The impacts of TRIPS on patenting in Latin America: the different performance of residents and non residents

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The economic theory and the available evidence suggest that technological change is a key factor for fostering growth and development. In turn, technological change may come from domestic innovations or from the adoption and diffusion of foreign innovations. Developing countries are usually more dependant on foreign innovations, but as shown, for example, by the stories of successful East Asian countries (such as Korea, Taiwan, Singapore or nowadays China), as the development process proceeds, the relevance of domestic R&D as source of innovations usually grows.

This brings at the forefront the issue of appropriability as a driving factor of technology transfer and innovation. Although appropriability may be achieved through many different mechanisms (secrecy, lead times, complementary sales, etc.), Intellectual Property Rights (IPRs) in general and patents in particular are by far the most analyzed and debated both in the academic arena as well as in policy making forums.

No doubt that one of the major new developments in the recent history of IPRs has been the signature of the agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS) at the World Trade Organization (WTO), which in practice meant a big step towards the international harmonization of IPR regimes around the world. Heated debates about its impacts on developing countries have surrounded this agreement.

On one hand, TRIPS supporters claim that the agreement could help to: i) foster domestic R&D activities in developing countries insofar those countries must reform their IPR legislations in order to improve the legal appropriability conditions for innovations ii) stimulate technology transfer from developed countries (DC) as their firms face a more secure legal environment for selling and using their technologies via trade, foreign direct investment (FDI) and licensing; iii) create more incentives for R&D activities in developed countries to be oriented towards the technological needs (especially in the health area) of the developing countries (see Sharma and Saxena, 2012, for a review of these arguments).

On the other hand TRIPS contenders state that: i) for most developing countries the adoption and adaptation of foreign technologies (which could be easier and cheaper with lax IPR regimes) is more important than the potential development of their own world-first innovations. Moreover, insofar stronger IPR regimes hinder the possibilities of technological imitation through reverse engineering and other channels, the road towards the development of innovation capabilities in developing countries through a "learning to innovate" path may be blocked (Chang, 2001); ii) the effect of stronger IPRs in the South on R&D in developed countries is at best marginal and they do not generate enough incentives as to orient it towards the needs of developing countries (Kyle and McGahan, 2012; Qiu and Yu, 2010; Sharma and Saxena, 2012); iii) the distribution of benefits from TRIPs agreement are very uneven, and the bulk of them go to DC, with developing countries probably suffering net losses –measured in terms of payments abroad- in the short run (McCalman, 2005) ; iv) stronger IPR protection in those countries may lead to higher prices of medicines impairing the access of poor people and/or creating strong pressures on the State budget (Chaudhuri *et al*, 2006; Nair, 2012).

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Notwithstanding the relevance of this debate, empirical studies on the impacts of TRIPS are not very abundant (see the next section for a review of some of them). This is the more troubling considering that it is probably the case that stronger IPR regimes may lead to very different outcomes according to the level of technological and economic development of each country (Fink and Maskus, 2005; World Bank, 2001).

This paper aims at contributing to the empirical literature on TRIPS impacts focusing in the case of Latin American countries (LAC). We focus on the arguments regarding the effects of TRIPS on patenting and will aim at answering two questions: i) did TRIPS-driven modifications in patent laws in LAC (or, more in general, stronger IPR regimes) have a positive impact on patenting in those countries?; ii) have those modifications had different impacts on patenting by residents and non-residents?

The paper is organized as follows. Section 1 briefly discusses the theoretical and empirical background regarding IPR regimes and TRIPS impacts in developing countries (focused on the access and generation of technology). In section 2 we present the methodology employed in our study, the data sources and the main descriptive statistics. Our main results regarding the effect of TRIPS on patenting in LAC countries are presented in section 3. Section 4 concludes and suggests avenues for future research.

1. Background

The relation between intellectual property and innovation is controversial. The widespread rationality that justifies the existence of monopoly rights over patented knowledge is that it provides incentives to invest in R&D that otherwise would not exist. Economic theory suggests that in an "ideal" perfect competition setting –i.e. a situation in which, among other assumptions, no producer has market power, there is no product differentiation and all firms have immediate and perfect access to the same technologies- the rate of innovation in a market economy would be very low.

It is accepted that monopoly power creates market inefficiencies but it is somehow assumed that they are offset due to dynamic gains associated to investment in R&D and innovation outcomes.

However, the IPR systems –including patents, copyrights, trademarks, industrial designs, utility models[2], plant variety protection[3], etc- are not the only mechanism to appropriate the benefits of innovation. There are also "market" mechanisms, including the exploitation of lead time, moving rapidly down the learning curve, the use of complementary manufacturing, sales and services capabilities and secrecy, etc. (see Cohen *et al*, 2000)

The pioneer study by Levin *et al* (1987) about appropriability methods in the United States industry found that firms valued more secrecy, lead times or complementary sales, services and manufacturing facilities than patents in most sectors. Later on, Cohen *et al* (2000) confirmed and expanded these results. In fact, patents were not deemed as the most effective

[2] Utility models -which are sometimes referred to as "petty patents" or "innovation patents"- are more adapted to incremental or minor innovations since they grant exclusive rights to inventions that lack some of the requirements needed for patents –such as novelty of non-obviousness-. Hence, they could be better suited for small firms and/or innovators in developing countries.
[3] The International Union for the Protection of New Varieties of Plants (UPOV) regulates the protection of new plant varieties through intellectual property rights.

protection mechanism in any industry, although they ranked high in drugs, medical equipment and special purpose machinery (for product innovations).

A number of other papers, mainly exploring data corresponding to DC, reach the same conclusions. In a recent review López (2008) found that most of them suggest that lead time and secrecy seem to be the most relevant appropriability devices for most sectors and innovations types. Manufacturing and marketing capabilities are also a very relevant tool for protecting innovations.

