WORKING PAPERS

N° 1354

September 2022

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Intellectual Property Rights Protection and Trade: An Empirical Analysis*

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July 2022

Abstract

The paper proposes an empirical analysis of the determinants of the adoption of Intellectual Property Rights (IPR) and their impact on innovation in manufacturing. The analysis is conducted with panel data covering 112 countries. First we show that IPR protection is U-shaped with respect to a country's market size and inverse-U-shaped with respect to the aggregated market size of its trade partners. Second, reinforcing IPR protection reduces on-the-frontier and inside-the-frontier innovation in developing countries, without necessarily increasing innovation at the global level.

JEL Classification: F12, F13, F15, L13, O31, O34.

Keywords: Intellectual Property Rights, Innovation, Developing Countries, Market Potential, Trade.

*We thank Zhifeng Yin, Margaret Kyle, José de Sousa, Miren Lafourcade, Nicolas Sahuguet, and Julien Gordon for useful comments and suggestions. We also thank participants of the scientific meetings of the European Union Development Network, DIAL Development Conference, CESIfo Area Conference in Applied Microeconomics, EARIE Stockholm, the "Economics of Intellectual Property" Conference held in Toulouse, the Fourteenth CEPR/JIE Conference at the University of Bologna, and seminar participants at THEMA - CY Cergy Paris Université, Université de Caen Basse-Normandie, Université de Nanterre, Université Paris 11, and CERDI - Université de Clermont-Ferrand for their criticisms and suggestions. Emmanuelle Auriol acknowledges TSE-IAST funding from the French National Research Agency (ANR) under the Investments for the Future (Investissements d'Avenir) program, grant ANR-17-EURE-0010, and financial support from the French Development Agency. Sara Biancini and Rodrigo Paillacar gratefully acknowledge support from the Labex MME-DII program (ANR-11-LBX-0023-01). Emmanuelle Auriol has worked on this paper while visiting the World Bank on a fellowship and is grateful for the stimulating environment. Finally we thank the editor and three anonymous referees for their suggestions and comments on early versions of the paper. They helped us greatly improve the paper's content and organization. All remaining errors are ours. Declarations of interest: none.

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1 Introduction

Over the past three decades, developed countries have spared no effort to protect their Intellectual Property Rights (IPR) in the face of globalization. They have been met with strong resistance from developing countries. For instance, the agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS), which imposes a common framework on all WTO members as regards IPR, has been challenged by many countries, including Korea, Brazil, Thailand, India, and the Caribbean states. One source of conflict between developed and developing/emerging countries is that a strong IPR regime limits the possibility of technological learning through imitation, while innovation and growth in poor countries seem to be driven by imitation (see, for instance, Goldberg and Pavcnik, 2007 and Madsen et al., 2010). A second source of conflict concerns the fact that TRIPS does not stimulate research designed to benefit the poor, who are unable to afford the products once they are developed. This controversy has made the headlines, and in 2001 it led to the Doha Declaration, the aim of which was to ensure easier access to medicines by all. As a result of these international disputes, IPR protection legislation varies considerably around the world. There is a substantial theoretical literature on the link between North–South trade and IPR protection, but there are surprisingly few empirical studies which focus on how potential access to foreign markets impacts countries' willingness to protect IPR. The present paper contributes to exploring this issue.

With the help of panel data covering 112 countries, innovation, and IPR protection, the paper analyzes developing countries' incentives to protect IPR. Using a methodology developed in the new economic geography literature for measuring foreign market potential, the empirical analysis shows that IPR protection is U-shaped with respect to a country's market size and inverse-U-shaped with respect to the aggregated measure of a country's trade market potential. Using detailed trade data we are able to decompose the effect by different types of trade partners. We show that the effect is entirely driven by the trade partners that strongly protect IPR.

This result is consistent with the work of legal scholars who show that advanced economies use their market power, and the threat of trade sanctions, to get their developing country trading partners to adopt IP rules that conform to Western standards (Braithwaite and Drahos, 2000; Shadlen et al., 2005; Zeng, 2002; May and Sell, 2006; Morin and Gold, 2014). Since small countries benefit more from trade than large ones (Alesina et al., 2005), economic theory predicts that the former should be more willing to protect IPR than the latter (Auriol et al., 2019). Morin and Gold (2014) hence explain that many small countries, such as Nicaragua, which exports more than 12% of its GDP to the United States, agreed to endorse strong IP rules in exchange for preferential access to the US market. Some countries, such as Jordan and the Dominican Republic, were even placed on the Priority Watch List, or on the Out-of-Cycle Review, in the three years prior to the signature of their bilateral trade agreements with the United States, to force them to adopt strong IP rules.[1] Contrary to small poor countries, which seek to avoid IPR disputes and challenging the WTO, the large emerging economies are more able to withstand the threat of trade sanctions because of their power and size. The BRICS have therefore lobbied to limit the scope of the TRIPS agreement and to allow flexibility in the choice of their IPR policies (Dreyfuss, 2009).

We document the importance of trade incentives in the adoption of IP rules by developing countries to Western standards. Using our long and fairly comprehensive panel data that covers both developing and advanced economies, we identify non-monotonic relationships between export and domestic market size on the one hand and incentives to protect IPR on the other. The former is U-shaped, while the latter is inverted U-shaped. As far as we know, these results are new proposals as compared with previous empirical papers on IPR determinants. Consistent with the trade argument, they show that when the size of its internal market, measured by its GDP, is small compared with its export

[1] The use of the Special 301 and the suspension of preferential access to the US market under the GSP program to goods coming from Argentina, Honduras, India, Mexico, and Thailand was instrumental during the Uruguay Round to conclude the TRIPS agreement (Morin and Gold, 2014). The US government noted that "the Special 301 annual review is one of the most effective instruments in our trade policy arsenal" (USTR, 1997) and that the GSP program was an effective point of leverage with some of US trading partners (USTR, 2004).

opportunities, measured by a weighted sum of the GDP of its trade partners, a developing country tends to respect IPR, while it prefers to free-ride on the North's innovations to serve its internal demand when this is large relative to its export opportunity. Finally, rich countries with a large GDP and a high level of innovative activity strictly enforce IPR to protect their innovations, while small rich countries that innovate less (i.e., Belgium, the Netherlands, Luxembourg, and Switzerland) are less strict, explaining the declining part of the inverted U-shape.

We next study the impact of strengthening IPR protection on innovation in developing countries. Intuitively it could have an adverse effect on the ability of the South to develop high-tech industries and autonomous research capacity (see Sachs, 2003). The existing empirical evidence has not identified a clear effect of enhanced patent protection on R&D and innovation (see Lerner, 2009 and Budish et al., 2016). Most of the empirical literature, however, has focused on the pharmaceutical industry (see for instance Chaudhuri et al., 2006, Gamba, 2017; Qian, 2007; Kyle and McGahan, 2012; Williams, 2013; Sampat and Williams, 2019). The situation could well be different in other industries. Our paper is one of the first to examine, using rich panel data, the relationship between stronger IPR protection and innovation in manufacturing in an international trade context. Controlling for the endogeneity of IPR protection through instrumental variable regressions, we find that stricter IPR protection decreases patent activity by Southern firms in manufacturing sectors. Patent data allow us to distinguish between resident and non-resident patents, which are good proxies for indigenous and foreign innovation in developing countries. Restricting our panel to 54 developing countries that yield enough observations, we confirm the detrimental effect of IPR protection on resident patents. We also find some evidence of a positive effect for non-resident patents, suggesting that stronger local IPR favors foreign firms.

Finally, in order to explore the channel through which stronger protection of IPR might hamper developing countries' autonomous research capacity we next consider export discoveries, i.e., the discovery of products for export that have been invented abroad but that are new to the country (Klinger and Lederman, 2009, 2011). Strong IPR, by limiting the possibility of technological learning through imitation should impede innovation (see Goldberg and Pavcnik, 2007 and Madsen et al., 2010). Controlling again for the endogeneity of IPR protection through the same instrumental variable regressions, we find that a stronger protection of IPR negatively impacts export discoveries. Our results lend credibility to the idea that by preventing the imitation of Northern technologies, universal IPR protection limits the development of Southern R&D activities in all manufacturing sectors, and not solely in the pharmaceutical industry.

2 Link with the literature

Chin and Grossman (1988), Deardoff (1992), and Helpman (1993) were the first to study the effect of patent protection in an international context, using a North–South framework. These theoretical papers assume that only firms in the North can innovate. Lai and Qiu (2003) and Grossman and Lai (2004) have extended these models to look at the case where both countries can innovate (the North is high innovation and high demand while the South is low innovation and low demand). This literature predicts that stricter protection of IPR generally has a positive impact on global innovation and that the level of IPR protection increases monotonically with the level of economic development.[2] This monotonicity result is challenged by Diwan and Rodrik (1991). Assuming that only Northern firms innovate, they show that when the market size of the South is small, the country is better off protecting IPR in order to give incentives to the Northern firms to produce innovations best suited to their needs. But when the market size of the South increases, firms in the North start putting greater weight on Southern demand, so that the incentives of the South to protect IPR are relaxed and free-riding becomes more

[2] The North protects more because it is the main innovator and has the larger demand for innovative goods. The South has an incentive to free-ride, which decreases when the South represents a larger share of total demand. Given that the North is either the unique or the main innovator in this literature, when the share of total demand in the South increases, the temptation to free-ride is reduced because of its adverse effect on the North's innovation.

tempting.

These earlier contributions do not look at the economic retaliation in trade that non-compliance with IPR implies today. The European Union has enacted a regulation concerning customs for intellectual property rights, which came into force on 1 January 2014 (see IP/11/630 and MEMO/11/327): Suspicious goods can now be destroyed by customs control without the need to initiate legal proceedings to determine the existence of IPR infringement. In the United States, Customs and Border Protection similarly targets and seizes imports of counterfeit and pirated goods, and enforces exclusion orders on patent-infringing goods. At the international level, if a WTO member is found guilty of violating its IPR obligations, the complainant government obtains the right to impose trade sanctions in the form of punitive tariffs.[3] The empirical literature confirms that weak IPR creates barriers to South–North trade. Using OECD data, Maskus and Penubarti (1995) find that an increase in patent protection has a positive impact on bilateral manufacturing imports. Similarly, Smith (1999), who studies US exports, shows that stronger IPR has a market expansion effect in countries with a strong capacity for imitation.

Taking stock of the recent evolution of international legislation regarding IPR, Auriol et al. (2019) propose a theoretical model where the ability of developing countries to export to rich countries depends on their willingness to respect northern firms' IPR. This creates a trade-off between enforcing IPR to be able to trade and infringing IPR to serve domestic demand. Auriol et al. (2019) show that small/poor countries have a greater incentive to increase IPR protection in order to access large/rich foreign markets, while large developing countries can afford to relax IPR protection to benefit from technological diffusion through imitation to serve internal demand. In other words, both Diwan and Rodrik (1991) and Auriol et al. (2019) predict that the willingness to protect IPR is U-shaped with respect to the relative size of a country's internal market as compared

[3]There have hence been more than 30 TRIPS-related disputes since the enactment of the agreement. In many cases the simple threat of sanctions was enough for the parties to find a solution (see Fink, 2004 for a discussion and https://www.wto.org for the more recent disputes). In other cases sanctions were implemented (see Žigić, 2000 for EU examples and Harris, 2008 for US ones).

with its export market: rich countries with a large GDP relative to their export market protect IPR to protect their innovations, poor/small countries relative to their export market protect IPR to be able to trade and to stimulate innovation from rich countries, while intermediate countries in terms of total market size/wealth compared with their export market, in particular those with large populations, tend to free-ride on northern firms' innovation.

Whether or not the relationship between IPR and economic development is monotonic is ultimately an empirical question. Maskus (2000), Primo Braga et al. (2000), and Chen and Puttitanun (2005) explore the link between patent protection and GDP per capita. They have all identified a *U-shaped* relationship. This empirical result is a first step towards a better understanding of the link between IPR protection and development. Its main limitation is that it does not take into account the trade dimension of IPR. Maskus (2000), Primo Braga et al. (2000), and Chen and Puttitanun (2005) essentially regress a measure of a country's IPR protection on its per-capita income and other country-level controls. Yet both the recent evolution of international legislation and the theoretical literature mentioned above stress the importance of trade in countries' incentive to protect IPR. The present paper therefore conducts a thorough empirical analysis of the relationship between economic development and IPR that explicitly takes into account the trade dimension.

Theoretically, the impact of IPR on innovation in an open economy is controversial. In Chin and Grossman (1988), Deardoff (1992), Helpman (1993), Lai and Qiu (2003), and Grossman and Lai (2004), stricter protection of IPR generally has a positive impact on global innovation: enforcing IPR according to Western standards amounts to introducing strong protection in the South to the benefit of Northern firms, which encourages greater innovation (i.e., in the North), but decreases welfare in the South. In Auriol et al. (2019) both the South and the North innovate and universally strong protection of IPR is not necessarily conducive to more innovation at the global level because it prevents the South from closing its technological gap. As a result, asymmetric IPR (weak in the

South, strong in the North) is often conducive to more innovation. Whether in practice strong IPR fosters innovation or hinders it is an empirical issue.

To address this question, the empirical literature has mostly focused on the pharmaceutical industry. Using a product-level dataset on antibiotics from India, Chaudhuri et al. (2006) built a counterfactual simulation of prices and welfare which assumed protection had been as strong in India as it was in the US at the time. Their results suggest that concerns about the potential adverse welfare effects of TRIPS are legitimate. Qian (2007), using a panel of pharmaceutical patents for 16 countries, shows that strong protection only increases domestic innovation in countries with higher levels of economic development, educational attainment, and economic freedom. Gamba (2017) finds that, while positive, the effect of TRIPS on innovation in the pharmaceutical industry is lower for developing countries, and not persistent. Kyle and McGahan (2012) find that drug patent protection in high-income countries is associated with an increase in R&D effort, but that the introduction of patents in developing countries has not been followed by greater R&D investment in the diseases that are most prevalent there. Williams (2013) compares the innovations following the sequencing of the human genome realized by the public Human Genome Project with the ones developed by the private firm Celera. She finds that the effect of Celera's contract-based form of intellectual property has led to a decline in follow-up scientific research and commercial product development of the order of 20-30 percent. In a follow-up paper, Sampat and Williams (2019), when controlling for selection problems and using a larger database, show that, on average, gene patents have no real effect on follow-on innovation. They tentatively explain the difference with the results in Williams (2013) by the specific disclosure obligations prevailing in human-gene patenting, which the database protection used by Celera was able to partially bypass.

