Authors
Emmanuelle Auriol
Sara Biancini
Rodrigo Paillacar
Coordination
Julien Gourdon (AFD)
Bertrand Savoye (AFD)

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Intellectual Property Rights Protection and Trade: An Empirical Analysis

Authors

Emmanuelle AURIOL
Toulouse School of Economics

Sara BIANCINI
CY Cergy Paris Université,
THEMA UMR CNRS 8184

Rodrigo PAILLACAR
CY Cergy Paris Université,
THEMA UMR CNRS 8184

Coordination
Julien GOURDON (AFD)
Bertrand SAVOYE (AFD)

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 enforcement is U-shaped in a country's market size relative 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.

Keywords

Intellectual Property Rights, Innovation, Developing Countries, Market Potential, Trade

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JEL Classification

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Résumé
Être capable d'évaluer le risque de conflit au niveau local est crucial pour prévenir la violence ou pour atténuer ses conséquences. Cet article développe une nouvelle approche pour prédire l'occurrence d'évènements de conflit à partir de données historiques sur la violence. Il adapte la méthodologie développée dans Tapsoba (2018) pour mesurer le risque de violence dans l'espace et le temps à la prédiction des conflits. La violence est modélisée comme un processus stochastique avec une distribution sous-jacente inconnue. Chaque évènement conflictuel observé sur le terrain est interprété comme une réalisation aléatoire de ce processus et sa distribution sous-jacente est estimée en utilisant des méthodes d'estimation par noyau dans un espace en trois dimensions. Les paramètres de lissage optimaux sont estimés pour maximiser la vraisemblance des futurs évènements de conflit. Une illustration des gains pratiques (en termes de performances de prévision) de cette nouvelle méthodologie par rapport aux modèles standards auto-régressifs est présentée à partir des données de la Côte d'Ivoire.

Mots-clés
Conflit, insécurité, estimation par noyau, méthode de Parzen-Rosenblatt

Intellectual Property Rights Protection and Trade: An Empirical Analysis. *

Emmanuelle Auriol[†]
Sara Biancini[‡], Rodrigo Paillacar[§]

October 2021

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 enforcement is U-shaped in a country's market size relative 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.

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[†]Toulouse School of Economics, emmanuelle.auriol@tse-fr.eu.
[‡]CY Cergy Paris Université, THEMA UMR CNRS 8184, sara.biancini@cyu.fr.
[§]CY Cergy Paris Université, THEMA UMR CNRS 8184, rodrigo.paillacar@cyu.fr.

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,[1] 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 strong IPR limit the possibility of technological learning through imitation, while innovation and growth seems to be driven by imitation in poor countries (see for instance Goldberg and Pavcnik, 2007 and Madsen et al., 2010). A second source of conflict concerns medical drugs, specifically the fact that TRIPS does not stimulate research designed to benefit the poor, because they are unable to afford the products once they are developed. The controversy has made the headlines and in 2001 it led to the Doha Declaration, the aim of which is to ensure easier access to medicines by all.[2] This declaration made a significant dent in the TRIPS agreement and has been challenged by the US and other developed countries with the help of organizations such as PhRMA (representing pharmaceutical companies in the US). As a result of these international disputes, the enforcement of IPR legislation varies considerably around the world. There is a substantial theoretical literature on

[1]The TRIPS agreement, negotiated through the 1986–94 Uruguay Round, is administered by the World Trade Organization and applies to all WTO members.

[2]The declaration states that TRIPS should not prevent a country from addressing public health crises, and, in particular, that developing countries should be able to copy medicines for national usage when tackling such major issues as AIDS, malaria, tuberculosis or any other epidemics. They should also be able to import generic drugs if the domestic pharmaceutical industry cannot produce them.

the link between North–South trade and IPR protection, but there are surprisingly few empirical studies which focus on how trade impacts countries' willingness to enforce IPR. The present paper is a first attempt to fill this gap.

With the help of panel data covering 112 countries, innovation and IPR enforcement, the paper analyzes developing countries' incentive to enforce IPR. Using a methodology developed in the new economic geography literature for measuring foreign market potential, the empirical analysis shows that IPR enforcement is U-shaped in the aggregated market size of a country's trade partners, relative to its own market size. 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 enforce IPR.

Intuitively, violating IPR of the North imposes barriers to trade on the South, as advanced economies monitor their imports to block out goods suspected of infringing intellectual property rights. They also use their market power to encourage/coerce their trade partners from developing countries to adopt Western-style IP rules. A number of legal scholars have hence documented the importance of economic incentives in triggering the adoption of TRIPS (Braithwaite and Drahos, 2000; Shadlen et al., 2005; Zeng, 2002; May and Sell, 2006; Morin and Gold, 2014).[3] Morin and Gold (2014) explain that many small countries, such as Nicaragua, which exports more than 12% of its GDP to the

[3]The use of the Special 301 and lifted privileged 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: 1) and that the GSP program was "an effective point of leverage with some of our trading partners" (USTR 2004).

