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A B S T R A C T

With the rise of the knowledge economy, delivering sound innovation policies requires a thorough understanding of how knowledge is produced and diffused. This paper takes a step to analyze a new form of globalization, the so-called system of Global Innovation Networks (GINs), to shed light on how the protection of intellectual property rights (IPRs) influences their creation and development. We focus on the role of IPR protection in fostering international innovative activities in emerging economies (South), such as China and India, and more generally, how IPRs affect the development of GINs between newly industrialized countries and OECD countries. Using both survey-based firm-level and country-level global data, we find IPRs to be an important determinant of participation in GINS from a Southern perspective. We find IPR protection at home and its harmonization across county pairs foster South-North formation of GINs. We also find that a stringent regime in the destination country discourages foreign international innovative activities that originate in NICs. Both levels of our analysis confirm the ICT industry, particularly the hardware segment, to rely on IPRs when engaging in the international outsourcing and offshoring of innovation or in patenting activities abroad.

Keywords: Gravity Model, Information Communication Technology, Innovation, Intellectual Property Rights, International collaborations, Networks.

1. Introduction

The growing demand for technology in an increasingly competitive global market is changing the geography of innovation. Today multinational enterprises (MNEs) seek not only to exploit knowledge generated at home in other countries, but also to source technology internationally and tap into worldwide centers of knowledge (OECD, 2008a). This implies a faster pace for the internationalization of R&D, a wider range of actors involved worldwide, and a greater scope of international innovative activities. This trend has given birth to Global Innovation Networks (GINs), or "globally organized networks of interconnected and integrated functions and operations by firms and non-firm organizations engaged in the development or diffusion of innovations" (Chaminade, 2009). The main features of a GIN are: (i) a truly global character, (ii) a variety of actors engaged in innovation, (iii) integrated internalized and externalized networks, (iv) a high degree of functional integration and (v) a focus on innovation (Pilat et al., 2009).

A great number of empirical studies find how intellectual property rights (IPRs) can contribute to innovation through different channels. For example, Chen and Puttitanun (2005) show that IPRs increase patent application filed at the US office by residents of developing countries. Branstetter et al. (2006) find that R&D expenditure and total levels of foreign patent applications by MNE affiliates increase after IPR reforms in host countries. Yet, the decision to include international standards of IPR protection in the WTO has proved problematic, particularly for developing countries (Correa, 2000; Barton et al., 2002) and it begun to be questioned whether harmonization of IPRs under the TRIPS at the developed world's standards is workable given the extreme differences in the technological effort of countries, differences in cost and benefits of intellectual property and difficulties of enforcement.

As knowledge starts to flow more freely across the globe, Intellectual Property theft remains the most important risk for GINs (OECD, 2008b, Pilat et al., 2009). While most R&D investments still go to OECD countries, non-OECD countries have attracted an increasing amount of R&D investments in recent years. With Newly Industrialized Countries (NICs) taking a lead in developing technologies of global standards, of the view of high-technology companies with headquarters in the South towards IPRs takes a new meaning. Previous literature on the catching-up process of the South has mainly emphasized on North-South technology transfer highlighting the trickle-down effect from technological frontier (Acemoglu, Aghion and Zilibotti, 2006) or globalization arguments, such as decreasing transportation and migration costs, coupled with the non-rival nature of technology.

This paper instead places the development of innovation capacities and the internationalizing of R&D by the new class of firms in and from the South under spotlight. It investigates the relevance of IPRs from a South-North perspective to study the incentives of actors in emerging countries to tap on to international knowledge networks. In so doing, we also define measures for the new concept of GINs to assess the degree to which emerging countries are linked to GINs. In short, the study aims to shed light on how GINs operate and to find the factors influencing their operation.

Our empirical findings, based on survey data discussed in more detail below, suggest that depending on the definition of GINs, both skill availability and a credible IPR regime can contribute to Southern firms' involvement in GINs. To validate our findings on a global scale, we attempt to explore whether IPR protection fosters global innovative activities that originate from NICs. Using data on patents filed by nationals from 14 NICs in 31 OECD countries in a gravity framework, we show IPRs in both the original and the destination country, as well as the degree of harmonization between each country pair, can matter for South-North innovation initiatives. We show South-North foreign patenting to be positively related to domestic IPRs, *negatively* to foreign IPRs, and positively to harmonization between the two regimes. Both analyses confirm the particular essentiality of IPR for international innovation activities in the ICT sector, primarily the hardware segment.

The reminder of the paper is organized in the following way: the next section reviews the literature on IPRs and emerging economies. This is followed in Section 3 by an outline of the research questions and the empirical strategy we follow. Section 4 presents survey data and the relative empirical analysis. In section 5 we report methodology, data, and results for the cross country gravity estimation. Section 6 concludes.

2. Foreign patents and the internationalization of innovation activities.

2.1. The surge in international patent applications from and in emerging economies

The increase in the 'propensity to patent'[1] by 20 percent in less than 20 years in OECD countries is generally attributed to technological change, economic transformations, and a shift of patent policy since the 1990s (OECD, 2004). The same trend has occurred in emerging economies after reforming their legal framework of IPRs protection according to WTO standards. In 1985, the total number of patents granted in China was only 138. This number increased to 100,156 in 1999 (Sun, 2003). The total amount of patent applications in China today exceeds 7 million ranking as the third largest patent office in the world and fourth in terms of PCT filings. In some new technical areas, such as digital communication, telecommunication and high-speed trains, 20% of the total of PCT applications in the field of digital communications have come from China in the years 2008-2010.[2] China accounts for 3.5% of triadic patents and aims to join the top five countries receiving triadic patents by 2015 (Zhao, 2006). The first Patent Law came into force in China in 1985 and the two major rounds of modifications occurred in 1992 and 2000.

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[1] That is, the number of patents taken per dollar or euro of R&D, assuming the productivity of R&D constant.

[2] Tian, L., 2011.WIPO PCT/MIA/18/12.

In India, the Patents Act, 1970 was amended in 1999, 2002 and 2005. Since the country became signatory to the Patent Cooperation Treaty in 1998, patent filings in India have registered a sustained growth up to 43%.[3] 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 36,812 applications in 2008 (WIPO, 2010). If we look at the contribution of local inventors to foreign-owned patent applications[4], 65% of Indian inventors and 43.9% of Chinese inventors are associated with foreign PCT applications, ranking respectively 1st and 5th in the world.[5]

2.2 IPRs and Innovation in the ICT sector

Patent and copyright laws in the ICT sector still vary across countries and enforcement mechanisms continue to differ. The recognition of copyright as a main modality for the protection of computer programs was a major objective of industrialized countries[6] in the TRIPS agreement. The use of patent protection or other IPRs to secure innovation on the other hand has not proved easy in ICT due to the incompatibility of the pace of the industry with the long registration prodecures involved (Hurmelinna and Puumalainen, 2007). Nonetheless, the global ICT sector, especially in relation to the internet, semiconductors, telecommunications, computer hardware and computer software heavily patent with more than 100 patents involved in an average ICT product (Dutfield and Suthersanen, 2008). Such 'patent thickets' are attributed mostly to the interrelated nature of

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[3] WIPO Magazine 10, 2002. PCT Applications continue to grow in Developing countries.