If patents are not effective for appropriating the results of innovation, why have patenting activities been continuously increasing? Cohen et al, (2000) argue that many firms, especially the biggest ones, patent for strategic purposes, either to prevent other firms from achieving similar developments (technological blocking), or to increase their potential earnings in future litigations (or to minimize potential losses), or to strengthen the negotiation power for cross-licensing especially in complex industries where each new product development requires license agreements with many actors. Firms also patent to license their technology, to attract venture capitalists, to increase the value of the company for future acquisitions or to generate extraordinary rents from mature technologies where market appropriation mechanisms are no longer effective.

Hence, insofar these latter drivers are increasingly common (Hall and Ziedonis, 2001), when we observe a firm applying for a patent we cannot assume that its purpose has necessarily to do with the appropriability of the results of some innovation. In other words, although patenting has always been an imperfect indicator of innovation outcomes for a number of reasons (e.g. not all patents lead to market innovations, many innovations are not patented, patents may have very different economic value and technological relevance, etc.), nowadays their use is even more debatable due to the abovementioned fact that patent applications may be driven by strategic motivations.

Moreover, even within mainstream economics, there is a debate on the impacts of stronger patent regimes on innovation (and in fact most economists working in this area tend to be skeptical about the idea that there is a lineal relation between stronger IPRs and innovation outcomes) –see Hall and Harhoff (2012), for a review of the recent literature on the subject.

On the one hand, in certain industries in which innovation processes are cumulative, patents could harm innovation by limiting access to the previous common knowledge base (Menell and Scotchmer, 2007) . Of course, this situation is worsened when firms deliberately patent in order to block potential innovations by competitors. In these cases, not only technical progress may slow down but also the return to any firm's R&D investment diminishes when the relevant knowledge is patented. Oppositely to the widespread rationale for patenting, in this kind of industries knowledge spillovers from rival firms increase the marginal returns to their own innovation creating higher incentives to continue investing in R&D (Levin, 1988).

There are also some researchers that argue that inefficiency costs due to monopoly power are not compensated because the monopolist has no incentive to reduce the welfare loss even if it is considerably higher than its monopoly rents (Boldrin and Levine, 2008). There are some studies that show these negative effects emerging in the pharmaceutical industry for instance (Chaudhuri *et al*, 2006). Among the dynamic costs, the literature mentions the loss of technological diversity insofar potential innovations may not find the way to implement license agreements with patentees of relevant knowledge; hence, providing monopoly rights to explore means leaving out many potential inventors who fail to undertake such agreements

(Merges and Nelson, 1990). This can be particularly harmful in the type of cumulative systems referred above from which biotechnology is a very good example (Mazzoleni and Nelson, 1998). Innovations in these systems are connected with previous innovations to which access is required in order to move forward. Also, although to patent new knowledge it is legally required to specify an industrial application, inventions that are distant from concrete utility (e.g. scientific discoveries that were previously in the public domain) and fractions of knowledge which are only useful to guide the search for new knowledge and even research tools have been increasingly patented (Mazzoleni and Nelson, 1998) These patents discourage downstream developments (Nelson, 2004). The case of biotechnology is once again a good example. Each transgenic seed development involves negotiating multiple licenses, which highly increases transaction costs of research in this area. In practice, this means that research (and patents) have been increasingly concentrated in a few big players with enough power to negotiate over several patents. For example, researchers working in public institutions who developed the Golden Rice (transgenic rice rich in vitamins) had to sell their invention to a multinational company (Syngenta) because they were not able by themselves to face the transaction costs of having to negotiate with holders of 70 to 105 patents (Chang, 2001).

What happens when trying to translate this debate to developing countries? First, the term developing countries comprises a wide variety of nations that are at very different stages of economic development and have very heterogeneous levels of technological capabilities. Hence, the innovation-appropriability dynamics will be very different, for instance, in advanced developing countries such as some Latin American or Asian economies where industrial, export and innovation capabilities are more or less strong *vis à vis* the reality of most African countries which unfortunately are still based mainly on traditional agricultural activities and have poor productive and technological capabilities.

There are three types of theoretical studies that anticipate a positive impact of strengthening IPR in developing countries. Firstly, based on the assumption of different preferences between developed and developing countries, some studies claim that stronger IPR systems in developing countries encourage investment in innovation by developed countries actors to solve typical problems faced by actors in developing countries (Akiyama and Furukawa, 2009; Diwan and Rodrik, 1991).

Secondly, as in developed countries, some theoretical models anticipate a positive relation between strong IPR and domestic innovation. To do so, they need to assume a similar behavior in developed and developing countries in key parameters about the cost of imitation, the cost of innovation and the demand elasticities. However, the relation between competition patterns, productive structures and innovation in developing countries is very different from that in DC, and hence we should also expect to find differences in the pattern of use of IPRs and other appropriability mechanisms (and differences should also be found when comparing developing countries which are at different industrial and technological development stages). Unfortunately, we often lack the theoretical tools to make clear predictions about the shape of these dynamics.

Finally, a third group of studies, motivated by the key role of foreign technology on innovation in developing countries, model the relation between stronger IPR system and technology transfer in terms of FDI, trade or licensing agreements (Ivus, 2011; Maskus and Penubarti, 1995). Results tend to be theoretically ambiguous (Fink and Maskus, 2005) and therefore the actual effect can only be disentangled by empirical verification.

Unfortunately, there are few empirical studies on all these topics. Most of them assess the impact of strengthening IPR regulation in general (rather than signing TRIPS) on innovation or technology transfer using cross-national database mixing samples of developed and developing countries. Moreover, developing countries included in the samples are to a large extent the better-off among this group, normally those informed by the OECD statistics. Most of these studies approximate the strength of patent protections using rankings of countries' IPR systems, mostly the index developed by Ginarte and Park that captures different aspects of IPR regulation for 122 countries[4] for different years. As argued by Fink and Maskus (2005) in the introduction of their book, although Ginarte and Park did a great effort to create an index that allow to compare the IPR systems across countries, by combining in a single 0 to 5 index complex issues such as coverage, enforcement and administration of IPR systems, it is likely to miss the specific aspects of IPR protection that matters to the actors operating in different industries[5]. In the following paragraphs we summarise the available evidence leaving to the end the discussion on TRIPS specifically.

