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Does the Patent Cooperation Treaty work? A global analysis of patent applications by non-residents

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Preface

The European ICT Poles of Excellence (EIPE) research project at the Institute for Prospective Technological Studies is investigating the issues of growth, jobs and innovation, which have become main priorities of the European Union's growth strategy programme 'Europe 2020'.

The overall objectives of the EIPE project are to set the general conceptual and methodological conditions for defining, identifying, analysing and monitoring the existence and progress of current and future EIPE, in order to develop a clear capacity to distinguish these among the many European ICT clusters, benchmark them with non-European poles, observe their dynamics and offer a thorough analysis of their characteristics.

The EIPE project started late in 2010 and has, since then, developed a large database of original ICT innovation indicators, enriched with geographical information in order to allow localisation and aggregation at NUTS 3 and NUTS 2 level. The tool helps us to answer such questions as: How is ICT innovation and economic activity distributed and how is it evolving in Europe? What locations are attracting new investments in ICT R&D or manufacturing? What is the position of individual locations in the global network of ICT activity?

To date, the following additional publications have emerged from the research:

- A Framework for assessing Innovation Collaboration Partners and its Application to BRICs. G. De Prato and D. Nepelski, JRC-IPTS Working Paper, (2013).
- The global R&D network. A network analysis of international R&D centres, G. De Prato and D. Nepelski, JRC-IPTS Working Paper, (2013).
- Internal Technology Transfer between China and the Rest of the World. G. De Prato and D. Nepelski, JRC-IPTS Working Paper, (2013).
- International Patenting Strategies in ICT. G. De Prato and D. Nepelski, JRC-IPTS Working Paper, (2013).
- [Asia in the Global ICT Innovation Network. Dancing with Tigers](#), G. De Prato, D. Nepelski and J.-P. Simon (Eds), Chandos Asian Studies Series: Contemporary Issues and Trends, Chandos Publishing, (2013, forthcoming),
- [Global technological collaboration network. Network analysis of international co-inventions](#), G. De Prato and D. Nepelski, Journal of Technology Transfer, 2012,
- [Internationalisation of ICT R&D: a comparative analysis of Asia, EU, Japan, US and the RoW](#), G. De Prato and D. Nepelski, Asian Journal of Technology Innovation, (2012),
- [A network analysis of cities hosting ICT R&D](#), G. De Prato and D. Nepelski, (2013 - forthcoming).

More information can be found under: <http://is.jrc.ec.europa.eu/pages/ISG/EIPE.html>

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1. Introduction

A company that wishes to protect its inventions and products in a particular market needs to do so within the jurisdiction of the relevant country. The associated costs and barriers are substantial (Hall and Harhoff 2012). Over the years, it has been believed that promoting international patent harmonization and greater cooperation and work-sharing among national patent authorities is the key to reducing these costs and barriers (van Pottelsberghe 2009, Guellec and Van Pottelsberghe de la Potterie 2002). The motivation behind the considerable efforts to streamline the international patenting process is to foster trade and innovation. Moreover, political pressure to continue the patent system harmonization efforts has increased recently (Chu 2008, Chun and Kang 2011). This increase has happened despite the fact that patent regimes have been found to have ambiguous effect on cross-border economic activity (Co 2004, Nair-Reichert and Duncan 2008, Qiu and Yu 2010) and patent harmonization seems to be a suboptimal global-growth policy (Dinopoulos and Kottaridi 2008, McCalman 2001).

This paper aims to answer questions about how the Patent Cooperation Treaty (PCT) works. The PCT is one of the main efforts to harmonize the global patent system. We address the issue of the factors behind non-resident applicants applying for patent protection under foreign jurisdictions and whether PCT membership of a country whose protection is sought plays a role in this process.

In our analysis, we used PATSTAT, a comprehensive dataset provided by the European Patent Office (EPO), which contains information on the global population of about 65 million patent applications submitted to around 110 patent offices in the world. For the purpose of our analysis, based on priority patent applications, we constructed bilateral measures of foreign subsequent patent applications for the global population of countries,

which are both sources of patents and destinations for foreign applicants seeking patent protection abroad, for the period 1970 - 2009. In order to cast new light on the phenomenon of subsequent filings and the role of the PCT in this process, we applied a gravity model to analyse what factors determine a country's attractiveness for foreign applicants and to what extent the length of a country's PCT membership plays a role.

The reason for focusing our attention on the role of the PCT as a facilitator of subsequent applications is the ambiguity that emerges when we look at the data on foreign patent filings and their composition (Furman et al. 2002). The following points are worth noting:

- First of all, up until recently, first filings to applicants' national patent offices have constituted the majority of patent filings in the world.
- Second, a surge of subsequent filings, i.e. filings that mostly represent applications to foreign patent offices, started only at the beginning of the 90s. Today, the share of subsequent filings is 50 percent of total filings. To a large extent, this increase has been driven by rapidly growing international commerce. Whenever a company enters a new market commercially, it is also likely to be interested in protecting its inventions and products within this country.
- Lastly, since the 70s the number of PCT applications has continuously increased. However, despite this rapid growth, the PCT procedure is far from widely used in the process of seeking patent protection in several countries. For example, in 2010, of all applications submitted to German or UK patent offices by foreign applicants, less than 25% were submitted through the PCT procedure (OECD 2009). Moreover, a large share of PCT applications terminate at the international phase and the option to seek patent protection at the national level is not exercised. In other words, only a small share of PCT applications enters the national phase. Instead, it seems that applicants approach patent offices

individually and file patents without making use of the PCT procedure and, as a result, a lion's share of non-resident filings to national offices is represented by direct subsequent filings.