While strong IPR protection tends to have a negative impact on innovation in the pharmaceutical industry in developing countries, less is known about its impact in other sectors. Our paper contributes to the literature by looking at the relation between stronger IPR protection and innovation in manufacturing, exploiting aggregate country data. The drawback of our approach is that we have to work without the fine-grained information of micro-level data. In the case of IPR protection this is not such a big concern, as we are interested in public policies aimed at promoting IPR at the national level in relation to trade concerns. Macroeconomic considerations are fundamental to understanding a government's choice to promote IPR. In the case of innovation, the big advantage is that, by using the Ginarte and Park (1997) and Park (2008) index of IPR protection and a large set of countries' patents over a long period, we are able to directly test the impact of changes in IPR policy on innovation at the macroeconomic level as measured by patents. In contrast, the above studies on the pharmaceutical sector are typically based on indirect evidence of patent protection (for instance, different paths of subsequent innovations for patented and non-patented goods, or counterfactual simulations) or on before-after analysis of wide reforms which are rare events (e.g., the effect of TRIPS affiliation or of major patent law reforms). They do not capture variation of IPR protection over time and therefore miss its dynamic impact on innovative activity.

Using an instrumental-variables approach to tackle the concern of IPR endogeneity, we exploit the information on IPR policy variations to assess their impact on innovation at the country level. Consistent with the findings of Hudson and Minea (2013), who show that the same level of IPR has a different impact on innovation in rich and poor countries, we find that stricter IPR protection has a negative impact on the patenting activity of Southern firms and a positive impact on that of foreign firms.

Finally, we explore the impact of IPR on export discoveries (Klinger and Lederman, 2009, 2011). On the one hand, Goldberg and Pavcnik (2007) and Madsen et al. (2010) suggest that innovation in poor countries is driven by imitation. Strong IPR, by limiting the possibility of technological learning through imitation, should impede innovation. On the other hand, studies show that reinforcing IPR can increase FDI inflows and multinational firms' activities (Javorcik, 2004; Branstetter et al., 2011), as well as licensing and technology transfers (Yang and Maskus, 2001; Branstetter et al., 2006; Park and Lippoldt, 2008). FDI and technology licensing could provide alternative mechanisms through which countries can acquire technology without relying on imitation. Whether these benefits of stronger IPR compensate for their negative impact on learning through imitation is an empirical issue that our paper aims to elucidate by looking at discoveries in manufacturing. We find that strong IPR protection decreases both the learning (inside-the-frontier) and the innovation (on-the-frontier) activities of poorer countries.

The remainder of the paper is structured as follows. Section 3 presents the data and some descriptive statistics. Section 4 analyzes countries' choice of the strength of IPR protection in relation to international trade. Section 5 investigates the relationship between the strength of IPR protection and innovation. Finally, Section 6 concludes.

3 The data

We use several data sources to conduct our empirical analysis. Descriptive statistics for the variables included in the regressions are in Table 1. Complementary data are from the OECD and the World Bank. Cross-country *human capital levels* are from Barro and Lee (2010). This widely used dataset reports levels of education attainment in periods of 5 years. *Trade data* are from *TradeProd*, a cross-country dataset developed at CEPII, based on COMTRADE, from the United Nations Statistical Department.[4] This source covers the period 1980–2006. A detailed description of the original sources and procedures to develop TradeProd is available in the Appendix and in De Sousa et al. (2012). The dependent variables, as well as the procedure used to construct the foreign market potential variable, are presented below.

[4]Although COMTRADE contains data from the 1960s to the present, more accurate information is derived from TradeProd. In particular, this dataset takes advantage of COMTRADE mirror flows (reports for both exporting and importing countries) to improve the coverage and quality of trade flows at a very disaggregated product level. TradeProd is available from the CEPII website (http://www.cepii.fr) in their section *Data*, subsection *International Trade*.

Table 1: Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
a. Regressions in Table 3 IPR equation (1965–2005)					
GDP (constant, US$)	906	1.94e+11	7.85e+11	1.21e+08	1.12e+13
GDP per capita (constant, US$)	907	5699.768	8130.752	62.23672	40617.84
b. Regressions in Table 4 IPR equation (1985–2005)					
GDP (PPP constant, US$)	511	3.79e+11	1.10e+12	2186223	1.26e+13
F.MKT	511	6.93e+08	1.36e+09	3.65e+07	1.44e+10
F.MKT-strong	511	5.04e+08	1.33e+09	2.30e+07	1.42e+10
IPR index	511	2.744106	1.074442	.588	4.875
Freedom index	511	6.089041	1.183049	2.3	9.1
GATT/WTO	511	.8630137	.3441698	0	1
c. Regressions in Table 5 Patent equation (1985–2005, Only developing countries)					
Number of patents - Residents	225	1746.991	8437.349	1	98283.6
Number of patents - Non Residents	244	2067.908	6008.872	1	74654.4
Number of patents - Total	225	3938.51	14225.87	13.4	172938
d. Regressions in Table 6 Discoveries equation (1985–2005, Only developing countries)					
Number of Discoveries	332	2.765716	1.324959	0	6.246107
Human Capital (Log)	332	9.855564	1.539248	6.509135	14.75079

Control variables are reported for the regression where the higher number of observations is included. Yearly data was averaged over 5 years.

3.1 Measuring IPR

The data on IPR protection are drawn from Park (2008), who updates the index published in Ginarte and Park (1997), covering the period 1960 to 2005 for 122 countries (it is calculated in periods of 5 years). This widely used index is the sum of scores (varying between 0 and 1) in five categories associated with patent protection: coverage, duration of protection, enforcement mechanisms, ratification of international treaties (such as TRIPS), and restrictions that limit the control over an invention by a patent holder. Since the five categories are based on weighted scorings of 16 attributes of IPR protection measured as binary subcategories, plus one continuous category for duration of patents, the index is treated as continuous in our regressions, in accordance with what has been done in the literature since the seminal paper by Ginarte and Park (1997).[5] The index

[5]Between 0 and 5 there are 289 unique values of the variable and the vast majority accounts for less than 1% of the observations (only two values account for more than 2% of the observations: one for 4.3% and another for 2.24%).

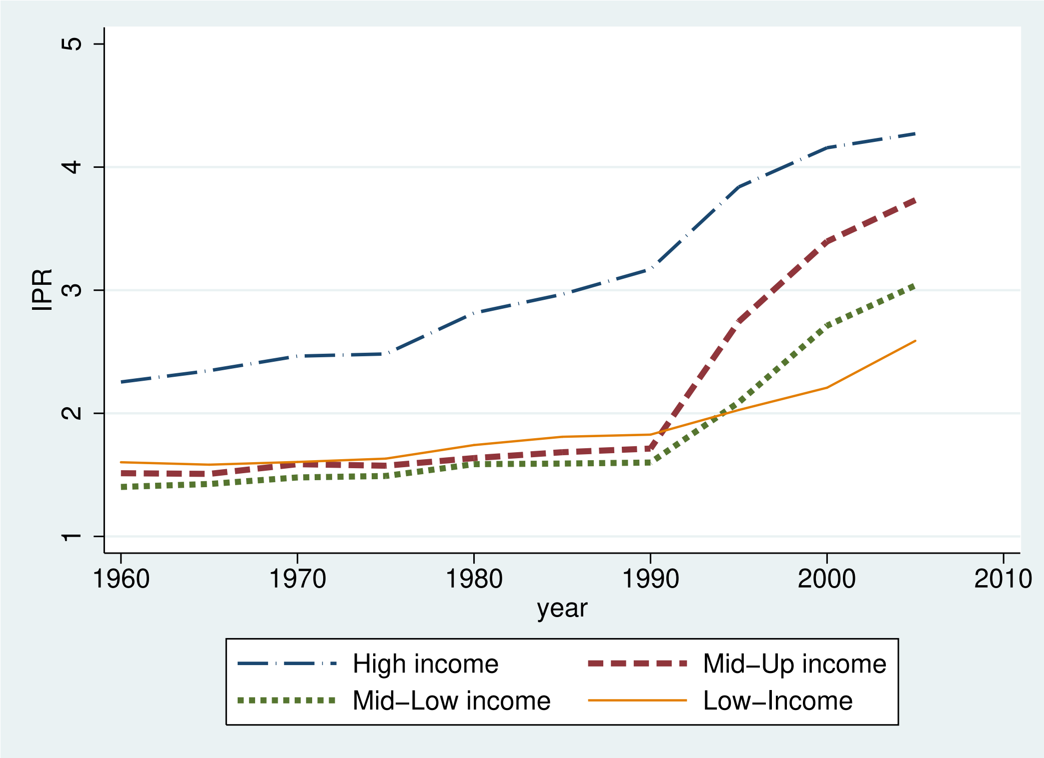
does not measure actual enforcement directly, which would require information on cases that went to court in each country. Although recognizing this limitation, Ginarte and Park (1997) show some evidence that complaints by US multinationals are more focused on the statutory dimensions (lack of legislation) than enforcement (execution of laws). The index therefore captures the most salient aspects of a country's IPR regime and practice. Moreover, since this IPR index is not a self-reported variable, it is not subject to potential concerns raised in other linear regressions using a summating index as dependent variable, as do, for instance, the Happiness scales (see Ferrer-i-Carbonell and Frijters, 2004). Finally, as did Chen and Puttitanun (2005), we also checked that we have no observations on the boundary values (0 or 5), to be sure that there is not a truncation problem. As expected, the inclusion of regressors reduced the number of countries, from 122 to 118 (when only *GDP* and *GDP per capita* are included) and to 112 (when all controls are included).

Figure 1 shows the evolution of the IPR index in four income groups, following the World Bank classification of countries by income levels. It is striking that throughout the 1960s, 1970s, and 1980s, the indexes are almost constant and identical for the last three quartiles (i.e., the index curves are flat throughout these decades). They start to rise and to become differentiated by quartile only in the 1990s, that is, after the end of the Cold War and the acceleration of the integration of the world economy.[6] This hints at the importance of international trade in a country's choice in strength of IPR protection.

What Figure 1 does not show is the great diversity in the evolution of IPR policies across countries and over time. Table 7 shows that the growth in the IPR index in recent decades is accompanied by an increase in the indexes' dispersion in the case of developing countries, suggesting different strategies for adopting IPR protection. This is in contrast to the situation in advanced economies where the dispersion has decreased. This divergence in IPR indexes is also important across continents. For instance, developing countries in Europe and Asia had similar levels of IPR protection in 1985 (i.e., 1.7). The

[6]Table 7 in the Appendix provides some descriptive statistics of these changes by groups.

Figure 1: Evolution of IPR protection by income level (1960–2005)



Source: Own calculations based on Park (2008). Simple average of IPR index. WB classification starts in 1980. For periods before 1980, countries are classed in the category given in 1980.

prospect of enhanced market access associated with the European enlargement provided poor European countries with incentives to be early adopters of several regulatory reforms in IPR protection. As a result, in 2005, European developing countries had almost reached (on average) the level of high-income countries (i.e., 4.2 vs. 4.3) and exhibited a lower dispersion than comparable countries in other regions. By contrast, developing countries in Asia have shown a much slower growth rate in their IPR index. Their average level is similar to that of African countries (i.e., 2.8). In fact, Asian countries made little progress on IPR protection until the early 2000s, when their integration into the global economy through trade increased. In addition, they show considerable dispersion at the end of the period. This paper aims at analyzing this heterogeneity in countries' willingness to promote IPR.

3.2 Measuring foreign market potential

To compute a suitable measure of the foreign market potential we use gravity models, a methodology developed in the new economic geography literature (see Head and Mayer, 2004, and Redding and Venables, 2004). In the recent literature, gravity equations are increasingly used to obtain an exogenous source of variation to explain countries' exports. This empirical strategy is deemed better than other measures, such as trade openness, because it considers the evolution of bilateral trade costs. In particular, our specification is similar to the gravity equations used in Blanchard and Olney (2017) and Feyrer (2019).

The measure of the foreign market potential we use, denoted $F.MKT$, is a weighted sum of the size of the markets of the foreign trade partners. The weights given to each partner take into account the existence of trade costs. Our empirical methodology thus includes a measure of exportation costs, weighting each potential destination market by its accessibility. To be more specific, we define the foreign market potential of country i at time t as

$$F.MKT_{it} = \sum_{j \neq i} \hat{\Phi}_{ijt} GDP_{it}, \tag{1}$$

where $\hat{\Phi}_{ijt}$ is a weight specific to the relationship between countries i and j. We use a trade gravity equation (see Head and Mayer, 2014) to obtain these weights for each year of our sample. The gravity equation relates bilateral trade flows to variables that are supposed to deter (e.g., distance among partners) or favor (e.g., common language) economic exchanges between trade partners. In our analysis we include bilateral distance (in log), and dummies equaling one if the partners share a common language or border and if one of the countries was a colonizer of the other.[7] Of course, these bilateral variables are not the only components of trade costs. There are also variables specific to the exporter or the importer, such as institutional quality or landlocked status. We include exporter and importer fixed effects in the trade equations to control for these country-specific variables. All these explanatory variables are available from the CEPII

[7]As expected, in the trade equation the coefficient for distance is negative and the coefficients for common language, border, and colonial past are positive (regressions available on request).

Gravity Dataset.[8] We estimate for each period the following cross-country regressions:

$$\ln Trade_{ij} = FX_i + FM_j + \delta \ln distance_{ij} + \lambda_1 Contiguity_{ij} + \lambda_2 Language_{ij} + \lambda_3 Colony_{ij} + u_{ij}$$

The terms FX_i and FM_j stand for country-exporter and country-importer fixed effects. Using the coefficients of the bilateral variables in the gravity equation, we compute the weights $\hat{\Phi}_{ijt}$ for each pair of trade partners and the corresponding $F.MKT_{it}$. Our measure is obtained as follows:

$$\hat{\Phi}_{ijt} = distance_{ij}^{\hat{\delta}_t} \exp\left(\widehat{\lambda}_{1t} Contiguity_{ij} + \widehat{\lambda}_{2t} Language_{ij} + \widehat{\lambda}_{3t} Colony_{ij}\right) \tag{2}$$

To assess the impact of trade motive on a country's IPR policies it is necessary to find a good proxy for the size of the foreign markets a country might lose by infringing intellectual property rights. The measure of the foreign market potential we use, denoted $F.MKT$-strong, is the weighted sum of the GDPs of trade partners that strongly protect IPR during each period (i.e., that have an IPR index in the highest quartile).