The empirical evidence on whether IPR systems in developing countries affect innovation in developed countries is not conclusive. Some case study research on the pharmaceutical industry suggest that there were better solutions to tropical disease when countries such as India strengthened their property rights regimes (Lanjouw and Cockburn, 2000). However, more general evidence shows that stronger IPR regimes in developing countries did not motivate increases in R&D in DC (Sharma and Saxena, 2006) probably because those research lines represent a tiny proportion of the R&D budget in developed countries.

Regarding the relation between IPR systems and domestic innovation, most studies seem to reject the hypothesis of a positive relation in developing countries when innovation is defined as the creation of frontier or world-first innovations (Sharma and Saxena, 2012). Few studies, however, claim positive effects (Chen and Puttitanun, 2005; Kanwar, 2007; Kanwar and Evenson, 2003).[6] We believe there are some methodological drawbacks in this line of empirical research. Firstly, empirical studies mostly mix a sample of developed and developing countries. Since IPR indexes are normally correlated to other institutional factors, they could be taking the explanatory power of other key variables that make the lion share of the institutional difference between these types of countries that may explain innovation (e.g. infrastructure, rule of law, etc.). In fact, some studies show that when the sample between developed and developing countries is split in two groups the relation turns up to be negative for the second group (Schneider, 2005). Secondly, some problems also emerge in the decisions about dependent variables. Positive results are sometime found in studies where innovation is measured exclusively by patents counts. Rather than claiming an effect on innovation, a more correct interpretation of this evidence would be that stronger patent regimes encourage more patenting activity. As we have lengthy discussed above, patent and innovation cannot be assimilated without making risky assumptions.

In developing countries, assimilation of technology is of paramount importance for successful innovation (Chang, 2001). Actors in developing countries are mainly imitators or adopters of technologies and knowledge developed elsewhere. *Strictu sensu*, even copying and making

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[4] This index was originally elaborated by Ginarte and Park (1997) and then updated to 2005 by Park (2008).

[5] In this regard, the doctoral thesis by (Hamdan-Livramento, 2009) is an interesting endeavor because it constructs an specific index to assess TRIPS implementation in developing countries and another indexes that assess enforcement measured as the perception of private actors.

[6] Some studies even claim negative results. For example Allred and Park (2007) found negative effects on middle income developing countries using R&D intensity and patent application by residents as proxies of domestic innovation.

reverse engineering imply some kind of innovation efforts and in fact are seen by some authors as a pre-condition for the deployment of learning processes that could lead in the medium and long run to the creation of “genuine” innovation capabilities in developing countries. The evolutionary trajectory of some East Asian countries such as Korea or Taiwan illustrates how economies that begin copying and adapting foreign technologies may gradually generate endogenous innovation capabilities as their firms progressively become world-class innovators (see for instance, Lall, 2000) .

Hence, the empirical debate on IPRs in developing countries is often focused on the third issue: on whether lax or strong IPRs are more favorable for the adoption and adaptation of foreign technologies. While lax IPRs are thought to favor imitation, copy and reverse engineering, it is often stated that strong IPRs are a condition for developing countries to receive updated technology transfers in the ways of licenses, FDI and trade (see Sharma and Saxena, 2012). Empirical evidence is normally favorable for technology transfer to developing countries (Watson, 2011), particularly in relation to licensing (Branstetter *et al*, 2006) and trade (Fink and Braga, 2005) that to a large extent occur within multinational companies (Di Vita, 2013; Dinopoulos and Segerstrom, 2010) but not so much in terms of improving the attraction for greenfield FDI (Bronckers, 1994).

In sum, although this is a crucial debate, it is often conducted at a mainly theoretical level or using anecdotal information and rigorous empirical studies are not abundant as to generate strong conclusions on the key issues. Saxena and Sharma (2012) have recently made a good review of those studies, and find that, not surprisingly, the effects of stronger patent protection on developing countries is conditional on a number of domestic factors.

Going now to the evidence on TRIPS itself, there are extremely few studies that assess specifically for its impacts on developing countries. The few exceptions normally incorporate a dummy variable taking the value one for the period after TRIPS (1995 onwards) in econometric analysis using cross-national samples mixing developed and developing countries.[7] This type of approach creates methodological problems because it is not possible to identify the extent to which changes are strictly related to TRIPS rather than to other contextual factors that affect patenting simultaneously to the TRIPS period. One interesting exception is the doctoral thesis mentioned above (Hamdan-Livramento, 2009) that uses indexes for TRIPS compliance and enforcement for a sample of developing countries exclusively for the period 1994-2005 and shows that the impact is positive on technological transfer measured as FDI flows and licensing but negative for the actual application on new technologies (measured as the ratio between entrepreneurs using new technologies over total entrepreneurs). The interpretation for this finding offered in the thesis is that TRIPS compliance may increase the costs of using new technology by entrepreneurs in developing countries.

These findings are in line with our interpretation of the fragmented evidence on the effects of strengthening IPR and innovation in developing countries: it seems that the effect is much more positive on technology transfer than on domestic innovation defined as world-first creations and also as application of new technologies. This suggests that TRIPS may have different effects on different actors in developing countries, those strictly related to the transfer of foreign technology, namely foreign firms, may benefit more largely than domestic

[7] For example, Da Vita (2013) that includes it in panel-data models over application for patents by residents and technological publication and found positive effects.

actors, at least in the short-medium run.[8] In fact, TRIPS compliance and enforcement imply an international convergence in IPR systems and while multinational firms have long experience in patenting world-first innovation abroad –and as discussed above they also do so for strategic purposes- domestic actors rarely achieve patentable innovations and their imitative capabilities may be hampered by stronger IPR systems.[9].