The question that we tackle in this paper is closely related to the one analyzed by Lerner (1997, 1998). Regarding the evidence on the impact of patent reforms on patenting activity, he shows that, in general, both domestic and foreign patent applications increased in countries undertaking patent protection-enhancing shifts (Paci et al. 1997, Eaton et al. 1998). However, his analysis explaining the drivers of patenting activity is limited in terms of coverage to only sixty countries with the highest GDP. Moreover, it includes aggregate measures of incoming foreign patent applications to a country, and neglects the differences in bilateral relationships between countries. In contrast, our study covers all the countries that are present on the map of patenting activity and uses bilateral measures of cross-country patenting as a unit of observation.

Other studies in this area deal with selected effects of the changes in IPR protection strength. One example is the effect of IPR changes on international businesses. It was shown that U. S. multinational firms benefit from a series of IPR reforms undertaken by other countries in the form of increases in royalty payments (WIPO 2012). Another obvious way of benefiting from IP protection in overseas markets is through trade. Strong foreign patent rights enhance market power and stimulate the expansion of large multinational markets across countries (Arora et al. 2001).

A number of studies concerned with the reforms of the patent system suffer from limitations resulting from a focus on single events in patent system design. This restricts the possibility of generalizing the findings and extending the implications to countries operating in a different context. Examples of such works include, for example, the analysis

on the broadening scope of Japanese patents (Sternitzke 2009) and the establishment of the Court of Appeals for the Federal Circuit in the United States (Hafner 2008). These studies find no evidence of an impact of patent reforms on innovative output and, attribute the surge in patenting to changes in the management of research. Interestingly, as shown for the case study of India, the unclear effects of patent reforms on innovation and patenting activity hold for developing countries as well (Eaton and Kortum 1999).

By taking a global view of the issue of patent system harmonization and covering all the countries involved, we expand our understanding of the problem and avoid the risk of mixing causes with effects. The results of our study show that being a member of the PCT is not positively related to the attractiveness of a country for foreign applicants. Instead, it is the size of the market or a country's inventive capacity that attracts foreign applicants to seek patent protection in this country. Thus, our analysis casts new light on the determinants of the intensity of interactions between countries that are a result of the international patenting activity. Moreover, we provide unique evidence on the working of the PCT system and its implications for patenting activity.

The rest of the paper proceeds as follows: Section 2 reviews the issue of patent harmonization with an emphasis on the PCT. Section 3 formulates the gravity model of subsequent international patent filings between countries. Section 4 explains the data and indicators used in the study. Section 5 presents and discusses the results of empirical estimations. Section 6 discusses the results and Section 7 concludes.

2. The PCT: towards the patent system harmonization

A patent is the right of an inventor to exclude others from making or using a particular invention. This right is sometimes termed an 'intellectual property right' and is viewed as an incentive for innovation (Arora and Merges 2004, Monk 2009). Seen this way, patents are

among diverse factors motivating technological change (Fulton 1997; Lence et al. 2003; OECD 2010b; Siegel and Wright 2007). Despite the fact that strong IPRs can also inhibit competition (Lence et al. 2003, WIPO 2008, Branstetter et al. 2006, Arora 1995), the protection of intellectual property rights has received a fair amount of attention of both developed and developing countries. One of the implications of the rise of an interest in the protection of IPR is that the international policy advocates strengthening intellectual property protection.

Patenting an invention is a costly process and, as patent protection is territorial in nature, any additional patent application filed to a foreign patent office significantly increases this cost. The empirical evidence clearly confirms that the price elasticity of the demand for patent applications is strictly negative (Pagano 2007, Moy 1993). This point is very well illustrated by the case of Europe and the discussion about a single European patent (Hall and Harhoff 2012). A natural way of addressing the problem of high costs and barriers to IP protection in a number of countries are the attempts to harmonize patent system across national jurisdictions (van Pottelsberghe 2009, Guellec and Van Pottelsberghe de la Potterie 2002).

The turning point in the development of patent law harmonization was the Vienna exhibition of 1873 (Moon 2011, Oh et al. 2010). Before the exhibition, American participants were concerned about the Austrian patent law and the risk of plagiarism and piracy. As a result, parallel to the exhibition, a congress was held to discuss the issue of patents and the harmonization of the patent system across countries. Following these discussions, a series of conferences took place and finally the Paris Convention for the Protection of Industrial Property (commonly referred to as Paris Convention) was signed in 1883.

