Intellectual Property Rights Harmonization and the Internationalization of Southern Innovation[†]

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Abstract

This paper explores the role of intellectual property rights (IPR) protection in the internationalization of R&D that originates from the newly emerging economies (South). Global bilateral patent data is used to investigate the location-specificity of IPR enforcement for the emergence of this phenomenon. We find that strengthening the IPR regime at home encourages foreign patenting activities of Southern firms, whereas a stringent IPR regime in advanced economies (North) discourages the entry of Southern innovation there. Our findings suggest that a global convergence of IPRs can stimulate internationalization of Southern innovation. As the North and the South grow closer in terms of levels of development, a harmonized institutional structure becomes more adequate as they increasingly share similar markets.

Keywords: Intellectual property rights, Foreign patenting, Southern innovation.

JEL Classification*:* F2, O1, O3

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1. Introduction

Growing demand for new and affordable technologies in an increasingly competitive global market is changing the geography of innovation. The impact of geographic distance on international research and development (R&D) investments has diminished over the last decade owing it partly to the ability of multinational enterprises (MNEs) to absorb and transfer knowledge on an international scale (Castellani, et al., 2013). Today, MNEs do not only seek to exploit their knowledge in other countries, but also strive to source technology internationally and tap into new hubs of knowledge around the world (OECD, 2008a). We now observe a faster pace for the internationalization of R&D, a wider range of actors involved worldwide, and a greater scope of international innovative activities in the form of integrated networks.

While most R&D investments still take place in OECD countries (also referred to as North), newly industrialized countries (NICs, also referred to as the South) have attracted an increasing amount of R&D investments in recent years (OECD, 2008b). As knowledge starts to flow more freely across the globe, the heated debate on the suitability of a globally uniform set of intellectual property rights (IPR) standards becomes more complex. A survey by the Economist Intelligence Unit (EIU) in 2004 revealed that 84% of all executives perceive the lack of IPR protection in emerging markets as a challenge when outsourcing their R&D. Branstetter, et al. (2006) provided solid evidence that IPR enforcement encourages Northern firms to increase their R&D activities abroad (in terms of foreign patent applications as well as R&D expenditure and royalty payments). Does the same motivation apply for firms from the South? The issue is no longer a duel between developed and developing countries. With NICs taking a lead in developing technologies of global standards, the Southern view towards IPRs has taken a new meaning.

This paper sheds light on the development of innovation capacities and the internationalization of R&D by the new class of firms in the South. It investigates the relevance of IPRs from a South-North perspective to study the incentives of inventors in the newly emerging economies to engage in international markets. In so doing, we measure international patenting activities of NICs to assess the degree to which Southern firms engage in global networks of innovation, and find out how IPR protection contributes to or impedes this phenomenon. Our main results reveal that foreign patenting is highest in those countries where the North-South IPR distance is small. We interpret this as an indication that convergence of IPR

standards tends to contribute to the expansion of South-North innovation. The gravity findings suggest that this is also the case because similar levels of development produce similar markets and also require similar institutional structures.

Previous literature underlines the need for a reliable IPR protection system for innovative firms in advanced countries. But is the blessing of a strong IPR regime also valid for Southern firms? And if so are the effects of IPR protection uniform across locations, or are IPRs location-specific? In the spirit of Braga and Fink (1999) and Falvey, et al. (2009) who estimated a gravity equation to study the impact of IPRs on international trade, we use an empirical gravity-like model designed to capture the extent of NICs' involvement in the internationalization of innovation activities in OECD countries. We use the number of patents filed by nationals from 14 NICs in 30 OECD patent offices as the variable of interest to estimate the impact of country and country-pair specific variables such as IPR protection in both countries. We show that the location of IPR enforcement is crucial for South-North innovative activities. To capture a more precise measure of our variable of interest, we also make use of newly available data from the World Intellectual Property Organization (WIPO) that allow us (i) to identify original patents from the South that were first filed in the North, and (ii) to classify patents by technology field to account for the fact that industries differ with respect to their vulnerability to imitation (Ivus, 2011; Ivus, et al., 2016). The results suggest that South-North foreign patenting is positively related to domestic IPR enforcement, whereas enforcement in the receiving country discourages patent applications from NICs.

The effect of IPR protection on the internationalization of R&D for economies in the catch-up phase is therefore heterogeneous and location-specific. The positive impact of a strong domestic IPR regime in countries that have overcome the developing stage works in a similar manner as in advanced economies. IPRs create incentives to innovate, promote growth and allow Southern firms to enter into the world market for knowledge. The negative impact of IPR protection in the North for the entry of Southern patents can be associated to a market power effect that obstruct entry by new firms and the consequent difficulty faced by firms from NICs with less advance technologies to obtain patents in countries with a tougher IPR regime.

Essentially, the conclusion drawn from the results reinforce the positive implications of IPR harmonization for the internationalization of Southern innovation. However, the empirical findings reveal that a more complex mechanism of harmonization is required for this to be effective in catch-up economies, placed in a limbo state between the developing and the developed world. In particular, the results suggest that a convergence of IPR enforcement in the two regions, that is weakening (strengthening) the level in the North (South), can be beneficial for Southern innovation. This is slightly, but meaningfully, different from the TRIPS obligations that requires the South to upgrade its IPR regime to the standards in force in the North. It instead hints at the idea that similar institutional structures are more adequate for economies that have comparable levels of development and therefore share similar markets.

This study contributes to the literature by considering the issue of IPRs from a new perspective by accounting for today's rapidly growing knowledge economies. It has been established in Disdier, et al. (2015) that the harmonization of technical barriers between developed and developing expands South-North trade. The question that arises is whether IPR harmonization has the same consequences for South-North integration of innovation. Our framework also partially draws upon Yang and Kuo (2008). However, their analysis is limited to the 4 contiguous years of 1995-1998 and does not study South-North linkages, but bilateral relations between 30 selected WIPO members. While their aim is to uncover the influence of trade and IPRs in the destination country on outward patenting activities, we focus on the IPR regime on both sides of the activity and its harmonization between the country pairs.

The reminder of the paper is organized in the following way: the next section gives a number of stylized facts on recent innovation activities in major emerging economies, followed by a short literature review on which our conceptual framework is based on. In section 3 we report methodology, data, and results for the cross-country estimation. Section 4 concludes.

