International Cooperation in Pharmaceutical Research

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Abstract

The introduction of the Trade-Related Aspect of Intellectual Property Rights (TRIPS) agreement in 1995 has represented an important evolution of the Intellectual Property Rights regime. In this paper we aim at studying whether the new patent regime has stimulated international cooperation on innovative activities between WTO members, focusing on less developed countries. Despite the attention devoted to the issue by the theoretical literature, scattered empirical evidence is available at date. We adopt a gravity framework in order to examine the impact of the level of enforcement of property rights on bilateral flows of knowledge within the pharmaceutical domain. The analysis is conducted using data from PatentScope and ISI WEB of knowledge, and the results provide a sound test of conflicting theories about the effect of TRIPS enforcement on international technology transfer.

Keywords: IPR, pharmaceutical products, R&D co-operation.
JEL classification: F13; O34; O57.

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1 Introduction

The agreement on Trade-Related Aspect of Intellectual Property Rights (TRIPS) has represented an important evolution of the Intellectual Property Rights (IPR) regime at the international level. Even though one of the most controversial issue in the protection of IPR, the agreement was introduced with the aim to establish an international patent regime able to foster technological innovation, facilitating at the same time the transfer and dissemination of technologies among countries. Establishing a minimum standard in the protection of the IPR, the TRIPS agreement was directed to converge all national patent system towards an international system that is able to boost the technological cooperation between developed and developing countries. It is widely recognized that the level of IPR represents an important attraction of foreign direct investment (Ferrantino, 1993; Lee and Mansfield, 1996; Saggi 2000), affecting the decision-making concerning international R&D partnering (Hagerdoorn, Cloodt and van Kranenburg, 2005). Indeed, an effective protection of IPR may reduce the risk for companies when they invest in less developed countries, spurring thus foreign investments, technology transfer and joint research programs that offer additional resources targeted to the local needs (Maskus, 1997; Correa, 2007; Ito and Wakasugi, 2007)

From January 2005 the TRIPS regulations about the new patent regime came into force in all WTO members including the new developed countries with innovative and technology capabilities (as India, Brazil and Thailand), which were allowed to retain their own national patent regime until 2005. The new rules impose to provide patent protection in all productive areas for which such protection previously was not available (e.g. pharmaceutical products).[1] This date has represented an important step toward an harmonized international patent regime, providing an opportunity to estimate the impact of a stricter IPR system on technological and scientific cooperation.

Of course the patent system is not the only mechanism available to spur innovation efforts (Mansfield, Schwartz and Wagner, 1981; Chin and Grossman, 1990; Deardorff, 1992). Secrecy and licensing agreements can be more effective than patents in the appropriation of the returns from R&D (Levin *et al.*, 1987; Cohen, Nelson and Walsh, 2000; Gallini and Scotchmer, 2001). However, the pharmaceutical industry is a unique setting in this respect, as it does widely rely on patents to protect the returns from R&D investments (Diwan and Rodrick, 1991; Levin *et al.*, 1987; Cohen, Nelson and Walsh, 2000).[2]

[1] With the exception of least-developed members of WTO, for which enforcement of product patent protection and undisclosed information rights for pharmaceuticals is postponed to 2016.

[2] It is interesting to note that during the transition period these new developed countries had the

Although there is a huge consensus about the role that patent plays in health-related R&D, only scattered empirical evidence it is available about the effect of the IPR on cooperation and technology transfer at the international level. Within this scenario, we report a novel empirical strategy to assess the enforcement of the TRIPS agreement on cooperative innovation in the pharmaceutical industry using a gravity approach. Specifically, we seek to investigate whether the increased strength of patent protection has effectively spurred the international cooperation in the pharmaceutical sector between WTO members, focusing on the less developed countries. To address this issue, we build a dataset covering a broad international panel of countries over the period 1998 to 2008, and count the number of patented drugs and health-related publications jointly signed by researchers in the developed and developing world. This is a very strong form of collaborative research, involving direct communication between research in the two countries.

The paper is organized as follows. Section 2 reviews the main literature about international technology transfer and cooperation. Section 3 describes the data and empirical measures used in the analysis, while in Section 4 we test the effect of increased protection of IPR on technological and scientific collaborations and report our findings. Section 5 concludes.

2 Literature Review

Although it is beyond any doubts that the linkages between technology flows and IPR may have important dynamic effects, today the question whether the TRIPS agreement have reached the expected results in terms of increased technological transfer is still an open issue. It needs to be mentioned that most of the studies on the effect of IPR on the technology transfer has been undertaken before the timing of full enforcement of the TRIPS agreement in developing countries (up to the year 2005).