The Paris Convention did not address all issues that were raised prior to it and it constituted rather a flexible framework for the protection of industrial property (van Pottelsberghe 2009). Under the Paris convention procedure, in order to obtain a patent in more than one country, subsequent patent applications had to be filed in foreign countries within 12 months from the submission of the priority application. However, formal requirements between countries still persisted and, consequently, applicants were forced to prepare different versions of the application for each patent office. Moreover, as the applicants were required to translate their applications into other languages and were obliged to hire a local agent to file their applications, the direct filing of patent applications in multiple countries was still an expensive undertaking.

In 1966, the Executive Committee of the International Union for the Protection of Industrial Property asked the United International Bureaux for the Protection of Intellectual Property (BIRPI), the predecessor of the World Intellectual Property Office (WIPO), to propose solutions to reduce the duplication of the effort both for applicants and national patent offices (OECD 2010a). One year later, a draft of an international treaty was presented, which after a few round of negotiations was adopted in Washington in 1970 as the Patent Cooperation Treaty. The treaty came into force in 1978 and today has 145 signatory countries (Lerner 2002a, Lerner 2002).

The PCT is one of the major undertakings in the process of patent harmonization. It is an international treaty for rationalization and cooperation with regard to the filing, searching and examination of patent applications and the dissemination of the technical information contained therein. The PCT does not give the right to “international patents” and the task of and responsibility for granting patents remains exclusively in the hands of the national patent offices in which protection is sought for, i.e. designated countries. In other words, the

PCT procedure allows applicants seeking for patent protection in a large number of countries to file an "international" patent application to a patent office of a contracting state for the search of previous inventions (OECD 2008a). In order to obtain patent protection in a particular state, the applicant still needs to file a patent application in a patent office of interest. Thus, although application and search are to some extent standardized across offices, grants are not. This way the PCT, along the Paris convention or the TRIPS Agreement, forms a basic framework for patent protection across countries.

The principal objective of the PCT is to simplify and streamline the previously established means of applying for protection for inventions in several countries (Oh et al. 2010). This is expected to benefit the patent offices and the users of the patent system. Considering that individual patent offices are confronted with the increasing number of applications, they face a problem of maintaining a high quality of the system. Under the PCT system, by the time the international application reaches the designated office, it has already went through the examination process that took place in the receiving office, searched by the International Searching Authority and possibly examined by an International Preliminary Examining Authority. This way, national patent offices benefit from lower work loads, as they do not need to duplicate those efforts. Regarding the benefits to the users of the patent system, the main benefit of a PCT application is that fewer searches need to be conducted, which reduces the cost of international filings. It goes without saying that poor results of a patent search or poor examination can have negative consequences for the applicant.

Moreover, the PCT is meant to facilitate and accelerate the access by interested parties to technical information related to inventions and to speed the technology diffusion process in developing countries (Schneiderman 2007). To achieve this, the PCT was to provide an

infrastructure and access to an effective source of up-to-date technical information from which third parties may derive knowledge and by encouraging direct technology transfer from companies willing either to invest in infrastructure in a country or to sell or license technology to companies in that country based on patents.

Considering the above discussion on the PCT, we could expect that the introduction of this procedure would have a positive impact on the level of international patenting activities (Schneiderman 2007). In other words, applicants who are interested in protecting their inventions in several countries would file an application under the PCT procedure, rather than to file separate patent applications at the same time in all of the countries in which they would like to protect their inventions.

3. Gravity model of international patent applications

In this paper we are interested in addressing empirically the question of what factors are behind companies' motivations in seeking for patent protection under foreign jurisdictions and whether PCT membership of a country whose protection is sought for plays a role in these motivations. In order to carry out our analysis, it would be useful to adhere to a model that specifies what determines international patent filings. Unfortunately, to our best knowledge, there are not fully adequate theoretical models dealing with this issue.

The closest theoretical concept suitable for an empirical analysis of international patenting is the gravity model of trade, which, except for being widely used in the studies of international trade (De Benedictis and Tajoli 2011) and has already found its way to study other types of bilateral relationships between countries. One example includes the phenomenon of international collaboration between inventors (Picci 2010, Thomson 2011, Guellec and Van Pottelsberghe de la Potterie 2001, De Prato and Nepelski 2012). Thus, we believe that the gravity model allows us to formulate predictions concerning the

determinants of international patenting, i.e. why applicants seek patent protection overseas.

The straightforward form of the gravity equation can be expressed by

$$L_{ij} = \frac{GDP_i \cdot GDP_j}{D_{ij}} \quad (1)$$

where two countries i and j with non-negative GDP and the distance D_{ij} , where distance might be measured in terms of geographical and cultural proximity, are expected to develop a positive exchange link (i.e. $L_{ij} = 1$).

Taking this theoretical prediction as a starting point, we proceed with formulating a gravity model in which we expect that a country's attractiveness for foreign applicants depends on some of its characteristics. To identify these characteristics, we derive a set of factors that are used in studies conceptualising the issue of international trade, the internationalisation of innovation and international technology transfer (De Benedictis and Tajoli 2011, Head et al. 2010, Macdonald 2004, OECD 2008b, Dunning 1994, Kuemmerle 1999). Except for geographic and cultural distance, we include a number of other explanatory variables that are meant to capture the proximity between countries that are involved into a relationship of patent seeking and patent granting. These variables can be grouped into two main blocks: economic capacity and inventive capacity of a country. In addition, we include measures related to the PCT membership.