[4] When the countries of residence of the patent applicant and inventor differ, this indicates differences in geographical *location* and *ownership* of the invention itself.

[5] China ranks 5th after Russia, Belgium and Canada. Figure A.7c in *World Intellectual Property Indicators*, WIPO, 2010.

[6] In US a Software Amendment to the Copyright Act was introduced in 1980 while in Europe the European Commission issued a directive concerning the application of copyright to software in 1991.

these technologies, but in certain cases are being used as barriers to entry and to accumulate large patent portfolios (Hall and MacGarvie, 2010).

Overall, patent law protects *functional* products and processes, such as all new components of a new microprocessor, while copyright law protects source codes of computer programs provided that they are *expressive* works. If software and computer programs are both functional and expressive, they may susceptible of protection by both IP tools. That is, while the computer code is not patentable, the underlying inventions themselves, or computer implemented inventions (CII) are patentable when they have a 'technical character' (Guellec et al., 2007).

Art.27.1 (TRIPS) does not define what an invention is and it does not provide a uniform definition of patentability criteria and art.9.2 (TRIPS) leaves to domestic copyright laws the decision to set the dichotomy expression/ idea, therefore differences across countries may still persist (Correa, 2007). Even if the EU phraseology concerning patent protection for computer-implemented inventions as been detected in both Indian and Chinese patent laws, significant problems remain in their jurisdiction and administration of IPRs (Perthuis and Van der Bulk, 2005; Pai, 2007). In the next years, a more effective enforcement of ICT-related IPRs is expected in these countries to help the innovation environment for their emerging international R&D based ICT industry (Maskus et al., 2005; van Welsum and Xu, 2007; Bhattacharya and Vickery, 2010).

Indian IT sector is estimated to aggregate revenues of 88.1 USD in 2011, with the software and service sector, excluding hardware, accounting for 86.4%.[7] Conversely, China contributes for 14.6% of the global electronics hardware production (Bhattacharya and Vickery, 2010). Indeed, the large share of Chinese patent applications in ICT-related areas is associated with the considerable focus on ICT hardware production (van Welsum and Xu, 2007).

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[7] NASSCOM cited by India Brand Equity Foundation, 2011 (Updated 11 Feb 2011) Available at: <http://www.ibef.org/industry/informationtechnology.aspx> [Accessed 15 April 2011].

3. The research questions and the empirical strategy

Our study aims to investigate the role of the institutional environment for IPR protection in fostering international innovative activities in emerging economies, such as China and India. More precisely, the two key questions that we want to address are: (a) to what extent are institutional frameworks for IPR protection at home and away relevant for fostering the involvement of firms in the South in GINs? (b) how do IPRs impact international innovation activities of the South and its country-level propensity to form GINs?

For each of these tasks we will use specific data. To address the first question we rely on a firm-level survey that has been specifically designed to gather information on firms' behavior in terms of international innovation activity. Across four continents, firms were asked to provide information about experiences with regulation, practices and jurisprudence around IPRs faced in the internationalization of their innovation activities. We focus on a high-technology industry in which the use and development of new technologies through innovation is more pervasive and sector specific.[8] As anticipated, we focus on Chinese and Indian firms active in the ICT sector.[9]

Thanks to the findings of the first step of the analysis, we address the second question by means of an empirical gravity model designed to capture the extent of NICs involvement in the internationalization of innovation activity, in particular in OECD countries. To do so, we first define an appropriate variable to measure the phenomenon, related to the number of patents that NICs nationals file in OECD patent offices. We then regress this variable on country and country-pair specific variables such as IPR protection in both countries, degree of ICT-specificity of exports,

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[8] This is partly driven by the survey design, which lets each partner-country select one sector of particular economic relevance. The ICT sector has been selected by both Indian and Chinese survey partners, letting us obtain indications for emerging economy-, country- and industry-specific policies.

[9] A description of the firm-level survey design and implementation is provided in Appendix I.

together with standard gravity model specific controls such as distance, GDP per capita, common language and common border dummies.

4. Descriptive statistics of survey data

4.1. Defining GINs and the independent variables of interest

To assess the presence of GINs in the sample, we use two different dependent variables. The first, *GIN1*, defines firms that have established collaborations with foreign actors for the development of their most important innovation. Such actors could be indistinctively clients, suppliers, competitors, consultancy companies, governmental institutions, Universities, research institutions or open source communities. Therefore, *GIN1* allows us to assume that a firm is part of a GIN if it networked in the last three years with foreign actors for the development of its most important innovation. Differently, *GIN2* considers as part of a GIN those firms that perform some specific/core innovation activities through offshoring or outsourcing abroad. These activities include product and process development, operations, procurement, logistics and distribution, building and maintenance of IT systems.[10]

Table 1 presents the distribution of the dependent variables across countries in the sample. Comparing the distribution of *GIN1* and *GIN2* at country level, the letter provides a more restrictive definition of international collaborations for innovative activities, nonetheless with some exceptions.[11] Looking at the correlation coefficients across sectors of the dependent variables, they

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[10] The selection of activities included in the set of 'innovation activities', has been conducted by looking at what firms defined as 'innovation'. Firstly, we looked at the set of firms that indicated to conduct 'offshoring innovation'. Secondly, we constructed dummies that included the possible combinations of functions that respondents perform through offshoring. The highest correlation coefficient was found in correspondence of the dummy including the group of functions listed above.

[11] We observe that *GIN2* is more widespread than *GIN1* in Germany and Brazil. This could be driven by sector peculiarities. Indeed, observing the distribution of the independent variable across sector, the difference between *GIN1* and *GIN2* is less pronounced for the automotive industry than for the ICT.

all result particularly low, from 0.29 for ICT firms to 0.47 for agro-processing firms. This highlights that two variables capture different activities firms may perform in the internationalization of their innovative activities.

Table 1
GIN distribution across national samples and according to the different types of definitions utilized.

	China	India	Brazil	Denmark	Estonia	Germany	Norway	South Africa	Sweden	TOTAL
GIN1	87	182	15	17	9	22	54	38	93	517
	35,80%	56,17%	21,74%	34,69%	52,94%	41,51%	29,83%	45,24%	47,69%	42,55%
GIN2	27	140	16	10	3	24	24	21	50	315
	11,11%	43,21%	23,19%	20,41%	17,65%	45,28%	13,26%	25%	25,64%	25,93%

Source: Authors' calculation based on INGINEUS survey.