No direct measure of international technology transfer exists, and the literature has relied mainly on measurable flows, such as foreign direct investments (FDI), trade flows, as well as royalty payments between firms located in different countries (Maskus, 2004). Moreover, in order to study the role of IPR in spurring technology transfer and cooperation, empirical and theoretical studies have addressed the issue from different perspec-

opportunity to strengthen a stable pharmaceutical industry, creating the conditions for some of the foreign companies in the industry to initiate investments in cooperation with these countries (Lippoldt, 2006). Some of the countries taken into account were already implementing major changes in the IPR regime before the year 2005. In 2002 India has already extended patent protection from 14 years to 20 years (Padmashree, 2007).

tives.

All in all, the theoretical literature provides grounds to the idea that an increase in the stringency of the IPR can be beneficial as it can lead to a rise in R&D investments, fostered by a greater monopolistic power, and therefore it can lead to faster growth (e.g. Nordhaus, 1969; Grossman and Helpman, 1991; Grossman and Lai, 2004; Valletti and Szymanski, 2005). The introduction of the international patent regime in developing countries is largely called for by northern firms, because failure to provide such protection would raise the incentives to invest in imitation barring strategies, causing a decline in aggregate R&D efforts and in technology transfer across countries, with a negative impact on worldwide growth (Taylor, 1993; 1994).

In the recent years developing countries have shown a growing interest in attracting FDI and technology transfer, for which IPR clearly plays a crucial role. Although the theory indicates that the scales are tipped in favor of a positive relationship between IPR and FDI, the empirical evidence is far from being sufficient to confirm this conjecture. There is a strong presumption that FDI and licensing are beneficial for the recipient country but it is important to stress that it is not a warranted outcome in all circumstances. Indeed, the development of innovation and the decision where to locate R&D laboratories and production plants could be influenced by local/regional characteristics (such as the availability of proximal skilled labor force), that have stronger effect on innovation than national and international policies (such as strengthening IPR).

Under a different perspective, other studies underline the role of trade in driving innovation and technology transfer between countries. The basic idea builds on the fact that imports act as a means through which new technologies can be introduced in the receiving countries (Coe and Helpman, 1995; van Pottelsberghe de la Potterie and Lichtenberg, 2001; Acharya and Keller, 2007). Maskus and Penubarti (1995) have used an extend version of the Helpman-Krugman model of monopolistic competition to measure the effect of the patent protection on international trade flows. Their study points out how an increase in the stringency of the IPR can have a positive impact in terms of increased flows of bilateral trade in developing countries. Their results are confirmed by Primo Braga and Fink (1997), who show a positive link between tighter patent protection and manufacturing trade flows.

Contrary to the sharp predictions yielded by the theoretical literature, the empirical studies have provided ambiguous and controversial results. Empirical works analyzing the impact of IPR reforms often do not take into account the efficacy of enforcement, strictly correlated with country characteristics. Branstetter, Fisman and Foley (2006) analyze whether a stronger IPR system accelerates technology transfer. Building on affiliate-level data and aggregate patent data of US multinational firms over the period 1982-1999, they study the effect of patent protection reforms on the royalty payments and R&D expenditures. Their results show that stronger IPR encourages multinational firms to engage in larger technology transfer, as they find a significant rise in the number of patents filed by nonresidents after the reform.[3] Some studies underline how IPR alone are not able to work as incentive to knowledge transfer. Also large markets and strong technological capabilities are required (Bascavusoglu and Zuniga, 2002). In addition, the effect depends on the threat-of-imitation posed by the receiving country, where stronger IPR in weak-threat market may actually decrease trade flows from US companies (Smith, 1999).

The critique to stronger IPR is reinforced by Lanjouw and Lerner (1998) and McCalman (2001), who demonstrate how the international harmonization of the IPR could yield negative effects for the developing countries. They show that a strong patent regime provides large income transfer between countries (for which the developing countries are the major contributors) to the advantage of the patent holder, i.e. multinational firms located in the developed countries. Even though there is a positive relation between patent protection and the level of R&D, the relationship weakens at higher levels of protection, and the effect is largely dependent upon the characteristics of the country in terms of FDI, import flows, and income level. Particularly, the main mechanism for technology transfer is an important discriminating factor: a stronger IPR system can increase the rate of innovation if FDI is the channel of production transfer, whereas the opposite result holds true in the case that the technology transfer occurs by imitations processes (Deardorff, 1992; Glass and Saggi, 1995; Lai, 1998; Alvi *et al.*, 2007). However, if licensing is allowed, an increase in the stringency of IPR provides additional resource available for R&D, thus rising innovation and technology transfer (Yang and Maskus, 2001).