This paper further explores this issue by analyzing patent grants and applications by residents and non-residents in a sample of countries, focusing on the situation in LAC. Besides analyzing the effect of TRIPS on domestic patenting in general we also ask: do foreign actors increase their local patents relatively more than resident actors as a consequence of TRIPS implementation? In other words, we question whether by complying TRIPS developing countries are mostly inviting foreign firms to patent locally rather than motivating domestic patentable innovation by local actors.

2. Methodology, data sources and descriptive statistics

Two econometric exercises are presented. In the first place we estimate a fixed effects panel-data negative binomial regression to learn whether stronger IPR regimes have an impact on domestic patenting. As the literature has previously done, we employ the Ginarte-Park index.

The index is calculated for 122 countries for the period 1960-1990 and then also for years 1995, 2000 and 2005. It computes the sum of five scores: coverage (a maximum of one when it is possible to patent pharmaceutical, plant and animals, software, microorganisms, utility models, chemicals, food and surgical products), memberships in international treaties (a maximum of one when the countries signed Paris convention, patent cooperation treaty, protection of plant varieties, Budapest treaty and TRIPS), duration (a maximum of one when there are 20 years of protection), enforcement mechanisms (a maximum of one when preliminary injunctions, contributory infringement and burden of proof reversal are available) and restrictions (a maximum of one when working requirements, compulsory licensing and revocations o patents do not exist).

Table 1 shows that although the average score is higher for DC, LAC countries have been converging to international standards in the after-TRIPS period. In fact, the average score of the index has increased much more for LAC countries (190% between 1990 and 2005) than for developed countries (61% between 1990 and 2005).

However, differently to the received literature, we estimate the relation between IPR strengthening and domestic patenting using different subsamples of countries to disentangle the particular effect this may have on LAC countries and also by type of residency of patent holders.

Insofar the Ginarte-Park index is strongly related to other institutional phenomena, we believe that by homogenising our sample design we will be more accurate at interpreting the Ginarte-Park as proxing stricter IPR regimes. Moreover, fixed-effects panel data estimation allows us to control for specific country effects and hence to obtain a better estimation of the impacts of IPR regimes.

[8] Since innovative capabilities are accumulative this gap may be even enlarged in the long-run.
[9] For world-class firms in developing countries it is perhaps more relevant to patent abroad than to patent in their own home countries (since this type of firms target profitable markets are those of developed countries) See Basant (2004) for this argument applied to the Indian IT firms.

Table 1: Evolution of the Ginarte-Park index by LAC and DC included in our sample

	countries	**1990**	**1995**	**2000**	**2005**
DC	28	2.741	4.016	4.253	4.419
LAC	13	1.205	2.323	3.288	3.505

Source: Own elaboration based on Park (2008)

A second exercise involves further fine-tuning our research strategy by specifically analyzing the effects of signing TRIPS (rather than strengthening IPR regimes in general) using an experimental design. In order to learn about the impacts of TRIPS on LAC countries, we will compare the patenting trends in that group with those observed in DC (our control group). We assume that DC were not exposed to treatment during the period of analysis since their IPR legislation were already adapted to TRIPS provisions. We estimate the differences-in-differences (DD) and a difference-in-difference-in-difference (DDD) estimator in a zero-truncated negative binomial regression framework using cluster (by country) standard errors.

We use a zero-truncated model because we work with over-dispersed county data where only positive observations were informed. We correct for cluster standard error to control for country-related unobserved factors.

The DD has been used widely since its introduction by Ashenfelter and Card (1985). It is a methodological design to assess the effect of treatment for one group controlling for the differences between treated and un-treated groups that may be unrelated with the treatment. In our case, we divide the sample in two periods, before and after the applications of TRIPS by LAC countries (year 2000).[10]

The method implies to evaluate simultaneously the difference between periods (average gain) with the difference across groups. The average gain of the control group (DC) is substracted from the average gain of the treated group (LAC). This strategy removes the biases in the comparison between control and treated groups during the post-TRIPS period that may be unrelated to the application of such treatment (while those biases may be present when just one dummy variable for TRIPS is included in the model, as the scarce empirical literature has done so far).

The DDD methodology is similar but it includes the analysis by residency of the patent applicant/holder. This is important since our research hypothesis is that non-residents could have taken larger advantage of treatment (TRIPS) due to their possibility of patent replication across different national patent offices.

Following the empirical literature on determinants of patents, we include country control variables as proxies for size (population), wealth (constant PPP GDP per capita), infrastructure (electric power consumption per capita), IPR regulations (the Ginarte-Park index) and trade openness (imports plus exports as a proportion of GDP). We estimate several

[10] Based on secondary sources, we may be confident that by year 2000 all LAC countries have applied TRIPS to their national laws. Some countries started applying TRIPS by 1996. Chile was the only LAC country that has TRIPS aligned national law as early as 1991 (see Hamdan-Livramento, 2009; Oliveira *et al*, 2004; Thorpe and Britain, 2002).

model specifications to increase the robustness of our results.[11] Since our main results did not change, we present only one specification.

We built a dataset of 28 DC and 13 LAC countries that applied TRIPS before year 2000. For these countries we have World Intellectual Property Organization (WIPO) data for granted patents and applications by residents and non-residents in each national patent office. We employ World Bank data (World Development Indicators database) for selected macroeconomic control variables[12] and the abovementioned Ginarte-Park index[13] for IPR regulations. Data go for period 1980-2011 but it is unbalanced. Table 2 presents descriptive statistics for year 2010 since there are a few missing values for the most updated 2011.

Going to the descriptive statistics, Figure 1 shows that in the post TRIPS period patent grants have increased much more in DC than in LAC. Moreover, different to what happened in DC, in LAC non-residents increased their participation in total patents in the post-TRIPS period. The same trends can be observed in the case of applications, as showed in Figure 2.