The presence of GINs prevails in the ICT sector if we look at *GIN1*, but not in the case of *GIN2*. Moreover, *GIN2* is more widespread in the Indian ICT sector and in the German automotive only. It's worth noticing that having significant R&D activity does not necessarily mean a greater involvement in GINs. The correlation coefficient between being part of a GIN and having significant R&D activity resulted lower than expected.[12] Indeed, there is a relevant fraction of firms in the sample that outsource and offshore innovation abroad without conducting in-house R&D (21.7%), indicating that the core of their knowledge has foreign origin. This is also confirmed by looking at the most important source of innovation for firms. Among respondents, 40% of the sample do not consider their headquarters as the most important source of technology inputs and 29.4% have as technology source an entity external to the firm.

Given this *open* nature of technology attainment, in what follows we concentrate on factors relevant for the internationalization of firms' innovative activities. These are (i) human resource

[12] The correlation coefficient between having significant R&D activity and the variables *GIN1* and *GIN2* resulted 0.32 and 0.14, respectively.

development, the key area in supplying quality skilled workers for global and local markets, and (ii) the legal environment for IPR protection. Since fostering innovation and investments in indigenous R&D is the lifeblood of GINs, strengthening IPRs according to international standards could prove effective in promoting GINs by simplifying procedures and reducing the costs of disclosing innovation.

In our simple linear probability model, our main regression equation is:

$$GIN_i = \beta_0 + \beta_1 HR_i + \beta_2 IPR_i + \boldsymbol{\beta_3 X_i} + \delta_c + \delta_s + \upsilon_i \quad (1)$$

Where subscript *i* indicates firms. The main explanatory variables denote firms' experience with regard to (i) HR: relevant labour force training and skills, (ii) IPR: regulation, practice and jurisprudence around IPRs. These are treated as dummy variables taking value one if the firm indicates a positive experience with above factors. $\mathbf{X}_i$ is a vector of further controls, such as type of ownership of the firm (domestic or foreign) and type of linkages developed with foreign partners (formal and/or informal).[13] When the regression equation is performed with *GIN2* we further control for the region of origin of its innovations partners. Finally, to control for unobserved heterogeneity, we include dummies at the country and sector levels, δ_c and δ_s, respectively.

4.2. Empirical analysis

After defining the main dependent and independent variables, we perform OLS estimates of Equation (1) for each definition of GIN. Table 2 reports the results of the OLS regressions to shed light on whether having had a positive experience with the analyzed factors has contributed to GIN participation. The findings affirm that having had a positive experience with IPRs regulations and skilled labor force increases significantly the probability of networking with foreign actors for

[13] Firms were asked to indicate whether they developed formal or informal linkages with different kinds of foreign organizations (where *Informal* implies no written contract or financial obligation exists). Therefore, the control variables *formal* and *informal linkages* are not mutually exclusive in each observation.

innovative activities when GIN1 is the dependent variable (columns [1] to [3]). However, we can observe human resource availability to be the important factor for participation in GINs when we look at the activity of outsourcing and offshoring (columns [4] to [6]).

The control variable *foreign* indicates that being a subsidiary of a MNC increases significantly the probability of being part of a GIN. Such impact is greater when MNCs seek to establish innovative collaborations abroad than for outsourcing and/or offshoring innovation. Observing the control variables formal and informal linkages, they are both statistically significant. Formal linkages present a greater marginal effect than informal ones when we look at the activity of networking (*GIN1*), while this effect is lower for activities that could be performed across branches of a same firm, i.e. by offshoring (*GIN2*).

Table 2: Determinants of GIN participation

	OLS regressions: Dependent variable is networking with foreign actors for the most important innovation (GIN1).			*OLS regressions: Dependent variable is offshoring and/or outsourcing innovation activities abroad (GIN2).*		
	[1]	[2]	[3]	[4]	[5]	[6]
HR	0.194 (0.032)***		0.142 (0.038)***	0.129 (0.031)***		0.147 (0.035)***
IPR		0.190 (0.034)***	0.118 (0.039)***		0.031 (0.032)	-0.040 (0.037)
country dummies	YES	YES	YES	YES	YES	YES
sector dummies	YES	YES	YES	YES	YES	YES
partner's origin				YES	YES	YES
foreign	0.153 (0.034)***	0.146 (0.035)***	0.147 (0.035)***	0.074 (0.035)**	0.071 (0.035)**	0.076 (0.035)**
formal links	0.234 (0.036)***	0.246 (0.036)***	0.231 (0.037)***	0.058 (0.032)*	0.071 (0.033)**	0.058 (0.032)*
informal links	0.179 (0.037)***	0.185 (0.037)***	0.178 (0.037)***	0.081 (0.031)**	0.087 (0.032)***	0.081 (0.031)**
Constant	0.688 (0.154)	0.694 (0.156)	0.673 (0.156)	0.306 (0.139)	0.324 (0.142)	0.311 (0.139)
Observations	1074	1074	1074	1074	1074	1074
R-squared	0.1661	0.1615	0.1734	0.2005	0.1864	0.2015

Robust standard errors in parenthesis;
(*) p-value<0.1; (**)p-value<0.05; (***)p-value<0.01

The survey results reveal India to be the only emerging economy with a strong and positive probability of being part of a GIN while China in all cases results amongst the least involved.[14] In our sample, Chinese ICT firms are amongst the most unsatisfied with regard to relevant labour force skills (68.3%).[15] On the IPRs side, the Chinese sample presents the greatest percentage of firms requiring more stringent IPR regulations to consider future innovation activities (64.2%). The relative value increases if we look specifically at those firms that make part of a GIN. Alternatively, India results more open in conducting research activities with foreign partners even if it presents a lower R&D intensity compared to China.[16] Recalling that the INGINEUS data collected in India and China pertains to the ICT sector, these observations call for a more in-depth analysis of the Chinese and Indian ICT firms.

4.3. ICT sector in India and China

We now estimate our linear probability model for the Indian and Chinese sample only. Again, we control for country fixed effect but, different from the previous analysis, here we also include control variables for the ICT sub-sectors, namely the hardware[17] and the software industry.[18]

[14] This may confirm that, despite the absolute abundance and talented endowment in human resource in engineering that is attracting foreign firms to invest in China (Asakawa and Som, 2008), there is the increasing difficulty for local R&D laboratories to hire the local talent attracted by MNCs laboratories (Yuan, 2005).

[15] It's the greatest fraction after Estonia with 70.6%.

[16] Looking at the size of the R&D units (measured as number of full time R&D employees by firm size) in the ICT sector for the Chinese and Indian sample, in China they result on average larger than in India with only exception being very small firms with less than 10 employees. Chinese firms result more R&D intensive, employing a greater number of individual in R&D than Indian firms do. This may confirm recent studies on the Indian ICT sector that, despite public efforts, investments in R&D by the private sector is still relatively low and largely based on the outsourcing market (Bhattacharya and Vickery, 2010).

[17] The *hardware* segment includes (i) the manufacture of communication equipment and (ii) other information technology and computer service activities, such as, computer disaster discovery, setting up personal computers and software installation.