Taking the above considerations into account, a function that is expected to capture the relationship between the propensity to file patent applications by applicants overseas can be expressed as follows:

$$IntApp_{ijt} = f(CommLang_{ij}, Dist_{ij}, GDP_{it}, GDP_{jt}, FDI_{jt}, Inv_{it}, Inv_{jt}, PCT_{jt}, \alpha, \varepsilon_{ijt}) \quad (2)$$

where $IntApp_{ijt}$ represents the count of subsequent patent applications filed by applicants residing in country i to the national patent office of country j in $t \in (1970, 2009)$. To explain the emergence and intensity of relationships between countries we use a number of variables capturing factors discussed above, i.e. economic and innovation capacity, together with additional characteristics related to geographical and cultural proximity, and, finally, a variable controlling for the length of a country membership in the PCT. Unobserved time and country effects are captured by ε_{ijt} .

Concerning the geographical proximity, we use a variable controlling for the distance between countries i and j , $Dist_{ij}$. In addition, in order to account for other frictions in the process of international patenting resulting from cultural differences, we include a dummy variable $CommLang_{ij}$, which indicates whether two countries share a common official language.

Regarding economic size of countries linked through patents submitted by non-resident applicants to foreign patent offices, information on GDP (in current US\$) both country i and j in period t is included. Altogether, as discussed above, measures of a country's GDP are expected to capture the economic prowess of a country of an applicant, on the one hand, and the attractiveness of the market in which patent protection is sought for, on the other hand. In addition, in order to control for the openness of a country to internationalisation of economic activity, we also include measures of foreign direct investment FDI_{jt} , referring to a country in which a foreign applicants seeks to protect her invention (in current US\$).

Following our expectations that not only distance hinders and economic factors motivates applicants to commercialize their technology and know-how in overseas markets, we

control for the innovation capacities of both countries by the total number of patents of country i and j at time t .

Finally, to address our question concerning the working of the PCT, we measure the duration of a country's membership in the PCT by PCT_{jt} . This variable refers to the country in which non-resident applicant seek to protect her inventions. Intuitively, countries with longest record of PCT membership would have the highest share of subsequent patent applications among the total number of foreign applications submitted to their national patent offices.

4. Data

As already pointed out, the variables used for the investigation carried on in the present work can be grouped into those referring to the economic capacity of countries on one side, and those intended to measure the inventive capacity of countries themselves, on the other. Moreover, the information regarding the enforcement of the PCT is considered.

Measures of international patent filings

In making use of indicators based on patent data to provide evidences on innovative activity, some considerations have to be taken in mind. For the extent patent statistics are used in the present paper, for example, it must be briefly recalled that patent is not the only method to protect the exploitation of inventions, and not all inventions are patented. Moreover, the approach to patent invention is also differing from country to country, and different patenting strategies could result in difference in the number of files per single invention too. Therefore, direct comparison could result difficult. Notwithstanding these and further aspects which literature already addressed extensively (WIPO 2008, OECD 2010b, De Rassenfosse et al. 2011), the availability of patent data allow for a valuable insight on innovation and on the behaviour of innovative companies.

With regard to the block of variables regarding countries inventive capacity, the dataset built for the present paper is based on patent data coming from the European Patent Office (EPO) Worldwide Patent Statistical Database (known as the PATSTAT database), which provides a snapshot of the data available in the EPO's 'master bibliographic database DocDB' at a specific point in time. This database provides a worldwide coverage of patent applications submitted to around 90 Patent Offices in the world. The present analysis is based on indicators built by extracting and elaborating patent application data from the October 2011 release of the PATSTAT database, taking into account patent applications filed at 59 Patent Offices: the EPO itself and 58 National Patent Offices including those of the 27 EU Member States, the US Patent and Trademark Office (USPTO), the Japan Patent Office (JPO) as well as the other most active Patent Offices worldwide, including China and India. To the selected patent offices in 2009 were filed about 99% of the total number of priority patent applications. The time period taken into account covers from January 1st, 1970 to December 31st, 2009. Data coming from PATSTAT are elaborated through a series of methodological steps, starting with those consolidated in literature (De Rassenfosse et al. 2011, Turlea et al. 2011, Picci 2010) to deal with some remaining criticalities, mainly related to the process of exchange of information among patent offices, which affects patent data. First, as the needed variables are intended to provide measure of the inventive capability of countries, rather than of the productivity of patent offices, the subset of 'priority patent applications' is initially taken into account, to avoid double counting and the limitation coming from considering granted patents. The year is assigned along with the information coming with the filing date given when the application is first filed at a patent office by an applicant seeking patent.