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[11] The most relevant of these model variations is the decision about the breaking point for TRIPS, since different LAC countries adopted TRIPS at different time. We include all possible breaking points from 1996 onwards including the whole period 1996-2000. We also estimate the models using different proxies for the control variables (for example, to account for infrastructure we included gross fixed capital formation and electric power consumption), we exclude Japan and United State from the sample, to control for outliers and we also try by excluding the European Patent Organization (EPO) member countries. This is so because of the growing relevance of European patents granted through EPO *vis a vis* the diminishing trends in terms of patenting at the European national offices. This could be the result of the fact that patent applicants have incentives to file patents at EPO in order to get a patent valid in all Europe instead of patenting in each country.

[12] Sometimes we also use data from the Iberoamerican Network of Science and Technology Indicators (RICYT by its Spanish acronym) to complete some missing WIPO data. http://bd.ricyt.org/explorer.php/query/submit?excel=on&indicators%5B%5D=PATOTO&syear=1990&eyear=2009&

[13] The Ginarte-Park index is only available for four points in time (1990, 1995, 2000 and 2005). To fill in the data for non-estimated years, we consider that the IPR regimes remained the same for the following five years (so the Ginarte-Park index in 2010 is the same as in 2005).

Table 2: Descriptive statistics, main variables year 2010

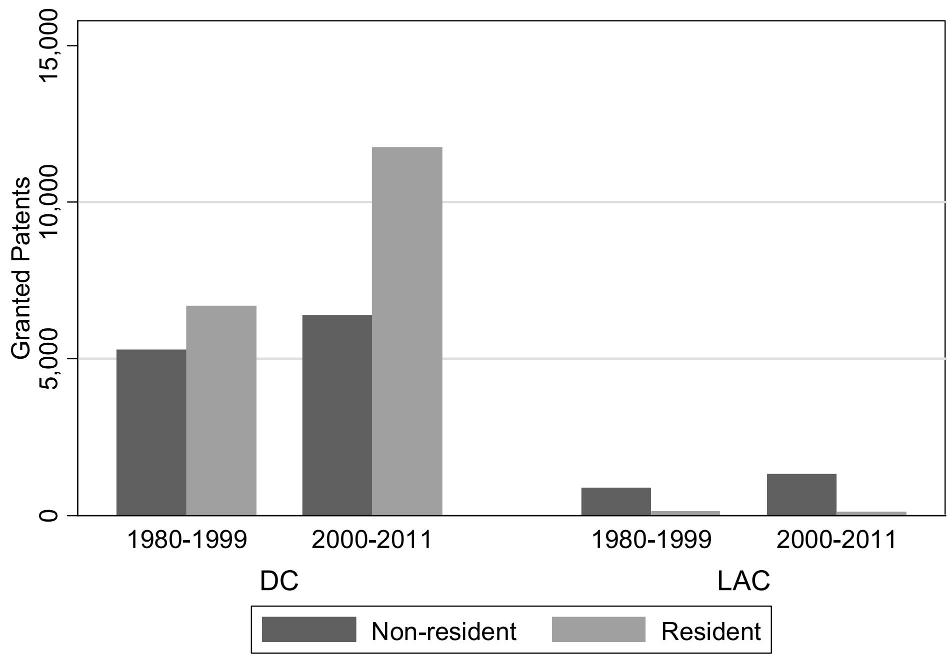
							Patent Grants			Patent Applications		
	Gross fixed capital formation (% of GDP)	GDP per capita, PPP (constant 2005 international $)	Population in millions	Trade (% of GDP)	Ginarte-Park Index	Electric power consumption (kWh per capita)	Resident	Non-resident	Total	Resident	Non-resident	Total
Argentina	22	14,363	40	40	4.0	2,904	211	1155	1366	552	4165	4717
Bolivia	17	4,350	10	76	3.4	616	5	67	72	80	333	413
Brazil	19	10,093	195	23	3.6	2,384	314	2937	3251	2705	19981	22686
Chile	21	14,520	17	70	4.3	3,297	95	925	1020	328	748	1076
Colombia	22	8,479	46	34	3.7	1,012	26	613	639	133	1739	1872
Costa Rica	20	10,453	5	78	2.9	1,855	0	45	45	8	1212	1220
Ecuador	25	7,201	14	72	3.7	940	2	31	33	4	690	694
Guatemala	15	4,297	14	62	3.2	567	0	104	104	7	374	381
Mexico	21	12,481	113	62	3.9	1,990	229	9170	9399	951	13625	14576
Paraguay	17	4,626	6	110	2.9	1,003	1	5	6	18	347	365
Peru	25	8,555	29	48	3.3	1,106	4	361	365	39	261	300
Uruguay	19	12,642	3	53	3.4	2,763	4	25	29	23	761	784
Venezuela	19	10,973	29	46	3.3	3,287				33	33	66
13 LAC (mean)	20	9,464	40	60	4	1,825	74	1,287	1,361	375	3,405	3,781
13 LAC (coeff of var)	15%	38%	136%	38%	12%	56%	151%	204%	198%	201%	181%	183%
Australia	28	34,602	22	40	4.2	10,286	1178	13379	14557	2409	22478	24887
Austria	21	35,313	8	104	4.3	8,356	955	175	1130	2424	249	2673
Belgium	20	32,882	11	158	4.7	8,388	424	108	532	620	140	760
Canada	22	35,223	34	61	4.7	15,137	1906	17214	19120	4550	30899	35449
Czech Republic	25	23,625	11	130	4.3	6,321	279	632	911	868	114	982
Denmark	17	32,379	6	95	4.7	6,327	112	43	155	1626	142	1768
Finland	19	31,310	5	79	4.7	16,483	722	201	923	1731	102	1833

Table 2 (cont)