3.3 Measuring innovation

It is challenging to find good measures of innovation. Usual measures are based on total factor productivity, R&D expenditure, and patent activity. However, total factor productivity is only an indirect measure of innovation, and its utilization raises measurement error issues (see Griliches, 1979).[9] R&D expenditure also has shortcomings, because expenditure is an input for R&D rather than an output.[10] For these reasons, researchers have increasingly used patent statistics as a measure of innovation (see Nagaoka et al., 2010). Among available patent statistics, we use the number of patent applica-

[8] Available through the CEPII website (http://www.cepii.fr) in their section *Data*, subsection *Gravity*.

[9] Sweet and Eterovic (2019) did not find any effect of IPR protection on total factor productivity using dynamic panel regression analysis for 70 countries from 1965 to 2000.

[10] Lederman and Saenz (2005) collected data on R&D spending for developing countries from national surveys. Their dataset is extended to more recent periods by Goñi and Maloney (2017) to study R&D returns for 70 countries, of which 44 would correspond to developing countries. Still, the panel is highly unbalanced: for our period of study only 35 developing countries exhibit more than three observations.

tions from domestic and foreign firms resident in a country. This information is provided by the World Bank (World Development Indicators) and collected yearly by the World Intellectual Property Organization (WIPO). They include worldwide patent applications filed through the Patent Cooperation Treaty procedure or with a national patent office for exclusive rights for an invention[11]. Patent applications are generally preferable to patent grants when considering international comparison, because processing practices vary widely across countries and can take from 2 to 10 years after application (see Ang and Madsen, 2015). Although the number of patent applications is a good proxy of the level of a country's R&D activity, this measure is not perfect either. First of all, not all patents represent innovation, nor are all innovations patented. Second, the raw count of patents generates a purely quantitative measure, while the quality of patents also matters. For this reason, other measures have been proposed such as patent citations, patent families, or utility models. Unfortunately, these statistics are only available for a limited number of countries (mainly highly developed and/or OECD countries) and years. To be able to consider a broad panel of developing countries and periods, we thus concentrate on patent counts. Reassuringly, Hagedoorn and Cloodt (2003), using a large international sample of 1200 companies in high-tech sectors, have established that the statistical overlap between alternative indicators of innovation such as R&D inputs, patent counts, and patent citations, as well as new product announcements, is very strong, and using any of these indicators should give similar results. For instance, Coelli et al. (2016), who study the impact of episodes of trade liberalization on innovation, show that their results are not affected when using alternatively patent counts, patents corrected by citations, the size of the research team, and measures of patent breadth, among others. We are therefore confident in using the number of patents to assess the innovation activity of countries.

Nevertheless, for a robustness check, we also use the number of patents filed by de-

[11]The series in the World Development Indicators (WDI) are IP.PAT.NRES for nonresidents and IP.PAT.RESD for residents. According to WDI, the specific source is *WIPO Patent Report: Statistics on Worldwide Patent Activity.*

veloping country firms in the United States as an alternative to the number of patent applications filed locally.[12] Using the total number of patents in a country does not, in fact, provide a quality check. Because it is difficult to create quality-adjusted patent data for a wide range of developing countries, we use U.S. patent grants and applications instead. Indeed, it seems plausible that firms respond to stronger IPR protection by focusing on a smaller number of high-quality innovations.

4 IPR protection and trade

This section empirically assesses the role of export opportunities on the determinants of IPR protection. To guide the analysis we rely on the theoretical results discussed in Section 2 (see Diwan and Rodrik, 1991; Auriol et al., 2019). These papers illuminate the trade-off between the benefit for a developing country of infringing rich countries' IPR to serve its domestic market and the cost this yields in terms of trade. Consistently with these contributions, we assume that a developing country j that respects the IPR of developed countries enjoys greater export opportunities F_j, compared with a country that violates these IPR and has reduced export opportunities $f_j < F_j$.

The benefits of disregarding IPRs arise from the imitation and incorporation of foreign technology into domestic production, which, by helping the developing country to catch up technologically, stimulates local innovation and domestic demand D_j. This boost does not occur if the developing country respects IPR so that the size of the domestic market is $d_j < D_j$. Let $D_j - d_j = N_j \Delta_j$, where $\Delta_j > 0$ is the per capita benefit of infringing IPR, and N_j is the population size of country j. Table 2 summarizes the payoffs in function of the policy implemented.

A developing country will choose to respect IPR if the total gains in the foreign and domestic markets of doing so exceed the benefits of imitation:

$$(F_j - f_j) - N_j \Delta_j > 0 \tag{3}$$

[12] We thank one of the referees for the suggestion to use US patent data.

Table 2: Developing country's payoffs when choosing IPR policy

	Foreign Market	Domestic Market
Respect IPR	F_j	d_j
Violate IPR	f_j	$d_j + N_j\Delta_j$

It is easy to see that in the absence of trade opportunity concern (i.e., $F_j = f_j$) the country does not protect IPR, while in the absence of internal demand concern (i.e., $N_j\Delta_j = 0$) it protects them. This implies that a country will have no incentive to respect IPR if it trades mainly with other developing or emerging countries which do not protect IPR strictly. Indeed, in this case f_j is not very different from F_j, $f_j \simeq F_j$, which implies that (3) is violated since $N_j\Delta_j > 0$.

Now if a country aims to trade with countries strictly enforcing IPR (typically rich countries), this implies that f_j is very small (i.e., $f_j \simeq 0$). In this case the decision to respect IPR boils down to:

$$F_j - N_j\Delta_j > 0 \tag{4}$$

Equation (4) implies that the decision of a developing country to protect IPR depends on the size of its internal market relative to its export opportunities: the larger the gap between F_j and $N_j\Delta_j$, the bigger its incentives to protect them. More precisely, everything else being equal, the willingness of a developing country to protect IPR should be decreasing in the size of its GDP and increasing in $F.MKT$. Since advanced economies are already strictly protecting IPR, for a given foreign market potential, the willingness of a country to protect IPR should then be U-shaped with respect to the size of its internal market. Intuitively, poor countries with a small population desire to protect IPR to be able to trade. Developing and emerging countries with large populations and high internal demand are more reluctant to do so. Finally, high-income countries with large GDP enforce IPR to protect their innovations. This result is a new proposal in the empirical literature. The previous studies relating IPR to the level of development of a country have mainly focused on a country's per-capita GDP to explain its willingness to protect IPR. Yet an empirical assessment of IPR determinants must take into account both total domestic market size as measured by GDP (i.e., the developing country's population size matters) and export opportunities.

4.1 A first look at the IPR-trade data

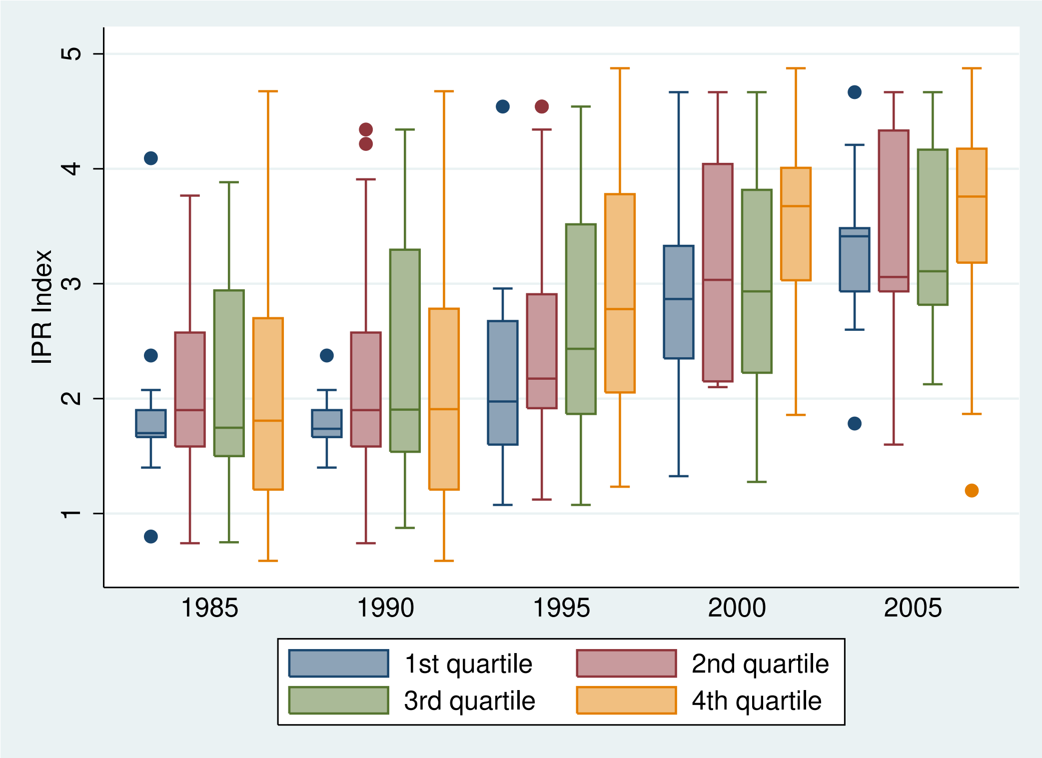
Since the size of the foreign markets a country might lose by infringing intellectual property rights depends on whether its trade partners strictly protect IPR, Figure 2 shows how the ratio of the internal market of a country, measured by GDP, over $F.MKT$-strong, the measure of foreign market potential of the country's trade partners strictly enforcing IPR, correlates with the index IPR. The magnitude and the dispersion of this ratio is depicted by quartile. Because it is quite demanding in terms of data, it covers a shorter period (1985–2005) than the IPR series (1960–2005).[13] The summary statistics associated with the graph are shown in row (f) of Table 7 in section 7.1 of the Appendix, which also illustrates export opportunities in developing countries with some examples from our database.

The ratio $GDP/F.MKT$-strong covers all types of countries, with both developing and advanced economies. Countries that have a low ratio have a relatively small economy, either because they are very poor in per capita terms (e.g., Zimbabwe, Liberia, Guyana), or/and because they are rich but their population is relatively small and they are very open (e.g., Belgium, The Netherlands, Switzerland). At the other extreme, we find countries with a large ratio either because they are very rich (e.g., Japan, United States) or if they are developing countries because they have a large population and are relatively closed to international trade (e.g., Brazil, Argentina, India during the 1980s and 1990s).

Figure 2 shows that IPR protection increases for all the quartiles of the GDP/$F.MKT$-strong ratio, but with substantial heterogeneity across countries. Focusing on IPR median

[13]Over the long term, we found similar trends using another proxy, "trade openness" (i.e., the sum of exports and imports over total GDP), available since 1960 from the World Development Indicators. It is computed using national accounts and including agriculture and oil exports and imports, which are quite volatile due to changes in world prices. Our measures, while covering a more limited time period, are better suited to focusing on manufacturing industries, which are relevant for studying IPR, and limit the effects of price volatility. A correlation test shows that trade openness is positively correlated with our measure of foreign market potential.

Figure 2: Evolution of IPR protection by quartiles of $GDP/F.MKT$-strong



Source: Own calculations based on Park (2008). Simple average of IPR index within each quartile. The line in the middle of the inter-quartile range is the median.

values (i.e., the horizontal line in the boxes), we see that not much happens up to the mid 1990s. Then the median rises in all quartiles to become U-shaped in 2005: the median IPR of the first and of the fourth quartile is much larger than the median of the second and third quartile. We will explore these non-monotonicities in more detail in what follows.[14]

4.2 Internal market and IPR

In Table 3 we take a first look at the relationship between IPR regimes and measures of economic development and internal market size. Regressions (a) to (d) are pooled regressions. We regress the IPR index on $GDPpc$, the per-capita income, and on GDP, the total income, and their squared values. Continuous variables are in logs. The variables

[14]In the econometric specifications, GDP and $F.MKT$ and $F.MKT$-strong are included separately. This is because our foreign market potential measures are not directly comparable with the countries' GDP. And indeed, our estimated coefficients for GDP and for $F.MKT$-strong (and $F.MKT$) differ significantly.

describing economic development or market size are lagged by one period (i.e., 5 years).[15] Results (a) to (d) confirm non-linear relationships in all cases.

Table 3: Correlation between IPR indicator and economic variables

	(a)	(b)	(c)	(d)	(e)	(f)
GDPpc	–1.40***	–0.40***			0.88	
	(0.13)	(0.04)			(0.95)	
GDPpc^2	0.12***	0.05***			–0.03	
	(0.01)	(0.00)			(0.06)	
GDP			–1.35***	–0.92***		–2.14*
			(0.15)	(0.09)		(1.10)
GDP^2			0 .03***	0.02***		0.05**
			(0.00)	(0.00)		(0.02)
freedom					0.59*	0.59*
					(0.32)	(0.31)
gatt/wto					0.43***	0.45**
					(0.16)	(0.16)
Country FE	no	no	no	no	yes	yes
Period	1965–2005	1985–2005	1965–2005	1985–2005	1985–2005	1985–2005
N. of obs	907	553	906	553	511	511
Adjusted R^2	0.68	0.61	0.60	0.49	0.70	0.70

Robust Standard Errors in parentheses. ***, ** and * represent, respectively, statistical significance at the 1%, 5%, and 10% levels. All regressions include a constant and time effects. Regressions (e) et (f) include country fixed effects. All variables describing the market size are lagged one period. All variables are in log transformation except the GATT/WTO and the IPR index. In all regressions, GDP is in constant values. In regressions (b), (d), (e) and (f), GDP per capita or GDP are PPP-deflated. The difference in the number of observations between (a) and (c) is due to one missing observation for GDP in Ghana. In regressions (c) and (d), Ghana is not included to ease comparability between the coefficients for GDPpc and GDP. This exclusion has no noticeable effect on the results.

