015) Migration flows and local systems of production: New comparative evidence on Italy and Spain. Doctoral thesis, University of Trento.

D'Ambrosio, A. and Montresor, S. (2016). Migration and trade flows: new evidence from Spanish provinces. mimeo.

De Arcangelis, G., Di Porto, E. and Santoni, G. (2013), Migration, Production Structure and Exports. http://dx.doi.org/10.2139/ssrn.2249943

De Benedictis, L. and Taglioni, D. (2011) The Gravity Model in International Trade, in De Benedictis, L. and Salvatici, L. (eds.) "The trade impact of European Union preferential policies: An Analysis through gravity models", Springer, pp.55-89, 2011.

Dekker, P. and Uslaner, E.M. (2001). 'Introduction' in "Social Capital and Participation in Everyday Life", Uslaner, E.M., London: Routledge, 1-8.

Dunlevy, J. (2006). The impact of corruption and language on the pro-trade effect of immigrants: Evidence from the American States. Review of Economics and Statistics 88 (1), 182-186.

Faggian, A. and McCann, P. (2006) Human capital flows and regional knowledge assets: a simultaneous equation approach Oxf. Econ. Pap. (2006) 58 (3): 475-500. doi: 10.1093/oep/gpl010)

Felbermayr, G., V. Grossmann, and W. Kohler (2012, October). Migration, International Trade and Capital Formation: Cause or Effect? IZA Discussion Papers 6975, Institute for the Study of Labor (IZA).

Gagliardi, L. (2015) Does skilled migration foster innovative performance? Evidence from British local areas. Papers in Regional Science, 94: 773–794. doi: 10.1111/pirs.12095.

Girma, S. and Z. Yu (2002). The link between immigration and trade: Evidence from the United Kingdom. Weltwirtschaftliches Archiv 138, 115–30.

Gould, D. M. (1994). Immigrant links to the home country: Empirical implications for U.S. bilateral trade flows. The Review of Economics and Statistics 76 (2), 302-316.

Head, K. and T. Mayer (2014). Gravity equations: Workhorse, toolkit, and cookbook. In G. Gopinath, E. Helpman, and K. Rogo (Eds.), Handbook of International Economics. Elsevier.

Lewis, E. (2013) “Immigration and Production Technology,” *Annual Review of Economics* 5, August 2013.

Maggioni, M., T. Uberti, and S. Usai (2011). Treating patents as relational data: knowledge transfers and spillovers across Italian provinces. Industry & Innovation 18, 39–67.

Maurseth, P. and B. Verspagen (2002). Knowledge Spillovers in Europe: A Patent Citations Analysis. Scandinavian Journal of Economics 104(4), 531–45.

Miguélez, E. (2016) Inventor Diasporas and the Internationalization of Technology, The World Bank Economic Review, doi 10.1093/wber/lhw013.

Miguélez, E. and Moreno, R. (2013), "Research Networks and Inventors' Mobility as Drivers of Innovation: Evidence from Europe", Regional Studies, 47(10), 1668-1685.

Miguélez, E. and Moreno, R. (2015),"Knowledge flows and the absorptive capacity of regions", Research Policy, 44(4), 833-848.

Montobbio, F. and Sterzi, V.A., 2013. "The Globalization of Technology in Emerging Markets: A Gravity Model on the Determinants of International Patent Collaborations," World Development, Elsevier, vol. 44(C), pages 281-299.

Niebuhr, A. (2010). Migration and innovation: Does cultural diversity matter for regional R&D activity? Papers in Regional Science 89, 563–585.

Ottaviano, G.I.P, and Peri, G.. "Rethinking the effect of immigration on wages." *Journal of the European economic association* 10.1 (2012): 152-197.

Paci, R. and S. Usai (2009). Knowledge flows across the European regions. Annals of Regional Science 43, 669–690.

Paci, R. and Usai, S. (2000) "Technological Enclaves and Industrial Districts: An Analysis of the Regional Distribution of Innovative Activity in Europe," Regional Studies, 34(2), 97-114.

Parrilli M.D. (2012), Heterogeneous social capital: a window of opportunity for local economies, in Cooke P., Parrilli M.D. and Curbelo J.L., Innovation, global change and territorial resilience, Edward Elgar.

Peri, G. and F. Requena-Silvente (2010). The trade creation effect of immigrants: Evidence from the remarkable case of Spain. Canadian Journal of Economics 43 (4), 1433-1459.

Peri, G. and Sparber, C.. 2009. "Task Specialization, Immigration, and Wages." *American Economic Journal: Applied Economics*, 1(3): 135-69.

Picci, L. (2010). The internationalization of inventive activity: A gravity model using patent data. Research Policy 39, 1070–1081.

Piore, M. J. (1986), Perspectives on Labor Market Flexibility. Industrial Relations: A Journal of Economy and Society, 25: 146–166.

Ponds R., Van Oort F., Frenken K. (2007) The geographical and institutional proximity of research collaboration. Papers in Regional Science 86: 423–443

Portes, A. (1995) The economic sociology of immigration. New York: Russell Sage Foundation.

Portes, A. (2000). Globalization from Below: The Rise of Transnational Communities. In Kalb, D. van der Land, Starting, R., van Steenbergen, B. and Wilterdink, N., “The Ends of Globalization: Bringing Society Back in”, Rowman & Littlefield, Lanham.

Portes, A. and J. Sensenbrenner (1993). Embeddedness and immigration: Notes on the social determinants of economic action. American Journal of Sociology 98, 1320–50.

Putnam R. (2000), Bowling alone: the collapse of the American community, Simon and Schuster, New York.

Putnam, R. and K.A. Goss (2002) ‘Introduction’, in R. Putnam (ed.) Democracies in Flux. The Evolution of Social Capital in Contemporary Society, pp. 1–19. Oxford: Oxford University Press.

Quatraro, F. and S. Usai (2016). Are knowledge flows all alike? Evidence from European regions. Forthcoming in Regional Studies.