More recently, Park and Lippoldt (2008) have studied how trade flows (including licensing and FDI) for different sectors could serve as a means for technology transfer directed toward the developing countries.[4] They investigate the role played by the strength of the new IPR system, as proxied by a set of indicators that includes patents, copyrights and trademark rights. Park and Lippoldt (2008) find that trade inflows are positively associated with the strength of patent protection. Their results show that a wide and enforced IPR system facilitates foreign investments for the development of new

[3]However, nothing can be inferred on the welfare effects of a stronger IPR system for these countries, because the analysis does not take into account the impact of the reforms at the national level.

[4]Still, they employ data up to the year 2005, before full enforcement of the TRIPS provisions in developing countries.

innovations. These results are in line with the traditional literature which assumes that IPR is the only possible tool apt at guaranteeing innovation incentives. However, even though the IPR system encourages firms to invest in R&D devising new technology, the same system discourages them to introduce the second generation products (Scotchmer, 1991). In addition, although a stronger protection in the short term foster the rate of innovation, in the long run this effect vanishes (Helpman, 1993).

Focusing the attention on our field of investigation, Kyle and McGahan (2009) find that the investment in developing new drug increased as consequence of a stronger patent protection (when adopted in high income countries). On the contrary, investments in developing countries have not grown as a consequence of the introduction of patents. Particularly, a positive relationship is in place between drug development and market size (Acemoglu and Lin, 2004).

We take a different perspective here and analyze a very strong form of technology transfer, i.e. joint signature of patent documents or scientific articles by researchers located in different countries. This is a very strong form of collaborative research, implying transfer of both codified and tacit knowledge and capabilities across the two countries. We provide novel empirical evidence on the role of TRIPS in spurring international cooperation in pharmaceutical R&D.

3 Data and measures

In order to study the international cooperation in pharmaceutical R&D we have integrated data from many different sources. Our measure of technological and scientific collaboration rely on the information contained in patents and publications. The dependent variables were constructed employing ad hoc queries on *PatentScope registered* for inventions (patents) related to pharmaceuticals,[5] and from *ISI Web of Knowledge* for the peer-reviewed research articles published about health-related subjects (Lerner, 1994; Zucker, Darby and Armstrong, 2002).[6]

Based on patent information, a measure of technological collaboration between two countries is computed exploiting the information about the country reported in the nationality of the applicants[7]. A collaboration is counted if a patent is signed by ap-

[5] The PatentScope search service enables full-text search in over 1.6 million published international patent applications from 1978. See http://www.wipo.int.

[6] See http://apps.isiknowledge.com. The database was queried in February 2009 for articles containing the following terms: pharma OR biotech OR drug OR therapeutic OR disease OR medical.

[7] The applicant is the person who first claims to be the inventor. In the US the applicant must be the inventor (Patent Cooperation Treaty, article.9).

plicants located in both countries (irrespective of the country of the patent assignee). In order to identify pharmaceutical patents, the classes A61K and A61P of the International Patent Classification (IPC) are consider. Indeed, with references to IPC scheme, these two classes contain information about the drugs or other biological compositions for medical, dental or toilet purposes, and therapeutic activity of chemical compounds or medicinal preparations.[8] Using the PatentScope database we construct a sample of 234,126 patents published between 1998 and 2008 in cooperation between thirty partner countries, of which eleven are developing or transitional economies.[9]

For the same panel, from *ISI Web of Knowledge* we extract more than 1.5 million health-related research articles published over the period 1998-2008.[10] The database reports the affiliation of all the authors involved in a publication, along with information about the country. A scientific collaboration between two countries is considered if the publication is jointly signed by researchers located in two different countries.

The choice of the countries considered in the analysis has been driven by considerations about their size and importance in the pharmaceutical sector, in particular in the production of generics (World Generic Market Report, 2009). Moreover, in the past, with few exceptions, they were recognized as having the weakest protection (Mansfield, 1994; 1995; Lee and Mansfield, 1996). Therefore, it is of interest to examine how the international patent regime has affected the R&D potential of these countries. Indeed, in the recent years owing to the TRIPS agreement, these countries have been among those undergoing major reforms in their national legislation about IPR protection. Furthermore, due to their little effective patent protection some countries (such as Brazil, China, and India) were not parties of the Paris Convention or the Patent Cooperation Treaty.[11]

Two different strategies have been employed to measure the level of IPR enforcement in the developing or transitional countries considered in the analysis. First, we consider two dummy variables identifying the time periods that are mostly relevant in terms of the TRIPS agreements in the countries analyzed: a dummy variable for the time period 2000-2004 and a dummy variable identifying the years from 2005 on (the base

[8]The class A61K includes "preparations for medical, dental, or toilet purposes", whereas the class A61P considers the "therapeutic activity of chemical compounds or medicinal preparations". For more details see: http://www.wipo.int/classifications/ipc/ipc8/?lang=en.