Many observable and unobservable country characteristics may confound the non-linear relationship in (a) to (d). For example, institutional aspects crucial to growth may also influence the adoption of stricter IPR regulations. Consequently, in the regressions presented in columns (e) and (f) in Table 3, we fully exploit the panel dimension of our database by including country fixed effects in addition to time dummies. Standard errors are robust and clustered by country. We also include additional controls, namely an economic freedom index, *freedom*, and a dummy indicating the year of entry into the

[15]Strong IPR protection could possibly stimulate investment or FDI and in turn affect GDP. However, this channel would take time. To avoid endogeneity problems, the variables are lagged by 5 years.

GATT, or, later, the WTO, $gatt/wto$.[16] Intuitively, these two variables, $freedom$ and $gatt/wto$, should positively influence the level of IPR protection. For instance, entering into the GATT/WTO agreements imposes higher IPR standards upon joining countries. It is thus unsurprising that the coefficients of these controls are positive and significant in all specifications.

The regression in Table 3, column (e), focuses on the relationship between economic development, as measured by $GDPpc$ and its square, and IPR regimes using this more demanding specification. With country fixed effects, time effects, and new controls, the relationship is no longer significant. In column (f) we regress IPR against GDP and its square, with time, country fixed effects, and controls. This last regression confirms that the strength of IPR protection is a U-shaped function of a country's total GDP. As a robustness check, we have performed the same regression without the controls $freedom$ and $gatt/wto$, to be able to consider a larger time span, covering the period 1965–2005 for which the controls are not available. This allows us to consider a larger unbalanced panel of 118 countries and 906 observations. We have obtained very similar and significant coefficients for both GDP and GDP^2. Finally, the same results are obtained if we restrict the analysis to a balanced panel of 79 countries, covering the period 1965–2005. These different robustness checks are presented in Table 8 in Appendix 7.2.

These first results complement the empirical findings by Primo Braga et al. (2000), Maskus (2000), and Chen and Puttitanun (2005), who were the first to illuminate the non-linearity between IPR protection and country wealth as measured with $GDPpc$. We refine it by showing that the results are driven by total national income rather than by per-capita income, which does not yield robust results. IPR protection is U-shaped with respect to total GDP. According to the theoretical literature reviewed earlier (see Diwan and Rodrik, 1991; Auriol et al., 2019) this is because total GDP is a better measure of a country's relative weight in the global economy than per-capita wealth.

[16] The WTO began operations in 1995, replacing the GATT agreements. Our dummy variable takes the value of 1 from the year a country joined either the GATT (before 1995) or the WTO (after).

4.3 Foreign market potential and IPR

One of our contributions is to show that a developing country's desire to trade with advanced economies has an impact on its incentives to adopt IPR legislation in line with Western standards. To directly assess this trade-based argument, the empirical challenge is therefore to find a good proxy for a country's export opportunities. As explained in section 3.2, we use gravity models (see Head and Mayer, 2004, and Redding and Venables, 2004) to calculate an appropriate measure of foreign market potential, referred to as $F.MKT$, when the measure includes all of the country's trading partners, and $F.MKT$-strong, when it includes only those trading partners that strictly protect IPR.

4.3.1 Estimation results

The results of our estimations are displayed in Table 4. Based on the discussion in section 4.2, country fixed effects and time dummies are included in all specifications. In column (a) we add our measure of the foreign market size from equation (1) and its square (in addition to the fixed effects and controls). Due to data limitations, the regressions including the foreign market variable focus on the period 1985–2005. The results show an inverse U-shape with respect to $F.MKT$ and $F.MKT^2$. The coefficients of GDP and its square are still significant and of similar size, as in Table 3 column (f).

The foreign market potential used in the regression presented in column (a) of Table 4 includes all the trade partners of a country. However, if access to foreign markets is indeed the main driving force behind changes in a country's IPR index, it is useful to distinguish between trade partners who strongly protect IPR and those who do not. If a country trades only with countries that do not protect IPR, it will have no incentive to increase IPR for trade motives. By contrast, if a country trades mainly with countries enforcing IPR it will have a strong incentive to increase them in order to be able to export. In other words, the impact of the size of the foreign market should be conditioned on whether the trade partners protect IPR or not. We decompose a country's trade opportunities into different groups based on the strength of IPR protection of the trade partners. In column

Table 4: IPR Equation

	(a)	(b)	(c)	(d)	(e)	(f)
GDP	–2.06*	–2.02*	–1.57	–1.68	–1.19	–1.31
	(1.18)	(1.11)	(1.42)	(1.39)	(1.00)	(0.92)
GDP^2	0.05**	0.05**	0.04	0.04	0.03	0.03
	(0.02)	(0.02)	(0.03)	(0.03)	(0.02)	(0.02)
F.MKT	2.72**		3.69**		1.34	
	(1.27)		(1.46)		(0.82)	
F.MKT^2	–0.06**		–0.09***		–0.03*	
	(0.03)		(0.03)		(0.02)	
F.MKT-strong		2.36***		3.45***		1.54***
		(0.76)		(1.04)		(0.51)
F.MKT-strong^2		–0.06***		–0.09***		–0.04***
		(0.02)		(0.03)		(0.01)
freedom	0.56*	0.57*	0.38	0.38	0.23	0.16
	(0.31)	(0.31)	(0.27)	(0.26)	(0.19)	(0.18)
gatt/wto	0.43***	0.44***	0.35**	0.33**	0.36**	0.39***
	(0.15)	(0.16)	(0.16)	(0.16)	(0.14)	(0.13)
time-continent FE	No	No	Yes	Yes	No	No
time-B&M group FE	No	No	No	No	Yes	Yes
N. of obs	511	511	511	511	511	511
N. of countries	112	112	112	112	112	112
Within R^2	0.71	0.71	0.77	0.77	0.82	0.82

Robust Standard Errors in parentheses, clustered by country. ***, **, * represent statistical significance at the 1%, 5% and 10% levels respectively. All regressions include country fixed effects and time effects. Regressions (c) and (d) include time-continent effects and regressions (e) and (f) include time-grouped-fixed effects using the method by Bonhomme and Manresa (2015). Variables describing the market size are lagged one period. All variables are in log transformation except the GATT/WTO and the IPR index.

(b) we replace $F.MKT$ with the variable $F.MKT$-strong, which is the weighted sum of the GDPs of trade partners that strongly protect IPR during each period (i.e., that have an IPR index in the highest quartile). The results shows that the impact of the foreign market size is driven by the countries that strongly protect IPR. We also tried a regression including, in addition to all the other variables in regression (b), the market size of trade partners with a weak IPR index (i.e., in the lowest quartile). The coefficient for the market potential of trade partners with a low IPR index is insignificant, and this is true whether we drop $F.MKT$-strong and its square from the regression or not. We also performed a sensitivity analysis on the definition of countries with "weak" and "strong" protection (considering various alternative thresholds, such as the highest quintile instead of the quartile, and the top 30%). The details of these robustness checks are presented in Table 9 in section 7.2 of the Appendix. They show that the result in Table 4, column (b), which is our main specification for the IPR equation, is qualitatively preserved.[17]

4.3.2 Robustness tests

We ran robustness tests for our full-sample regression (b), to capture possible sources of unobservable heterogeneity in the panel that would not be fully captured by country fixed effects. One could be concerned that changes in institutional quality over time (not measured by the Freedom House index) may affect IPR adoption. Although the country fixed effects should account in great part for this heterogeneity, since institutional quality changes slowly over time, there may be still some variation due to rapid institutional changes in some parts of the world. For example, countries in Asia or Eastern Europe have undergone specific deep and relatively rapid structural reforms over the last decades. To control for this unobserved time-varying heterogeneity, we include continent-time fixed effects in regressions (c) and (d). This is a very strong test that considerably reduces the variation to identify the impact of our variables of interest. Unsurprisingly, GDP is no longer significant at conventional levels, although the sign and magnitude of the coefficients remain stable.[18] However, despite the stringency of the test, the measures of foreign market size remain significant.

It may be argued that using continents to capture heterogeneity is arbitrary. Bonhomme and Manresa (2015) propose a method to select the grouping of countries that maximizes between-group variation. Following their method,[19] we define four groups of countries that are used in our regressions in addition to all the other controls. While these additional robustness tests, which are presented in columns (e) and (f), may help explore

[17]Including measures of trade openness (sum of exports and imports over GDP) and human capital does not change these results, as shown in Table 9 in the Appendix. Both variables are non-significant.

[18]We have also re-run the regressions in Table 3 with similar controls. The GDP coefficients are no longer significant, for the same reason (see Table 8 in the Appendix).

[19]The authors propose a variable neighborhood search algorithm that iteratively "reassigns" countries into groupings if the objective function decreases and provide a Stata code and the Fortran file to perform the calculations. We set the parameters of this heuristic method to the values proposed by the authors. For more details, see section S1.1 in the Appendix of Bonhomme and Manresa (2015).

the effect of possible unobserved heterogeneity, they are probably excessive since we also control for country fixed effects and common trends. Indeed, Bonhomme and Manresa (2015) present their controls as to be used *instead* of country fixed effects. Combining them drastically reduces the variation to identify the impact of our variables of interest so that the GDP and $F.MKT$ coefficients, while stable, are no longer significant at conventional levels.[20] Nevertheless, in all our regressions, the $F.MKT$-strong, which is our main variable of interest, remains significant at the 1% level. This result is extremely robust.

To confirm the hypothesis of the existence of a U-shape, we perform a last test, using the Sasabuchi-test (Sasabuchi, 1980). The test is performed for our main specification in column (b) of Table 4. It directly tests for the existence of a U-shape with respect to GDP and an inverse U-shape with respect to $F.MKT$-strong. In both cases the test supports the U-shape hypothesis (i.e., the test does reject the null hypothesis of the non-existence of a U-shape).

4.3.3 Discussion of the results

The decreasing part of the inverse U-shape relative to the foreign market potential is puzzling.[21] Why, all else being equal, do countries with very high values of $F.MKT$-strong tend to protect their IPR less? The role of trade, as captured by the variables measuring foreign market potential, can be understood considering the cost and benefits of protecting IPR. For the vast majority of developing countries, which do not invest in R&D, passing laws and regulations to protect IPR is costly internally.[22] They have very few domestic innovations to protect, while these legislations prevent them from copying innovations by others, and are costly to pass and promulgate. It is useful to them only to meet international (i.e., advanced economies) standards and to be able to export there, as

[20]Excluding country fixed effects or using random fixed effects, GDP squared and $F.MKT$ and its square are significant in a regression like (e) using the method of Bonhomme and Manresa (2015).

[21]We are grateful to an anonymous referee for suggesting this discussion.

[22]Innovative activities are concentrated in a handful of countries. For instance, in 2011, seven countries (the US, China, Japan, Germany, France, the UK, and South Korea) were accounting for 71% of the total R&D worldwide expenses. See WIPO Publication No. 941E/2011 ISBN 978-92-805-2152-8.

shown by legal scholars (see, for instance, Braithwaite and Drahos, 2000; Shadlen et al., 2005; Zeng, 2002; May and Sell, 2006; Morin and Gold, 2014). All else being equal (i.e., for a given GDP), we therefore expect that developing countries should be more willing to protect IPR the larger their foreign market potential. That is, we predict an increasing monotonic relationship between IPR and $F.MKT$-strong for developing countries.

We test this prediction in Table 10 in the Appendix where we reproduce the main result of column (b) excluding advanced economies from the regressions. Columns (a) and (b) in Table 10 present the results obtained on the sub-sample of developing countries. Column (a) confirms that the willingness of developing countries to protect IPR is increasing with $F.MKT$-strong, while the inverse U-shape is not identified, as shown in column (b).

The decreasing part of the inverted-U shape for $F.MKT$-strong is obtained only when developed and developing countries are included simultaneously in the sample of IPR regressions. In other words, it comes from the behavior of some advanced economies. In particular, we find that the results are sensitive to the inclusion of Belgium, Luxembourg,[23] the Netherlands and Switzerland in the panel of countries used in the IPR regressions. As shown in Column (d) of Table 10, the coefficients of $F.MKT$-strong and $F.MKT$-strong^2 lose significance when we reproduce the main result of column (b) excluding these rich countries.[24]

It is worth mentioning that only these four countries affect the significance of our foreign market potential measures. Regressions that discard the other 109 countries one by one give the same results as columns (a) and (b) in Table 4 for $F.MKT$ and $F.MKT$-strong, respectively. This shows that the decreasing part of the inverse U-shape is related to the behavior of small, rich, open economies. Intuitively, as discussed in section 4.1, small, rich, open economies have very large values of $F.MKT$-strong. Yet at some point

[23]Trade data for Belgium and Luxembourg are reported together for our period of analysis, which explains why we consider these two countries as a single one in the regressions.

[24]The full sample, including Belgium, Luxembourg, the Netherlands and Switzerland is still used to compute the foreign market potentials $F.MKT$ and $F.MKT$-strong for all other countries. The four countries are just dropped from the IPR regression.

the benefits in terms of trade of additional IPR protection stop. They have no advantage in going beyond the level that enables them to export. The situation is different for large advanced economies with relative lower values of $F.MKT$-strong as they invest heavily in R&D. They want to promote the strictest IPR to protect their innovations.

We also run the inverse U-shape test on the result in Column (d) of Table 10 (i.e., excluding the Benelux countries and Switzerland). The test is not passed when excluding them. To further explore the sources of the decreasing part of the inverse U-shape, we also run the test excluding the 109 remaining countries one by one from regression (b) of Table 4. The results of the inverse U-shape test are then always preserved. This confirms that to identify both the U-shape with respect to GDP and the inverse U-shape with respect to $F.MKT$, the full sample of advanced and developing countries is needed, as suggested by our economic interpretation.

Taken together, our results show that the measure of foreign market potential is critical in explaining IPR protection in developing countries, and the outcome is largely determined by export opportunities to countries that strictly protect IPR. At the aggregate level they confirm that a country's strength of protection of IPR is U-shaped relative to its internal market and inverse-U-shaped relative to its export opportunities in countries strictly enforcing IPR, which is our main contribution regarding IPR protection. To our knowledge, this empirical result is novel.

5 IPR and innovation

The fact that some developing countries are pressured into raising IPR standards to developed country standards may have consequences for the ability of these countries to develop an autonomous research capacity. We now turn to the exploration of the relation between stricter IPR protection and innovation in developing countries.