Rauch, J. and V. Trinidade (2002). Ethnic Chinese networks in international trade. Review of Economics and Statistics 84 (1), 116-30.

Saskia Sassen (1998), *Globalization and its Discountents.* New York: New York Press.

Saxenian, A. (2006). The new Argonauts: Regional advantage in a global economy. Cambridge, MA: Harvard University Press.Schuller, T., S. Baron, and J. Field (2000) “Social Capital: A Review and Critique” in eds. Baron et al. *Social Capital: Critical Perspectives* (Oxford: Oxford University Press).

Singh, J. (2005) Collaborative networks as determinants of knowledge diffusion patterns. *Management Science,* 51: 756–770.

Sonderegger P. and Taube F. (2010), Clster lifecycle and diaspora effects: evidence from the Indian IT cluster in Bangalore, *Journal of International Management*, Vol.16, pp.383-397.

Thompson P. and Fox-Kean M., (2005). "Patent Citations and the Geography of Knowledge Spillovers: A Reassessment," *American Economic Review* 95(1), 450-460,

Tödtling, F. and Trippl, M. (2005) One size fits all?: Towards a differentiated regional innovation policy approach, Research Policy, 34(8), 1203-1219.

Trippl, M. (2013) Scientific mobility and knowledge transfer at the interregional and intraregional level. Regional Studies 47 (10) p.1653-1667.

Vertovec, S. (1999) "Conceiving and researching transnationalism." *Ethnic and racial studies* 22.2: 447-462.

Wagner, D., K. Head, and J. Ries (2002). Immigration and the trade of provinces. Scottish Journal of Political Economy 49 (5), 507-525.

Williams, A. (2007). Listen to me, learn with me: International migration and knowledge transfer. British Journal of Industrial Relations 45, 361–382.

Table 1. Estimation results. Base-line model: stocks of immigrants and emigrants

Dependent variable: $\ln(1+Coinv_{ijt})$	(1)	(2)	(3)	(4)	(5)
	1998-2010	2006-2011			
$\ln(GDP_{it})$	0.0666***	0.0512***	0.0582***	0.0340***	0.0256**
	(0.0097)	(0.0092)	(0.0122)	(0.0105)	(0.0115)
$\ln(1+Patent\_Stock_{it})$	0.0332***	0.0299***	0.0403***	0.0404***	0.0398***
	(0.0041)	(0.0038)	(0.0061)	(0.0061)	(0.0061)
$\ln(Distance_{ij})$	-0.1547***	-0.1220***	-0.1535***	-0.1339***	-0.1149***
	(0.0253)	(0.0244)	(0.0311)	(0.0278)	(0.0296)
$\ln(1+Immi_{ijt})$		0.0295***	0.0184***		0.0118**
		(0.0052)	(0.0060)		(0.0058)
$\ln(1+Emi_{ijt})$				0.0485***	0.0456***
				(0.0067)	(0.0064)
Region-time effects	Yes	Yes	Yes	Yes	Yes
Country-time effects	Yes	Yes	Yes	Yes	Yes
Country-region effects	Yes	Yes	Yes	Yes	Yes
N	47450	47450	18250	18250	18250
R^2	0.585	0.588	0.638	0.641	0.641
AIC	994.7367	620.9364	3219.9550	3078.6445	3062.5455
BIC	16802.4162	16428.6160	11727.1362	11585.8258	11577.5387

OLS estimates. Robust standard errors clustered at the country-province pair level in parentheses.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 2. Estimation results. Augmented model: social capital at Spanish province level.

Dep. Var.: *ln(1+Coinv$_{ijt}$)*	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	1998-2011		*2006-2011*					
ln(GDP$_{it}$)	0.0514***	0.0524***	0.0615***	0.0326***	0.0252**	0.0622***	0.0312***	0.0261**
	(0.0093)	(0.0094)	(0.0123)	(0.0109)	(0.0117)	(0.0123)	(0.0109)	(0.0118)
ln(1+Patent_Stock$_{it}$)	0.0304***	0.0274***	0.0356***	0.0403***	0.0398***	0.0322***	0.0342***	0.0343***
	(0.0039)	(0.0038)	(0.0055)	(0.0061)	(0.0061)	(0.0054)	(0.0058)	(0.0058)
ln(Distance$_{ij}$)	-0.1227***	-0.1277***	-0.1604***	-0.1319***	-0.1143***	-0.1562***	-0.1105***	-0.0984***
	(0.0247)	(0.0251)	(0.0312)	(0.0284)	(0.0299)	(0.0310)	(0.0279)	(0.0297)
ln(Social_Capital_Host$_{it}$)	-0.0052	-0.0314***	-0.0051	0.0050	0.0021	-0.0299***	-0.0289***	-0.0261***
	(0.0050)	(0.0068)	(0.0062)	(0.0063)	(0.0061)	(0.0076)	(0.0071)	(0.0073)
L.ln(1+Immi$_{ijt}$)	0.0298***		0.0204***		0.0116**			
	(0.0053)		(0.0059)		(0.0058)			
ln(1+Emi$_{ijt}$)				0.0489***	0.0458***			
				(0.0066)	(0.0063)			
ln(1+Immi$_{ijt}$)* Social_Capital_Host_H		0.0322***				0.0238***		0.0056
		(0.0053)				(0.0060)		(0.0058)
ln(1+Immi$_{ijt}$)* Social_Capital_Host_L		0.0149***				0.0111*		0.0104*
		(0.0052)				(0.0059)		(0.0059)
.ln(1+Emi$_{ijt}$)* Social_Capital_Host_H							0.0611***	0.0613***
							(0.0075)	(0.0074)
ln(1+Emi$_{ijt}$)* Social_Capital_Host_L							0.0357***	0.0321***
							(0.0066)	(0.0066)
N	47450	47450	21900	18250	18250	21900	18250	18250
R-sq	0.588	0.592	0.630	0.641	0.641	0.632	0.645	0.645
AIC	617.7860	234.7400	3746.1816	3079.5162	3064.3403	3648.5847	2868.1881	2858.5823
BIC	16425.4655	16042.4195	13179.3870	11594.5094	11587.1454	13089.7844	11390.9932	11397.0113

OLS estimates. Robust standard errors clustered at the country-province pair level in parentheses.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

All specifications include country-time, region-time and region-country effects.