[9] The following countries are considered in the analysis: Argentina, Austria, Belgium, Brazil, Canada, Chile, China, Denmark, Finland, France, Germany, Greece, India, Ireland, Italy, Japan, Luxembourg, Mexico, Morocco, Netherlands, Portugal, Rep. of Korea, Russian Federation, Spain, Sweden, Switzerland, Thailand, Turkey, United Kingdom and United States.

[10]Since journals publish scholarly material in a variety of matters, we confine our data to research articles that are defined by their health-related contents.

[11]For a specific analysis of these countries see Park and Lippoldt (2008).

category is the period before 2000). As an alternative, we rely on the effectiveness of the legal regime and the quality of governance as measured by the Economic Freedom of the World (EFW) index provided by the *World Economic Forum and the Economic Freedom Network*. The index, published in the annual report of the Economic Freedom of the World (Gwartney and Lawson, 2008), measures the degree to which the policies and institutions of countries are supportive of economic freedom (on a scale from 0 to 10).[12] The EFW index assesses the degree of economic freedom present in five major areas,[13] and we rely on data about the legal structure and security of property rights, and specifically of protection of IPR (area 2C).[14] The EFW is an index that provides with information not only based on the subject matter that can be patented, but also the length of protection, the mechanisms for enforcing patent rights, the evolution of the international patent laws (Park and Wang, 2002). Figure 1 reports the average values of the index computed considering the developed and developing countries included in our sample. The average value for the year 1995 is also included in the graph, unfortunately information over the period 1996-1999 is not available for this dimension. The year 2005 represents a clear turning point for the protection of IPR in these countries, driven by the implementation of the TRIPS agreement.[15] Note that the value for the year 2000 closely resembles the value recorded in 1995, suggesting that the signing of TRIPS agreements did not induce any significant changes in the protection of IPR up to the year 2005, when enforcement was required.

Finally, we use variables extracted from international databases, in order to assess the impact of the national endowment on collaborative activities. Particularly, we considered data from World Bank (*World Development Indicator)*, UNIDO, and OECD (*Main Science and Technology Indicators*).

4 Methodology and results

Gravity models have been largely employed for the study of international flows between countries (Anderson and van Wincoop, 2003). Building on the Newton's law of universal

[12]See www.fraserinstitute.org for complete methodological details.

[13]These five areas are: i) size of government: expenditures, taxes, and enterprises; ii) legal structure and security of IPR; iii) access to sound money; iv) freedom to trade internationally; v) regulation of credit, labor, and business (Gwartney and Lawson, 2008 - pp. 4).

[14]Data for area 2C are continuously available only from the year 2000. Information is also available for the year 1995, that will be used for descriptive purposes but not in the regression analysis.

[15]Even though the TRIPS agreement came into force at the beginning of 1995, developing countries were granted a transition period, ending on the 31st December 1999. Pharmaceuticals (and all productive areas where protection was not available at the time of TRIPS signature) were an exception, where the transition period ended on the 31st December 2004.

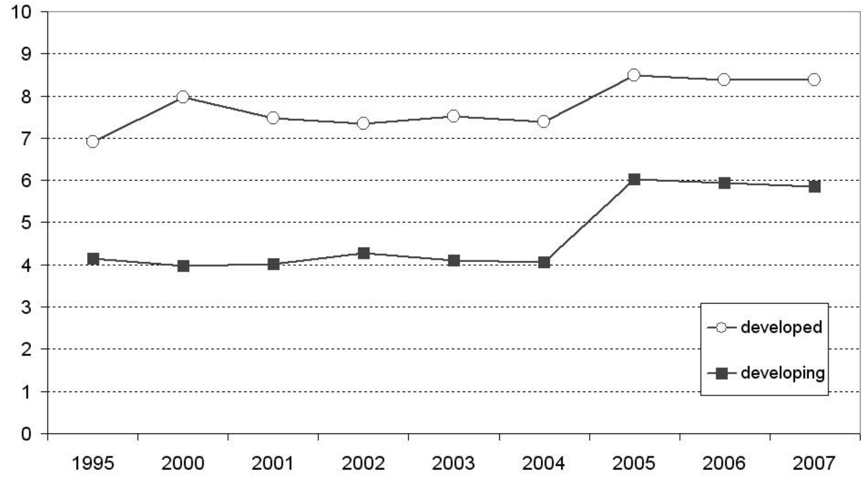

Figure 1: EFW index for the protection of IPR (EFW_2C): basic trend for the developed and developing countries included in the analysis

gravitation, the model posits that the flow F_{ij} (most commonly trade flow)[16] between two countries i and j is proportional to their "masses" (respectively M_i and M_j) and inversely proportional to the distance between them D_{ij}:

$$F_{ij} = \frac{\beta_0 M_i^{\beta_1} M_j^{\beta_2}}{D_{ij}^{\beta_3}} \tag{1}$$