5.1 Addressing IPR endogeneity

From an empirical point of view, trying to assess the impact of IPR on innovation presents a problem of endogeneity. The innovation equation should be estimated simultaneously with the equation describing the choice of IPR. However, many of the variables used to explain IPR, as presented in Table 4, columns (a)–(f), are likely to be explanatory variables of innovation as well, and do not represent valid instruments for IPR in the innovation equation.

We address this problem with instrumental variable regressions, relying on two original instruments for IPR. Both instruments are based on the exploitation of spatial and temporal lags in the innovation process. To eliminate endogeneity problems, we discard information from the country itself and consider only data from neighboring countries with a time lag of three periods (15 years). This identification strategy takes advantage of cross-country correlations resulting from worldwide/regional trends, favoring the diffusion of economic policies or inducing a common "country exposure" to certain effects. It consists in using a spatial correlation arising from common patterns among countries that are correlated with the variable of interest (in our case, strengthening of IPR) but are uncorrelated through other mechanisms with the outcome (in our case, innovation).[25] Similar identification strategies have been employed in different contexts.[26] As explained in Acemoglu and Restrepo (2020), choosing a significant time-lag for the instruments in the first-stage equation improves the identification strategy. This avoids the introduction of mechanical correlations or mean reversions that were temporary or in anticipation of the effects of the explanatory variable.[27]

[25]This strategy is analogous to the identification of price coefficients in product demand equations using characteristics of product substitutes (Berry et al., 1995) and the identification of housing price coefficients using attributes in locations at a sufficient distance from a residence (Basten et al., 2017).

[26]For instance, in a similar way, Persson and Tabellini (2009) and Acemoglu et al. (2019) use waves of democratization, Acemoglu and Restrepo (2020) the increase in robot-based automation, David et al. (2013) the increases in exports from low-income countries, Fontagné and Orefice (2018) the activism in trade-reducing regulations, Ellison et al. (2010) the Marshallian externalities in the same industries of different countries, and finally Guasch et al. (2007) the application of similar recommendations from international institutions in public concessions design.

[27]In Acemoglu and Restrepo (2020), the instrumented variable (robot exposure in the US) is measured for the periods in the 2000s, while the instrumental variable (robot exposure in European countries) uses

The first instrument is a measure of past technological adoption and diffusion. The idea is that the diffusion of modern technologies can change the attitude towards IPR protection. Among similar indices of technology diffusion, we choose the lagged number of tractors (in log). There are two main reasons for this choice. First, it is a relatively old innovation in a traditional sector which is important in developing countries.[28] Since tractors are generally employed with other inputs such as certified seeds and fertilizers, this may have stimulated the adoption of strong IPR in countries that wanted to take advantage of the potential increase in agricultural productivity implied by mechanization. Second, from a statistical point of view this instrument offers several advantages. It presents significant variation not only in the spatial dimension but also in the temporal one. For instance, Manuelli and Seshadri (2014) have shown that in the United States, tractor diffusion took several decades. Nonetheless, the diffusion process is likely to be correlated with the choice of a broader set of public policies (not exclusively IPR protection). As such, it could be correlated with other unobservable variables influencing innovation (thus violating the exclusion restriction from the innovation equation). For this reason, we do not use the number of tractors in the country. Instead we use the diffusion of tractors in other countries, excluding the country of interest. We use the bilateral distances as weights to generate a single indicator for each country and each period: for each country i we sum up the number of tractors in countries $j \neq i$, weighted by bilateral distances between countries i and j, for all j.[29] The good data availability allows us to introduce the instrument lagged by three periods (15 years) to eliminate any further endogeneity concerns.

The second instrument is the lagged number of students leaving their home country to study abroad. We expect migrant students to have an indirect effect on innovation through IPR. This is in line with studies showing that students who have spent

information from the 1970s.

[28] According to the FAO (2019), roughly 2.5 billion people worldwide derive their livelihoods from agriculture, most of them in developing countries. Approximately three-quarters of the world's agricultural value added is generated in developing countries.

[29] The information is provided by Comin and Hobijn (2009) in their Cross-country Historical Adoption of Technology (CHAT) dataset.

time abroad can influence the development of institutions in their home country.[30] In addition, student migrations favor technological transfers by having an impact on the technological gap between the home and foreign countries (see, for instance, Naghavi and Strozzi, 2015; Dominguez Dos Santos and Postel-Vinay, 2003; Dustmann et al., 2011).[31] Again, to eliminate endogeneity problems, we do not consider the number of migrant students leaving a given country i, but rather the average number of migrant students from neighboring countries, weighted by distance to country i. Several versions of student migration flows are available in the dataset proposed by Spilimbergo (2009). We have tested several versions, as well as different techniques of aggregation (using alternatively weighted distances or contiguity dummies). All specifications give the same type of results. We thus have retained the best instrument in terms of exogeneity and relevance, which corresponds to the variable $Students(FH)$, the number of students studying in foreign democratic countries (as defined by Freedom House). This second instrument is also lagged by three periods (i.e., 15 years). The coefficients of the excluded instruments in the first-stage equations explaining IPR are reported in the bottom parts of Table 5.

One concern is that our instrument based on lagged student flows may affect innovation through a positive correlation between human capital and foreign direct investment (FDI): if neighboring countries become more attractive for innovation-enhancing FDI, there could be a bias induced by potential substitution or complementarity effects between investments in neighboring and domestic countries. Recent papers in the literature control for these potential economic linkages through a spatial weighted measure of neighbors' GDPs.[32] In our regression we already control for these effects, because the $F.MKT$ is included in all specifications.[33] We also control for local human capital in the regression.

[30]For instance, Spilimbergo (2009) shows that individuals educated in foreign democratic countries can promote democracy in their home country.

[31]Naghavi and Strozzi (2015) have shown that the knowledge acquired by emigrants abroad can flow back into the innovation sector at home. This is also in line with findings by Dominguez Dos Santos and Postel-Vinay (2003) and Dustmann et al. (2011), who put the accent on the positive effects of return migration on technological transfers.

[32]See, for example, Acemoglu and Restrepo (2020) and Cherif et al. (2018).

[33]Controlling for foreign market access is also important because of a potential direct effect on innovation. For instance, Coelli et al. (2016) identify, both theoretically and empirically, a positive impact of market access on innovation. In their empirical analysis, they consider two components of market access:

5.2 On-the-frontier innovation and IPR

As a dependent variable, we use patent applications as a proxy for innovation. We focus on the subsample of less developed countries (i.e., excluding the highest income quintile).[34] The list of countries included in the regressions is given in Table 11 in the Appendix. We measure domestic innovation as the number of patent applications made by resident firms and innovations made by foreign firms (i.e., mainly from developed countries) by the number of patent applications made by non-resident firms.[35]

In addition to the variables used as controls in the previous regressions, we add the stock of human capital, *hcap*, and its square, as it should have a direct influence on the innovative capacity of the country. The variable *hcap* is the level of human capital computed with the Hall and Jones method using the new series proposed in Barro and Lee (2010). Fixed effects and time dummies are included in all specifications. First, in columns (a), (b), and (c) of Table 5, we show the result of the regressions when we do not correct for the endogeneity of IPR,[36] and next, in columns (d), (e), (f), IPR is instrumented using $N.\ of\ tractors$, the lagged number of tractors in neighboring countries and $Students(FH)$, the lagged flows of students in neighboring countries.

The first-stage regressions confirm that the instruments are statistically adequate. The regressions presented in Table 5 pass the exogeneity and relevance tests. In Table 13 in the Appendix, we explore the results when the instruments are considered separately. The $Students(FH)$ instrument is not significant on its own, while the $N.\ of\ tractors$

the level of tariffs and market size. They find a positive role for trade-cost reductions (as measured by tariff changes) on innovation. Moreover, the coefficient is reduced when they control for destination market size, suggesting that the two components of market access have an impact on innovation.

[34]For each year in our sample, we classify a country as developed if it belongs to the highest quintile in terms of GDP per capita, and as developing otherwise. South Korea is the only country that switched from a developing to a developed country during the period, that is, the country was found in the highest quintile during the 1990s. All results in Table 5 are robust to the exclusion of this country. We also discard oil-exporting countries with very high GDP per capita levels (higher than 40,000 USD in 2000 value). All these countries are highly dependent on this commodity (measured as a share of exports) and exhibit low diversification of their economies.

[35]The vast majority of patents of non-resident firms in the world originate from firms located in high-income economies. For more on this see "World Intellectual Property Indicators," 2011 WIPO Economics & Statistics Series, at www.wipo.int.

[36]In the Appendix, we provide a robustness check for these estimations by performing negative binomial regressions. Results are shown in Table 12.

Table 5: Patent Equation

Patent type	Resident	Non-Resid	All	Resident	Non-Resid	All
	(a)	(b)	(c)	(d)	(e)	(f)
IPR	–0.41***	0.13	0.01	–1.17***	0.35*	0.06
	(0.10)	(0.14)	(0.12)	(0.25)	(0.19)	(0.20)
GDP	–6.58**	2.27	0.88	–11.34***	3.32	1.19
	(2.97)	(3.93)	(4.54)	(4.06)	(4.01)	(4.38)
GDP^2	0.16***	–0.03	0.01	0.26***	–0.05	0.00
	(0.06)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)
F.MKT-strong	–2.14	4.60*	2.29	–1.54	4.57*	2.25
	(1.55)	(2.57)	(2.18)	(2.06)	(2.48)	(2.03)
F.MKT-strong^2	0.06	–0.12*	–0.06	0.04	–0.12*	–0.06
	(0.04)	(0.07)	(0.06)	(0.05)	(0.06)	(0.05)
freedom	0.69**	0.29	0.57	0.46	0.31	0.58**
	(0.28)	(0.36)	(0.34)	(0.43)	(0.31)	(0.30)
gatt/wto	–0.38	0.22	0.10	–0.06	0.12	0.08
	(0.23)	(0.22)	(0.17)	(0.28)	(0.20)	(0.16)
hcap	5.10**	–0.60	1.20	4.74*	–0.40	1.22
	(2.03)	(1.77)	(1.74)	(2.69)	(1.69)	(1.68)
hcap^2	–0.16*	0.06	0.01	–0.18	0.06	0.01
	(0.09)	(0.10)	(0.09)	(0.12)	(0.10)	(0.08)
IPR Endogenous	No	No	No	Yes	Yes	Yes
No. of obs	225	244	225	225	244	225
N. countries	54	59	54	54	59	54
Within R^2	0.56	0.31	0.50	–	–	–
Hansen (p-val.)	–	–	–	0.76	0.70	0.87
First-stage regs.						
N. of tractors				315.69***	303.43***	315.69***
				(60.00)	(56.10)	(60.00)
Students(FH)				4.82***	4.95***	4.82***
				(1.46)	(1.45)	(1.46)
F (all instr.)	–	–	–	15.26	15.71	15.26
Partial R^2	–	–	–	.17	.18	.17

Robust Standard Errors in parentheses, clustered by country. ***, ** and * represent, respectively, statistical significance at the 1%, 5%, and 10% levels. All regressions include country fixed effects and time effects. All variables describing the market size are lagged one period. All variables are in log transformation except the GATT/WTO and the IPR index. First-stage regressions include all controls shown in columns (a) and (b) of Table 4. Instruments are lagged several periods (see the text for details). F-stat is the Angrist and Pischke version.

instrument is significant and gives similar results for the IPR coefficient. The only change is that the coefficient for the non-resident patent is no longer significant at conventional levels.[37] Since the simultaneous introduction of the instruments yields significant coefficients for both in the first stage, we present this better specification here. As a last robustness check, we run all IV regressions in Table 5 using alternative estimation methods that are robust to weak instruments. In particular, we use the Limited Information Maximum Likelihood (LIML) and Fuller's modified LIML (see Murray, 2011 for details). We find basically the same coefficients for the IPR variable. These robustness checks are available upon request.

The results in Table 5 show that failing to correct for endogeneity leads to an underestimation of the impact of IPR on innovation activities. The sign of the bias is consistent with intuition. First, innovation and IPR are determined simultaneously, confounding the causal relation. Countries which already produce more indigenous innovation and rely less on imitation have greater incentive to protect IPR. Second, we do not observe country technological capabilities, that is, all aspects affecting the innovation performance, such as firms' absorptive capacity, the quality of the National Innovation System, and R&D subsidies, as well as the complementarities with other factors of production such as physical and human capital (see Cirera and Maloney, 2017, for a discussion). In this regression we thus miss the relation between high technological capabilities, high innovation, and high propensity to protect IPR (leading to a possible omitted variable bias). Both effects explain that countries with more mature R&D sectors innovate more, and tend to protect IPR more strictly. These are at the origin of the underestimation of the negative (respectively positive) effect of stricter IPR on indigenous (respectively foreign) innovation in column (a) (respectively in b).

The results of the instrumental approach in columns (d) and (e) in Table 5 show that increasing IPR strength decreases on-the-frontier innovation of resident firms in developing countries (resident patents), but increases innovation of non-resident firms

[37]The coefficients are almost identical (i.e., 0.35 and 0.32) but this small difference is enough to make the coefficient insignificant.

(which are mostly firms based in developed countries).[38] The two effects cancel out when the two sets of patents are merged (see the "All" regression). This result contradicts the idea that stronger protection of IPR in developing countries will lead to more patents at the global level. The total number of patents in the countries that protect IPR more strictly is not affected: there seems to be a substitution between domestic and foreign patents.

The use of national data on resident and non-resident patents as a measure of innovation in a country is worth discussing. On the one hand, it is plausible that inventors in a developing economy might decide to patent their invention only in the North, where, because of national treatment, foreign firms enjoy the same protection as Northern firms (see Scotchmer, 2004). The IPR regime in the South would therefore no longer be relevant for innovation activities, as domestic firms would have strong incentives to innovate through the IPR system in rich countries.