2. Intellectual Property Right Standards and Southern Innovation

2.1. Patenting trends in emerging economies

In OECD countries, the 'propensity to patent' has increased by 20 percent in less than 20 years (OECD, 2004).[2] This change is generally attributed to technological change, economic transformation, and a shift of patent policy in the region since the 1990s. A same trend can be observed in emerging economies after reforming their IPR legal framework according to the standards set by the WTO. In 1985, the total number of patents granted in China was only 138. This figure grew by 700 times in 1999, though Chinese domestic enterprises were still not considered innovative compared to their foreign counterparts (Sun, 2003). In 2011, China's patent office received 526,412 patent applications becoming the largest patent office in the world. Today, the growth in patent filings in China is mostly due to substantial growth in resident filings (WIPO, 2012).[3] In some new technological sectors such as digital communication, telecommunication and high-speed trains, some 20% of total world PCT applications in years 2008-2010 came from China (Tian, 2011). The first Patent Law came into force in China in 1985 and the two major rounds of modifications occurred in 1992 and 2000.

In India, the Patents Act 1970 was amended in 1999, 2002 and 2005. The stagnant level of patent applications in the country experienced a remarkable change with a peak in 1997.[4] PCT applications by Indian inventors and industries registered a sustained growth up to 43% in 2001.[5] Today, the country stands above Japan, Korea and China in terms of patent filings abroad relative to resident patent applications (WIPO, 2011). Trends in ICT-related patent applications to the European Patent Office (EPO) show that India ranked second after China between 1995 and 2003. Over the period 2004-2007, the country presented the highest average growth rate in terms of patent applications (26.3%) reaching almost 37 thousand applications in 2008 (WIPO, 2010).

If we consider the extent of cross-border collaboration by looking at the share of Indian and Chinese inventors in PCT applications by foreign-owned firms, in 2006 they ranked 1st and 2nd in the world respectively with 66.9% of Indian and 59.5% of Chinese inventors contributing to foreign-owned patent

[2] That is, the number of patents created per dollar or euro of R&D, assuming the productivity of R&D is constant.
[3] Chinese providers of telecommunications equipment and network solutions, namely, ZTE Corporation, Huawei Technologies and Huawei Device are among top world PCT applicants ranking respectively, 1st, 3rd and 40th.
[4] This can mostly be attributed to Indian accession to the WTO-TRIPS and the implementation of the transitional mailbox procedure before extending patent protection on pharmaceutical products.
[5] WIPO Magazine 10, 2002.

applications. Today, India still presents the greatest share of inventors contributing to innovative activities of foreign companies (66.2%), while the percentage of Chinese inventors in foreign-owned patent applications has declined to 26% ranking 12th in the world (WIPO, 2012). Finally, Indian IT sector is estimated to aggregate revenues of US$88.1 billion in 2011, with the software and service sector (excluding hardware) accounting for 86.4%.[6] Conversely, China accounts for 14.6% of global electronics hardware production (Bhattacharya and Vickery, 2010). Indeed, the large share of Chinese patent applications in ICT-related areas is associated with considerable focus on ICT hardware production (van Welsum and Xu, 2007).

[Figure 1 about here]

As we are concerned with global knowledge flow in terms of engagement in international scientific activities, an index of interest would be patent applications by citizens of the newly emerging economies away from their home patent office. To pin down the idea, here we focus on the largest NICs, namely the BRICS countries. As WIPO patent data does not represent whether the applicant is a resident in his home country or the country of application, the raw patent count abroad together with the proportion of applications that have been made abroad could be a more adequate measure. We first look at patent applications abroad in the top panel of Figure 1 and find China and to a lesser degree Russia to be successfully active in international innovation activities. An interesting observation is India, whose patent applications abroad has been increasing in a remarkable rate and has surpassed Russia. This suggests that Indians may be more active in patenting activities away from their country of origin. The bottom panel of Figure 1 confirms this, where the share of Indian patent applications abroad have increased to above 40 percent, only second to South Africa. Brazil also demonstrates to be active internationally, but to a slightly lesser degree in absolute terms with a modest growth in the share of their innovation activities abroad in recent years. Interestingly Russia and China fall very short in their share of patent applications abroad, as a large amount of their patent activities take place in their home countries.

[Figure 2 about here]

[6] NASSCOM cited by India Brand Equity Foundation, 2011.

To get a better understanding of the globalized nature of knowledge and its worldwide circulation, we use another measure from the newly made available WIPO data on patent statistics to see more details of the international patenting activities conducted by the BRICS countries. This measure looks at home versus foreign PCT international applications, which should contain patents of higher qualities. When filed, PCT international applications are valid in all the PCT member countries, which currently consist of 144 countries. This can clearly lead to a large amount of cost saving for the innovator. Although a large share of PCT applications take place by the US and other OECD countries, the share of emerging economies, particularly China and India, has been growing over the last two decades. Figure 2 shows that PCT applications, which can be related to patents of higher importance than those applied for as a normal patent at the home patent office, have been growing in China, and to a lesser degree in India, Russia, and Brazil respectively. South Africa has not been very successful in this area. It is interesting to observe foreign PCT international applications by each of the countries under study to get a picture of the degree to which they engage in international innovation activities. Here India surpasses China to show the extent of the globalization of R&D by Indians, whereas South Africa and China have also shown a modest growth. The data on South Africa here shows a remarkable contrast to home PCT international applications made there. Russia and Brazil here lie low, suggesting lower levels of international collaboration in terms of PCT international applications.

2.2. Theoretical background

Our analysis is based on theories that explore the consequences of differences in IPR standards in the North and the South. Our starting point is Lai and Qiu (2003), who question the suitability of North's IPR standards for the South. The conceptual framework also relates to Chu, et al. (2014), who build a model to show that the optimal degree of IPR protection for each country depends on its stage of development. Lorenczik and Newiak (2012) specifically consider the role of IPRs in generating a shift from an imitating to an innovating South. Empirically, Chen and Puttitanun (2005) illustrate the trade-off created by IPR protection for developing countries between imitation and innovation and find that a country's optimal level of IPRs is U-shaped in their level of development. A similar non-monotonic relationship was also found in Maskus (2000)

and Braga et al. (2000). In what follows, we divide the problem at hand to first isolate the effect of IPR protection in the North and in the South. Our ultimate aim is to build a framework through which we could draw conclusions with respect to the worldwide harmonization of IPR standards and differentiate between the dynamics through which it can be achieved.