In order to obtain an estimate of the parameters in equation (1), the model is usually customarily log-linearized and ordinary least squares is applied. This traditional approach has been recently subject to a strong critique, as it fails to provide consistent estimates of model elasticities if heteroschedasticity is present in the original equation (Santos Silva, Tenreyro, 2006). As a robust alternative, the Poisson pseudo-maximum likelihood estimator is to be preferred, allowing the researchers to solve the consistency issue, as well as the possibility of zero flow between two countries.

Moreover, the empirical assessment of the scientific and technological collaboration relies on the number of patents co-invented by applicants (or inventors) located in countries i and j, as well as the number of publications by scientists located in countries i and j.[17] As a count variable, the Poisson regression framework would be more appropriate

[16]The gravity equation has been also applied to study migration flows, equity flows and FDI (see e.g. Portes and Ray, 1998; Brenton *et al.*, 1999).

[17]See footnote 9 for the full list of countries in the analysis.

for estimation in this context.

Let C_{ijt} be the measure of technological and scientific collaboration between country i and country j at time t. Collaboration between North American and European countries (i) and selected developing countries and transitional economies (j) is taken into account. A gravity equation is considered, where we also include the IPR regime of country j ($IPRR_{jt}$) among the attraction factors:

$$E[C_{ijt}|M_{it}, M_{jt}, IPRR_{jt}, \tau_j, \alpha_{ij}] = \exp(\beta_0 + \beta_1 \log M_{it} + \beta_2 \log M_{jt} + \beta_3 \log IPRR_{jt} + \tau_j + \alpha_{ij}) \quad (2)$$

with α_{ij} representing a dyad-specific characteristics, M_{it} and M_{jt} the "masses" of, respectively, country i and j, and $IPRR_{jt}$ measures the level of enforcement of IPR, proxied using (i) time specific dummies and (ii) the index of IPR protection published in the annual report of the Economic Freedom of the World (area 2C). Country-specific time trends are included in all specifications (τ_j).

In order to proxy M, the international trade literature has relied on GDP and population measures. Here, we use the level of GDP and also take into account the production of the pharmaceutical sector,[18] as well as the overall research capabilities of the countries, as measured by the total value of R&D expenditures.[19] We apply the fixed effect Poisson estimator in order to control for neglected heterogeneity at the dyad/country level.[20] In addition, standard errors are estimated via bootstrap as it is not possible to assume independence among the dyads (dyad ij is likely correlated with dyad ik even if $j \neq k$).[21]

Descriptives statistics of the variables included in the regressions are reported in Table 1, along with the source of the data.

The Figure 2 depicts the dynamics of the average value of our dependent variables. The year 2005 seems to be a break-point in the dynamics characterizing collaboration

[18] As data are available over a shorter time period, we use the observed share of production in GDP in order to estimate the value of production (GDP data are available over the whole time period analyzed).

[19] We also experimented other variables, such as the share of R&D expenditures in GDP and the number of researchers (per million population). We haven't been able to find indicators of the research capabilities at the country level specific of the pharmaceutical sector, that is generally not available for the developing and transitional economies. Even if the proposed indicators imperfectly measure the level of attraction of each country, results about the TRIPS are fairly consistent over different specifications of the regression equation.

[20] Put it differently, we explicitly tackle the possibility for correlation between the regressors included in the model and the dyad-specific component α_{ij}. As a drawback, we are not able to estimate the effect of the distance between the two countries (as time-invariant). However, this effect is not directly of interest to our research.

[21] One hundred bootstrap replications are considered.