Table 3. Estimation results. Augmented model: social capital at the country-level

Dep. Var.: *ln(1+Coinv$_{ijt}$)*	(1)	(2)	(3)	(4)
	1998-2010	*2006-2011*		
ln(GDP$_{it}$)	0.0620***	0.0615***	0.0346**	0.0231
	(0.0148)	(0.0167)	(0.0142)	(0.0158)
ln(1+Patent_Stock$_{it}$)	0.0391***	0.0440***	0.0453***	0.0450***
	(0.0055)	(0.0072)	(0.0081)	(0.0081)
ln(Distance$_{ij}$)	-0.0337	-0.1673***	-0.1430***	-0.1237***
	(0.1573)	(0.0415)	(0.0267)	(0.0279)
ln(1+Immi$_{ijt}$)* Social_Capital_Im_H	0.0619***	0.0470***		0.0225*
	(0.0115)	(0.0121)		(0.0124)
ln(1+Immi$_{ijt}$)* Social_Capital_Im_L	-0.0040	-0.0047		0.0025
	(0.0061)	(0.0094)		(0.0076)
L.ln(1+Emi$_{ijt}$)* Social_Capital_Em_H			0.0962***	0.0863***
			(0.0157)	(0.0151)
L.ln(1+Emi$_{ijt}$)* Social_Capital_Em_L			0.0071	0.0114
			(0.0112)	(0.0096)
N	23850	13000	10900	10900
R-sq	0.632	0.660	0.674	0.674
AIC	7232.5144	4385.8846	3420.5740	3403.6690
BIC	16330.0759	10319.2120	8790.8113	8788.4993

OLS estimates. Robust standard errors clustered at the country-province pair level in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 4. Estimation results. Immigrants/emigrants and language commonality

	(1)	(2)	(3)	(4)
	1998-2011	2006-2011		
$\ln(GDP_{jt})$	0.0533***	0.0650***	0.0300***	0.0240**
	(0.0093)	(0.0121)	(0.0103)	(0.0114)
$\ln(1+Patent\_Stock_{it})$	0.0306***	0.0368***	0.0400***	0.0402***
	(0.0039)	(0.0055)	(0.0061)	(0.0061)
$\ln(Distance_{ij})$	-0.1275***	-0.1732***	-0.1477***	-0.1313***
	(0.0245)	(0.0314)	(0.0285)	(0.0302)
$\ln(1+Immi_{ijt})$*Spanish	-0.0267***	-0.0469***		-0.0232***
	(0.0051)	(0.0073)		(0.0053)
$\ln(1+Immi_{ijt})$*Non_Spanish	0.0391***	0.0305***		0.0171***
	(0.0060)	(0.0066)		(0.0065)
$\ln(1+Emi_{ijt})$*Spanish			-0.0238***	-0.0073*
			(0.0056)	(0.0043)
$\ln(1+Emi_{ijt})$*Non_Spanish			0.0742***	0.0660***
			(0.0091)	(0.0086)
N	47450	21900	18250	18250
R^2	0.591	0.634	0.646	0.647
AIC	259.5331	3535.4991	2825.2012	2778.4015
BIC	16075.9801	12968.7046	11340.1943	11309.0185

OLS estimates. Robust standard errors clustered at the country-province pair level in parentheses.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

All specifications include country-time, region-time and region-country effects.

Table 5. Estimation results – Augmented model: immigrants and human capital

Dependent variable: *ln(1+Coinv$_{ijt}$)*	(1)	(2)
	1997-2011	*2006-2011*
L.ln(GDP_{it})	0.0547***	0.0687***
	(0.0105)	(0.0138)
L.ln(1+$Patent\_Stock_{jt}$)	0.0327***	0.0375***
	(0.0044)	(0.0062)
ln($Dist_{ij}$)	-0.1315***	-0.1686***
	(0.0272)	(0.0343)
L.ln(1+$Immi_{ijt}$)*Hi_Qualified	0.0523***	0.0480***
	(0.0081)	(0.0099)
L.ln(1+$Immi_{ijt}$)*Lo_Qualified	-0.0047	-0.0252***
	(0.0072)	(0.0059)
N	39650	18300
R^2	0.600	0.644
AIC	4130.3519	4482.8556
BIC	17347.0472	12297.5119

OLS estimates. Robust standard errors clustered at the country-province pair level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. All specifications include country-time, region-time and region-country effects. Col. 1 refers to the full period; the specification in column 2 refers to the 2006-2011 period.

APPENDICES

Appendix 1 - Data sources

Data on cross-regional foreign co-inventorship for Spanish provinces have been obtained from the OECD REGPAT, covering patent applications filed to the European Patent Office (EPO) and under the Patent Cooperation Treaty (PCT).

As far as migration is concerned, provincial data on residents with a foreign citizenship in Spain have been taken from the official Spanish register of residents (the "*Padron Municipal*"), publicly available from the Spanish Institute of Statistics ("*Instituto Nacional de Estadistica, INE*"). The records include data on residents with foreign nationality. As they are not matched with the register on the stay permit, they may also include part of the irregularly residing foreigners. Provincial data on emigrants are drawn from the "*Censo Electoral de Residentes Ausentes", CERA*, as in Murat and Pistoiesi (2009), that is, from electoral registers of Spanish nationals who reside abroad, but maintain their voting rights in Spain.