On the other hand, counting domestic patents gives no indication of their quality. A question that remains to be answered is the impact of IPR protection on patent quality. If the level of IPR protection is higher, firms may respond by focusing their efforts on fewer, but higher quality innovations. There would then be a trade-off between the quantity and quality of innovations. To address these two concerns, we use as an alternative measure of innovation the number of patents filed by developing country firms in the United States. These patents are generally considered to be of higher quality than those filed only locally. Since they are more expensive than local patents, only the most promising innovations are likely to be filed there. In section 7.3.1 of the Appendix, we discuss in detail the advantages and disadvantages of using US data to study innovation in developing countries. We run regressions (a) and (d) from Table 5 using patents granted in the United States to residents of developing countries in our sample. Our

[38]Since the coefficient for IPR in the non-resident patent equation is significant at the 10% level, we test the robustness of this result by estimating a second specification using $F.MKT$ instead of $F.MKT$-strong (as in columns (a),(c),(e) of Table 4) and a third one including $F.MKT$-weak and its square in addition to $F.MKT$-strong (as in the robustness check presented in Table 9 in the Appendix). In all these specifications, the size of the IPR coefficient and its significativity are preserved.

results, which are available in Table 14 in the Appendix, confirm a negative coefficient for domestic IPR measure in the IV regression. These results provide additional evidence that increased IPR protection does not appear to increase the quality of innovation in developing countries, which is consistent with other results found in the literature using US patent data (Schneider, 2005; Hudson and Minea, 2013; Kim et al., 2012).

5.3 Inside-the-frontier innovation and IPR

Our empirical results suggest that increased IPR in developing countries has a negative effect on the level of innovation produced in these countries. According to their critics, this is because a universally strong IPR regime reduces technology free copying and diffusion. By preventing developing countries from closing their initial technology gap through imitation and reverse engineering, IPR undermines their ability to innovate. To assess the empirical relevance of this argument, we explore the effect of stricter IPR on inside-the-frontier innovation (i.e., goods that are new to a country's production basket, but have already been discovered elsewhere). To measure inside-the-frontier innovations we follow Klinger and Lederman (2009, 2011), who propose export discoveries, i.e., the discovery of products for exports that have been invented abroad but that are new to the country.[39] This is measured by the number of new products that enter a country's export basket in any given year, calculated using trade data from COMTRADE[40]. Measuring export discoveries requires a strict set of criteria to avoid the inclusion of temporary

[39]The use of export discoveries as a measure of inside-the-frontier innovation is inspired by the work of Imbs and Wacziarg (2003). These authors show that economic development is associated with increasing diversification of employment and production across industries rather than specialization. Sweet and Eterovic (2019) argue that the absence of correlation between productivity and IPR protection may be explained by the fact that what matters is not IPR per se, but the degree of diversification and sophistication that a country may achieve. Consequently, they use a measure that combines these two dimensions, known as the Economic Complexity Index (ECI). They found a positive impact of ECI on productivity. In other work (Sweet and Eterovic, 2015), they found that IPR protection affects ECI positively, but only for countries that already have a high initial level of ECI. Both results suggest that diversification may be an important channel to understand the role of innovation and IPR in development, especially for middle-income countries.

[40]We are not using TradeProd because we need a product-level dataset (SITC Rev. 2 for COMTRADE) instead of an industrial level dataset (ISIC Rev. 2 for TradeProd). Other papers exploring export discoveries like Klinger and Lederman (2009, 2011) also prefer COMTRADE.

exports not really reflecting the emergence of a new product in the export capabilities of the country.

First, we use the highest possible level of disaggregation of products for the period analyzed. Using COMTRADE data for the period 1980–2005, the available classification is SITC Rev 2, which allows for 1,836 potential product categories. Second, we follow Klinger and Lederman (2009) by considering a threshold of US$ 1 million (in constant 2005 prices) to assess whether a new product has entered the domestic export basket. In addition, we only include products that meet at least this threshold for two consecutive years. It is indeed possible that some exporters try new products and temporarily exceed this threshold, but stop exporting in subsequent years. In order to have a reasonable time window for the last year of our study, we consider exports through 2007.

We perform the same exercise as for on-the-frontier innovation presented in Table 5, but using inside-the-frontier innovation (discoveries) as the endogenous variable. We use the same instrumentation strategy to address the endogeneity of IPR and the same set of less developed countries (see section 7.1 of the Appendix). The results are presented in Table 6. Fixed effects and time dummies are included in all specifications. For the sake of comparison, in column (a) we show the result of the OLS regressions when we do not correct for the endogeneity of IPR. In column (b) IPR is instrumented by outward migration of students and the spatial distribution of tractors as in Table 5. Finally, as a robustness check, column (c) presents a negative binomial estimation. This specification does not allow us to use the same instrumentation strategy, but it allows us to treat discoveries as count data.[41] In this regression, as in the instrumented cases, the coefficient of IPR is significantly negative (however, the size of the coefficient of this regression cannot be compared with the ones in the other columns because of the negative binomial functional forms). We interpret the negative coefficient of IPR as evidence that a stricter protection of IPR reduces inside-the-frontier innovation. This last set of results gives credit to the idea that by preventing imitation and reverse engineering, IPR slows down

[41] The negative binomial regression has been preferred to a Poisson estimation because the data display very strong over-dispersion.

Table 6: Discoveries Equation

SAMPLING:	Panel OLS	Panel IV	Neg. Binomial
	(a)	(b)	(c)
IPR	–0.15	–0.38*	–0.17**
	(0.11)	(0.23)	(0.07)
GDP	–2.68	–3.70	1.62**
	(2.91)	(2.93)	(0.73)
GDP^2	0.05	0.07	–0.04**
	(0.06)	(0.06)	(0.02)
F.MKT-strong	–2.68	–2.90	–1.77
	(2.04)	(1.99)	(1.52)
F.MKT-strong^2	0.07	0.08	0.04
	(0.05)	(0.05)	(0.04)
freedom	0.39	0.42	0.63**
	(0.35)	(0.37)	(0.30)
gatt/wto	–0.02	0.10	0.10
	(0.15)	(0.18)	(0.12)
hcap	5.29***	5.06***	0.93
	(1.98)	(1.76)	(0.62)
hcap^2	–0.23**	–0.23**	–0.03
	(0.10)	(0.09)	(0.03)
IPR Endogenous	No	Yes	No
No. of obs	332	332	332
N. countries	74	74	74
Within R^2	0.73	–	–
Hansen (p-val.)	–	0.92	–
First-stage regs.			
Students(FH)		2.91**	
		(1.35)	
N. of tractors		273.51***	
		(52.07)	
F (all instr.)	–	13.83	–
Partial R^2	–	.17	–

Robust Standard Errors in parentheses, clustered by country. ***, ** and * represent, respectively, statistical significance at the 1%, 5%, and 10% levels. All regressions include country fixed effects and time effects. All variables describing the market size are lagged one period. All regressors are in log transformation except the GATT/WTO and the IPR index. In regressions (a) and (b), also the dependent variable is in log format. First-stage regressions include all controls shown in Table 4. Instruments are lagged three periods. F-stat is the Angrist and Pischke version.

innovation in developing countries because it makes it harder for them to close their initial technology gap.

The results in Table 5 and Table 6 highlight the conflict between advanced and developing countries regarding universally strong IPR. Developing countries face a dilemma between taking advantage of innovations from advanced economies to close their technology gap as shown in Table 6, and the cost to them in terms of reduced export opportunities. Importantly, our results in Table 5 show that universally strong IPR are not necessarily conducive to greater global innovation. Asymmetric protection of IPR, stronger in developed countries and weaker in large developing countries, may be desirable both from the perspective of developing country welfare and the promotion of global innovation.

6 Conclusion

The paper contributes to the understanding of the forces that can encourage or discourage innovation at the global level, focusing on two issues: first, the incentives that developing countries have to protect IPR; second, the impact of their choices on innovation. It establishes that linking the ability of developing countries to trade with advanced economies to IPR protection is a powerful tool to encourage small countries to adopt IPR legislation. Large emerging economies are better able to disregard the threat of trade sanctions due to their size. Consistent with the international balance of power, our empirical analysis hence shows that the strength of patent protection is a U-shaped function of the size of countries' domestic market and an inverse U-shaped function of their export opportunities. Small developing countries are obliged to adopt international legislative standards promulgated by leading advanced economies, such as the United States and the European Union, while large emerging countries are better able to withstand the pressure in their adoption. Rich countries adopt strong IPR policies with some heterogeneity.

The paper shows that choosing a stricter IPR regime does not necessarily increase innovation in poor countries. A higher level of IPR in developing countries is detrimental to innovation by local firms (as measured by patents), without bringing clear benefits to the total level of innovations in these countries. One explanation for this result is that stronger IPR protection reduces the ability of countries to close their technology gap. We provide evidence that stronger IPR protection, by blocking imitation and reverse engineering, reduces the set of new goods that poor developing countries are able to produce.

From a political economy perspective, the paper contributes to the understanding of the forces that lead poor countries to adopt a common set of rules or legislation, here related to IPR. An interesting question for further research would be to study the actual enforcement of IPR (as opposed to formal protection and legal enforcement mechanisms). Although some improvements have been made in the construction of IPR enforcement indices, their coverage remains limited in terms of the number of countries and time periods. For example, Papageorgiadis and Sharma (2016) developed a combined index for 49 countries between 1998 and 2018, and Palangkaraya et al. (2017) quantified differences in the processing of foreign and local applications in developed countries for the period 1990–1995. Any efforts to expand coverage will improve our understanding of the differences and similarities between *de jure* and *de facto* intellectual property protection.

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7 Appendix

7.1 Descriptive statistics of IPR and trade data

Our source to compute the market size measures is *TradeProd*, a bilateral trade dataset developed by the French institution CEPII. Their primary source is, like most of world-wide trade datasets, COMTRADE from the United Nations Statistical Department. They collect trade flows using reports from national customs and process the information to reduce mistakes. As importer and exporter provide independent reports concerning the same bilateral trade flow (often termed as *mirror flows*), some researchers have compared these data to confirm strong discrepancies, specially for developing countries. As a consequence, several institutions have further processed COMTRADE to generate new datasets. CEPII developed TradeProd in two stages. First, the original product categories are preserved and the focus is on correcting mistakes in national reporting using import and export information for the same bilateral trade flow weighted by measures of accuracy reports as explained by De Sousa et al. (2012). This is crucial to increase the coverage for developing countries since many of their export flows are missing or systematically underreported, but may be registered (for the same product category and year) as an import by the trade partner. In a second stage, the improved COMTRADE data is aggregated to allocate each flow to an industrial category (ISIC Revision 2) in order to match information from trade flows by OECD (STAN database) to check consistency with other primary sources (e.g. National Accounts figures harmonized by OECD). The final dataset contains 151 countries. In order to save space, we have not listed those countries, since they are available in De Sousa et al. (2012). Since its inception in 2010, TradeProd is increasingly used in academic research and policy analysis and it is available in the CEPII website (http://www.cepii.fr).

Since the size of the foreign markets a country might lose by infringing intellectual property rights depends on whether its trade partners strictly protect IPR, Figure 2 shows how the ratio of the internal market of a country, measured by its GDP, over

$F.MKT$-strong, the measure of foreign market potential of the country's trade partners strictly enforcing IPR, correlates with the index IPR. The magnitude and the dispersion of this ratio is depicted by quartile. Because it is quite demanding in terms of data, it covers a shorter period (1985–2005) than the IPR series (1960–2005).[42] The summary statistics associated with the graph are shown at the bottom of Table 7, row (f). It is important to note that this ratio covers all types of countries, both developing and advanced economies. Countries that have a low ratio have a relatively small economy, either because they are very poor in per capita terms (e.g., Zimbabwe, Liberia, Guyana), or/and because their population is relatively small and they are very open (e.g., Belgium, Malta, Slovakia, Uruguay). At the other extreme, we find countries with a large ratio either because they are very rich (e.g., Japan, United States) or, if they are developing countries, because they have a large population and are relatively closed to international trade (e.g., Brazil, Argentina, India during the 1980s and 1990s).

Figure 2 shows that IPR protection increases for all the quartiles of the internal/foreign market ratio, but increases more (with respect to the initial level) for the first quartile than for the second and third ones.[43] This is consistent with the fact that small countries are willing to defend IPR more strictly to obtain better access to international markets. Finally, consistently with the stylized facts reviewed in the introduction, countries in the fourth quartile have also significantly strengthened their IPR legislation, mainly to protect their innovations. Focusing on IPR median values (i.e., the horizontal line in the boxes), we see that not much happens up to the mid 1990s. Then the median rises in all quartiles to become U-shaped in 2005: the median IPR of the first and of the fourth

[42] Over the long term, we found similar trends using another proxy, "trade openness" (i.e., the sum of exports and imports over total GDP), available since 1960 from the World Development Indicators. Although widely used, we think it is a crude measure of the potential gain from trade. The World Bank computed this measure using national accounts and including agriculture and oil exports and imports, which are quite volatile due to changes in world prices. Our measures, although covering a more limited span of time, allow a focus on manufacturing industries, where most of the debate on IPR is concentrated, and this limits the effects of price volatility.

[43] Focusing on internal demand only (GDP row c in Table 7) suggests that countries with a large internal demand increased their IPR protection proportionally less than countries with a smaller demand. This is a reminiscence of the U-shape results illuminated by Maskus (2000), Primo Braga et al. (2000) and Chen and Puttitanun (2005), while focusing on GDP per capita. However Section 4.2 shows that this result is not robust to the inclusion of controls.

Table 7: Summary statistics of the IPR index

Groupings		Mean 1985	Mean 2005	Mean var(%)	SD 1985	SD 2005	SD var(%)
(a) Income	Low	1.81	2.59	43.1%	0.38	0.63	67.3%
	Middle-Low	1.59	3.04	90.9%	0.59	0.73	22.4%
	Middle-Up	1.68	3.73	121.6%	0.50	0.53	6.2%
	High	2.97	4.27	44.0%	0.87	0.46	–47.5%
(b) Developing	Africa	1.88	2.76	47.2%	0.39	0.54	37.1%
countries	America	1.44	3.32	130.4%	0.54	0.52	–5.0%
by region	Asia	1.67	2.75	64.6%	0.57	1.02	77.1%
	Europe	1.65	4.18	153.0%	0.44	0.27	–38.8%
(c) GDP	1st quartile	1.77	2.70	52.9%	0.33	0.51	55.9%
	2nd quartile	1.66	2.91	74.6%	0.52	0.61	16.7%
	3rd quartile	2.23	3.67	64.8%	0.89	0.80	–10.8%
	4th quartile	2.92	3.99	36.6%	1.24	0.75	–39.4%
(d) F.MKT	1st quartile	1.86	2.81	50.8%	0.70	0.79	13.3%
	2nd quartile	1.77	3.10	75.3%	0.51	0.65	29.3%
	3rd quartile	1.82	3.42	87.7%	0.77	0.95	22.9%
	4th quartile	2.62	3.97	51.6%	0.98	0.79	–19.3%
(e) F.MKT	1st quartile	1.85	2.84	53.5%	0.72	1.01	40.2%
-strong	2nd quartile	1.59	2.96	86.1%	0.48	0.70	47.7%
	3rd quartile	1.95	3.24	65.8%	0.70	0.60	–13.2%
	4th quartile	2.76	4.15	50.3%	0.94	0.61	–34.7%
(f) ratio	1st quartile	1.83	3.17	73.2%	0.67	0.80	20.1%
GDP/	2nd quartile	2.09	3.29	57.7%	0.77	0.88	14.5%
F.MKT	3rd quartile	2.16	3.32	53.2%	0.90	0.80	–11.0%
-strong	4th quartile	2.04	3.55	74.2%	0.99	0.87	–12.5%

Own calculations. Quartiles computed using the distribution on the previous period.

quartile is much larger than the median of the second and third quartile.