Variable	Mean	Std. error	Min	Max	N	Source
pt_coop	11.21	59.29	0	1315	1881	PatentScope
publ_coop	28.08	76.23	0	1421	2299	ISI Web of Knowledge
GDP_i (log)	26.94	1.423	23.69	30.21	1881	World Bank
GDP_j (log)	26.48	1.028	24.33	28.61	1881	World Bank
PRD_i (pharma, log)	22.87	1.409	20.43	25.90	1683	UNIDO
PRD_j (pharma, log)	21.46	1.219	19.23	23.32	1881	UNIDO
RD_i (total, log)	27.74	1.954	24.24	41.40	1694	World Bank
RD_j (total, log)	26.28	1.368	23.16	28.96	1558	World Bank
EFW_2C (log)	1.493	.3283	.6419	2.067	1444	EFW

Table 1: Descriptive statistics

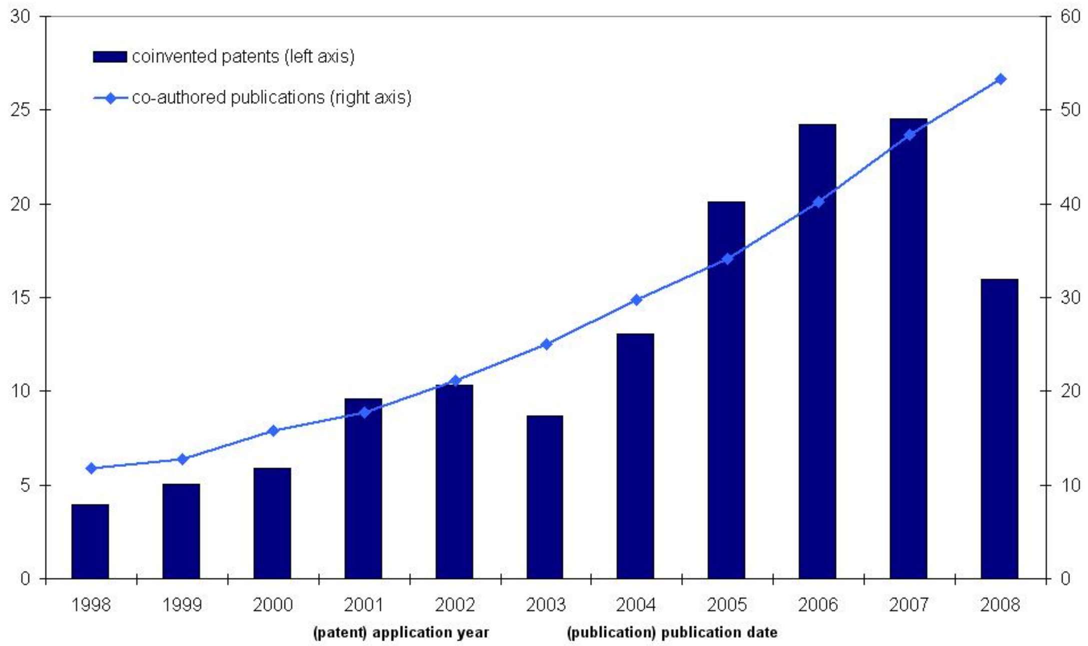

Figure 2: International R&D collaboration in patents and publications (sample average)

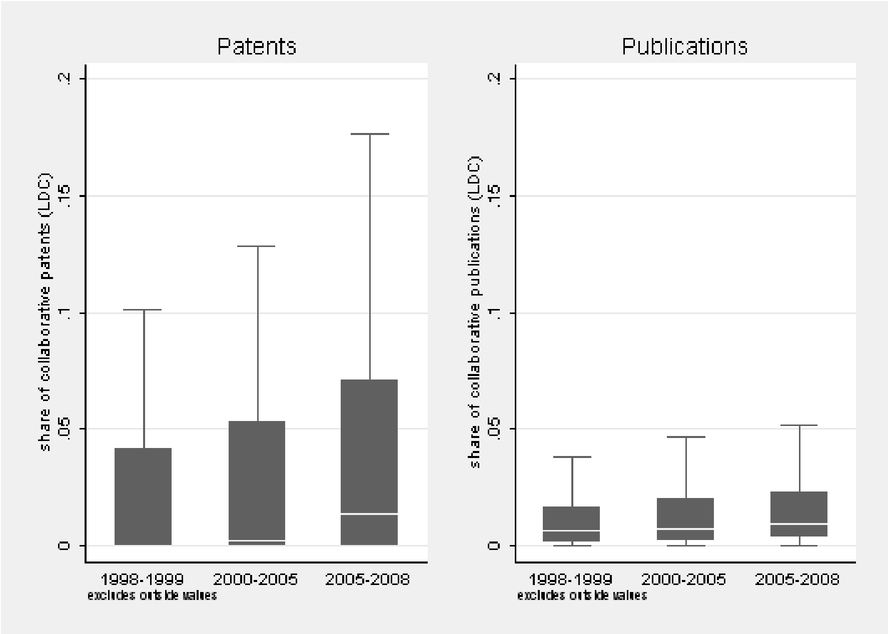

Figure 3: Evolution in patents and publications, average values for developing countries in the analysis

in patents, whereas this is not case for scientific publications. Need it here to stress the fact that patents are recorded according to the application date, that is closer to the actual timing of the patented invention than the publication date. As a drawback, patent data for the years 2007 and 2008 are censored, due to the time lag between the application date and the publication date, on average 2 years (Hall et al., 2001).[22] The different dynamic recorded in patents and publications is interesting, and somehow expected, given the different reward system and behavioral norms that characterize the publication of a patent and of a scientific paper (Dasgupta and David, 1994).