	Gross fixed capital formation (% of GDP)	GDP per capita, PPP (constant 2005 international $)	Population in millions	Trade (% of GDP)	Ginarte-Park Index	Electric power consumption (kWh per capita)	Patent Grants			Patent Applications		
							Resident	Non-resident	Total	Resident	Non-resident	Total
France	19	29,484	65	53	4.7	7,729	8779	1120	9899	14748	1832	16580
Germany	17	33,565	82	88	4.5	7,215	9630	4048	13678	47047	12198	59245
Greece	18	23,982	11	54	4.3	5,242	467	12	479	728	16	744
Hungary	18	16,958	10	167	4.5	3,876	0	65	65	649	47	696
Iceland	13	32,779	0	103	3.5	51,440	7	132	139	57	19	76
Ireland	12	35,993	4	183	4.7	6,025	211	32	243	733	59	792
Israel	18	25,995	8	72	4.1	6,856	343	1950	2293	1450	5856	7306
Italy	20	27,083	60	55	4.7	5,384	14454	1652	16106	8877	846	9723
Japan	20	30,965	127	29	4.7	8,394	187237	35456	222693	290081	54517	344598
Netherlands	17	36,925	17	148	4.7	7,010	1597	350	1947	2527	240	2767
New Zealand	19	24,400	4	55	4.0	9,566	394	3953	4347	1585	5051	6636
Norway	20	46,906	5	70	4.2	25,175	431	1200	1631	1117	696	1813
Poland	20	17,348	38	86	4.2	3,783	1385	1619	3004	3203	227	3430
Portugal	20	21,665	11	69	4.4	4,929	121	19	140	499	46	545
Republic of Korea	28	26,774	49	102	4.3	9,744	51404	17439	68843	131805	38296	170101
Slovakia	22	20,121	5	164	4.2	5,164	57	319	376	234	48	282
Spain	22	26,901	46	57	4.3	6,155	2499	274	2773	3566	213	3779
Sweden	18	34,125	9	93	4.5	14,939	1116	264	1380	2196	353	2549
Switzerland	20	39,072	8	92	4.3	8,175	461	280	741	1622	533	2155
United Kingdom	15	32,814	62	63	4.5	5,733	2323	3271	5594	15490	6439	21929
United States of America	14	42,079	309	29	4.9	13,394	107792	111822	219614	241977	248249	490226
28 DC (mean)	19	30,402	37	89	4	10,258	14,153	7,751	21,904	28,015	15,354	43,369
28 DC (coeff of var)	19%	24%	167%	48%	6%	91%	286%	282%	264%	258%	310%	259%

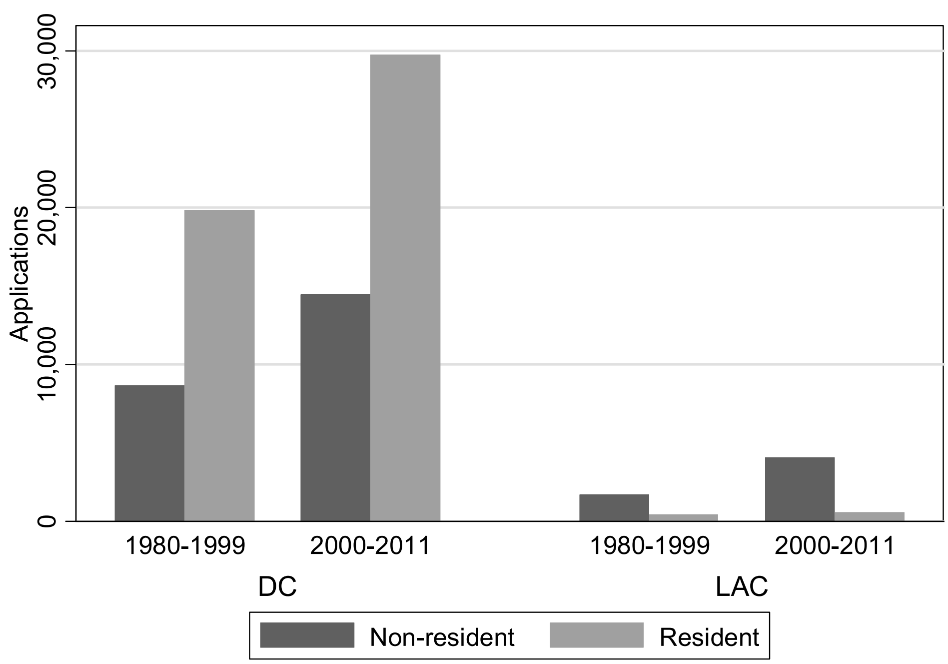
Source: WIPO and World Bank

Figure 1: Granted patents in LAC and DC country by period and residency, yearly average for 1980-2011



Source: WIPO

Figure 2: Patent applications in LAC and DC country by period and residency, yearly average for 1980-2011



Source: WIPO

3. Results

In Table 3 we present the results of our panel-data estimations. Columns A and B show that the Ginarte-Park index is negatively associated to granted patents and has no effect on applications. These results may be capturing different effects.

Firstly, the behaviour by residents and non-residents may be different in reaction to stricter IPR regimes. Column C to F split the sample by type of residency and we find that while the effect on granted patents is similar for residents and non-residents (column C and E), the effect on patent applications is negative for residents (F) and positive for non-residents (Column D). We do no risk an interpretation for these findings, because we believe that that would not be indistinctively applied to DC and LAC.

Since the Ginarte-Park index has mostly increased in developing countries, it could be also be interpreted as a proxy for that group of countries. So it could be said that the negative effect is spurious because it is mostly capturing the fact that developing countries patent less (even though we are controlling for fixed effects). So it would be better to restrict the sample just to LAC (Columns G to J). Hence, now the question is, did patenting in countries with more improvements in the Ginarte Park index increase more?

We find that the answer to this question depends on whether we refer to residents or non-residents. When the Ginarte-Park index increases, LAC residents patent (and apply for patents) less (Columns I and J). However, non-residents patent (and especially apply for patent) more when the Ginarte-Park index increases (Column G and H). So, is TRIPS (or stronger IPR regimes) mostly inviting foreigners to patent rather than motivating nationals to innovate? We now explore this same issue in more detail using the difference in difference methodology.