As regards the measurement of social capital, that of the *hosting* communities has been captured through the social capital indicator provided by the Ivie[11] study (Fernandez et al 2015; Pérez et al., 2005; Tortosa-Ausina and Peiro, 2012), reporting the "returns" from social capital of the Spanish provinces over our reference period, with respect to the degree of connectivity of social networks, the inequality in society, and the extent to which an individual's social capital decisions affect the behaviour of others (see Fernandez et al. 2015, Pérez et al., 2005; Tortosa-Ausina and Peiro, 2012). As for the social capital of the *migrating communities*, we have integrated two waves of the European Value Survey with four waves of the World Value Survey (Cortinovis et al., 2016; Granato et al., 1996a; Knack and Keefer, 1997; Zak and Knack, 2001) to be able to cover all years and countries under consideration. Relying on these data implies assuming that the level of social capital of one country is a good proxy for that of its migrating communities, and that such a capital does not change significantly within the different years of the waves.

The data on the human capital of migrants are drawn from the OECD-DIOC database, which provides aggregate (and cross-sectional, referring exclusively to 2007) information on the immigrants' qualification by country of origin, by referring to the International Standard Classification of Education (ISCED) codes developed by UNESCO to evaluate the quality of the

11 Instituto Valenciano de Investigaciones Económicas (www.ivie.es), in collaboration with the Fundacion Banco Bilbao Vizcaya (FBBVA, www.fbbva.es).

world countries' education systems. Unfortunately, data availability prevents us from building up a reliable measurement of the human capital qualifications of the Spanish emigrants by destination countries.

Appendix 2 - Variables descriptives

Insert Tables A2.1, A2.2, and A2.3 here

Appendix 3 – Econometric strategy

Following Head and Mayer (2014), we notice that, in case the coefficient of the variable of interest in the population model is non-constant, the PPML estimator may be severely biased because it gives more weight to the observations with the largest expected values of the dependent variable. In this case, the authors have shown that OLS more accurately estimates the average elasticity. The critique could apply to our analysis if, for instance, immigrants in larger cities have a larger effect than immigrants in rural areas. In turn, the OLS estimator may be biased because of heteroskedasticity. Overall, the OLS estimates likely represent a lower bound in the range of possible elasticities of coinventorships to migration, and the PPML an upper bound. In what follows, we report the more conservative OLS estimates and deal with the zeros by taking the natural log of the variables to which we add one unit. This yields a log-log model where the estimated coefficients can be interpreted as elasticities.

Appendix 4 - Robustness checks

In Tables A3.1-A3.5 we estimate by Poisson PML the same specifications reported in Tables 1-5 in the main text. The baseline model is thus:

$$Co\text{-}inventorship_{jit} = exp[\psi_{jt} + \varphi_{rt} + \chi_{rj} + \beta_1 * \ln(GDP_{it-1}) + \beta_2 * \ln(1 + Patent\_Stock_{it-1}) +$$

$$+ \beta_3 * \ln(1 + Immigrants_{jit-1}) + \beta_4 * \ln(1 + Emigrants_{ijt-1}) + \beta_5 * \ln(Distance_{ij}) + \varepsilon_{jit}] \quad (2)$$

which is equivalent to the one in equation (1) and gets this time estimated by PPML.

The accuracy of the gravity model in accounting for the knowledge flows at stake is confirmed, as well as the positive impact of immigrants on co-inventorships. In Table A3.1, we report the estimates of the baseline model. As expected, the coefficients are much larger than those estimated by OLS (about five-six times larger), and we interpret them as the upper bounds in the possible effects of migration on co-inventorships. The positive and relatively large coefficients of immigration and emigration further confirm H1.a and H1.b. Furthermore, the results confirm a much larger role of emigrants than immigrants in promoting co-invention networks.

Insert Table A3.1 around here

In Table A3.2, we report the results of our analysis on the role of social capital at the province level. Again, the results of the OLS estimates are confirmed as regards their signs and relative magnitudes. As in the OLS case, the effect of immigration is found to be positive and significant over the whole time period mainly due to its pre-crisis effect. As regards emigrants, the effect is not found to differ significantly between expatriates from provinces with high and low social capital. So H.2a.1 is still supported while H.2b.2 does not find the strong support that was found by OLS.

In Table A3.3 we report the results for the moderating role of the social capital of the country of origin.Again, when looking at immigrants, the sign and significance of the results is confirmed for the pre-crisis period: high levels of bridging social capital significantly facilitate the establishment of coinventorship networks with the home countries. The results for the crisis period, instead, are not significant. H.2a.2. is again confirmed, at least as regards the pre-crisis period. Turning to the emigrants' side, the country-level analysis provides a (second-best, as we discussed) test for H2.b.1, i.e. the role of the social capital of the destination community. As expected, emigrants to countries with high levels of bridging social capital result to contribute to coinventorship more than emigrants to countries with low levels of bridging social capital, (though the difference is not statistically significant; cfr. Column (3)). When we include both immigrants and emigrants (Column (4)), the only coefficient that retains its significance is the one of emigrants to countries with high bridging social capital. Overall, the results confirm the OLS findings and provide further support to H2.b.1.

Insert Table A3.2 around here

Insert Table A3.3 around here

The results of the OLS specifications are also confirmed with regards to immigrants' human capital (Table A3.4). Instead, the PPML estimates yield opposite results than the OLS with regards to the language commonality: PPML coefficients for Spanish-speaking immigrants would support, instead of contradicting, our argument about it.

Insert Table A3.4 around here

Insert Table A3.5 around here

While we include a large number of fixed effects, we still cannot exclude that our results are driven by endogeneity or simultaneity. In Table A3.6, we run an additional set of fixed effects specifications (both by OLS and PPML) where we include dyadic dummies (i.e. province-country instead of region-country) and country-time effects, while we exclude region dummies to avoid model saturation. This specification allows us controlling for all time-invariant dyadic variables that may simultaneously affect migration and co-inventorships. Not surprisingly, the role of the province-level time-varying attractor variables is now attenuated by the inclusion of fixed effects. Instead, the positive effect of migration is confirmed. Having tried different lag specifications, we conclude that the effect of immigration and emigration may have different timings: while the effect of immigration results significant after three years, the effect of emigration requires apparently a shorter time lag and only two years are necessary.