On the one side, the increase in the number of collaborative patents could be ascribed to an overall increase in the patenting activity within the analyzed countries.

On the other side, increasing protection of IPR could lead to an increase in the *proportion* of collaborative patents. In order to dig further into this issue, Figure 3 depicts the evolution in the share of collaborative patents within the developing countries. By means of box-plots,[23] the Figure shows that the share of collaborative patents and publications in our sample is increasing over time.

[22]The patent data for the years 2007 and 2008 will not be used in the regressions.
[23]Outliers are excluded from the graph.

Table 2 reports the estimation of the model of technological collaboration as in equation (2), taking into account both the number and the share (within developing and transitional countries) of patents with applicants located in country i and j. Table 3 consider the collaborations built on the basis of scientific publications.[24]

Scientific and technological collaboration is increasing over time at a pace of about 20% in the case of collaboration in patents and 15% for scientific publications.

The different effect of patent right protection and enforcement of the TRIPS agreements on technology and science is confirmed by the regressions.

On the one side, the index of IPR protection exerts a positive and statically significant effect of cooperation in patents. On the other side, it seems to have no influence on scientific collaborations, as measured by joint publications.

The coefficient of the variable measuring the level of protection of IPR (EFW_2C_j) is positive and statistically significant in all specifications, when collaboration in patents is considered, whereas statistical significance vanishes when we study the collaboration in scientific publications. The same result holds true if time dummies are considered, where we proxy the increase in property right protection with the time dummy $I_{t \geq 2005}$, grouping the years from 2005.

Overall, we provide evidence of a positive effect of security of property rights and TRIPS enforcement on technological collaboration, as measured trough patents. On the contrary, the variables seems to have no effect on scientific collaborations.

Contrary to standard results within a gravity framework, we find a negative effect of the attraction force of M_i in the "patent" equation, either measured by GDP, pharmaceutical production or R&D expenditures.[25] No effect is detected when publications are taken into account.

On the contrary, the national endowment of the developing and transitional economies considered in the analysis (M_j) seem to have no effect as an attractor of technological and scientific collaboration from the developed world. In the analysis of patents, only the level of protection of IPR seem to be an attractor force.[26]

[24] Due to the application-grant lag, only data up to the year 2006 are considered. On the contrary, all available observations are exploited in the estimation of the "publication" equation. Still, data about EFW_2C_j are available over the period 2000-2006.

[25] Even though in the case of pharmaceutical production and R&D expenditures, statistical significance is weaker.

[26] Besides, the development of innovation and the decision where to locate R&D labs and production plants could be influenced by local/regional characteristics (such as the availability of proximal skilled labor force), that may exert strong effect on innovation. The estimation framework allow us to control for these characteristics, as long as these are stable over the analyzed time window. Unfortunately, lack of suitable data prevent us to include variables other than dummies identifying each pair of countries in our specification.

Variables	GDP	GDP	Production	Production	R&D	R&D
	Measure of Mass					
Count of collaborations						
M_i	-1.025**	-.7235*	-.8038*	-.2740	-.0307*	-.0232
	(.5212)	(.4255)	(.4141)	(.4368)	(.0160)	(.0190)
M_j	.4969*	-.0314	.0158	-.3475	.2333	-.0363
	(.2656)	(.1857)	(.3429)	(.2489)	(.3388)	(.1941)
EFW_2C_j	.4754***		.5131***		.7411***	
	(.0957)		(.1282)		(.2130)	
$I_{2000 \leq t \leq 2004}$		.1384		.2252**		.2913
		(.1109)		(.0919)		(.1294)
$I_{t \geq 2005}$		.4779***		.5806***		.7074
		(.1427)		(.1212)		(.1728)
Obs.	1170	1575	1066	1440	897	1161
Log-lik.	-2423.9	-3122.5	-2250.6	-2828.7	-1805.9	-2292.3
Collaborative share (w.r.t. j-total)						
M_i	-1.018**	-.7212*	-.7846*	-.2743	-.0310	-.0232
	(.4795)	(.4262)	(.4322)	(.4007)	(.0422)	(.0256)
M_j	.4116*	-.0511	-.0218	-.3525	.1915	-.0684
	(.2387)	(.1829)	(.2843)	(.2285)	(.2679)	(.1698)
EFW_2C_j	.4375***		.4683***		.6641***	
	(.1042)		(.1148)		(.2375)	
$I_{2000 \leq t \leq 2004}$		.0545		.1441		.2127
		(.1087)		(.1083)		(.1376)
$I_{t \geq 2005}$		.3655***		.4700***		.5954***
		(.1230)		(.1226)		(.1668)
Obs.	1170	1575	1066	1440	897	1161
Log-lik.	-2362.6	-3048.9	-2191.3	-2758.7	-1760.8	-2243.2