The effect of export opportunities in developing countries can be illustrated with some examples from our database. Chile and Colombia experienced little progress in their international market access during the period 1985–1990 (the Cold War was still ongoing and Latin American countries were crippled by recurrent debt crises). They significantly increased their levels of IPR protection in the following period (from 2.25 in 1990 to 3.91 in 1995 for Chile, and from 1.13 to 2.74 for Colombia), in order to gain access to international markets, especially in advanced economies, as shown by the increase in their $F.MKT$ index.[44] Similarly, Korea, which already had a higher level of $F.MKT$ in 1980 significantly increased its IPR index from 2.65 in 1985 to 3.88 in 1995. Subsequent increases in $F.MKT$ during the 1990s were associated with further increases in IPR protection, culminating in a level of 4.3 in 2005. In contrast, the Philippines, which experienced declining foreign market access until 1995, did not attempt to improve IPR protection throughout the 1980s and 1990s (their IPR index barely changed from 2.36 in 1985 to 2.55 in 1995). Their IPR policy changed in the late 1990s (their IPR index reached 3.975 in 2000) in order to improve their access to international markets, as evidenced by the significant increase in their $F.MKT$ index.

7.2 IPR and (domestic/foreign) market potential

Table 8 presents some robustness checks. Columns (a) to (b) correspond to the regressions in Table 3, but they consider an unbalanced panel of 118 countries to maximize the number of observations. Columns (c) and (d) test the results on a smaller balanced panel of 79 countries. Due to data limitations and in order to be able to get the largest possible sample, we use data on GDP at constant 2000 prices (i.e., not corrected for PPP). For the GDP and squared GDP we get significant coefficients similar to the ones shown in column

[44] During the 1990s, both countries signed several trade agreements (e.g., Colombia with Mexico and several Caribbean countries, and Chile with Canada and Mexico) and enjoyed preferential trade agreements to the United States and the European Union. Also during the 1990s, both countries benefited from an improvement in the economic conditions in the Latin American region.

(b) of Table 3. In the unbalanced panel regression (a) we also find that the coefficient for GDPpc is not significant but the squared term of GDPpc is significant at the 1% level. Columns (e) and (f) present the same regression as in Table 3, except that the $GDPpc$ and GDP are computed using data in constant prices (year 2000 USD), not PPP. The main results are shown to be robust when using these alternative series of data. The signs of the coefficients of $GDPpc$ are compatible with the U-shape, but they are still insignificant.

Finally, columns (g) to (j) present additional robustness checks of the results presented in Table 3. We re-run the same regressions as those in Table 3 with additional controls for unobserved heterogeneity (i.e., the same as in columns (c) and (d) in Table 4). To be more specific, we include continent-time fixed effects in regressions (g) and (h). This is a very strong test. Unsurprisingly, $GDPpc$ and GDP are no longer significant.

In columns (i) and (j) we reproduce the results of (a) and (b) but this time using the method by Bonhomme and Manresa (2015) (as described in the main text to run the regressions in columns (e) and (f) of Table 4). Overall, we confirm our results, although this time GDP and its square are significant at the 10% level. Since we also control for country fixed effects and common trends, these additional controls are presumably too strong. In fact, Bonhomme and Manresa (2015) present their method to be used *instead* of country fixed effects.

Table 9 presents robustness checks for the Foreign Market measure and some additional controls. Column (a) corresponds to a regression with both $F.MKT$-strong and $F.MKT$-weak assessed together. We confirm that only $F.MKT$-strong is significant. The insignificance remains when we include $F.MKT$-weak alone in column (b). Columns (c) and (d) show that the results are robust to different definitions of the threshold for which countries are classified as strongly (respectively weakly) protecting IPR. In our benchmark (column (b) in Table 4) we used the top (bottom) 25% while in columns (c) and (d) of Table 9 we used the top (bottom) 20% and top (bottom) 30% respectively.

The following four regressions, (e) to (h), present the results of augmenting our bench-

Table 8: IPR Equation – IPR Protection and GDP

	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)
GDPpc	–0.48		–0.61^c		–0.25		1.23		0.52	
	(0.31)		(0.34)		(0.49)		(1.07)		(0.71)	
GDPpc^2	0.06^a		0.07^a		0.04		–0.06		–0.01	
	(0.02)		(0.02)		(0.03)		(0.07)		(0.04)	
GDP		–2.24^a		–2.42^a		–3.13^a		–1.31		–1.58^c
		(0.40)		(0.43)		(0.64)		(1.44)		(0.89)
GDP^2		0.05^a		0.06^a		0.07^a		0.04		0.03^c
		(0.01)		(0.01)		(0.01)		(0.03)		(0.02)
freedom					0.67^a	0.70^a	0.36	0.45	0.48^b	0.35
					(0.24)	(0.22)	(0.27)	(0.27)	(0.20)	(0.22)
gatt/wto					0.29^b	0.31^a	0.33^b	0.36^b	0.30^b	0.41^a
					(0.13)	(0.12)	(0.16)	(0.16)	(0.13)	(0.12)
Time-continent FE	No	No	No	No	No	No	Yes	Yes	No	No
Time-B&M group FE	No	No	No	No	No	No	No	No	Yes	Yes
No. of obs	907	906	711	711	709	709	511	511	511	511
N. countries	118	118	79	79	112	112	112	112	112	112
Within R^2	0.74	0.75	0.77	0.78	0.75	0.76	0.75	0.76	0.82	0.82

Robust Standard Errors in parentheses, clustered by country. ^{a}, ^{b} and ^{c} represent, respectively, statistical significance at the 1%, 5%, and 10% levels. All regressions include country fixed effects and time effects. All variables describing the market size are lagged one period. All variables are in log transformation except the GATT/WTO and the IPR index. GDP is in constant dollars. The difference in the number of observations between (a) and (b) is due to one missing observation for GDP in Ghana.

mark IPR regressions (regressions (a) and (b) in Table 4). Regressions (e) and (f) add the human capital variable used in the patent equations and explore a potential non-linear effect between education and our variables of interest. Regressions (e) and (f) reject any direct impact of educational levels on IPR protection and market-size variables remain significant. The next two regressions, (g) and (h), add the trade openness variable (imports plus exports over GDP). This variable is often used in other studies as a proxy for the integration level of a country. It is not significant, even if it is correlated with our $F.MKT$ and $F.MKT$-strong variables, which remain significant.

Table 10 shows the results of the regressions discussed in section 4.3.3. The Developing sample is established as follows. For each year in our sample, we classify a country as developed if it belongs to the highest quintile in terms of GDP per capita, and as developing otherwise. South Korea is the only country that switched from being a developing to a developed country during the period, that is, the country was found in the highest quintile during the 1990s. All results are robust to the exclusion of this country. We also discard oil-exporting countries with very high GDP per capita levels (higher than 40,000 USD in 2000 value). All these countries are highly dependent on this commodity (measured as a share of exports) and exhibit low diversification of their economies. Regressions (c) and (d) exclude Belgium, Luxembourg, the Netherlands, and Switzerland from the main sample. Belgium and Luxembourg are included as a single country because their trade flows were reported together.

7.3 Robustness check: Innovation and IPR

In Table 12, we provide a robustness check for the patent equation in Table 5. Specifically, we treat the dependent variable as count data by performing negative binomial regressions that include country fixed effects (as regression (c) in Table 6). Results confirm the panel regressions (a), (b), and (c) in Table 5. Resident patents are negatively correlated with IPR. There is no effect of IPR protection when the dependent variable is either the number of non-resident patents or the total number of patents.

Another robustness check concerns the instrumentation strategy proposed in regressions (d), (e), and (f) in Table 5. We explore the results when each instrument is included separately in regressions (a) to (f) in Table 13. The first two regressions concern the resident patents and use the number of tractors (column (a)) and the number of students studying in foreign democratic countries (column (b)), both lagged by three periods. The first instrument is significant and the coefficient for the instrumented IPR index is slightly superior to the value found for the IV using both instruments in Table 5 (–1.21 and –1.17, respectively). By contrast, the student instrument is not significant and gives a non-significant value for the IPR variable. This pattern is similar for the case of non-resident patents and total patents in regressions (c) to (f). First, the tractor instrument is significant in the first-stage regression and conveys an increase in the (absolute) value of the IPR coefficient when compared with using the OLS method.[45] Second, the IV regression is not valid for the student instrument taken alone.

The case of non-resident patents is of particular interest, since the use of the tractor instrument alone, although significant in the first stage, results in a non-significant coefficient. The remaining three regressions in Table 13 explore the case of alternative instrumentation for the case of non-resident patents. In column (g), we show that the student instrument is significant alone when using a lag of two periods. In the last two regressions, this lag for the student instrument is combined with the tractor instrument. Although these regressions result in a significant positive coefficient for the IPR variable, the F-stat and the Hansen test cast doubts on the validity of these choices. In sum, if we discard the student instrument, regressions using the tractor instrument confirm the results of the OLS regressions in Table 5: IPR negatively affects indigenous innovation as measured by resident patents and we find no effect on non-resident patenting. As such instrumentation is based on a single instrument we are not able to test the exogeneity of the number of tractors, and we rely on the fact that it is temporally and spatially lagged. Alternatively, we propose a combination with a second instrument that allows for a regression where the Hansen test is valid and the coefficient for non-resident patents is positive and significant at 10%, as shown in Table 5.

7.3.1 Using USPTO patents: Quality vs. quantity?

A final check on the robustness of the patent equation is to use an alternative source of patent data. Many papers consider patents granted to foreigners by the United States Patent and Trademark Office (USPTO). The main advantage of this source is that it eliminates any heterogeneity regarding granting procedures. A second advantage is to obtain a quality-adjusted measure of quantity, since only the most valuable inventions justify the cost of a US patent application. It is then possible that even if the total number of resident patents in a country decreases due to an increase in IPR protection,

[45] e.g. the IPR coefficient is 0.13 in the OLS regression, 0.32 when using number of tractors as a single instrument, and 0.35 when using both instruments.

the number of high-quality patents could increase. However, there are also drawbacks to using this dataset. First, the difficulty of patent application procedures may vary across countries, introducing some country heterogeneity. Second, if these patents are more globally oriented, many local innovations will not be taken into account and we will get a partial picture of the impact of IPR protection on innovation in a specific country. Thus, for a number of countries in our database, although we count patents registered at the national level, no patents are identified in the USPTO dataset.

We extracted granted and application patents from the website *Reports of the Patent Technology Monitoring Team (PTMT).*[46] The first group includes all types of granted patents: utility patents (i.e., patents for invention), design patents, plant patents, reissue patents, statutory invention registrations, and defensive publications. The second group only includes Utility Patent Applications. Here we present results only for granted patents, but all conclusions derived from the regressions are the same if we use the Utility Patent Applications.

Naturally, there is a positive correlation between the USPTO dataset and our WDI/WIPO sample. However, for 10 African countries in our sample,[47] we find no patents granted in the United States. Since we want to have comparability with our original results, we add one patent to these countries. By doing so, our regressions with a log transformation keep the same number of observations in the estimates as in the original database. This is also necessary in negative binomial regressions, as countries with zero patents over the entire period are automatically excluded from the estimation, since we have country fixed effects. As a robustness check, we reran the regressions assuming zero patents for these African countries and obtained the same qualitative results.

Since our IPR index is available on a 5-year basis, we need to aggregate the annual patent data. Our benchmark chooses five values centered around the IPR year. For example, for 1980 we use the values between 1978 and 1982. This approach attempts to

[46]Reports can be found at https://www.uspto.gov/web/offices/ac/ido/oeip/taf/reports.htm

[47]Mozambique, Rwanda, Botswana, Burundi, Central African Republic, Congo, Rep., Niger, Sierra Leone, Togo, and Zambia.

take into account both agents' expectations of changes in national IPR (e.g., due to the long process of negotiating international agreements) as well as the time lags between invention, application, and patent grant. This specification is called *Version 1* in the tables and is the same one we used in our main results in the paper using WDI/WIPO. We will present results from a second version (*Version 2*) that focuses on anticipation effects and chooses patent data from t−4 to t, as suggested by (Hu and Jefferson, 2009).[48] Since the empirical literature has not settled on the role of lags and anticipation effects on innovation outcomes (see Hall et al., 1986; Wang and Hagedoorn, 2014), it is reasonable to investigate the sensitivity of our results.

Our results using the USPTO data should be compared only with our regressions on patents by *resident* for two reasons. First, since we only include developing countries in our analysis, a portion of the patents in the WDI/WIPO dataset should be in the USPTO datasets (presumably the high-quality ones). Second, most of the patents associated with non-residents registered in developing country patent offices are from developed countries, and we do not have an equivalent of this in the USPTO datasets that reflects a patent office in a developed country. Therefore, for all regressions using the developing country sample, we expect a negative coefficient for the IPR variable (as in the regressions for resident patents for the WDI/WIPO dataset).