To the extent of the present analysis the issue of missing information is in fact still relevant, when it comes to identify the country of residence of applicants (or inventors), and several methodological steps are followed in order to collect missing country information from other records related to the patent application, and to proxy it with that of the country where the application has been filed only as a last resort. The ‘applicant’ criterion is applied, so that applications are attributed to countries along with the country of residence of the first applicant.

The priority applications considered were of standard applications and applications submitted under the PCT regime. In order to complete the dataset necessary to investigate companies strategies, each of the priority applications has been linked to all the subsequent filings to any extent referring to the application which represented the first request of protection of the invention. Subsequent applications were belonging to two sets: that of subsequent standard applications and that of PCT international applications entering the national phase; both have been considered in building the complete set of data. At this point, pair of countries were formed by linking the country of applicant of the priority applications, on one side, and the country of the patent office to which the subsequent application have been submitted, on the other side. To each pair of countries the number of applications, of each type, has been assigned, grouped along with the year of subsequent filing.

Patent data are exploited also to control for the innovation capacities of countries, by taking into account the total number of priority patent applications calculated this time along with the inventor criterion, for each of the considered countries and for each year in the period between 1970 and 2009. The relevant descriptive statistics are reported in Table 1.

Other data sources

In order to build the variable relative to the number of years of participation into the PCT framework, the date of enforcement of the PCT in each of the countries involved in the analysis has been considered. The WIPO indicates the full date of accession and of entrance into force for each of the contracting parties, which were 20 in 1978, then grown to 30 in 1980 and 45 in 1990 to reach 108 in 2000 and to be nowadays 144 (Argentina and Iran signed in 1970, but the participation does not result enforced yet). The number of years of enforcement has been calculated on the basis of the dates made available by WIPO on its website.¹

Besides the variable controlling for the length of a country membership in the PCT, a set of other indicators has been built to describe the economic capacity of each country. The size of the economy has been represented by the GDP in current US\$ provided by World Bank data for whole covered the period. To the same extent, data on net inflows of foreign direct investment in current US\$ came from the same sources, i.e. the World Bank.²

Additional characteristics related to geographical and cultural proximity, instead, are built upon data coming from the CEPII bilateral trade data (Head et al. 2010), and allow to take into account whether a pair of countries is sharing or not a common language, and to how much their geographical distance accounts for.

¹ Source: WIPO; available at: http://www.wipo.int/treaties/en/statistics/details.jsp?treaty_id=6 (last accessed Jan.26th, 2012).

² Available online at: <http://data.worldbank.org/indicator/BX.KLT.DINV.CD.WD> (last accessed on 31 January 2012)

Table 1: Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Nr of subsequent applications	51437	172,03	1018,87	1	38640
Nr of subsequent direct applications	51437	168,38	997,83	0	36595
Nr of subsequent PCT applications	51437	3,65	30,59	0	2045
Nr of patents (inventor criterion)	7840	1978,17	18217,17	0	322581,40
FDI in-flow (current US\$)	5771	3.11e+09	1.55e+10	-3.89e+10	3.28e+11
GDP (current US \$)	6749	1.33e+11	6,78e+11	1.43e+07	1.44e+13
PCT membership duration	2291	10,77	8,135356	0	31
Common Language	42336	0,17	0,372471	0	1
Distance in km	42336	8256,27	4632,74	1.88	19951,16

5. Empirical results

To estimate the function specified in (2), we run OLS regression with time and country fixed effects. Table 2 reports the estimation results for the following three models: the first model includes all subsequent patent applications by residents from country i that were submitted to the patent office of country j at time t . In order to get some more insights into the motivations of applications to seek for patent protection in foreign countries when using different patent filing procedures, the second and third specification concern PCT and direct applications respectively. For each model, we first report estimations with variables controlling for geographic and cultural proximity, economic size, and net FDI in-flows. The extended specification includes the control for the PCT membership duration of country j .

Regarding all the coefficients of the basic gravity model for all patent applications by non-residents submitted between 1970 and 2009, i.e. distance, common language, economy size and invention capacity, have the expected signs, and are significant. The coefficients of the FDI in-flows to country j are negative. Regarding the second estimation, we can see that the coefficient related to the number of years of a country's PCT membership is negative. In other words, the PCT membership has a reverse effect on a country's attractiveness for seeking patent protection by foreign applicants.

Concerning the sub-sample with PCT applications, the regression is restricted to the period between 1978 and 2009, i.e. it starts from the year in which the PCT came into force. To a large extent, the outcomes of these estimations overlap with the previous results. However, we can see that the coefficient of the variable controlling for the economic size of country i changed the sign. In other words, it points to the fact that PCT application procedure is likely to be used by economically smaller countries. However, due to the lower level of the coefficient controlling for the size of country j , the group of addressees of the very same applications includes smaller countries as well, as compared to the sub-sample with direct applications. Regarding the effect of a country's PCT membership duration, even in this case it is not relevant. Thus, even for applications submitted under the PCT procedure, the length and experience of a country with the PCT system does not affect non-resident applicants to file a patent application in the country.