[18] In the *software* segment have been included firms that perform computer programming activities, computer consultancy activities and computer facilities management activities.

We first look at differences in IPRs as determinants of GINs at country level, and observe whether the same conclusions can be applied equally to the domestic and foreign ICT firms located in China and India. We then conduct a sub-sector analysis considering that firms within the ICT sector may rely on different IP tools, namely patents in the case of the hardware segment and copyright in the case of firms that provide software programs, conduct activities relative to data processing and/or computer systems design. Results are reported in Table 3 and 4.

In columns [1] and [2] of Table 3, we can observe that IPRs are determinants of GIN participation. Chinese (Indian) firms are less (more) likely to be involved in a GIN but there is not a differential effect of IPR on GIN involvement among firms from a particular country. Moreover, firms operating in the hardware sector are more likely to be involved in a GIN when *GIN2* is used as dependent variable. Recalling that the control variable *foreign* resulted always positive and statistically significant when we looked at the total INGINEUS sample, in column [3] and [4] we look at IPRs as a determinant of GIN participation observing to what extent their relevance may vary according to the type of ownership. Moreover, we check whether human resource availability may be relevant in explaining GIN involvement of Chinese and Indian firms. We find that IPR is more relevant than human resource availability for the participation to GIN for *GIN1*, while is no longer significant for *GIN2*. The negative coefficient of the interaction term IPR_foreign shows that even if it turns out that foreign firms are *per se* more involved in GINs than domestic ones, IPRs tend to be a more essential factor for the participation of domestic firms in GINs when using *GIN1*.

In table 3 (column [1] and [2]) the control variable *hardware* resulted positive and statistically significant only when we looked at *GIN2*. This may indicate that in the hardware segment the activity of offshoring and/or outsourcing abroad is more widespread than networking with foreign partners .[19]

Table 3: IPRs as determinants of GIN participation for Chinese and Indian ICT sector

Dep. Variable	*GIN1*	*GIN2*	*GIN1*	*GIN2*
	[1]	*[2]*	*[3]*	*[4]*
IPR	0.204	0.131	0.197***	0.105
	(0.058)***	(0.057)**	(0.070)	(0.067)
IPR_China	-0.059	-0.113	-0.062	-0.130
	(0.084)	(0.070)	(0.084)	(0.071)*
China	-0.150	-0.240	-0.087	-0.211
	(0.065)**	(0.055)***	(0.068)	(0.059)***
HR			0.092	0.146
			(0.051)*	(0.067)*
foreign			0.327	0.170
			(0.076)***	(0.072)**
IPR_foreign			-0.183	-0.075
			(0.095)*	(0.091)
hardware	0.001	0.106	-0.093	0.014
	(0.041)	(0.036)***	(0.061)	(0.047)
constant	0.425	0.289	0.306	0.267
	(0.052)	(0.050)	(0.051)	(0.049)
Obs	567	567	544	544
R-sq.	0.0706	0.1460	0.1193	0.1460

Robust standard errors in parenthesis;
(*) p-value<0.1; (**)p-value<0.05; (***)p-value<0.01

In table 4, we focus on hardware and software firms that are part of GINs. Here we look at the relevance of their experience with the IP framework (*IPR*) and to their need for more stringent IPRs when considering their future innovation activities (*fIPR*). Again, we control for country and type of ownership. Columns [1] and [3] indicate IPRs are a determinant of international networking activities, while the hardware segment is not, *per se*, more involved in GINs or more reactive to IPRs. Looking at how IPRs determine firms' activity of outsourcing and offshoring innovation abroad (Columns [2] and [4]), reveals firms in the hardware sector are positively reactive to IPRs.

[19] It is worth recalling from table 2 that the marginal effect of formal linkages resulted lower for GIN2 than GIN1, that is, written contracts, such as license or no-disclosure agreements, are less relevant when innovative activities are internationalized across branches of a same firm.

Table 4: IPRs as determinants of GINs participation for ICT sub-sectors

Dep. variable	*GIN1*	*GIN2*	*GIN1*	*GIN2*
	[1]	[2]	[3]	[4]
IPR	0.171 (0.060)***	-0.008 (0.043)		
fIPR			0.198 (0.060)***	-0.065 (0.053)
IPR_hardware	-0.015 (0.083)	0.157 (0.074)**		
fIPR_hardware			-0.070 (0.083)	0.153 (0.049)**
hardware	-0.020 (0.064)	0.003 (0.057)	0.010 (0.059)	0.017 (0.057)
China	-0.172 (0.042)***	-0.293 (0.035)***	-0.225 (0.042)***	-0.297 (0.036)***
foreign	0.205 (0.045)***	0.102 (0.042)**	0.217 (0.045)***	0.108 (0.042)***
constant	0.398 (0.053)	0.347 (0.049)	0.415 (0.048)	0.388 (0.035)
Obs	544	544	544	544
R-sq.	0.1031	0.1525	0.1043	0.1471

Robust standard errors in parenthesis;
(*) p-value<0.1; (**)p-value<0.05; (***)p-value<0.01

4.4. Conclusions of the survey-based research and Limits

The conclusions from our micro-analysis are threefold: first, the analysis suggests that IPRs are among the determinants of the participation of firms in the South to GINs. Second, focusing on differences between the foreign and the domestic sector operating in these countries we found that IPRs are more relevant for domestic (hence Southern) than foreign firms, even if foreign firms are in general more involved in GINs. Finally, differentiating between experience and need of more stringent IPRs across ICT sub-sectors, we found that, while the former is relevant for networking activities for every firm, the latter is a determinant of international outsourcing and offshoring innovation for the hardware segment only.

Even if the high tech industry was the most represented in the entire sample, the survey, as designed, does not let us advance considerations with regard to IPR framework in the countries of origin of innovation partners. Furthermore, the role of IPRs results ambiguous. On one side, the positive and statistically significance of its impact (when considered alone) may reflect the general argumentations on the impact of the IPR framework on the business environment and its relevance for the internationalization of R&D activities. However, its lower significance when considered in concomitance with other factors, under different definitions of GINs, or if observed for specific countries or sectors may confirm that stronger IPRs must be embedded in a broader set of complementary initiatives, such as human capital development, to be effective (Maskus et al., 2005). Furthermore, they may indicate that there are emerging trends or new factors affecting innovation and GINs participation decisions. Several issues that emerge from the above firm-level analysis could be verified only when accompanied by generalizing the analysis using global data.

5. Global Analysis

5.1. Data and Methodology

In this section we extend the analysis to a cross country level. Specifically, we try to generalize the findings of the previous sections, therefore testing whether the determinants that make a firm get involved in GINs hold at national level. To this end, we look at the filing of patents in OECD countries' patent offices by researchers resident in NICs. We believe this measure could capture the idea of internationalization of innovation activity in the spirit we have highlighted in the previous Sections: theoretically, this should include a (team of) researcher(s) working in the NIC-located branch of an MNC that files a patent through the MNC's headquarters in a OECD country.