Appendix references

Cortinovis, N., Xiao, J., Boschma, R. and van Oort, F. (2016). Quality of government and social capital as drivers of regional diversification in Europe. Papers in Evolutionary Economic Geography # 16.10. http://econ.geog.uu.nl/peeg/peeg.html

Fernandez, J., Pérez, F., and Serrano, L. (2015) Crisis Económica, Confianza y capital social. Bilbao, Fundación BBVA. http://www.fbbva.es/TLFU/dat/DE_2015_IVIE_crisis_economica.pdf

Granato, J., Inglehart, R., and Leblang, D. (1996b). The effect of cultural values on economic development: theory, hypotheses, and some empirical tests. American Journal of Political Science, 40(3):607–631.

Head, K. and T. Mayer (2014). Gravity equations: Workhorse, toolkit, and cookbook. In G. Gopinath, E. Helpman, and K. Rogo (Eds.), Handbook of International Economics. Elsevier.

Knack, S. and Keefer (1997). Does social capital have an economic payoff? A cross country investigation. The Quarterly Journal of Economics, 112:1251–1288.

Murat, M. and B. Pistoiesi (2009). Migrant networks: Empirical implications for the Italian bilateral trade. International Economic Journal 23 (3), 371–390.

Pérez, F., Montesinos, V., Serrano, L., and Fernández de Guevara, J. (2005). La Medición del Capital Social: Una Aproximación Económica. Bilbao, Fundación BBVA.

Tortosa-Ausina, E. and Peiró, P. (2012). "Social Capital, Investment and Economic Growth: Evidence for Spanish Provinces," Working Papers 2012122, Fundacion BBVA / BBVA Foundation.

Zak, P. and Knack, S. (2001). Trust and growth. The Economic Journal, 111(470):295–321.

Table A2.1 List of countries

European Union and Western Europe	Eastern Europe	Africa	Middle East and Central Asia	South and Eastern Asia	Latin America and the Caribbean	North America	Oceania
Andorra (EU)	Croatia	Algeria	Armenia	China	Argentina	Canada	Australia
Austria (EU)	Cyprus (EU)	Egypt	United Arab Emirates	India	Bolivia	United States	New Zealand
Belgium (EU)	Bulgaria (EU)	Morocco	Israel	Japan	Brazil		
Denmark (EU)	Czech Republic (EU)	Madagascar	Jordan	Korea, Republic of	Chile		
Finland (EU)	Estonia (EU)	South Africa	Kazakhstan	Malaysia	Colombia		
France (EU)	Hungary (EU)		Uzbekistan	Pakistan	Costa Rica		
Germany (EU)	Lithuania (EU)			Saudi Arabia	Cuba		
Greece (EU)	Latvia (EU)			Singapore	Ecuador		
Ireland (EU)	Poland (EU)			Thailand	Guatemala		
Iceland	Romania (EU)				Honduras		
Italy (EU)	Russia				Mexico		
Luxembourg (EU)	Serbia, Republic of				Peru		
Malta (EU)	Slovakia				Uruguay		
Netherlands (EU)	Slovenia (EU)				Venezuela		
Norway	Turkey						
Portugal (EU)	Ukraine						
Switzerland							
Sweden (EU)							
United Kingdom (EU)							

Table A2.2. Summary statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Coinv$_{ijt}$	51100	.2806849	3.000209	0	170
ln(GDP$_{it}$)	47450	9.214565	.9198684	7.169193	12.17186
ln(1+Patent_Stock$_{it}$)	47450	1.986786	1.364139	0	6.144035
ln(Dist$_{ij}$)	51100	8.233646	.8652303	4.121954	9.901465
ln(1+Immi$_{ijt}$)	47450	2.643166	2.862025	0	12.25877
ln(1+Emi$_{ijt}$)	18250	2.708727	2.359518	0	10.74817
ln(SocCapHost$_{it}$)	47450	1.710193	.7873647	-.3319823	4.246955
ln(1+Immi$_{ijt-1}$)*Social_Capital_Host_H$_{it-1}$	51100	1.564212	2.675089	0	11.85789
ln(1+Immi$_{ijt-1}$)*Social_Capital_Host_L$_{it-1}$	51100	1.181174	2.194242	0	12.29727
ln(1+Emi$_{ijt-1}$)*Social_Capital_Host_H$_{it-1}$	21900	1.411354	2.141555	0	10.80286
ln(1+Emi$_{ijt-1}$)*Social_Capital_Host_L$_{it-1}$	21900	1.329865	2.181531	0	10.76931
ln(1+Immi$_{ijt}$)*Social_Capital_Im_H	26150	2.048824	2.753478	0	11.73982
ln(1+Immi$_{ijt}$)*Social_Capital_Im_L	26150	1.325336	2.547654	0	12.29727
ln(1+Immi$_{ijt}$)*Social_Capital_Em_H	13200	2.161707	2.642117	0	10.76931
ln(1+Immi$_{ijt}$)*Social_Capital_Em_L	13200	.7155386	1.476496	0	10.67812
ln(1+Immi$_{ijt-1}$)*(Spanish_Speaking$_j$)	51100	.705774	1.992892	0	12.06447
ln(1+Immi$_{ijt-1}$)*(1-Spanish_Speaking$_j$)	51100	2.039612	2.680104	0	12.29727
ln(1+Emi$_{ijt-1}$)*(Spanish_Speaking$_j$)	21900	.8279354	1.961881	0	10.80286
ln(1+Emi$_{ijt-1}$)*(1-Spanish_Speaking$_j$)	21900	1.913284	2.216	0	9.777244
ln(1+Immi$_{ijt-1}$)*Hi_Qualified$_j$ (Education-based)	39650	1.667762	2.440833	0	11.77762
ln(1+Immi$_{ijt-1}$)*Lo_Qualified$_j$ (Education-based)	39650	1.336727	2.638884	0	12.25877
ln(1+Immi$_{ijt-1}$)*Hi_Qualified$_j$ (Occupation-based)	39650	1.674327	2.441057	0	11.77762
ln(1+Immi$_{ijt-1}$)*Lo_Qualified$_j$Occupation-based)	39650	1.330161	2.637836	0	12.25877