Turning our attention to the estimation results on the direct applications by non-residents, we can see that the results are very close to those obtained with the full sample. The reason for this is that this type of applications forms the majority of patent applications submitted by non-resident applicants. Nevertheless, a comparison between the PCT and direct applications provide some interesting insights. First of all, we can observe that the coefficient values of the variables controlling for countries proximity, i.e. geographical distance and common language, are of lesser importance for PCT applications than for direct applications. In other words, the PCT procedure has a mediating effect on the distance between countries and it facilitates filing applications to distant countries.

Furthermore, comparing the factors behind the propensity to use different patent application procedures, we can further say that there is a significant difference between using PCT and direct patent applications. First of all, we observe a strong difference with

respect to the economic size of both an applicant's country and the country where patent protection is requested. In the case of PCT applications, there is a strong negative impact of GDP_i , as compared to a positive effect of the same variable in the specification for direct filings. In practical terms, this means that the PCT procedure is more likely to be used by applicants residing in relatively small countries. Moreover, as the value of GDP_j is also relatively smaller in the case of PCT applications, we can expect that applications submitted under this procedure are directed to smaller countries, compared to direct patent applications. Similar observations can be made with respect to the innovation capacity of both countries, i.e. i and j .

All in all, the results show that the level of GDP and invention capacity of both countries, i.e. the source of technology and country whose patent protection is sought for, are the major reasons to seek for patent protection in overseas markets is the access to the market. Hence, as in the case of international trade, the potential size of the economy, as a measure of its attractiveness, together with the level of technological development can be considered as a major predictor of applicants' propensity to seek for patent protection for products and technology they market in a country. In light of this, we find that the role of the PCT membership is not significant for applicants seeking for IP protection in foreign countries.

Table 2: The drivers of patent applications by non-residents.

	(1)		(2)		(3)	
	Log of all subsequent applications submitted by residents of country i to country j between 1970 and 2009 $(IntApp_{ijt})$		Log of PCT subsequent applications submitted by residents of country i to country j between 1978 and 2009 $(IntApp_{ijt})$		Log of direct subsequent applications submitted by residents of country i to country j between 1970 and 2009 $(IntApp_{ijt})$	
Common Language ($CommLang_{ij}$)	0,360*** (18,26)	0,362*** (18,45)	0,237*** (7,35)	0,236*** (7,33)	0,361*** (18,23)	0,364*** (18,42)
Log Distance $_{ij}$ ($Dist_{ij}$)	-0,334*** (-41,56)	-0,332*** (-41,55)	-0,177*** (-13,99)	-0,177*** (-14,02)	-0,332*** (-41,1)	-0,331*** (-41,1)
Log real GDP $_{it}$ (GDP_{it})	0,523*** (18,27)	0,530*** (18,55)	-0,268*** (-4,63)	-0,267*** (-4,61)	0,521*** (18)	0,526*** (18,26)
Log real GDP $_{jt}$ (GDP_{jt})	0,240*** (8,01)	0,253*** (8,47)	0,131** (2,53)	0,139*** (2,66)	0,248*** (8,23)	0,261*** (8,67)
Log FDI $_{jt}$ (FDI_{jt})	-0,044*** (-6,81)	-0,037*** (-5,67)	-0,058*** (-5,12)	-0,058*** (-5,09)	-0,043*** (-6,56)	-0,035*** (-5,42)
Log Patent $_{it}$ (Inv_{it})	0,242*** (31,29)	0,242*** (31,47)	0,220*** (8,91)	0,219*** (8,91)	0,243*** (31,15)	0,243*** (31,36)
Log Patent $_{jt}$ (Inv_{jt})	0,069*** (8,71)	0,045*** (5,64)	0,057*** (2,78)	0,052** (2,48)	0,071*** (8,94)	0,047*** (5,89)
PCT membership duration (PCT_{jt})		-0,032*** (-17,58)		-0,008 (-1,38)		-0,033*** (-17,76)
Country and time effects included	YES	YES	YES	YES	YES	YES
Constant	-15,519	-16,375	1,506	2,501	-15,624	-16,460
Number of observations	42.639	42.639	11.059	11.059	41.892	41.892
R-squared	0,7132	0,7153	0,5920	0,5921	0,7157	0,7178

The econometric method is Ordinary Least Squares, including country and time fixed effects; t-values are in brackets.

***, ** and * denote significance at the 1%, 5% and 10% probability threshold respectively

6. Discussion

The results presented above show that the PCT patent filing procedure does not play a major role in the decisions of non-resident applicants to seek for patent protection in foreign countries. Instead, such characteristics as geographic, economic and inventive distance between countries facilitate international patenting. Below we would like to shortly discuss these findings and their interpretation.

Regarding the market size, it is worth noting that the issue of market attractiveness in the context of technology transfer is not only related to the trade in technologically advanced products. Instead, the demand for IP and patent protection is strongly related to the global rise of the knowledge economy, whose boundaries are not limited to developed countries. One implication of this development is the fact that, over the last years, technology and knowledge have become increasingly definable and tradable goods. The possibility to sell technology rather than final goods across the borders increased (WIPO 2012, OECD 2008b). A confirmation of this development is clearly visible in the increasing trend in the commercialization of IP and the resulting emergence of a market for IP, and more specifically a market in patents (Kanwar and Evenson 2003, OECD 2008b). In addition, organizations other than businesses have become aware of the value of their IP and new institutions have emerged to facilitate the creation and commercialization of IP across the countries (Greenhalgh and Rogers 2007). These trends have led to an increase in the size of the global market for technology and technologically advanced products and, as a result, spurred the growth in the demand for IPR protection at home and overseas.