Given the nature of our analysis, i.e. looking at the determinants of NICs' involvement in international collaboration in innovation activity in OECD countries, we make use of an *oriented* empirical gravity model. Rather than considering bilateral flows, the standard practice in gravity estimation of trade flows (see, for example, Frankel and Rose, 2002) or international invention activity (see 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).[20] Succinctly, our dependent variable PAT_{ijt} is the (log) average number of patents filed in the time period *t* by an applicant residing in country *i* in the patent office of country *j*, where index *i* runs over 14 NICs and *j* runs over the 31 OECD countries.[21] Note the different pools from which *i* and *j* are taken and that, in general, $PAT_{ij} \neq PAT_{ji}$. The variable *PAT* has been constructed using data from WIPO, the World Intellectual Property Organization, that 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.[22] 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. We take averages for two reasons related to the IPR protection index. First, data 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 movement. Our framework partially draws from Yang and Kuo (2008), that use the same dependent variable. However, their analysis is limited to the 4 contiguous years of 1995-1998 and do not study South-North relations, but study bilateral relation between 30 chosen WIPO members. While their aim is to uncover the influence of trade and IPRs in the destination country

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[20] We decided to look at the number of patent applications instead of granted patents because has the advantage of allowing an analysis of more recent data. Indeed, although any application is published by eighteen months after the date of filing or the earliest priority date, the patent grant procedure takes about three to five years from the date of the application (EPO, 2010).

[21] 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 included countries around which consensus in the economic literature is not yet reached. They are Argentina, Chile, Egypt, Indonesia and Russia, (Paweł Bożyk, 2006). OECD countries are Austria, Australia, Belgium, Canada, Switzerland, Czech Republic, Germany, Denmark, Spain, Finland, France, United Kingdom, Greece, Hungary, Ireland, Iceland, Italy, Japan, Korea, Luxemburg, Mexico, Nederland, Norway, New Zealand, Poland, Portugal, Sweden, Slovakia, Turkey, USA and South Africa.

[22] 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 by that of patent office. This is the case of multiple applicants of different residence, with the first applicant residing in the same country of the patent office in which the patent is filed.

on outward patenting activities, we focus on the IPR regime on both sides of the activity and its harmonization between the country pairs. The empirical model we estimate, written in general terms, is the following:

$$PAT_{ijt}=G_t+D_i+D_j+\boldsymbol{X}_{it}+\boldsymbol{Y}_{jt}+\boldsymbol{D}_{ij}+\boldsymbol{D}_{ijt}+u_{ijt} \quad (2)$$

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. The monadic terms $\boldsymbol{X}_{it}$ and $\boldsymbol{Y}_{jt}$ include variables common to both origin and destination countries, as well as variables only specific to either one or the other set of countries. [23] Among the monadic variables there are (logs of) GDP per capita and population: instead of having only GDP as mass variable, we separate size (population) and development (GDP per capita) effects as in Head et al. (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 have a measure of IPR protection from Park (2008) for both the origin and the destination country. This measure of IPR protection is the updated version of the worldwide used Ginarte and Park Index (Ginarte and Park, 1997), whose novelties are the following: it runs until year 2005, it incorporates the effects of the TRIPS agreements of 1995 and it takes into account the revisions in national patent laws required to conform to international and regional agreements (such as the North American free trade agreement (NAFTA), European patent convention (EPC), African Regional industrial property organization (ARIPO), and Cartagena agreement among others). All the technical details related to the construction of the index are in Park (2008). A priori, IPR protection in the destination country could have either a positive or a negative impact on patents' filing by foreigners: according to Allred and Park (2007), a positive effect of IPR protection on patenting in

[23] According to Baldwin and Taglioni (2006), we should include a full set of country times year fixed effects, but the short time variability would make it impossible to have enough degrees of freedom.

developed countries comes from increased appropriability of invention and a market expansion effect (i.e. a larger market creates innovation spillovers, so that new innovations are easier to produce), while negative effects can derive from defensive patenting or market power effect (a more concentrated market impedes the entry of new firms). About the effect that IPR protection level in the origin country could have on innovation, Picci (2010) suggests that poor IPR protection could result both in less internationalization of innovation (due to standard appropriability considerations) or more, if the branches MNEs located in NICs patent innovations in their headquarters. Recall from the previous Section that the greatest percentage of firms requiring more stringent IPR regulations in the INGINEUS survey were in China (64.2%). This could be driven by China's ICT sector's specialization in hardware production, which relies on patent protection more than software industry. To control for this, we will use the share of exported goods belonging to the ICT sector interacted with the IPR protection Index among other controls.[24]

$\boldsymbol{D}_{ij}$ includes all the time-invariant dyadic variables, collected by CEPII. 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 internationalization of innovation activity. The term $\boldsymbol{D}_{ijt}$ collects dyadic time-variant variables, that in some specifications will be the distance between IPR protection between country *i* and country *j*, or the impact of harmonization of the IPR regime between each country pair.

The theoretical number of observations should be $I*J*T$=1302, coming from 14 NICs, 31 OECD countries and 3 time periods. However 3 countries are coded as both NIC and OECD (South Africa, Mexico and Turkey) so we exclude these pairs. The number of observations we have for the

[24] Data on the share of exports in the ICT sector (that exclude software) comes from World Bank's World Development Indicators Database. They are relative to year 2000.

empirical work is therefore 1293 and for 649 of them the number of patents is positive. The distribution of patents filed in country *j* by an applicant residing in country *i* has a strong positive skew: it takes values between 0 and 3563.25, the average number of patents is 20.45, the median is 0.75 and standard deviation is 154.2.[25] Looking at the time dimension, the number of patents filed more than doubles every five years: in 1995 mean of *PAT* is 6.39, in 2000 it is 15.87 while in 2005 is 39.87, suggesting a remarkable increase in the international collaboration in patenting activity. The rise in average patents is due to both the intensive and extensive margin. The latter refers to the number of zeroes, that represents country pairs that are not collaborating: they are 87, 68 and 57 in the 1995, 2000 and 2005 periods, respectively.