While panel regressions without instrumentation (see regressions (a) and (b) in Table 14) show no significant coefficients for IPR protection levels, the same regressions using the two instruments proposed in the paper confirm a negative coefficient (regressions (c) and (d)). If we expect that higher IPR protection increases innovation in terms of quality-adjusted patents, we should observe a positive significant coefficient in the USPTO dataset (despite the fact that a negative coefficient could be found for patents of relatively low quality registered in national offices and collected in the WDI/WIPO

[48]We also explore two other alternatives: one with a focus on the delayed effect, by considering years t+1 to t+5; and one considering even longer delays for granting for the periods after 1995 as suggested by Dass et al. (2017). In addition, aggregating patents can be done by taking either the mean of the period or the sum of patents. Here we report results using the mean (as in the main results of the paper) but our results are qualitatively identical for all these choices.

dataset). Alternatively, it may be argued that USPTO patents are not a good representation of local innovations of developing countries (at least for this sampling), since some other variables like $F.MKT$-strong and human capital exhibit negative signs (unlike our regressions using the WDI/WIPO dataset), which is opposite to empirical results found in the literature. All in all, the literature is finding increasing evidence of a negative coefficient for a sampling of developing countries using USPTO data exploiting the panel dimension (Schneider, 2005; Hudson and Minea, 2013; Kim et al., 2012). Non-significant coefficients are also found in the negative binomial regressions (see columns (e) and (f)). Once again, these results remain qualitatively the same when considering additional specifications (see footnote 48).[49] We were not able to find papers using a comparable specification for developing countries.

Although less clear-cut than our regressions using WIPO/WDI data, we did not find any evidence that increases in IPR protection are increasing patenting levels in the US from innovation originated in developing countries.

[49]Interestingly, for the case of granted patents in version 2, we still get a significant negative coefficient when we discard countries without any patent in USPTO. The coefficient is indeed higher (–0.24) with a p-value of 0.03. But for all other versions, the coefficient for IPR protection is never significant.

Table 9: IPR equation – Additional Controls

	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)
GDP	-2.14^c	-2.26^b	-2.07^c	-2.09^c	-2.71^b	-2.34^b	-2.07^c	-1.98^c
	(1.15)	(1.10)	(1.18)	(1.19)	(1.11)	1.04)	(1.16)	(1.09)
GDP^2	0.05^b	0.05^b	0.05^b	0.05^b	0.06^a	0.05^a	0.05^b	0.05^b
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	0.02)	(0.02)
F.MKT					3.49^a		2.40^c	
					(1.28)		(1.26)	
F.MKT^2					-0.07^b		-0.06^c	
					(0.03)		(0.03)	
F.MKT-strong	2.36^a		2.26^b	2.69^a		2.76^a		2.30^a
	(0.79)		(0.96)	(0.76)		(0.81)		(0.74)
F.MKT-strong^2	-0.06^a		-0.06^b	-0.06^a		-0.06^b		-0.05^a
	(0.02)		(0.02)	(0.02)		(0.02)		(0.02)
F.MKT-weak	–1.72	–1.83	–1.60	–1.38				
	(1.15)	(1.11)	(1.14)	(1.17)				
F.MKT-weak^2	0.04	0.05	0.04	0.04				
	(0.03)	(0.03)	(0.03)	(0.03)				
hcap					0.97	0.50		
					(0.92)	(0.82)		
hcap $*$ F.MKT					–0.07			
					(0.04)			
hcap $*$ F.MKT-strong						–0.04		
						(0.04)		
Trade openness							–0.01	–0.02
							(0.10)	(0.10)
freedom	0.56^c	0.58^c	0.57^c	0.54^c	0.62^b	0.62^b	0.68^b	0.70^b
	(0.31)	(0.31)	(0.31)	(0.31)	(0.31)	(0.30)	(0.29)	(0.29)
gatt/wto	0.41^a	0.43^a	0.41^a	0.37^b	0.43^a	0.44^a	0.45^a	0.46^a
	(0.16)	(0.16)	0.15)	(0.15)	(0.16)	(0.16)	(0.16)	(0.16)
No. of obs	511	511	511	511	493	493	503	503
N. countries	112	112	112	112	106	106	112	112
Within R^2	0.72	0.71	0.72	0.72	0.72	0.72	0.72	0.72

Robust Standard Errors in parentheses, clustered by country. ^{a}, ^{b} and ^{c} represent, respectively, statistical significance at the 1%, 5%, and 10% levels. All regressions include country fixed effects and time effects. All variables describing the market size are lagged one period. All variables are in log transformation except the GATT/WTO and the IPR index. GDP is in constant dollars.

Table 10: IPR Equation – Exploring the U-shape

	Developing sample		Benelux & Switzerland	
	(a)	(b)	(c)	(d)
GDP	–4.12[a]	–4.20[a]	–1.91[c]	–2.01[c]
	(1.22)	(1.22)	(1.12)	(1.12)
GDP^2	0.09[a]	0.09[a]	0.05[b]	0.05[b]
	(0.02)	(0.02)	(0.02)	(0.02)
F.MKT-strong	0.27[a]	–1.69	0.20[b]	1.59
	(0.10)	(1.89)	(0.08)	(0.97)
F.MKT-strong^2		0.05		–0.04
		(0.05)		(0.03)
freedom	0.29	0.27	0.56[c]	0.55[c]
	(0.33)	(0.34)	(0.32)	(0.31)
gatt/wto	0.47[a]	0.47[a]	0.45[a]	0.44[a]
	(0.16)	(0.15)	(0.15)	(0.16)
No. of obs	386	386	496	496
N. countries	89	89	109	109
W. R^2	0.72	0.73	0.71	0.71

Robust Standard Errors in parentheses, clustered by country. [a], [b] and [c] represent, respectively, statistical significance at the 1%, 5%, and 10% levels. All regressions include country fixed effects and time effects. All variables describing the market size are lagged one period. All variables are in log transformation except the GATT/WTO and the IPR index. Benelux is Belgium, Luxembourg and The Netherlands.

Table 11: Countries included in the patent regressions

Algeria	Congo (Rep. of)*	India	Malta	Philippines	Thailand
Argentina	Costa Rica	Indonesia	Mauritius	Poland	Trinidad and Tobago
Bangladesh	Czech Republic	Iran	Mexico	Portugal	Tunisia
Bolivia	Ecuador	Jamaica	Morocco	Romania	Turkey
Brazil	Egypt	Jordan	Nepal*	Russian Federation	Ukraine
Bulgaria	El Salvador	Kenya	Nicaragua	Rwanda*	Uruguay
Burundi*	Ghana*	Korea (South)	Pakistan	Slovak Republic	Venezuela
Chile	Guatemala	Lithuania	Panama	South Africa	Zambia
China	Honduras	Malawi	Paraguay	Sri Lanka	Zimbabwe
Colombia	Hungary	Malaysia	Peru	Syria	

All countries in this sampling have at least three observations for the dependent variable during the period. All countries in the table are included in regressions for *Non-Resident* patents. Countries with * are not included in the regressions for *Resident* patents and and *Total* patents because they do not have enough data on these categories of patents (at least three observations over the period).

Table 12: Patent Equation – Negative Binomial Regressions

Patent type	(Resid)	(Non-Resid)	(All)
	(a)	(b)	(c)
ipr	–0.35[a]	0.12	–0.01
	(0.08)	(0.07)	(0.06)
GDP	–3.79[a]	–4.51[a]	–4.72[a]
	(0.53)	(0.92)	(0.88)
GDP^2	0.09[a]	0.09[a]	0.10[a]
	(0.01)	(0.02)	(0.02)
F.MKT-strg	–0.44	4.00[c]	2.55
	(1.81)	(2.16)	(1.96)
F.MKT-strg^2	0.01	–0.12[b]	–0.08
	(0.05)	(0.06)	(0.05)
gatt/wto	0.20	0.04	0.31[b]
	(0.17)	(0.16)	(0.13)
freedom	0.27	–0.41	–0.04
	(0.33)	(0.28)	(0.27)
hcap	–2.25[b]	0.90	–0.31
	(0.97)	(0.81)	(0.79)
$hcap^2$	0.08[c]	–0.04	0.02
	(0.05)	(0.04)	(0.04)
No. of obs	225	244	225
No. of countries	54	59	54

Robust Standard Errors in parentheses, clustered by country. [a], [b] and [c] represent, respectively, statistical significance at the 1%, 5%, and 10% levels. All regressions include country fixed effects and time effects. All variables describing the market size are lagged one period. All variables are in log transformation except the GATT/WTO, IPR and the dependent variables.

Table 13: Patent Equation – Additional IV Results

	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
Patent type	R	R	NR	NR	All	All	NR	NR	NR
ipr	–1.21^a	–0.08	0.32	1.42	0.04	0.37	1.27^c	0.41^b	1.50^b
	(0.29)	(3.26)	(0.21)	(3.12)	(0.21)	(1.82)	(0.75)	(0.21)	(0.62)
GDP	–11.62^a	–4.46	3.15	8.50	1.11	3.15	7.80	3.63	8.92
	(4.29)	(20.39)	(3.99)	(17.39)	(4.48)	(11.97)	(7.05)	(4.13)	(6.68)
GDP^2	0.26^a	0.12	–0.04	–0.15	0.00	–0.03	–0.14	–0.05	–0.16
	(0.08)	(0.40)	(0.08)	(0.35)	(0.08)	(0.24)	(0.14)	(0.08)	(0.13)
F.MKT-strg	–1.51	–2.40	4.58^c	4.45	2.26	2.01	4.47	4.57^c	4.44
	(2.12)	(3.09)	(2.48)	(3.17)	(2.05)	(2.16)	(3.11)	(2.50)	(3.42)
F.MKT-strg^2	0.04	0.06	–0.12^c	–0.12	–0.06	–0.05	–0.12	–0.12^c	–0.12
	(0.06)	(0.08)	(0.06)	(0.09)	(0.05)	(0.05)	(0.08)	(0.06)	(0.09)
gatt/wto	–0.04	–0.53	0.13	–0.38	0.08	–0.06	–0.31	0.09	–0.42
	(0.30)	(1.45)	(0.21)	(1.40)	(0.17)	(0.77)	(0.35)	(0.20)	(0.37)
freedom	0.44	0.79	0.30	0.38	0.58^c	0.68	0.37	0.31	0.39
	(0.45)	(1.03)	(0.32)	(0.57)	(0.30)	(0.61)	(0.49)	(0.31)	(0.59)
hcap	4.71^c	5.26^c	–0.43	0.60	1.21	1.37	0.47	–0.34	0.68
	(2.75)	(2.83)	(1.71)	(3.36)	(1.68)	(1.88)	(2.36)	(1.72)	(2.79)
hcap^2	–0.19	–0.15	0.06	0.07	0.01	0.02	0.07	0.06	0.07
	(0.12)	(0.12)	(0.10)	(0.15)	(0.08)	(0.12)	(0.13)	(0.10)	(0.15)
No. of obs	225	225	244	244	225	225	244	244	244
N. countries	54	54	59	59	54	54	59	59	59
Hansen (p-val.)								0.09	0.71
First-stage regs.:									
N. of Tractors	276.47^a		263.74^a		276.47^a			248.55^a	18.16^c
	(56.39)		(52.08)		(56.39)			(53.76)	(9.71)
Lags (periods)	3		3		3			3	2
Students (FH)		1.08		0.89		1.08	9.65^c	4.74	9.91^c
		(1.46)		(1.46)		(1.46)	(5.21)	(5.20)	(5.24)
Lags (periods)		3		3		3	2	2	2
F (all instr.)	24.04	0.54	25.64	0.37	24.04	0.54	3.42	14.27	2.78
Partial R^2	0.14	0.15	0.14	0.00	0.00	0.00	0.03	0.16	0.05

Robust Standard Errors in parentheses, clustered by country. ^{a}, ^{b} and ^{c} represent, respectively, statistical significance at the 1%, 5%, and 10% levels. All regressions include country fixed effects and time effects. All variables are in log transformation except the GATT/WTO and the IPR index. All variables describing the market size are lagged one period. First-stage regressions include all controls shown in Table 4. Instruments are lagged several periods (see the text for details). F-stat is the Angrist and Pischke version. R:Resident, NR: Non-Resident.

Table 14: Patent Equation – USPTO Data

	Panel		Instrumental Variable		Negative Binomial	
	(a)	(b)	(c)	(d)	(e)	(f)
	Version 1	Version 2	Version 1	Version 2	Version 1	Version 2
main						
ipr	0.06	–0.01	–0.64[b]	–0.69[c]	–0.05	–0.16[c]
	(0.08)	(0.09)	(0.31)	(0.35)	(0.09)	(0.10)
GDP	–1.88	–1.84	–6.29	–6.12	–3.96	–4.24
	(2.89)	(3.69)	(4.54)	(5.02)	(2.82)	(3.03)
GDP^2	0.06	0.06	0.15[c]	0.15	0.09[c]	0.10[c]
	(0.06)	(0.08)	(0.09)	(0.10)	(0.05)	(0.06)
F.MKT-strong	–4.07[b]	–4.39	–3.52[c]	–3.85	–0.52	2.56
	(1.85)	(2.83)	(2.02)	(2.90)	(2.15)	(2.41)
F.MKT-strong^2	0.11[b]	0.11	0.09[c]	0.10	0.01	–0.08
	(0.05)	(0.07)	(0.05)	(0.07)	(0.06)	(0.06)
gatt/wto	–0.08	–0.05	0.23	0.24	0.17	0.16
	(0.16)	(0.19)	(0.24)	(0.28)	(0.13)	(0.19)
freedom	0.51	0.61[c]	0.30	0.40	–0.09	–0.04
	(0.33)	(0.34)	(0.55)	(0.51)	(0.37)	(0.37)
hcap	–3.82[c]	–3.92	–4.16	–4.24	–5.37[a]	–2.96
	(2.28)	(2.82)	(2.90)	(3.31)	(1.98)	(2.19)
hcap^2	0.19[c]	0.19	0.17	0.16	0.21[b]	0.10
	(0.10)	(0.12)	(0.13)	(0.15)	(0.09)	(0.09)
No. of obs	225	225	225	225	225	225
N. countries	54	54	54	54	54	54
Within R^2	0.62	0.53				
Hansen (p-val.)			0.42	0.51		
F (all instr.)			15.26	15.26		
Partial R^2			0.17	0.17		

Robust Standard Errors in parentheses, clustered by country. ^{a}, ^{b} and ^{c} represent, respectively, statistical significance at the 1%, 5%, and 10% levels. All regressions include country fixed effects and time effects. All variables describing the market size are lagged one period. All regressors are in log transformation except the GATT/WTO and the IPR index. In regressions (a) to (d), also the dependent variable is in log format. Versions correspond to different specific years considered to aggregate patents (More details in the text). First-stage regressions include all controls shown in Table 4 of the paper. Instruments are lagged several periods (see the text for details). F-stat is the Angrist and Pischke version.