As we are particularly concerned with the internationalization of Southern R&D, we start by reviewing related literature on the role of IPR protection in encouraging or deterring Southern innovation. The basic economic consequences of IPR enforcement in the origin country on domestic innovation are by now well-established in literature. Patent protection provides firms with temporary monopoly power over their inventions increasing their incentives to innovate. The negative effects of IPR protection instead arise from the increased market power that is granted to inventors and their subsequent monopolistic behavior. [7]

The impact of IPR protection abroad on the internationalization of R&D is less obvious. According to Allred and Park (2007), IPR protection stimulates patenting in developed countries by increasing the appropriability of, and expanding the market for, inventions. Protection in the host country could reduce imitation risks faced by multinationals and induce them to engage in foreign R&D activities by outsourcing innovation (Lai, Riezman and Wang, 2009). In the context of newly emerging economies, a strong IPR regime at home may also facilitate the dissemination of knowledge by helping firms acquire governance capabilities and better manage R&D agreements abroad. This can for instance be due to lower transaction costs a firm has to incur to protect itself from risk of opportunism by a third party (Martínez-Noya and García-Canal, 2011). Perhaps more relevant in the viewpoint of today's rapidly-growing knowledge emerging economies, a stringent regime in the North can also discourage the entry of foreign patents by creating a more concentrated market impeding entry by new firms (Boldrin and Levine, 2008). Picci (2010) also suggests that a weak IPR regime fosters the internationalization of innovation if the patenting activities of MNE branches located in the South take place in their headquarters.

The conclusion drawn from previous literature is that the effect of IPR protection on the globalization of innovation is at best mixed. The results are even more complex and ambiguous when the question deals

[7] See Deardorff (1992) and Maskus (2000) for a clear in-depth overview of the basics.

with the new phenomenon of South-North knowledge transfer.[8] We proceed in the next section to study the above-mentioned trade-off created by IPRs for firms in NICs regarding their incentives to engage in global R&D networks and activities. We then apply the results to describe the location-specificity of IPR protection and show situations under which the foreign engagement of Southern firms in international R&D activities is at its highest level. Our aim is to test whether (i) IPR protection at home, (ii) IPR protection in destination, and (iii) the harmonization of IPR standards gives rise to or obstructs South-North innovation activities.

3. IPRs and Internationalization of Southern Innovation

In this section we examine the impact of IPRs on the internationalization of Southern R&D in a setting that consists of time-varying data on country pairs. Essentially, we are interested in examining the impact of IPRs on *South-North* innovation. Drawing from Section 2, the impact of IPR protection on this phenomenon can be ambiguous. We aim to determine whether and how location specific (domestic versus destination) IPRs contribute to the internationalization of Southern R&D. This further allows us to deduce whether the worldwide harmonization of IPR standards is a blessing or a curse for inventors from the South. To this end, we look at the filing of patents in OECD patent offices by researchers resident in NICs, using IPR protection in both NICs and OECD countries as the main explanatory variable. Similar exercises are performed using first filings of patents and filing of ICT-related patents only. We start by a brief description of the main data before turning to the empirical methodology and the results.

3.1. Patent data and IPR measure

The main variable for patent applications (*PAT*) has been constructed using WIPO data on patent count by filing office and by applicant's origin (http://ipstats.wipo.int/ipstatv2/index.htm?tab=Patent). Patent applications may refer to (i) PCT applications by NIC nationals designating one or several OECD countries to seek protection or (ii) direct filing in an OECD country by NIC residents (Paris Route).[9] We believe the foreign patenting activities of the South could at least partially capture the idea of the internationalization of

[8] See He and Maskus (2012) for a theory on local "reverse" knowledge spillovers from the South to Northern multinationals there.

[9] A detailed explanation of South-North foreign patenting is provided in Appendix 1.

innovation activity in the spirit of what we have highlighted earlier: this would include a (team of) researcher(s) working at the NIC-located branch of a MNC that files a patent through its headquarters in an OECD country.[10]

The complete WIPO dataset has information on 189 countries of origin of applicants and 139 countries (and groups of countries, such as the African Intellectual Property Organization or the European Patent Office) that host a patent office.[11] Information is available for years 1995-2008, so we construct averages for three periods: 1995-1999, 2000-2004 and 2005-2008, hereafter referred to as 1995, 2000 and 2005 respectively. The number of observations is 1248, coming from 14 NICs, 30 OECD countries and 3 time periods. Note that two countries are coded as both NIC and OECD (Mexico and Turkey) so we exclude these pairs. The distribution of *PAT* has a strong positive skew: it takes values between 0 and 3563, the average number of patents is around 14 and standard deviation is 128.[12] Looking at the time dimension, the number of patents filed more than doubles every five years: in 1995 mean of *PAT* is 4.4, in 2000 it is 10.9 while in 2005 is 26.9, suggesting a remarkable increase in the international collaboration in patenting activity.[13]

We also construct country-pair observations limiting patents to first filings abroad and to patents in the ICT sector to check the sensitivity of our results. Although these variables are in principle more appropriate to address the issue at stake, there are very few country pairs with non-zero observations. In the case of first filings only 348 out of 1248 country pairs record a positive number of patents, while in the case of ICT sector patenting, only 269 out of 1248 country pairs record positive numbers. Nevertheless, we believe these are important tests to guarantee that our results are robust. This is because looking at first filings limits the analysis to innovation from NICs that are truly linked to the North and not duplicate

[10] One could argue that foreign patenting could also represent for instance Chinese researchers working in Chinese firms who seek protection in a foreign market. However, over 90% of foreign (primarily OECD and the Asian NICs) applications for Chinese invention patents have claimed foreign priority, suggesting that patent applications had earlier been filed for the inventions with foreign jurisdictions (Hu, 2010).

[11] Since WIPO registers the residence of the *first* applicant of a patent, our measure could underestimate the real measure of patents whose applicants reside in a country different than the patent office. This is the case of multiple applicants with different residences, with the first applicant residing in the same country as the patent office where the patent is filed.