The IPR index for the 14 NICs shows a mean equal to 3.17 and a standard deviation of 0.87. 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 countries. In particular, mean and standard deviations are 2.52 and 0.81, 3.33 and 0.79 and 3.67 and 0.56 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 4.19 and a standard deviation of 0.51. This indicates not only higher protection of IPRs, but also more similar values of the index among OECD countries. The time pattern is similar to that of NICs: the index is increasing and its standard deviation is decreasing over time.[26]

We use the share of exported goods belonging to the ICT sector in 2000, obtained from World Bank's World Development Indicators, to account for the degree with which NICs should care

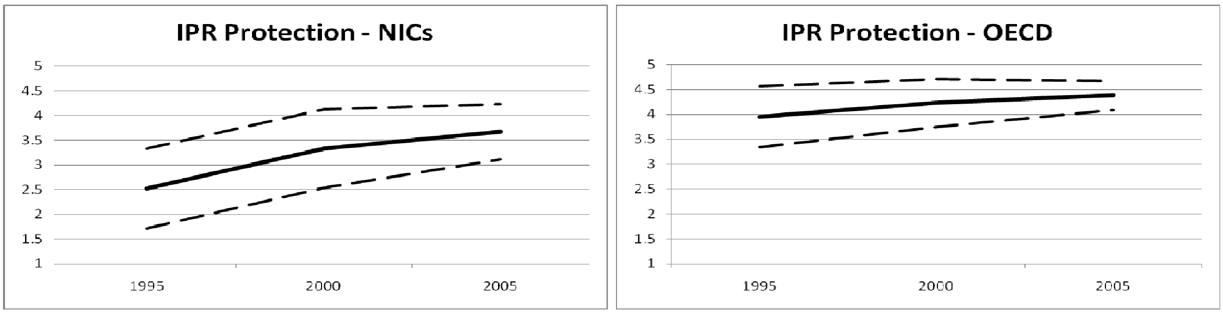
[25] The number of patents can take fractional values because we take the average across years.

[26] Mean and standard deviations are 3.95 and 0.61, 4.23 and 0.48 and 4.38 and 0.29 in the 1995, 2000 and 2005 periods, respectively.

about IPR protection.[27] As discussed above, *ceteris paribus* the more the production mix is biased toward technological goods, instead of software, the more IPR protection should be a factor that fosters innovation, since issues of appropriability of patents are more relevant. This measure varies a lot across NICs, ranging between 0% of Chile to 69% of Philippines. Within this group, India ranks fourth in 13 with 1.4% while China ranks ninth with 18.9%.[28]

We also have the counterpart of the firm-level analysis' variable human resources, that is the Barro and Lee (2010) data on the share of 25+ year old people holding at least tertiary education. As expected, average education is lower in NICs than in OECD countries (6.1 and 12.2 percentage points, respectively), but the most important difference with respect to IPR protection is a lack of convergence within each of the two groups. Standard deviation is in fact increasing from 1995 to 2005 for both NICs and OECD countries. To have a visual grasp of the difference in the evolution of IPR protection and tertiary education, in Figure 1 and 2 we report them for both NICs and OECD countries.

Figure 1: Average Park Index for NICs and OECD countries, together with + and – standard deviation bands.

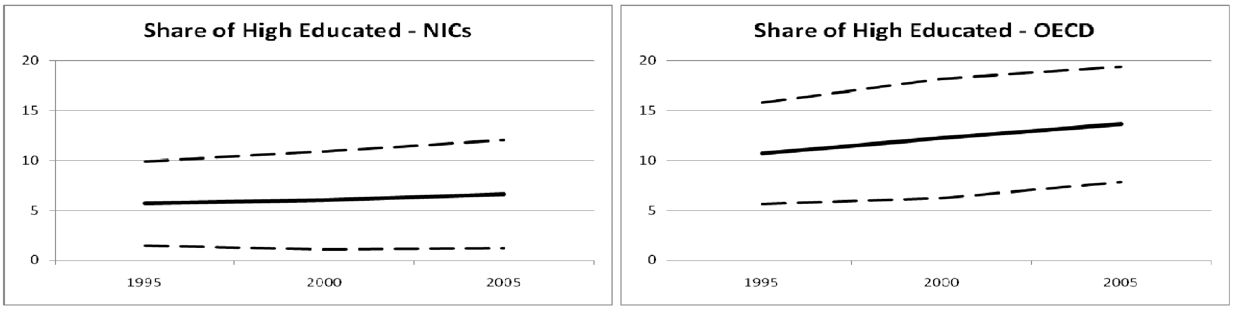


Source: Park (2008).

[27] The definition of this variable is: "Information and communication technology goods exports include telecommunications, audio and video, computer and related equipment; electronic components; and other information and communication technology goods. Software is excluded."

[28] The rank is over 13 instead of 14 NICs because no figures are available for Egypt.

Figure 2: Share of 25+ year old people with completed tertiary education for NICs and OECD countries, together with + and – standard deviation bands.



Source: Barro and Lee (2010).

5.2. Empirical Results

We start estimating the parameters of Equation 1 in a parsimonious specification. First, we want to pin down the values that the coefficients of the standard independent variables used in empirical gravity model take, so to compare our results with those established in literature. Our results are collected in column 1 of Table 5, where OLS are performed using a specification in which distance, dummies for common language and common border, population and GDP per capita are included among the controls. In all the specifications reported in Table 5, the dependent variable is the log of number of patents, so only country pairs showing a positive number of patents is included in the sample. As in all the following specifications, two (out of three) time dummies are included, together with NICs and OECD country dummies.[29] Distance shows an elasticity of -0.59 that is comparable with the upper bound found 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, probably because of the low variability: only 11 out of 649 observations report a one. Size measures (population) of origin and destination country have a positive impact and comparable magnitudes, while income per capita has a positive effect in the origin country and

[29] These dummies already control for a lot of variation: a regression that uses only those delivers an R^2 of 0.74.

negative 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. On the contrary, GDP per capita in the destination country negatively impacts on international patenting activity. This could be driven by the fact that NICs tend to collaborate with countries that are more similar to them in terms of level of development.[30]

In column 2 we introduce the IPR protection indices for both origin and destination country. The IPR protection index for the former country is positive but not significant, while the latter is negative and strongly significant. These results are opposite to those obtained in 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 defensive patenting or market power effect, as suggested by Allred and Park (2008). 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 the weakest 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 into account in specifications that use the distance between IPR protection indices within each country pair. Note that the introduction of the indices results in the loss of significance of GDP per capita in the destination country, that could be due to the high correlation of this variable with the IPR index (0.70).

Column 3 reports a specification in which we add to column 2 the interactions of the IPR protection index with the share of exported goods belonging to the ICT sector in 2000 for NICs. As highlighted above, countries like China, whose production (and therefore exports) is oriented toward ICT goods, should benefit comparatively more from the protection of IPR. As expected, the interaction

[30] 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.

between the share of exports in ICT sector and the IPR protection index in NICs is positive and strongly significant.[31] In column 4 we replicate the last results excluding country pairs involving China or India, two countries that host many headquarters of MNCs. In these cases PAT would be a spurious mix between genuine cross-border innovation collaborations and innovations carried on within China (India) by Chinese (Indian) MNCs that only register their innovations in foreign patent offices, subsequent to filing a domestic patent. Results hold even if less significant in some cases, possibly due to the smaller sample. Specification in Column 5 add tertiary education measures for both origin and destination country to that in Column 2. Only education in the origin country turns out to be positive and significant. We tried to add the interaction term of tertiary education and ICT, paralleling the regression in Column 3, but nothing changes. In column 6 we replicate specification 1 while using the squared distance between IPR protection indices within each country pair instead of the two IPR indices. This variable is negative as expected but not significant at conventional levels.