Poisson (conditional) fixed effect estimation.
Country j time trend included in all specifications.
Statistical significance: *** 1% ; ** 5% ; * 10%.

Table 2: Gravity model of research cooperation, patents

	Measure of Mass					
Variables	GDP	GDP	Production	Production	R&D	R&D
Count of collaborations						
M_i	.0852	.1302	.1590	.3617***	-.0166	-.0164**
	(.1507)	(.1664)	(.1456)	(.1197)	(.0106)	(.0075)
M_j	-.0068	-.0073	.0101	.0302	.0262	.0628
	(.0561)	(.0539)	(.0473)	(.0466)	(.0484)	(.0632)
EFW_2C_j	-.0006		-.0221		.0010	
	(.0355)		(.0422)		(.0403)	
$I_{2000 \leq t \leq 2004}$		.0188		.0565		-.0043
		(.0359)		(.0434)		(.0435)
$I_{t \geq 2005}$		.0022		.0477		-.0407
		(.0415)		(.0459)		(.0524)
Obs.	1391	2030	1161	1870	1095	1442
Log-lik.	-2860.6	-4395.0	-2398.8	-4245.6	-2267.9	-3076.8
Collaborative share (w.r.t. j-total)						
M_i	.0117	.0970	.1521	.3544***	-.0209*	-.0204**
	(.1762)	(.1810)	(.1349)	(.1132)	(.0123)	(.0101)
M_j	-.0091	-.0180	.0051	.0223	.0145	.0496
	(.0566)	(.0599)	(.0538)	(.0478)	(.0599)	(.0522)
EFW_2C_j	-.0173		-.0132		-.0174	
	(.0503)		(.0443)		(.0553)	
$I_{2000 \leq t \leq 2004}$		.0184		.0465		-.0080
		(.0389)		(.0452)		(.0481)
$I_{t \geq 2005}$		-.0072		.0380		-.0624
		(.0385)		(.0440)		(.0582)
Obs.	1258	1840	1161	1870	973	1288
Log-lik.	-2544.3	-3907.9	-2393.3	-4226.7	-1974.7	-2688.3

Poisson (conditional) fixed effect estimation.
Country j time trend included in all specifications.
Statistical significance: *** 1% ; ** 5% ; * 10%.

Table 3: Gravity model of research cooperation, publications

5 Summary and conclusions

Fast evolution is characterizing the IPR regime at the international level. The year 2005 represents an important turning point, when the TRIPS legislation enforced a stricter patent regime in most developing countries. The new rules provide a unique setting for understanding the impact of a stronger patent regime on international collaboration. A gravity equation is estimated where the dependent variables aim at measuring the level and intensity of technological and scientific collaboration between Europe and North American on the one side and selected developing countries on the other.

Two different strategies have been applied in order to measure the level of protection of IPR. First, we consider dummy variables identifying two relevant time periods for the enforcement of TRIPS agreement in developing countries: the year 2000 and the year 2005. Second, we rely on the index of legal protection, focusing on the protection of IPR, published in the Economic Freedom of the World report.

We take a partial view in the paper, where we only consider the effect of TRIPS on the collaborative research efforts between countries, and do not specifically tackle the issue of the effectiveness of TRIPS in promoting technological innovation at the country level, along with assessment of the economic growth. Furthermore, a strong form of collaboration is considered, where we take into account joint signature of scientific articles and patent documents. We claim that transfer of technology and scientific knowledge is captured by our measure, as it entails strict interaction between the people involved in the project/research.

Even though preliminary in nature, our results point to a positive effect of the new patent regime on the level of technological collaboration, whereas scientific collaborations seem to follow historical trends. The difference effect of TRIPS enforcement between the two worlds is indeed expected on the basis of the specific incentives and ethos underlying the publication of scientific results versus the request of a patent accruing monopoly rights to its holder (Dasgupta and David, 1994).

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