[12] The number of patents can take fractional values because we take the average across years in order to quantify our dependent variable as patents per year.

[13] We take 5-year averages for two reasons. First, data for the IPR protection index are only available for 5-year intervals and second, even if we had data on a yearly basis, IPR protection varies slowly in general, with large jumps when agreements are set in place: taking the averages helps to smooth out these irregular movements.

patenting of inventions originally filed in the home country. Looking at the ICT sector, in turn, singles out the impact of IPRs in a patent-reliant industry with a high risk of imitation.

The measure of IPR protection for both the origin and the destination country comes from Park (2008). The IPR index ranges between 0 and 5 and it is constructed adding five zero-to-one components relative to (i) the patentability of different industrial sectors, (ii) the membership in international treaties, (iii) the duration of protection, (iv) the type and number of available enforcement mechanisms and (iv) the type and number of restrictions on patent rights. The IPR index for the 14 NICs shows a mean equal to 3.17 and a standard deviation of 0.86. The pattern that it shows for the three periods is in line with the overall pattern that Park (2008) spots for the whole sample of countries for which he constructed the index: it is increasing over time and the standard deviation is decreasing, indicating a convergence of IPR protection among NICs. In particular, mean and standard deviations are 2.5 and 0.8, 3.3 and 0.8 and 3.7 and 0.5 in the 1995, 2000 and 2005 periods, respectively. Turning to OECD countries, the IPR index is overall larger than that of NICs: it shows a mean of 4.2 and a standard deviation of 0.5. This indicates not only higher protection of IPRs, but also more compressed values of the index among OECD countries. The time pattern is similar to that of NICs: the index is increasing, though more moderately, and its standard deviation is decreasing over time.[14]

3.2. Methodology and other variables

Given the nature of our analysis, i.e. looking at the determinants of R&D linkages from NICs to OECD countries, we make use of an *oriented* gravity-like model.[15] Rather than considering bilateral flows, the standard practice in gravity estimation of trade flows (Frankel and Rose, 2002) or international invention activity (Picci, 2010), we specifically look at the number of patents filed in the patent office of an OECD country (the destination country) whose first applicant resides in a NIC (the origin country). Succinctly, our main dependent variable PAT_{ijt} is the average number of patents filed in the time period *t* by an applicant

[14] Mean and standard deviations are 4.0 and 0.6, 4.2 and 0.5 and 4.4 and 0.3 in the 1995, 2000 and 2005 periods, respectively.

[15] Our framework partially draws upon Yang and Kuo (2008). However, their analysis is limited to the 4 contiguous years of 1995-1998 and do not study South-North relations, but bilateral relation between 30 selected WIPO members. While their aim is to uncover the influence of trade and IPRs in the destination country on outward patenting activities, we focus on the IPR regime on both sides of the activity and its harmonization between the country pairs.

residing in country *i* in the patent office of country *j*, where index *i* runs over 14 NICs and *j* runs over the 30 OECD countries. Countries officially considered as NICs are: Brazil, China, India, Mexico, Malaysia, Philippines, Thailand, Turkey and South Africa (Mankiw, 2007). In our definition of NICs, we also include countries over which consensus has not yet been reached in the economic literature: Argentina, Chile, Egypt, Indonesia and Russia (Bożyk, 2006). Note the different pools from which *i* and *j* are taken and that, in general, $PAT_{ijt} \neq PAT_{jit}$.

The empirical model we estimate, written in general terms, is the following:

$$PAT_{ijt} = G_t + D_i + D_j + \boldsymbol{\beta 1}\, \boldsymbol{X}_{it} + \boldsymbol{\beta 2}\, \boldsymbol{Y}_{jt} + \boldsymbol{\beta 3}\, \boldsymbol{Z}_{ij} + \boldsymbol{\beta 4}\, \boldsymbol{W}_{ijt} + u_{ijt} \qquad (2)$$

The monadic terms $\boldsymbol{X}_{it}$ and $\boldsymbol{Y}_{jt}$ include time-varying variables common to origin and destination countries, respectively. In particular, they include our main explanatory variables IPR_{it} and IPR_{jt}. Among other monadic variables there are (log of) GDP per capita and population: instead of having only GDP as mass variable, we separate size (population) and development (GDP per capita) effects in the spirit of Head, Mayer, and Ries (2010), so to better interpret our results. We expect that both GDP per capita and population in the origin country should have a positive effect on innovation activity, including the filing of patents abroad. We also use the Barro and Lee (2010) data on the share of people aged 25 and above holding at least tertiary education to account for human capital in both the origin and the destination.[16]

The matrix $\boldsymbol{Z}_{ij}$ includes all the time-invariant dyadic variables, collected by CEPII and used by Head, et al. (2010). We use (log of) distance between *i* and *j*, commonality of borders and commonality of language. These variables have proved to have strong explanatory power in gravity equations for trade flows, foreign direct investments and services. With this respect, we want to compare the elasticities of the internationalization of innovation activities. The term $\boldsymbol{W}_{ijt}$ collects dyadic time-variant variables. Specifically, it will include our alternative explanatory variable, the squared distance between IPR protection in country *i* and country *j* at time *t*, that should capture the impact of harmonization of the IPR regime within each country pair. In addition, it includes the value of aggregate bilateral import flows from country *j* to country *i*

[16] According to Baldwin and Taglioni (2006), we should include a full set of country/year fixed effects to take into account country-specific time-varying behaviors, but the short time variability would make it impossible to have enough degrees of freedom.

at time *t* from the IMF's Direction of Trade Statistics (DoTS) to account for bilateral trade intensity.[17] The term G_t is a common year-specific factor and we use year dummies to capture for it. Similarly, D_i and D_j take into account country-specific fixed effects.