Table A2.3 – Correlation matrix

Coinv$_{ijt}$	**1.0000**																						
ln(GDP$_{it}$)	**0.172**	**1.000**																					
ln(1+Patent_Stock$_{it}$)	**0.176**	**0.837**	**1.000**																				
ln(Dist$_{ij}$)	**-0.068**	**0.003**	**-0.029**	**1.000**																			
ln(1+Immi$_{ijt}$)	**0.148**	**0.350**	**0.282**	**-0.175**	**1.000**																		
ln(1+Emi$_{ijt}$)	**0.207**	**0.294**	**0.250**	**-0.046**	**0.530**	**1.000**																	
ln(SocCapHost$_{it}$)	**0.036**	**0.388**	**0.353**	**0.003**	**0.350**	**0.007**	**1.000**																
ln(1+Immi$_{ijt-1}$)*Social_Capital_Host_H$_{it-1}$	**0.104**	**0.347**	**0.301**	**-0.097**	**0.690**	**0.264**	**0.507**	**1.000**															
ln(1+Immi$_{ijt-1}$)*Social_Capital_Host_L$_{it-1}$	**0.067**	**0.041**	**0.004**	**-0.111**	**0.470**	**0.268**	**-0.160**	**-0.315**	**1.000**														
ln(1+Emi$_{ijt-1}$)*Social_Capital_Host_H$_{it-1}$	**0.141**	**0.345**	**0.309**	**-0.012**	**0.420**	**0.535**	**0.448**	**0.759**	**-0.446**	**1.000**													
ln(1+Emi$_{ijt-1}$)*Social_Capital_Host_L$_{it-1}$	**0.086**	**-0.018**	**-0.032**	**-0.038**	**0.162**	**0.559**	**-0.432**	**-0.459**	**0.728**	**-0.402**	**1.000**												
ln(1+Immi$_{ijt}$)*Social_Capital_Im_H	**0.203**	**0.250**	**0.196**	**-0.052**	**0.601**	**0.625**	**0.182**	**0.410**	**0.240**	**0.435**	**0.248**	**1.000**											
ln(1+Immi$_{ijt}$)*Social_Capital_Im_L	**-0.044**	**0.175**	**0.141**	**-0.139**	**0.504**	**-0.174**	**0.204**	**0.321**	**0.229**	**-0.064**	**-0.125**	**-0.387**	**1.000**										
ln(1+Immi$_{ijt}$)*Social_Capital_Em_H	**0.218**	**0.161**	**0.136**	**-0.051**	**0.302**	**0.835**	**0.008**	**0.141**	**0.146**	**0.442**	**0.469**	**0.814**	**-0.533**	**1.000**									
ln(1+Immi$_{ijt}$)*Social_Capital_Em_L	**-0.035**	**0.195**	**0.180**	**0.083**	**0.261**	**0.174**	**0.061**	**0.132**	**0.114**	**0.097**	**0.093**	**-0.413**	**0.663**	**-0.397**	**1.000**								
ln(1+Immi$_{ijt-1}$)*(Spanish_Speaking$_{j}$)	**-0.029**	**0.110**	**0.089**	**0.339**	**0.442**	**0.403**	**0.127**	**0.274**	**0.245**	**0.252**	**0.190**	**0.402**	**-0.018**	**0.287**	**0.180**	**1.000**							
ln(1+Immi$_{ijt-1}$)*(1-Spanish_Speaking$_{j}$)	**0.180**	**0.297**	**0.237**	**-0.440**	**0.745**	**0.180**	**0.281**	**0.536**	**0.323**	**0.200**	**-0.001**	**0.337**	**0.525**	**0.056**	**0.103**	**-0.270**	**1.000**						
ln(1+Emi$_{ijt-1}$)*(Spanish_Speaking$_{j}$)	**-0.041**	**0.068**	**0.062**	**0.410**	**0.333**	**0.488**	**-0.011**	**0.146**	**0.192**	**0.249**	**0.285**	**0.315**	**-0.031**	**0.300**	**0.267**	**0.908**	**-0.436**	**1.000**					
ln(1+Emi$_{ijt-1}$)*(1-Spanish_Speaking$_{j}$)	**0.256**	**0.253**	**0.213**	**-0.412**	**0.272**	**0.635**	**0.017**	**0.153**	**0.116**	**0.350**	**0.344**	**0.395**	**-0.159**	**0.632**	**-0.045**	**-0.374**	**0.578**	**-0.364**	**1.000**				
ln(1+Immi$_{ijt-1}$)*Hi_Qualified$_{j}$ (Education-based)	**0.212**	**0.260**	**0.205**	**-0.098**	**0.486**	**0.564**	**0.197**	**0.358**	**0.166**	**0.404**	**0.183**	**0.609**	**-0.159**	**0.482**	**0.015**	**0.268**	**0.293**	**0.301**	**0.303**	**1.000**			
ln(1+Immi$_{ijt-1}$)*Lo_Qualified$_{j}$ (Education-based)	**-0.037**	**0.163**	**0.130**	**-0.071**	**0.595**	**-0.087**	**0.192**	**0.363**	**0.295**	**-0.014**	**-0.076**	**0.026**	**0.630**	**-0.194**	**0.196**	**0.191**	**0.468**	**0.005**	**-0.094**	**-0.346**	**1.000**		
ln(1+Immi$_{ijt-1}$)*Hi_Qualified$_{j}$ (Occupation-based)	**0.217**	**0.269**	**0.210**	**-0.078**	**0.484**	**0.654**	**0.200**	**0.360**	**0.162**	**0.456**	**0.225**	**0.609**	**-0.163**	**0.546**	**0.082**	**0.181**	**0.360**	**0.208**	**0.480**	**0.824**	**-0.183**	**1.000**	
ln(1+Immi$_{ijt-1}$)*Lo_Qualified$_{j}$Occupation-based)	**-0.041**	**0.155**	**0.125**	**-0.090**	**0.597**	**-0.166**	**0.189**	**0.361**	**0.299**	**-0.060**	**-0.112**	**0.026**	**0.634**	**-0.249**	**0.141**	**0.271**	**0.407**	**0.083**	**-0.247**	**-0.183**	**0.849**	**-0.346**	**1.000**

Table A3.1. Robustness checks. Baseline model: stocks of immigrants and emigrants.