Table 3: Estimation of fixed-effects panel data negative binomial regression, original coefficients period 1980-2011

	All countries all residency		All countries, only non-residents		All countries, only residents		LAC countries, only non-residents		LAC countries, only residents	
	patent (A)	applic. (B)	patent (C)	applic. (D)	patent (E)	applic. (F)	patent (G)	applic. (H)	patent (I)	applic. (J)
GDP per capita, PPP (constant 2005 international $)	6.E-06 **	3.E-06	-2.E-05 ***	-2.E-05 ***	4.E-05 ***	3.E-05 ***	2.E-04 ***	1.E-04 ***	1.E-04 ***	1.E-04 ***
Electric power consumption (kWh per capita)	6.E-05 ***	2.E-05 ***	6.E-05 ***	2.E-05 ***	6.E-05 ***	3.E-05 ***	-5.E-04 ***	-1.E-04	-7.E-04 ***	-3.E-04 **
Population (in millons)	0.009 ***	0.018 ***	0.009 ***	0.022 ***	0.004 ***	0.012 ***	0.005 ***	0.007 ***	0.007 ***	0.013 ***
Trade (% of GDP)	-0.003 ***	-0.003 ***	0.001	0.000	-0.008 ***	-0.003 ***	0.003	0.001	0.007 **	-0.004 *
Regulation: Index Ginarte-Park	-0.115 ***	-0.011	-0.111 ***	0.030 *	-0.056 **	-0.060 ***	0.071 *	0.322 ***	-0.151 ***	-0.063 **
Constant	0.597 ***	0.418 ***	0.715 ***	-0.003	0.712 ***	1.253 ***	-0.116	0.326 **	0.704 ***	1.073 ***
Observations	2,232	2,312	1,120	1,157	1,112	1,155	337	358	331	357
Number of country	41	41	41	41	41	41	13	13	13	13
Average time periods	27.22	28.2	28.22	27.5	27.12	28.17	25.92	27.54	25.46	27.46
chi2	552.1	3715	305.3	2409	659	2684	27.23	850.3	51.61	181.4

*** p<0.01, ** p<0.05, * p<0.1

In Table 4 we chose to present the estimation of just one of the model specifications, because the significance of the key variables for our research goals remained stable across different specifications. We present the original coefficients along with the incidence-rate-ratio (IRR) to facilitate the interpretation of the results[14]. First we discuss the results pertaining to the treatment variable (TRIPS implementation) and then we deal with the control variables.

Table 4: Estimation of zero-truncated negative binomial regression, original coefficients and incidence-rate-ratio, period 1980-2011, clustered standard errors for 41 countries

	Original Coefficients				IRR			
	patent		applications		patent		applications	
a. Post-TRIPS period (>2000)	-0.668	***	-0.251		0.513	***	0.778	
b. LAC countries	-1.728	***	-1.696	***	0.178	***	0.183	***
c. Residents	-0.878	***	-0.195		0.415	***	0.823	
a x b	-0.184		0.325		0.832		1.385	
a x c	1.012	***	0.521	**	2.752	***	1.684	**
b x c	-1.167	***	-1.479	***	0.311	***	0.228	***
a x b x c	-1.66	***	-1.281	***	0.19	***	0.278	***
Electric power consumption (kWh per capita)	-8.74E-06		1.72E-05		1.000		1.000	
GDP per capita, PPP (constant 2005 international $)	8.31E-09		-1.69E-05		1.000		1.000	
Population (in millons)	0.020	***	0.0222	***	1.020	***	1.022	***
Trade (% of GDP)	-0.017	***	-0.0169	***	0.983	***	0.983	***
Regulation: Index Ginarte-Park	0.481	***	0.429	**	1.618	***	1.536	**
Constant	7.276	***	7.857	***	1,446	***	2,584	***
Observations	2,232		2,312		2,232		2,312	
chi2	456.3		659.6		456.3		659.6	

*** p<0.01, ** p<0.05, * p<0.1

The first results, which separately consider the effects of our three group-breaking dimensions (before and after TRIPS, LAC vs. DC, residents vs non-residents) –see the first three lines in table 4- suggest that in the post-TRIPS period countries in general patent less (-49% for granted patents). This effect becomes non-significant if EPO member countries are not considered in the analysis (remember that we are not considering European patents granted by EPO). In turn, patenting in LAC is on average lower than in DC (-82% for granted patents and also for applications). Finally, patent grants to residents are 59% lower than those granted to non-residents, but there is not such effect on patent applications[15].

When going to the DD estimators (three following lines in Table 4), which allow to learn about the interactions between couples of group-breaking dimensions we find that patenting

[14] In the negative binomial regression the coefficients are interpreted as the difference in log expected counts for a marginal change of independent variable. Since the difference of two logs is the log of the ratio, the coefficient can also be interpreted as the log of the ratio of expected counts. This explains the ratio in the incidence rate ratios. Since counts are rates (i.e. country patents per year), the coefficient can be interpreted as the log of the rate ratio produced for a marginal change in the independent variable. To calculate those incidence rate ratios we need to apply exp to the original coefficients.

[15] This difference could be due to the fact that filing by residents are of lower quality and do not reach the required standards and/or because non-residents mainly aim at revalidating patents already granted in other countries, both things would translate in lower ratios of successful applications for residents.

in LAC did not change in the after TRIPS period (the respective coefficient is not-significant). The same is valid for applications. This suggests an answer for our first research question: TRIPS had no effect in patenting activity in that region.[16]

Moreover, residents tend to patent (and to apply for patents) much more in the post-TRIPS period in general (all countries). Residents' patents multiply for a factor of 2.8 for grants and 1.7 for applications after TRIPS. Finally, residents patent systematically less than non-residents in LAC countries vis a vis developed countries (-69% for granted patents, -77% for applications)

The estimation of the DDD indicator (axbxc line in table 4) provides an answer our second research question. Confirming the estimations provided by the panel data model, we find that residents patent systematically less than non-residents in LAC countries after TRIPS (-81% for granted patents, -72% for applications). Hence, thanks to TRIPS, non-residents have increased their share in total patents and applications in national office of LAC countries.