3.3. Empirical Results

In terms of empirical model, the count nature of the dependent variable *PAT* suggests that the Poisson estimator is the most adequate choice (Picci, 2010; Santos Silva and Tenreyo, 2006). Moreover, a large number of zeroes and the over-dispersion of the variable *PAT*, especially in the case of first filings and ICT patents, call for an alternative estimation by means of a Negative Binomial model, which is presented in the last column of all tables.[18]

The results of our first specification are present in column 1 of Table 1, where the explanatory variables are IPR protection in origin and destination countries, and distance, dummies for common language and common border, population, GDP per capita, and bilateral imports from OECD countries to NICs are used as controls. In addition, NICs and OECD country dummies together with two (out of three) time dummies are included in all specifications.[19] IPR protection in NICs is positive and strongly significant, while it is negative but insignificant in the OECD countries. The results we obtain are in contrast to Yang and Kuo (2008), who find a positive and significant relation between IPR regime of the destination country and foreign patenting activity that takes place there. The negative effect could be a symptom of blocked access to important Northern technologies needed mainly by Southern firms to realize their own innovations. Also, since NICs are on average less technologically advanced than OECD countries, the former may find it easier to patent an innovation in OECD countries with weaker IPR regimes. This occurs because the technological frontier of the most developed OECD countries is difficult to reach, therefore few patent filings are recorded. We will take this pattern into account in those specifications that use the squared distance between IPR protection indices within each country pair.

[17] The specification is log (1+import) averaged for each five-year period under study.
[18] We have also tried but do not report the Zero-Inflated Poisson model. The results are identical in all cases.
[19] These dummies already control for a lot of variation: a regression that uses only those delivers an R^2 of 0.74.

Distance shows an elasticity of *-0.3* that is comparable with findings by Picci (2010), even though he uses a different measure for patents. Language proves to be an important determinant, while the common border dummy does not. Size measures (population) of origin and destination country are characterized by a positive but not statistically different from zero coefficient, while income per capita has a positive effect in the origin country and negative, not significant, in the destination. Referring to GDP per capita, the former effect could be the result of higher human capital and/or higher R&D spending, measures that are usually associated with higher GDP per capita. The negative sign on the GDP per capita in the destination country could be driven by the fact that NICs tend to collaborate with countries that are more similar to them in terms of the level of development.[20] Also bilateral trade between the two countries does not tend to have a significant effect on foreign patenting activities by NICs.[21]

[Table 1 about here]

In column 2 we introduce the measures of human capital for both origin and destination country. This marginally reduces the coefficient on GDP, as one could expect, while rendering the GDP per capital coefficient of the origin country negative and significant. The coefficients on human capital, though positive, are not statistically different from zero. The pattern of the IPR coefficients for the origin and destination countries remains unchanged. Column 3 adds the interactions of the IPR protection index with the share of exported goods belonging to the ICT sector in 2000 for NICs, obtained from World Bank World Development Indicators. Doing so takes into account the fact that countries more oriented toward production and exports in the patent-reliant ICT sector should gain more from IPR protection at home. As expected, the interaction between the share of exports in the ICT sector and the IPR protection index in NICs is positive and strongly significant.[22] In column 4 we replicate the specification in column 1 using the squared distance between IPR protection indices within each country pair instead of the two IPR indices. This variable is negative and strongly significant, indicating that a convergence of the IPR regimes between origin and destination

[20] A regression using the squared difference of GDP per capita of origin and destination country, rather than the two separate variables, gives a negative and significant coefficient.

[21] The results remain the same when using bilateral export flows from *i* to *j,* or the sum of exports and imports as a measure of trade intensity.

[22] The direct effect of the share of ICT cannot be estimated because it is collinear with NICs' country fixed effects.

country is conducive to research collaboration. Column 6 replicates this last specification using a negative Binomial estimator, which accounts for the over-dispersion of *PAT* (Hausman, Hall, and Griliches, 1984). This specification confirms the results obtained on the squared distance between IPR protection.

[Table 2 about here]

In Table 2 we replicate all specifications in Table 1 using first filing of patents as the dependent variable. The procedure used to construct the variable is similar to that for *PAT* with much smaller numbers as anticipated. The distribution of first filings has a strong positive skew, as was the case for *PAT:* it takes values between 0 and 873, with mean 3 and standard deviation 29. In all specifications, the findings suggest that first patenting is more sensitive to distance, possibly because first filing is more closely associated with cross-border collaboration than the original variable *PAT*. The coefficient of IPR protection in the OECD is negative and strongly significant, suggesting that push effects are at play: a weaker IPR environment makes it easier for researchers from NICs to file patents abroad. Results on the squared distance between IPR protection regimes are comparable with those obtained in Table 1. Interestingly, the relationship between the flow of imports and patents into the OECD countries is negative and becomes significant for patents first filed abroad. This could be because domestic innovation gains importance for countries already well integrated in the global market, or alternatively due to their dependence on foreign technologies embedded in the imported goods.

[Table 3 about here]

Finally, In Table 3 we report the results using the number of patents published specifically in the ICT sector as the dependent variable. Using the WIPO classification, we include technology fields of Telecommunications, Digital communication, Basic communication processes, Computer technology, IT methods for management and Semiconductors in the ICT sector. Numbers are even smaller than those for first filings: the number of patents go from 0 to 785, the average is 2 patents with a standard deviation of 24. The results mirror those in our baseline specifications in Table 1 with the exception of the interacted column 3. The positive effect of IPR protection regime in NICs and the negative effect of the distance between IPR regimes are in place. In particular, the coefficient on the distance between North-South IPRs is

larger in magnitude in specifications 3 and 4 with respect to their counterparts (columns 4 and 5 of Table 1, respectively). This is consistent with the positive effect of the interaction term between IPR protection and ICT export in column 3 of Table 1. Bilateral trade does not affect the impact of IPRs on foreign patenting, but remains negative and significant implying the reliance of NICs on the technology content of trade when the latter is a more prevalent option.

4. Concluding Discussion

This investigation can be viewed as an initial attempt to explore the different roles IPRs can play for the globalization of Southern innovation with respect to the location of enforcement. While the debate on the protection of IPRs has often been placed in a 'North-South' perspective, this paper addresses innovation that originates in the South. The investigation attempts to answer the question whether stronger IPR protection at home and away or its cross-borders harmonization could stimulate the internationalization of R&D from the South.