Table 6 collects results using different specifications and different estimation techniques, that we perform in order to check for the robustness of our findings. Our main concern with the results obtained is that half of the observations are not used because PAT takes a value equal to zero, causing a missing value for its logarithm. Also, differently from the case of bilateral trade flows, PAT is a count variable, for which the Poisson estimator has been suggested (see Picci, 2010 and Santos Silva and Tenreyo, 2006 among others). In column 1 we report results for the Poisson version of the specification 2 in Table 5. The distance variable is precisely estimated and the point estimate is around 0.3. Signs previously found are consistent, while now the IPR protection in NICs turns out to be positive and strongly significant. The significance being driven by the inclusion of more than 600 zeroes in the analysis suggests that IPR protection works at the extensive margin.

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

Our explanation is that MNCs open up research branches in NICs only if IPR protection is large enough, while once research branches are operative, the level of IPR protection plays a limited role in defining the intensive margin of innovation activity. In column 3 we add education variables to the previous Specification. As in the OLS case, tertiary education in origin country is positive and significant and now also education in the destination country has a positive effect, even if ten times lower than the effect in the origin country. In column 3 we replicate specification reported in column 4 of Table YY. There is little change with respect to the results in column 1 and the interaction term, as for the OLS case, is positive and strongly significant. In column 4 we substitute the two distinct measures of IPR protection (in NICs and OECD countries) with the distance between IPR indices within country pairs, as we did in column 6 of Table YY. The coefficient is again negative but it is now strongly significant, suggesting the extensive margin of patent production to also be at play when the similarity between IPR regimes are concerned. Finally, in column 5 we estimate the previous specification by means of the negative binomial method, that should improve estimates when the dependent variable is over-dispersed (Hausman et al., 1984), i.e. the variance to mean ratio is greater than one, as it is in our case. Results are broadly confirmed, together with the gain in significance of the positive effect of population in OECD countries.

Table 5: Determinants of strengthening South-North formation of GINs.

Dependent variable: log of number of patents filed in country j by residents in country i (all specifications include monadic country dummies and time dummies).

	(1)	(2)	(3)	(4)	(5)	(6)
DIST_ij	-0.59 (0.08)***	-0.59 (0.08)***	-0.58 (0.08)***	-0.49 (0.09)***	-0.59 (0.08)***	-0.59 (0.08)***
COM_LAN_ij	1.11 (0.15)***	1.12 (0.15)***	1.13 (0.15)***	1.25 (0.17)***	1.13 (0.15)***	1.12 (0.15)***
COM_BOR_ij	0.00 (0.31)	0.01 (0.31)	0.03 (0.31)	0.19 (0.32)	0.03 (0.31)	-0.00 (0.31)
POP_it	6.99 (1.73)***	6.44 (1.84)***	5.14 (1.85)***	4.88 (2.06)**	5.14 (1.93)***	6.37 (1.79)***
POP_jt	8.49 (2.25)***	7.74 (2.25)***	6.69 (2.25)***	5.09 (2.64)*	7.47 (2.25)***	8.59 (2.25)***
GDP_pc_it	1.04 (0.23)***	1.07 (0.22)***	1.02 (0.23)***	0.74 (0.29)**	0.90 (0.24)***	1.05 (0.22)***
GDP_pc_jt	-1.08 (0.40)***	-0.49 (0.43)	-0.49 (0.43)	-0.69 (0.50)	-0.47 (0.43)	-1.00 (0.41)**
IPR_it		0.05 (0.11)	-0.01 (0.11)	-0.23 (0.18)	0.05 (0.11)	
IPR_jt		-0.77 (0.21)***	-0.72 (0.21)***	-0.65 (0.25)***	-0.78 (0.21)***	
ICT_IPR_it			1.54 (0.49)***	1.83 (0.59)***		
EDU_it					0.12 (0.06)**	
EDU_jt					-0.02 (0.02)	
dist_IPR_ijt						-0.04 (0.03)
Obs.	649	649	632	476	649	649
R^2	0.79	0.80	0.81	0.78	0.82	0.80

Standard errors in parentheses. (***) p-value < 0.01, (**) p-value <0.05, (*) p-value <0.1

Table 6: Determinants of South-North formation of GINs.

Dependent variable: number of patents filed in country *j* by residents in country *i* (all specifications include monadic country dummies and time dummies).PAT

	(1)	(2)	(3)	(4)	(5)
Method	Poisson	Poisson	Poisson	Poisson	Negative Binomial
DIST_ij	-0.27 (0.02)***	-0.27 (0.02)***	-0.28 (0.02)***	-0.27 (0.02)***	-0.63 (0.07)***
COM_LAN_ij	0.53 (0.04)***	0.53 (0.04)***	0.54 (0.04)***	0.55 (0.04)***	1.06 (0.13)***
COM_BOR_ij	0.19 (0.10)*	0.16 (0.10)	0.17 (0.10)*	0.17 (0.10)*	-0.05 (0.28)
POP_it	2.98 (0.56)***	1.29 (0.58)**	3.52 (0.56)***	3.50 (0.57)***	7.41 (1.74)***
POP_jt	1.86 (1.07)*	6.18 (1.33)***	2.92 (1.07)***	-0.02 (0.98)	5.65** (2.30)
GDP_pc_it	1.33 (0.08)***	1.10 (0.08)***	1.08 (0.08)***	1.30 (0.08)***	1.27 (0.22)***
GDP_pc_jt	-0.99 (0.16)***	-1.56 (0.20)***	-0.97 (0.16)***	-0.65 (0.15)***	-1.08 (0.39)***
IPR_it	0.61 (0.02)***	0.59 (0.03)***	0.43 (0.03)***		
IPR_jt	-0.41 (0.13)***	-0.37 (0.13)***	-0.49 (0.13)***		
EDU_it		0.20 (0.02)***			
EDU_jt		0.02 (0.00)***			
ICT_IPR_it			3.29 (0.15)***		
dist_IPR_ijt				-0.12 (0.01)***	-0.07 (0.03)***
Obs.	1293	1293	1293	1293	1293
Pseudo-R^2	0.95	0.95	0.95	0.95	0.43

Standard errors in parentheses.
(***) p-value < 0.01, (**) p-value <0.05, (*) p-value <0.1

6. Conclusions

This paper has conducted an empirical analysis at micro and macro level of the influence of IPRs protection on the extent of innovative collaborations between emerging economies and OECD countries.

The debate on the protection of IPRs has often been placed in a 'North-toward-South' perspective. This paper looked at innovation originating from the South. The investigation attempts to answer the question whether stronger and more harmonized global levels of patent protection generate more innovation collaboration at an international scale.