Dep. Var.: $Coinv_{ijt}$	(1)	(2)	(3)	(4)	(5)
	1998-2011		*2006-2011*		
L.ln(GDP_{it})	0.4777***	0.3806***	0.1620	-0.1558	-0.2695
	(0.1261)	(0.1394)	(0.1847)	(0.1880)	(0.1844)
L.ln(1+$Patent\_Stock_{it}$)	0.6769***	0.6518***	0.7571***	0.8025***	0.8394***
	(0.0931)	(0.0901)	(0.1114)	(0.1197)	(0.1182)
ln($Distance_{ij}$)	-2.1090***	-2.0644***	-1.5200***	-1.2352***	-1.0542***
	(0.1853)	(0.1866)	(0.2214)	(0.2377)	(0.2067)
L.ln(1+$Immi_{ijt}$)		0.1469***	0.0994		0.0563
		(0.0532)	(0.0727)		(0.0718)
L.ln(1+Emi_{ijt})				0.2903**	0.2947***
				(0.1176)	(0.1094)
Region-time effects	Yes	Yes	Yes	Yes	Yes
Country-time effects	Yes	Yes	Yes	Yes	Yes
Country-region effects	Yes	Yes	Yes	Yes	Yes
N	47450	47450	21900	18250	18250
R-sq	0.950	0.950	0.950	0.950	0.950
AIC	21143.6685	21037.2610	11788.4795	9858.2257	9895.7424
BIC	28929.1479	28857.8101	16033.4220	13498.5806	13567.3450

Poisson PML estimates. Robust standard errors clustered at the country-province pair level in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A3.2. Robustness checks. Immigrants/ emigrants and social capital at the Spanish province level.

Dep. Var: $Coinv_{iit}$	(1)	(2)	(3)	(4)
	1998-2011	*2006-2011*		
ln(GDP_{it-1})	0.3864***	0.0919	-0.2813	-0.3931**
	(0.1361)	(0.1835)	(0.2006)	(0.1891)
ln(1+$Patent\_Stock_{it-1}$)	0.5941***	0.7514***	0.7789***	0.8214***
	(0.0955)	(0.1123)	(0.1225)	(0.1207)
ln($Dist_{ij}$)	-2.1030***	-1.5326***	-1.2081***	-1.0159***
	(0.2052)	(0.2396)	(0.2643)	(0.2162)
ln($Social\_Capital\_Host_{it-1}$)	0.0210	0.1642	0.3562**	0.3593**
	(0.1420)	(0.1620)	(0.1753)	(0.1763)
ln(1+$Immi_{iit-1}$)* $Social\_Capital\_Host\_H_{it-1}$	0.1488***	0.0977		0.0308
	(0.0522)	(0.0708)		(0.0734)
ln(1+$Immi_{iit-1}$)* $Social\_Capital\_Host\_L_{it-1}$)	0.0921	0.0481		-0.0336
	(0.0584)	(0.0757)		(0.0890)
ln(1+Emi_{iit-1})* $Social\_Capital\_Host\_H_{it-1}$			0.3677***	0.3780***
			(0.1239)	(0.1140)
ln(1+Emi_{iit-1})* $Social\_Capital\_Host\_L_{it-1}$)			0.3385***	0.4121***
			(0.1214)	(0.1150)
N	47450	21900	18250	18250
R-sq	0.952	0.952	0.952	0.952
AIC	20962.4961	11699.5707	9825.9433	9785.8132
BIC	28783.0453	15936.5189	13513.1697	13441.7919

PPML estimates. Robust standard errors clustered at the country-province pair level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. All specifications include country-time, region-time and region-country effects.

Table A3.3. Robustness checks. Social capital at the country level

Dep. Var.: $Coinv_{ijt}$	(1)	(2)	(3)	(4)
	1998-2011	*2006-2011*		
$\ln(GDP_{it-1})$	0.1181	0.0171	-0.1345	-0.1798
	(0.1405)	(0.1689)	(0.1831)	(0.2030)
$\ln(1+Patent\_Stock_{it-1})$	0.7760^{***}	0.8287^{***}	0.6847^{***}	0.6979^{***}
	(0.1009)	(0.1024)	(0.1171)	(0.1175)
$\ln(Distance_{ij})$	-1.5977^{***}	-1.1974^{***}	-1.0868^{***}	-1.0933^{***}
	(0.2959)	(0.3278)	(0.1986)	(0.2195)
$\ln(1+Immi_{iit-1})$* $Social\_Capital\_Im\_H_{jt-1})$	0.1990^{***}	0.1164		0.0072
	(0.0696)	(0.0867)		(0.0954)
$\ln(1+Immi_{iit-1})$* $Social\_Capital\_Im\_L_{jt-1})$	-0.0028	0.0169		0.1366
	(0.0839)	(0.1138)		(0.1154)
$\ln(1+Emi_{iit-1})$* $Social\_Capital\_Em\_H_{jt-1})$			0.4092^{***}	0.4275^{***}
			(0.1230)	(0.1362)
$\ln(1+Emi_{iit-\backslash})$* $Social\_Capital\_Em\_L_{jt-1})$			0.3502^{**}	0.2054
			(0.1775)	(0.2116)
N	23850	13000	10900	10900
R-sq	0.958	0.961	0.964	0.964
AIC	14029.4371	8142.7460	6783.3915	6775.2630
BIC	18957.9562	11004.7919	9220.4285	9241.4861

PPML estimates. Robust standard errors clustered at the country-province pair level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. All specifications include country-time, region-time and region-country effects.