Country-level data on the foreign patenting activities of NICs in OECD countries reveals that strengthening IPR protection in the South encourages domestic Southern firms to engage in global innovation activities. At the same time, the results reinforced the necessity of a strong IPR regime in the South to attract MNEs and for research activities to be operative there in the first place in order for the South to eventually engage in patenting activities abroad. In contrast, our findings show that a stringent IPR regime in the North could limit foreign patenting by NICs by making it more difficult for innovators from the latter to enter the Northern market. South-North R&D linkages should hence be at their peak if we observe a convergence of protection levels in the two regions. By convergence of IPR protection levels we do not necessarily mean the need for relaxing IPRs in the North and upgrading them in the South, but a convergence of IPR systems. That is, reaching a rallying point in the implementation of an effective IP policy to encourage the participation of each country in *international* innovation activities and the diffusion and use of new technology *across* countries. A starting point could be cooperating for the development of reciprocal legal and technical tools aimed at lowering barriers to foreign-patenting activities and improving the quality and transparency of the global patent system in general.

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Table 1: Determinants of South-North formation of GINs. Filing.

	(1)	(2)	(3)	(4)	(5)
Estimation method	Poisson	Poisson	Poisson	Poisson	Negative Binomial
Dep. Var.	*PAT_ijt*	*PAT_ijt*	*PAT_ijt*	*PAT_ijt*	*PAT_ijt*
DIST_ij	-0.301***	-0.286***	-0.260***	-0.304***	-0.648***
	(0.074)	(0.072)	(0.072)	(0.075)	(0.083)
COM_LAN_ij	0.531***	0.540***	0.531***	0.560***	1.094***
	(0.133)	(0.133)	(0.126)	(0.132)	(0.161)
COM_BOR_ij	0.267	0.215	0.132	0.263	0.025
	(0.239)	(0.235)	(0.221)	(0.244)	(0.242)
POP_it	3.306	1.919	3.390	3.791	7.356***
	(3.139)	(3.304)	(2.238)	(3.416)	(1.624)
POP_jt	2.057	7.848**	4.207	-1.034	8.350***
	(4.374)	(3.847)	(3.081)	(4.896)	(2.234)
GDP_pc_it	1.389***	1.197***	0.993***	1.364***	1.297***
	(0.276)	(0.360)	(0.296)	(0.274)	(0.171)
GDP_pc_jt	-0.643	-1.524***	-1.376**	-0.048	-1.130***
	(0.717)	(0.500)	(0.577)	(0.715)	(0.330)
IMP_ijt	-0.071	-0.054	0.057	-0.093	-0.034
	(0.054)	(0.056)	(0.038)	(0.063)	(0.024)
IPR_it	0.594***	0.583***	0.413***		
	(0.173)	(0.162)	(0.095)		
IPR_jt	-0.162	-0.130	-0.476		
	(0.345)	(0.338)	(0.372)		
EDU_it		0.157			
		(0.150)			
EDU_jt		0.031*			
		(0.017)			
ICT_IPR_it			3.672***		
			(0.391)		
dist_IPR_ijt				-0.116***	-0.062***
				(0.041)	(0.023)
Time dummies	YES	YES	YES	YES	YES
Country dummies	YES	YES	YES	YES	YES
Observations	1,248	1,248	1,158	1,248	1,248

Note: The dependent variable is the average yearly number of patents filed in OECD countries' patent offices filed by NICs-resident applicants. Poisson (1-4) and Negative Binomial (5) estimations. Note that *i* refers to NICs while *j* refers to OECD countries. All specifications include monadic country dummies and time dummies. Detailed descriptions of the set of controls in the text. Robust standard errors clustered at the country-pair level in brackets. (***) p-value < 0.01, (**) p-value <0.05, (*) p-value <0.1.

Table 2: Determinants of South-North formation of GINs. First filing.

	(1)	(2)	(3)	(4)	(5)
Estimation method	Poisson	Poisson	Poisson	Poisson	Negative Binomial
Dep. Var.	*F.PAT_ijt*	*F.PAT_ijt*	*F.PAT_ijt*	*F.PAT_ijt*	*F.PAT_ijt*
DIST_ij	-0.594***	-0.588***	-0.573***	-0.582***	-0.872***
	(0.135)	(0.134)	(0.127)	(0.137)	(0.139)
COM_LAN_ij	1.083***	1.082***	1.172***	1.132***	1.303***
	(0.229)	(0.227)	(0.214)	(0.226)	(0.239)
COM_BOR_ij	0.901*	0.902*	0.759*	0.953*	0.717*
	(0.510)	(0.500)	(0.445)	(0.540)	(0.428)
POP_it	-3.464	-3.370	-3.075	-4.193	-1.663
	(2.983)	(3.002)	(2.225)	(3.367)	(2.853)
POP_jt	23.848***	27.278***	25.168***	25.119***	22.066***
	(3.908)	(4.349)	(3.218)	(5.129)	(4.553)
GDP_pc_it	1.611***	1.605***	1.267***	1.566***	0.641**
	(0.338)	(0.320)	(0.357)	(0.350)	(0.316)
GDP_pc_jt	-0.685	-1.153	-0.861	-0.486	-2.292***
	(1.064)	(0.865)	(0.988)	(1.002)	(0.632)
IMP_ijt	-0.185***	-0.191***	-0.136***	-0.209***	-0.097***
	(0.060)	(0.063)	(0.051)	(0.060)	(0.026)
IPR_it	0.457***	0.453***	0.363***		
	(0.158)	(0.154)	(0.099)		
IPR_jt	-1.708**	-1.693**	-1.901**		
	(0.795)	(0.788)	(0.771)		
EDU_it		0.008			
		(0.106)			
EDU_jt		0.025			
		(0.020)			
ICT_IPR_it			2.301***		
			(0.434)		
dist_IPR_ijt				-0.110***	-0.133***
				(0.035)	(0.034)
Time dummies	YES	YES	YES	YES	YES
Country dummies	YES	YES	YES	YES	YES
Observations	1,248	1,248	1,158	1,248	1,248