Regarding the innovation capacity, we find evidence that both the invention capacity of an applicant's country and of the country in which patent protection is sought for is an important facilitator of international patenting. There are at least two reasons that can

explain this dependency. The first one relates to the fact that the innovation capacity of an applicant's country. The second one relates to the country in which an applicant seeks for patent protection.

Considering the inventive capacity of an applicant's country, it simply reflects the availability of inventions for which there may be demand inside and outside of its country. The implication of this is straightforward: the higher the production of invention in a country, the more knowledge and technology it has to offer to the rest of the world. Obviously, owners interested in transferring or exploiting their intellectual property abroad are also interested in having their assets protected in countries in which they do business.

The relationship between international patenting and the inventive capacity of a country whose IP protection is sought for is more complex. Intuitively, the level of innovation capacity of the destination country reflects its availability of technology and know-how, which might be either complementary or competitive to the invention for which protection is being sought for. Regarding the technological complementarity, technology transfer is justified if a country has the capability to either accumulate or complement the technology. This is related to the fact that technology transfer involves usually more than just the transfer of the knowledge covered by patents (Motohashi 2003). Alternatively, as noted by Furman (2002), the level of GDP also reflects a country's ability to transform its knowledge stock into economic development. Thus, the invention and/or absorptive capacity of a country and/or transferred know-how are complementary to the codified knowledge covered by patents. Regarding the issue of technological competition, the availability of know-how in a country to which technology is transferred is also a sign of the country's ability to copy the technology. In either case, i.e. technological complementarity or

competition, drawing boundaries of the transferred IP is critical for retaining the rents, once the technology evolves and is commercially exploited.

The level of invention capacity, expressed in terms of the number of patents, might also reflect the strength and efficiency of IP protection in a country in which an applicant wants to protect her invention (Eaton et al. 1998, Paci et al. 1997, Fulton 1997, Sternitzke 2009). In other words, efficient protection of intellectual property produced within a country gives a foreign applicant who is transferring its technology to that country a guarantee that her protection will also obtain a required level of protection.

After disentangling the effects of economic and inventive capacity of countries on different types of applications, we find that the PCT procedure is more likely to be used by applicants residing in relatively smaller countries and that PCT applications are submitted to smaller countries, as compared to direct patent applications. This can be interpreted in the following way: On the one hand, the PCT procedure makes it easier and cheaper for applicants from smaller countries to protect their inventions. On the other hand, however, the protection for these inventions is being sought for in markets with lower economic potential. This clearly raises the question of the value of inventions for which applicants choose different institutional tracks of protection.

7. Conclusions

The last few years of increasing international trade and globalization of economic activity, together with the rise of the knowledge economy, has raised an interest in IP protection both within national borders and across countries. However, intuitively speaking, the strong incentives for multinational companies doing what is necessary to have their inventions and technologies protected in many countries are weakened by the complexity, cost and redundancy of applying for patent protection in multiple national patent offices. As the

emergence of a global patent system is a long way off, we are witnessing a strong increase in the efforts to harmonize national patent systems in order to facilitate international patenting activity for businesses and to reduce the duplication of efforts of patent offices.

The PCT, the Madrid System, the European Patent Convention (EPC), the implementation of the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) and the Anti-Counterfeiting Trade Agreement (ACTA) (currently being negotiated) are some of the most important means of harmonizing of IPR protection across the world. They are also commonly referred to as the main drivers of the increase in patenting activity and facilitators of cross-border patent applications. In light of these developments, the relatively late take-off and still low level of PCT applications comes as a surprise.

In the preceding analysis, we aimed to fill the gap in understanding how harmonization works in practice and how it affects patenting activity. The results of our work do not confirm that the PCT has improved the process of international IP protection. Nevertheless, the results we obtained in our analysis allow us to formulate some conclusions and implications with respect to a number of areas ranging from the business patterns of international patenting, country innovation policy and the process of IPR protection harmonization.

First of all, from the business perspective of applicants who wish to protect their inventions in the global market, it can be said that the business world seems to have found a way of coping with the complexity and burden of multi-country patenting. Despite the availability of patenting procedures that facilitate patenting in multiple countries, such as the PCT, businesses make little use of them. Instead, driven probably by the need to have access to quick protection in a number of countries, they choose a patenting strategy that involves parallel and direct patent filings to a selected number of national offices. Judging by the

results of our analysis, we can conclude that the selection of these countries is based on their economic and inventive power. In other words, it is either the potential benefit of having secured revenues from a relevant market or the existence of potential competitors who are able to copy an invention, or both these factors, that motivate owners of IP to file patent applications in foreign countries. Consequently, a successful international patenting strategy should involve an assessment and selection of countries and patent offices whose protection is vital to a firm's success. This assessment should be based on the availability of technological complementary and/or competitive assets in a country. A result of this assessment would be a portfolio of countries ranked according to their importance with respect to the protection of a firm's intellectual capital.