Using both survey-based firm-level data on two of the fastest-growing emerging economies in one of the most technologically progressive industries and country-level global data, our analysis find IPRs to be an important determinant of global collaboration of Southern firms in innovation. While the survey data only confirmed the bare importance of IPRs for Southern firms and did not distinguish between their views on IPRs at home and away, the global data analysis uncovered a positive effect of IPRs at home and a negative one of IPRs abroad on foreign patenting activities of emerging countries. Both analyses also suggest the importance of sectors and subsectors in an analysis of IPRs and GINs. We found the ICT industry, particularly the hardware segment, to rely on IPRs when engaging in the international outsourcing and offshoring of innovation or in patenting activities abroad.

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APPENDIX A Survey Design and Implementation

From November 2009 to June 2010, INGINEUS project[32] administered a survey to firms' representatives of three different sectors dislocated in 9 countries and across 4 continents.[33] The aim was to collect empirical evidences that would support the study of the determinants and extent to which innovation is taking place in globally dispersed networks. The survey was jointly designed and run by 9 partner institutions dislocated in their respective country and each institute selected a sector of economic importance within its national or regional context. The sectors targeted, classified through the International Standard Industrial Classification of All Economic Activities (ISIC), were: ICT in China, India, Sweden, Norway and Estonia; agro-processing in South Africa and Denmark and automotive in Brazil and Germany, representing a range from high tech industry to progressively lower tech industry.

The survey was administered online, after significant work in designing and pre-testing the questions. Each institute chose the survey delivering method according to past experiences and knowledge of the best methods utilised in the country for high response rates.[34] Indeed, it was delivered electronically by mail or link, by face-to-face interviews, through telephonic interviews or by written mail. Furthermore, while in European countries and South Africa the survey was managed at national level, in Brazil, China and India, it was conducted at regional level.

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[32] INGINEUS is an international research project funded by the European Commission that studies global innovation networks. It involves 14 research institutes and universities in seven European countries plus Brazil, China, India and South Africa. For further information on INGINEUS project please see www.ingineus.eu.

[33] The sample of firms is not representative at the level of country or region, so the policy implication of the findings in this section should be treated carefully, without pushing too much issues of external validity.

[34] For instance, in both China and India, the survey was run mostly through face-to-face interviews or telephone interviews give the low electronic response rate experienced.

In Table 1 we report the distribution of the sample across sectors, countries and firm size[35], as well as the response rate registered and the representativeness of each national sample within each sector group. The survey received 1214 responses from the 14620 companies contacted, which is a response rate of approximately 8.3%. China and Germany registered the lowest response rates of respectively 2.7% and 5.5%.[36] The combined INGINEUS sample results dominated by the ICT sector (77%). This is due to the size of the Indian and Chinese markets, which represent respectively 26.7% and 20% of the entire sample (and 34.7% and 26% of the sample ICT firms), but it could be also attributed to the nature of the agro processing and automotive industries which tend to be more concentrated.

[35] Given the large number of small firms in the Swedish and Norwegian ICT databases, it was agreed that the minimum size of a firm for the survey would have been five employees, while no upper ceiling was defined.
[36] Low response rate in surveys conducted to assess international innovation by Chinese companies has been detected also in other studies. See: Chen J (2003), *Global Innovation,* Beijing: Economic Science Press.

Table A.1: Response rates and total sample distribution by sector, country and R&D activity.

Sector/country	dataset	responses	response rate (%)	% over total sector obs.	R&D active firms	% of R&D active firms over national sample
China[37]	9119	243	2.7	26	181	74.5
Estonia	121	17	14	1.8	2	11.8
Norway	519	179	34.5	19.1	53	29.6
India[38]	1287	324	25.2	34.7	195	60.2
Sweden	1662	171	10.3	18.3	76	44.4
Total EU	2302	367	15.9	39.3	131	35.7
Total emerging economies	10407	567	5.4	60.7	376	66.3
Total ICT	12709	935	7.3	100	507	54.2
Denmark	210	49	23.3	37.1	5	10.2
Norway	2	2	/	1.5	0	/
South Africa	325	81	24.9	61.4	27	33.3
Total EU	212	51	24	38.6	5	9.8
Total emerging economies	325	81	24.9	61.4	27	33.3
Total Agro-processing	535	132	19.6	100	32	24.2
Brazil[39]	241	69	28.6	46.6	17	24.6
Germany	963	53	5.5	35.8	31	58.5
South Africa	2	2	/	1.4	0	/
Sweden	168	24	14.3	16.2	13	54.2
Total EU	1131	77	6.8	52	44	57.1
Total emerging economies	243	71	29.2	48	17	23.9
Total Automotive	1374	148	10.8	100	61	41.2
TOTAL EU	3645	495	13.6	-	180	36.4
TOTAL emerging economies	10975	719	6.6	-	420	58.4
TOTAL	14620	1214	8.3	-	600	

[37] The Chinese sample was extracted from two regional databases: (i) the *Beijing database* and (ii) the *Schenzhen database*. The questionnaire was distributed in the five most developed provinces in China: 146 questionnaires came from Beijing, which account for 60% of the total questionnaires; 51 came from Guangdong province, which account for 21%; 35 from Shanghai, 14%, 10 from the Zhejiang province, representing the 4%, and only 1 from Shandong province.

[38] The Indian sample was extracted from the *NASSCOM Directory of IT firms 2009-2010*, distributed across the main cities and regions as it follows: 281 in Bangalore, which account for 21,8% of NASSCOM Directory; 256 in Delhi/Noida/Gurgaon representing the 19,9%; 185 in Mumbai(14,4%); 72 in Pune (5,6%); 147 in Chennai (11,4%); 184 in Trivandrum (14,3%); 107 in Hyderabad (8,3%) and 55 in Kochi (4,3%).

[39] The Brazilian sample was extracted from the *Annual Registry of Social Information (RAIS),* a registry of social and balance sheet information collected by the Brazilian Labour and Employment Ministry. The total number of firms classified in the automotive sector in Brazil is 2,625. Out of these, 233 companies are located in the state of Minas Gerais and, of these, 107 (46%) have employed, in 2008, 30 workers or more. From the dataset all automotive firms from the state of Minas Gerais were selected, provided the firm declared over 30 employees.

The overarching goal of the survey was to establish the presence of GINs: how global, how innovative and how networked the sample was.

The survey included a number of questions relating to the respondents' back-ground, such as main product (goods or services), firm size, percentage of sales activity abroad and R&D activity. In addition, to extract information on firm behavior, questions on (i) source of technology, (ii) geographic networks and collaborations established, (iii) factors determining offshoring activities and (iv) policy-factors for the internationalization of innovative activities were designed.

Observing the number of R&D active firms over total national sample, there is concern with regard to the presence of a response bias in favour of firms that perform R&D, mostly within the group of Indian and Chinese ICT firms (coupled with, South African firms in the agro-processing sector).[40] Nonetheless, we are interested in looking at the determinants that make an innovative firm go global, such response bias should not affect our analysis.

[40] This could lead to affirm that the ICT sector in emerging economies is more R&D active than in Europe.

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