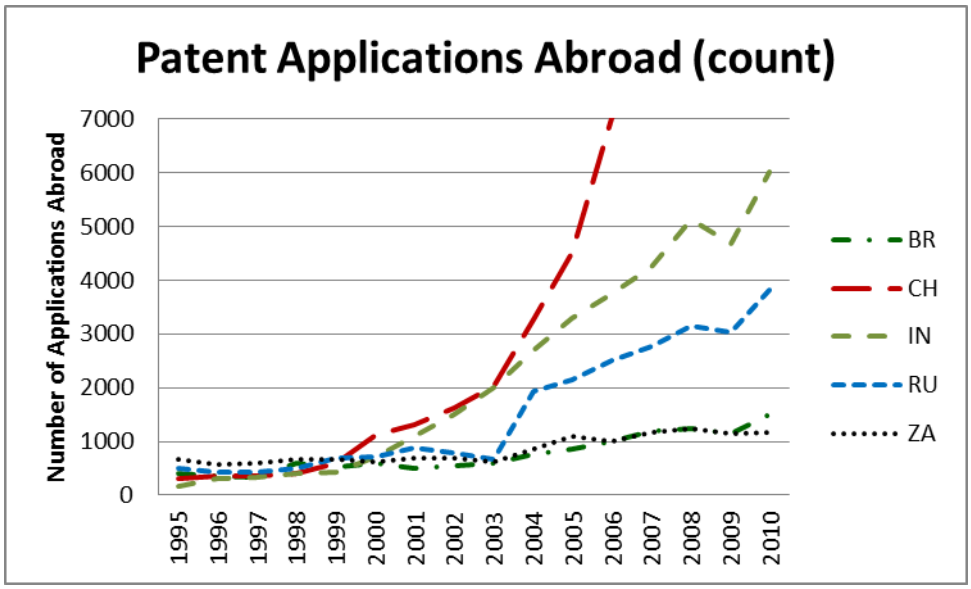
Note: The dependent variable is the average yearly number of patents first filed in OECD countries' patent offices filed by NICs-resident applicants. Poisson (1-4) and Negative Binomial (5) estimations. Note that *i* refers to NICs while *j* refers to OECD countries. All specifications include monadic country dummies and time dummies. Detailed descriptions of the set of controls in the text. Robust standard errors clustered at the country-pair level in brackets. (***) p-value < 0.01, (**) p-value <0.05, (*) p-value <0.1.

Table 3: Determinants of South-North formation of GINs. ICT Filing.

	(1)	(2)	(3)	(4)
Estimation method	Poisson	Poisson	Poisson	Negative Binomial
Dep. Var.	*ICT.PAT_ijt*	*ICT.PAT_ijt*	*ICT.PAT_ijt*	*ICT.PAT_ijt*
DIST_ij	-0.368***	-0.369***	-0.363***	-0.428***
	(0.094)	(0.093)	(0.099)	(0.088)
COM_LAN_ij	1.000***	1.013***	1.036***	1.011***
	(0.370)	(0.368)	(0.381)	(0.303)
COM_BOR_ij	-0.361	-0.554	-0.295	-0.462
	(0.383)	(0.337)	(0.439)	(0.319)
POP_it	2.815	1.015	2.830	7.557**
	(2.942)	(3.292)	(3.320)	(2.977)
POP_jt	22.999***	23.532***	15.323***	21.211***
	(4.256)	(5.815)	(5.485)	(4.636)
GDP_pc_it	1.211**	1.088*	1.200**	1.724***
	(0.541)	(0.614)	(0.548)	(0.477)
GDP_pc_jt	-0.499	-0.591	0.541	-0.817
	(0.881)	(0.862)	(1.089)	(0.797)
IMP_ijt	-0.197***	-0.181***	-0.246***	-0.127**
	(0.060)	(0.062)	(0.059)	(0.055)
IPR_it	0.867***	0.833***		
	(0.145)	(0.125)		
IPR_jt	0.464	0.345		
	(0.831)	(0.867)		
EDU_it		0.243*		
		(0.145)		
EDU_jt		0.000		
		(0.016)		
dist_IPR_ijt			-0.169***	-0.066**
			(0.040)	(0.033)
Time dummies	YES	YES	YES	YES
Country dummies	YES	YES	YES	YES
Observations	1,248	1,248	1,248	1,248

Note: The dependent variable is the average yearly number of patents in the ICT sector (Telecommunications, Digital communication, Basic communication processes, Computer technology, IT methods for management and Semiconductors, according to WIPO classification) published in OECD countries' patent offices filed by NICs-resident applicants. Poisson (1-3) and Negative Binomial (4) estimations. Note that *i* refers to NICs while *j* refers to OECD countries. All specifications include monadic country dummies and time dummies. Detailed descriptions of the set of controls in the text. Robust standard errors clustered at the country-pair level in brackets. (***) p-value < 0.01, (**) p-value <0.05, (*) p-value <0.1.