Second, regarding national interests, it emerges from the results of this study and the above discussion that the meaning and interpretation of the findings concerning the working of the PCT and the patterns of international patenting are not the same for each country involved in the process of patent harmonization. Depending on the perspective of a particular country, the implications may be perceived as positive by some countries and negative by others. The main reason for this is that, depending on the position of a country, the outcomes of the harmonization process are likely to affect the distribution of bargaining power (Moy 1993). Hence, it will determine not only its attractiveness as a market for technological products, but it will also influence its position as a producer of technology and a technological collaboration partner. This point is very well illustrated by the fact that, to a large extent, the persistence of differences in IP protection is of a political nature. Depending on the perspective, some countries favour patent harmonization and some are against it. It is often argued that the process of patent harmonization is supported by developed countries, as it benefits their economic expansion. However, the

differences among countries with respect to the policy of patent harmonization cannot be organized along the division between developed vs. developing countries. For example, although India and Brazil may show strong similarities in both the economic and political realm, they show contrasting interests in the area of IPRs and, as a result, their policies differ (Charnovitz 1998). Whereas India pursues a policy of strategic cooperation with the United States, Brazil remains reluctant in this respect. A partial explanation of this reluctance is related to concerns over an unequal accumulation of intellectual capital and, hence, benefits (Moy 1993). This implies that national innovation policies should include in their agenda an assessment of the implications of IPR harmonization developments and a plan to address them.

Third, the PCT was intended to encourage technology transfer, particularly to developing countries. However, the weak effect of a country's PCT membership on attracting foreign applicants to file patent applications in that country's patent office and, hence, to reveal information on the invention, raises some doubts as to its effectiveness for technology transfer between countries. As already pointed out (Schneiderman 2007), the infrastructure and instruments created for this purpose are still not sufficient and the recently proposed recommendations for improvement confirm that, so far, the PCT has not lived up to its promise of making technology available to developing countries. The parties involved in the design of the harmonization of IP protection should therefore be required address this point in their work.

Fourth, an implication of this analysis for further work on patent harmonization is that better assessment of the costs and benefits to other parties involved is required. Moreover, countries also need to take into account the broader environment, as in the case of FDI or international trade in general. Consequently, while designing IPR protection mechanisms

and policies, policy makers should give them a multinational dimension, acknowledging that whatever happens in one country, affects the other countries and vice versa. Rather than designing policies driven by the notion of securing profits from invention, it may be advisable to create a mutually beneficial system of collaboration, taking into account interactions with a large number of players. The new paradigm of inter-country relationships and mutual dependencies in the innovation process involves the creation of a holistic IP regime that creates the right balance between countries that source and countries that produce inventions. The success of this process will determine the process of innovation and new technology creation and, hence, the total payoff available to all the contributors.

Summing up, the structure and functioning of a global system of IP protection challenges the traditional way of thinking about a number of aspects of research and innovation policy in general, and IPR protection in particular. Approaches that were usually shaped by a one-sided perspective and defined by the notion of competition need to be adjusted to the changing ways of organising economic and innovative activity. A new approach needs to take into account the need to develop collaboration mechanisms that support mutual co-dependencies between countries. This confirms that the issue of IPR protection in the international context is still important and the implications of patent harmonization are far from being fully understood yet. Hence, comprehensive assessment of the efforts to harmonize IP protection is needed.

In conclusion, although this paper provides a number of valuable insights into the practical functioning of the PCT and the determinants of international patenting, it has a few limitations. First of all, due to the fact that there is no theoretical foundation which explains applicants' incentives for seeking for patent protection in foreign countries, we make use of

the gravity model and explain, at aggregate level, the intensity of bilateral links between countries. Moreover, we focus our attention only on one aspect, i.e. the attractiveness of a country for foreign applicants, and do not analyse other effects of patent harmonization reforms. Nevertheless, the results presented above show that the answers to the questions at the heart of this study are far from straightforward and they deliver additional information explaining the existence and intensity of international patenting. Moreover, they cast some new light on the working of IPR harmonization efforts and mechanisms and provide some guidance for further development in this area. This leads us to believe that future analysis of the effects of IPR harmonization on a range of socio-economic aspects would be valuable.

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Abstract

We study drivers of international patent applications by non-residents and assess the importance of the PCT membership in their motivations. We construct bilateral measures of foreign patent applications for all countries active as both a source of patents and a destination of applications filed between 1970 and 2009. The data used originates from the EPO Patstat database. Applying a gravity model to explain the determinants of seeking patent protection in foreign markets, we find that there is a negative relationship between PCT membership and a country's attractiveness for foreign applicants. It is mainly the size of the market and a country's inventive capacity that attract foreign applicants to seek for patent protection in foreign countries.

Keywords: patent harmonization, PCT, IPR, patenting strategies, international patenting, technology transfer

JEL classification: F2, O30, O31, O57

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