Finally, a word on control variables. We should read the coefficients from Table 3 rather than from Table 4, because in that case fixed-effects models is controlling for unobserved characteristics of countries in our samples which might interfere in the relation between these control variables and domestic patents.[17] Population is consistently significant and its impact is positive both fixed-effects as well as in the DD estimations. GDP per capita levels are positively correlated with patenting in the fixed-effect model (Table 3), but its significance vanishes in the DD estimations. Electric power consumption, as expected, shows a positive coefficient in fixed-effects models, but it becomes non-significant in DD models. Finally, openness shows opposite effect in both specifications, with a negative coefficient in DD and a positive one in fixed effects models, but only the latter (Table 3) should be considered.[18].Similarly, the Ginarte-Park index also shows opposite effects, but, again, it is only right to interpret results from the fixed effects (Table 3) estimations.

4. Conclusions

We studied the impacts of TRIPS on patenting in Latin America. We aimed at improving the methodological designs of previous studies that have i) mixed samples with few developing countries in them tipically using OECD data, ii) used aggregated (and necessarily imperfect) indexes on IPR regimes as explanatory variables rather than using experimental designs to capture what happen specifically after TRIPS.

Our findings suggest that TRIPS had no overall effect in patenting activity in the LAC region, but it has favoured patents by non-residents, while probably discouraging patents by residents. Similarly, when only the LAC countries are considered in the sample, stronger IPR regimes

[16] This coefficient becomes positive and significant for applications when the US and Japan are excluded from the sample. Since the patenting activity in the United States and Japan increased strongly after the TRIPS period if one excludes them from the sample, then patent applications in LAC increased significantly more than the rest of DC (control group) which are mainly European countries. For the abovementioned reasons, national patenting activity fell in favour of patenting activity at EPO. This is the only results that changes when these two countries are excluded. Since the US and Japan are not outliers in the sense of wrong cases, in fact, they are the leaders in patenting in the world, we do not think it is correct to exclude them from the sample.

[17] We must state clear that unobserved country characteristics were got rid off in the case of our main results in Table 3 (i.e. DD and DDD coefficients) but they were not in the case of control variables

[18] Recall that small countries tend to be more open, so results in Table 3 may be actually accounting for country size.

(measured by the well-used Ginarte-Park index) only increased the patenting activities by non-residents and decreased that of residents.

For those who are acquainted with the literature on innovation in developing countries, it comes as no surprise to find that stronger patent regimes are not per se capable of fostering innovation activities by domestic firms. Pervasive market failures (mainly related to finance), weaknesses in human capital availability and techno-scientific infrastructure, specialization in low tech areas, weak linkages within innovation systems, and macroeconomic and institutional instability are some of the factors that explain why firms in Latin America spend low shares of their sales in R&D and other innovation activities (Crespi and Zuñiga, 2012; Dutrénit and Katz, 2005; Katz, 2007; López and Orlicki, 2007; Maloney and Rodríguez-Clare, 2007; Maloney, 2002) even if potential returns are high (Lederman and Maloney, 2003).

However, our paper sheds new results regarding the different patenting outcomes between residents and non-residents. How could they be interpreted from the received literature? From the perspective of TRIPS supporters, it could be said that thanks to TRIPS foreigners feel safer to innovate and to develop and subsequently patent new technologies in LAC countries. For above mentioned reasons regarding the specificities of innovation in developing countries this does not occur with domestic actors.

However, as we discussed patents are a less than perfect innovation indicator, so rather than patenting world-first innovations multinational firms could be using these new opportunities for patenting to revalidate patents obtained elsewhere. Again from the perspective of TRIPS supporters, one can say that these decisions are possibly motivated by the genuine desire to transfer existing technologies to the region.

Alternatively, from the perspective of contenders, it could be said that technology transfer of existing technologies does not require patenting in local offices: license agreements and trade may suffice. In fact, mature technologies patented elsewhere more than one year before cannot be legally patented in LAC offices. Thus, the increase in patents by non-residents could actually respond to the motivation to block reverse engineering and other imitation procedures. This latter case would have a potentially damaging effect on the long run learning trajectories of LAC firms, which may eventually hamper residents' abilities to create patentable technologies.

Our study is not able to identify which interpretation is the right one hence further research is needed to ascertain the determinants and outcomes of increased patenting by foreigners, predominantly multinational firms, in LAC.

Which are the conclusions of our research in terms of policy? Regarding fostering innovation by residents, strengthening IPR regimes seems like putting the cart before the horse. First there is a need to deal with the structural factors blocking innovation in the region, a challenge that has incipiently began to be addressed through the adoption of state of the art technology policies in many countries (Cimoli *et al*, 2009; Hall and Maffioli, 2008; López, 2009; Rivas, 2013). However, in order to change the abovementioned scenario there is a clear need to go beyond the technology policy domain, and the related policy agenda is not an easy one to design and implement. Anyway, it may be the case that when innovation systems in LAC are on par with those in DC strong IPR regimes could be useful – in fact, current DC developed in an era when IPR systems were much more lax than in the present time. However, the effect today on domestic innovators of LAC seems to be harmful, probably due to the already mentioned blocking effects on learning trajectories of local firms. In the mean time, world class innovators in the region, which do exist in many countries, may have access patent protection in DC, which in the end is more relevant since that kind of firms aim to the world market and not merely the national ones.

Finally, although as said before the impacts of increased non-residents patenting are not clear and new research is needed to learn about them, we may think that some reforms in the IPR systems in the region may be desirable in order to prevent multinationals to undertake strategic patenting in the region, for instance, through compulsory licensing provisions.

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