Table A3.4. Robustness checks. Immigrants/emigrants and language commonality

Dep. Var.: $Coinv_{ijt}$	(1)	(2)	(3)	(4)
	1998-2011	*2006-2011*		
$\ln(GDP_{it-1})$	0.3786***	0.1760	-0.1563	-0.2246
	(0.1399)	(0.1865)	(0.1995)	(0.2113)
$\ln(1+Patent\_Stock_{it-1})$	0.6557***	0.7491***	0.8050***	0.8273***
	(0.0903)	(0.1119)	(0.1185)	(0.1206)
$\ln(Distance_{ij})$	-2.0832***	-1.6249***	-1.2016***	-1.2736***
	(0.1949)	(0.2476)	(0.2720)	(0.2910)
$\ln(1+Immi_{ijt-1})*(Spanish\_Speaking_j)$	0.2182*	0.3024***		0.1249
	(0.1237)	(0.0852)		(0.1645)
$\ln(1+Immi_{ijt-1})*(1-Spanish\_Speaking_j)$	0.1417***	0.0965		0.0550
	(0.0538)	(0.0741)		(0.0752)
$\ln(1+Emi_{ijt-1})*(Spanish\_Speaking_j)$			0.3522***	0.3994**
			(0.1008)	(0.1873)
$\ln(1+Emi_{ijt-1})*(1-Spanish\_Speaking_j)$			0.2867**	0.2714**
			(0.1306)	(0.1279)
N	47450	21900	18250	18250
R-sq	0.950	0.950	0.950	0.950
AIC	21022.8408	11783.0449	9832.4872	9831.6268
BIC	28843.3899	16059.9643	13480.6540	13495.4174

PPML estimates. Robust standard errors clustered at the country-province pair level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. All specifications include country-time, region-time and region-country effects. Column 1 refers to the full time period at our disposal (1998-2011); Columns 2-4 refer to the period for which emigration data are available, i.e. 2006-2011.

Table A3.5 Robustness checks. Immigrants and human capital

Dep. Var.: $Coinv_{ijt}$	(1)	(2)	(3)	(4)
	1998-2011	*2006-2011*	*1998-2011*	*2006-2011*
$\ln(GDP_{it-1})$	0.3667***	0.1881	0.3594**	0.1388
	(0.1408)	(0.1882)	(0.1404)	(0.1846)
$\ln(1+Patent\_Stock_{jt-1})$	0.6640***	0.7271***	0.6565***	0.7598***
	(0.0931)	(0.1130)	(0.0925)	(0.1124)
$\ln(Distance_{ij})$	-2.0166***	-1.5539***	-1.9309***	-1.4487***
	(0.2003)	(0.2158)	(0.1870)	(0.2177)
$\ln(1+Immi_{ijt-1})*Hi\_Qualified_j$ (Education-based)	0.1436***	0.1418*		
	(0.0553)	(0.0786)		
$\ln(1+Immi_{ijt-1})*Lo\_Qualified_j$ (Education-based)	0.1594	-0.1367		
	(0.1149)	(0.1201)		
$\ln(1+Immi_{ijt-1})*Hi\_Qualified_j$ (Occupation-based)			0.1773***	0.1361*
			(0.0547)	(0.0787)
$L.\ln(1+Immi_{ijt})*Lo\_Qualified_j$ (Occupation-based)			-0.1497	-0.1796
			(0.0920)	(0.1301)
N	39650	18300	39650	18300
R-sq	0.952	0.952	0.952	0.952
AIC	19612.1935	10855.2485	19550.5862	10921.3359
BIC	26731.5180	14692.2448	26695.6742	14766.1468

PPML estimates. Robust standard errors clustered at the country-province pair level in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. All specifications include country-time, region-time and region-country effects.

Table A3.1 Robustness checks: Fixed effects models

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Estimator	OLS				PPML			
Dep. Var.:	*ln(1+Coinv$_{ijt}$)*				*Coinv$_{ijt}$*			
	1998-2011	*2006-2011*			*1998-2011*	*2006-2011*		
$\ln(GDP_{it-1})*\ln(GDPj_{t-1})$	-0.0298	-0.0533	-0.0142	-0.0145	0.2367*	0.1255***	0.1050	0.0193
	(0.0546)	(0.0630)	(0.0630)	(0.0631)	(0.1432)	(0.0349)	(0.1230)	(0.1506)
$\ln(1+Patent\_Stock_{it-1})$	0.0063***	0.0048*	0.0065**	0.0066**	0.2859***	0.2874***	0.4371***	0.4364***
	(0.0023)	(0.0025)	(0.0032)	(0.0032)	(0.0755)	(0.0610)	(0.0712)	(0.0794)
$\ln(1+Immi_{ijt-3})$	0.0155***	0.0073**		-0.0030	0.1190**	0.1203*		0.1462
	(0.0031)	(0.0036)		(0.0059)	(0.0536)	(0.0669)		(0.1115)
$\ln(1+Emi_{ijt-3})$			0.0081	0.0082*			0.3835***	0.5101***
			(0.0049)	(0.0049)			(0.1390)	(0.1304)
Region-time effects	No	No	No	No	No	No	No	No
Country-time effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country-province effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country-region effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	40150	21900	14600	14600	40150	21900	14600	14600
R^2	0.051	0.024	0.023	0.023	0.955	0.970	0.975	0.974
AIC	-27687.1044	-20180.2363	-17592.7677	-17591.2071	14327.3191	8032.9031	5342.3615	5323.0541
BIC	-21383.0276	-17238.3553	-15908.0592	-15898.9099	17466.4569	10111.4060	6776.6403	6734.5666

Robust standard errors clustered at the country-province pair level in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.
All specifications include country-province dyadic effects and country-time effects. The income, immigrant and emigrant variables are lagged three years based on the lag structure observed in table A3.2