Figure 1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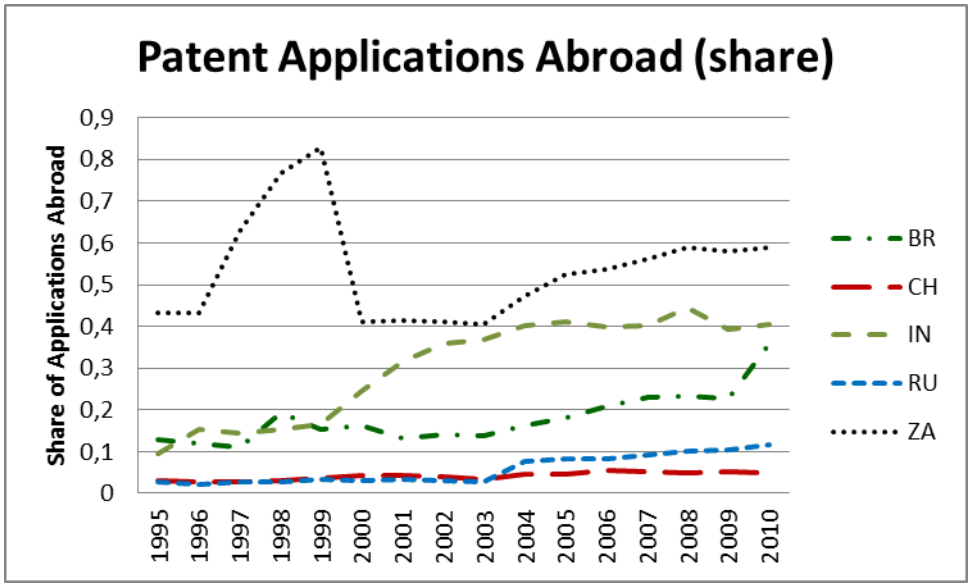
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Share of Applications Abroad
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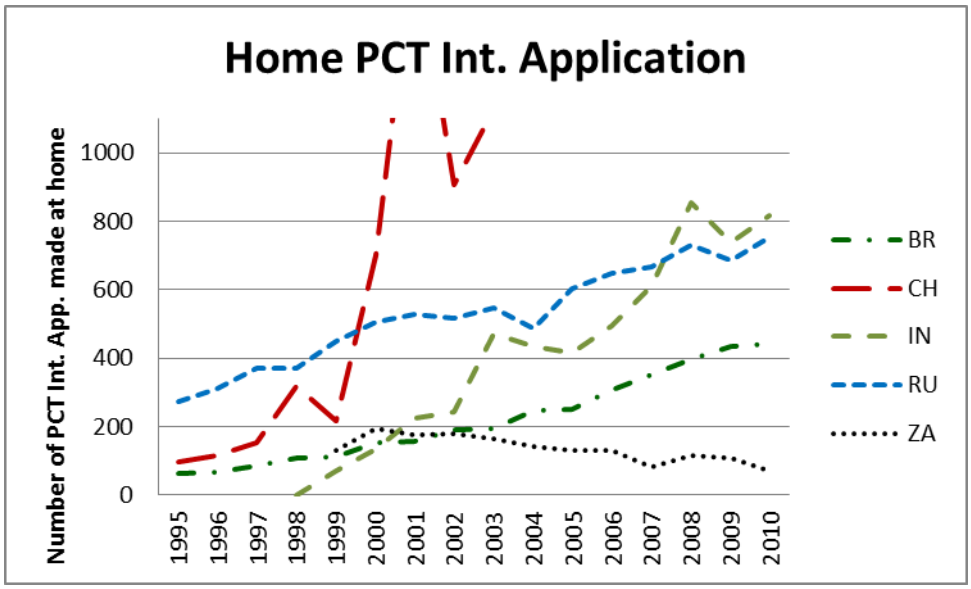
Figure 2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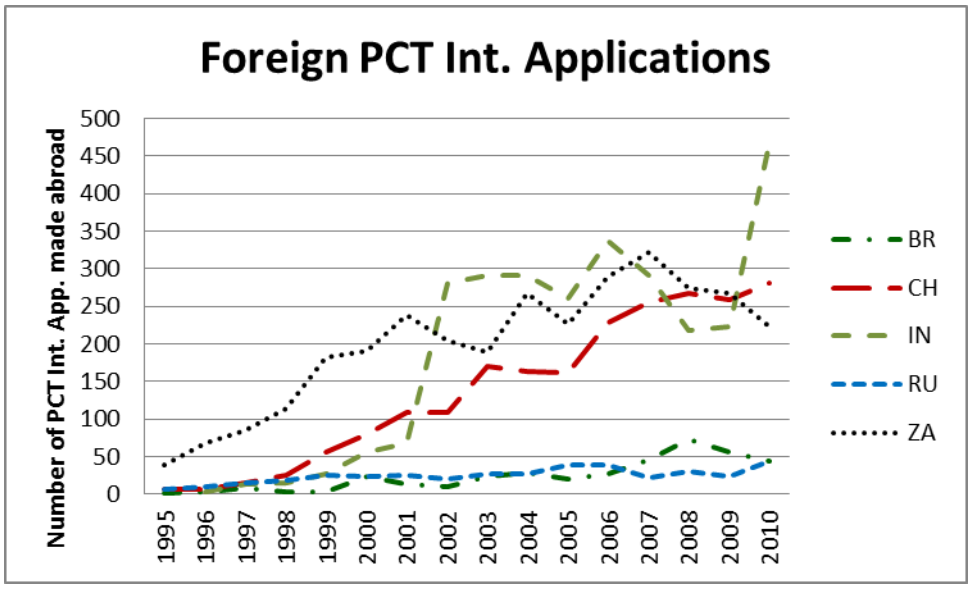
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APPENDIX 1 – South-North Foreign Patenting

We consider all (and only) foreign-oriented patent families of NICs looking specifically at the destination of their foreign applications, restricting such observations to OECD patent offices. As well-known, under the PCT, patent applicants may submit applications in multiple jurisdictions. This implies that a single application can, in theory, potentially lead to patent grants in 144 member states. For the purposes of the analysis of indicators of global patent activity by country of origin PCT applications may not be appropriate as they present duplicates.[23] However, this is not our objective. Our objective is to look at the determinants of demand for protection of emerging economies in high-income markets. The same is applicable to the case of NIC's residents that apply directly, through the Paris Route, at one or more OECD Patent Offices. This can occur for several reasons: the applicant may seek protection in only one OECD country or, more likely, the NICs is/was not yet part of Patent Cooperation Treaty. Argentina, for instance is not part yet of the PCT.[24]

Patent activity of NIC in multiple OECD jurisdictions can provide a proxy indicator for technological transfer and may let us advance considerations concerning its impacts on competition (i.e. exports) and other economic effects, such as rent transfers to the jurisdictions of patent holders. Our dependent variable *PAT* considers: (i) domestic firms set in NICs who seek protection in a foreign high-income market and (ii) foreign subsidiaries of an MNC set in NICs who seek protection in a market different from the one where they operate. Such foreign market could be the country where the HQ of the MNC is set as well as other third markets. Therefore, we focus on innovations (or potential innovations) developed in Southern countries that can meet the supply of Northern markets, including also innovations that both Northern and Southern MNC subsidiaries set in NICs develop not simply to adapt their products to the local markets, but that aim to meet the global demand of technology.

[23] Over the years, the percentage of patent families covering at least two patent offices has increased considerably. Among the top countries, there is considerable variation in this share. For example, fewer than 7% of patent families created by residents of the Russian Federation (1.5%), China (3.4%) and Brazil (6.6%) contained at least two patent offices between 2003 and 2007. In contrast, more than half of all patent families created by residents of France (51.5%), Sweden (54.3%) and Switzerland (60.5%) include at least two offices (WIPO, 2010).

[24] Amongst the other NICs, Turkey, Indonesia, India and South Africa signed the PCT in 1996, 1997, 1998 and 1999 respectively, the Philippines in 2001, Egypt in 2003, Malaysia in 2006, Chile and Thailand in 2009.