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 3 years prior to the signature of their bilateral trade agreements with the United States to force them to adopt strong IP rules.

More recently the European Union has enacted a regulation concerning customs enforcement of 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 complaining government obtains the right to impose trade sanctions in the form of punitive tariffs.[4] Consequently a developing country that wants to trade with advanced economies will find it easier if it enforces IPR more strictly (see Maskus and Penubarti, 1995 and Smith, 1999).[5]

Small countries benefit more from trade than large ones (Alesina et al., 2005). The former should be more willing to enforce IPRs than the latter, as enforcement has be-

[4]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).

[5]These authors show that an increase in patent protection has a positive impact, not only on a country's exports, but also on its imports, especially so if it has a high imitation capacity.

come essential to access foreign markets, notably in advanced economies. We test this prediction with our long and rich panel data. Consistent with the trade argument, we find a U-shaped relation between IPR enforcement and the size of a country's export opportunities relative to its internal market. When the size of its internal market is small relative to its export market, a developing country is willing to respect IPR, while it prefers to free-ride on the North's innovations to serve its internal demand when the latter is large relative to its export market. At the other end of the income distribution scale, very rich countries (i.e., with large GDP relative to their export market) enforce strictly IPR to protect their innovations. As far as we know this result, which predicts that countries with small and large export market relative to their internal market –or equivalently with large and small internal market relative to their export market– are more willing to enforce IPR than countries with intermediate export market relative to internal market, is a new proposal as compared to previous empirical papers on IPR determinants. It documents and nuances with statistical evidences, the finding by legal scholars on the impact of economic incentives on developing countries willingness to embrace western style legislation, such as TRIPS (Braithwaite and Drahos, 2000; Shadlen et al., 2005; Zeng, 2002; May and Sell, 2006; Morin and Gold, 2014). It establishes that linking developing countries ability to trade with advanced economies to the enforcement of IPR legislation is a powerful tool on small countries. Large emerging economies are abler to disregard the threat of trade sanctions due to their sheer power and big size.

We next study the impact of strengthening IPR protection on innovation in developing countries. Indeed, another crucial point within the TRIPS controversy concerns the potential adverse effect of universal IPR on global innovation and 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 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). Our paper looks at the relation between stronger IPR protection and innovation in sectors other than pharmaceutical and medical research. 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 in a large panel of 112 countries. When IPRs are enforced more strictly, the innovation of local firms decreases in developing countries. 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 favor foreign firms. Increasing the protection of IPR decreases on-the-frontier innovation in the manufacturing sector of resident firms in developing countries, but increases innovation of non-resident firms, usually based in developed countries.

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 exports that have been invented abroad but that are new to the country (Klinger and Lederman, 2009, 2011). Since Goldberg and Pavcnik (2007) and Madsen et al. (2010) suggest that innovation in poor countries is driven by imitation, it is likely that strong IPR limit the possibility of technological learning through imitation. However, FDI and technology licensing could provide alternative mechanisms through which countries can acquire technology, without relying on imitation. Indeed, studies show that reinforcing IPR in a given country 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). Whether these benefits of stronger IPR compensate their negative impact on learning through imitation on the total innovation capacity of poorer countries is an empirical issue. We find that a stronger protection of IPR impacts negatively export discoveries. Taken together with the empirical evidence on pharmaceutical, our findings give credibility to the idea that by preventing technological transfers from the North, universal protection of IPR limits the development of Southern R&D activities in all manufacturing sectors, and not solely in the pharmaceutical industry.

2 Link with the literature and motivational evidence

Chin and Grossman (1991), Deardoff (Deardoff) 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). There are three main findings that emerge from this theoretical literature. First, stricter enforcement of IPR has generally a positive impact on global innovation. The harmonization of IPR 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. Second, there is a conflict of interest between the North (which generally gains from stricter enforcement in the South) and the South (which generally loses). Third, the level of IPR protection generally increases monotonically with the level of economic development.[6]

This monotonicity 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 tempting. More recently, Auriol et al. (2019) have proposed a theoretical model where the ability of developing countries to export to rich countries depends on their willingness

[6]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.

to respect northern firms' IPR. This assumption is consistent with the evolution of international legislation and the recent tightening of sanctions against IPR infringement in the EU and the US. It is also consistent with the empirical literature, which shows that weak enforcement of 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 have a market expansion effect in countries with a strong capacity for imitation. This creates a trade-off between enforcing IPR to be able to trade and infringing IPR to serve domestic demand, explored theoretically in Auriol et al. (2019). They show that small/poor countries have 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 serve they large internal demand by fostering technological diffusion through imitation. In other words, both Diwan and Rodrik (1991) and Auriol et al. (2019) predict that the willingness to protect IPR is U-shaped in the relative size of one country's internal market as compared to its export market: rich countries with a large GDP relative to their export market enforce IPR to protect their innovations, poor/small countries relative to their export market enforce IPR to be able to trade and to stimulate innovation from rich countries, while intermediate countries in term of total market size/wealth, in particular those with large population, compared to their export market tend to free-ride on northern firms' innovation.

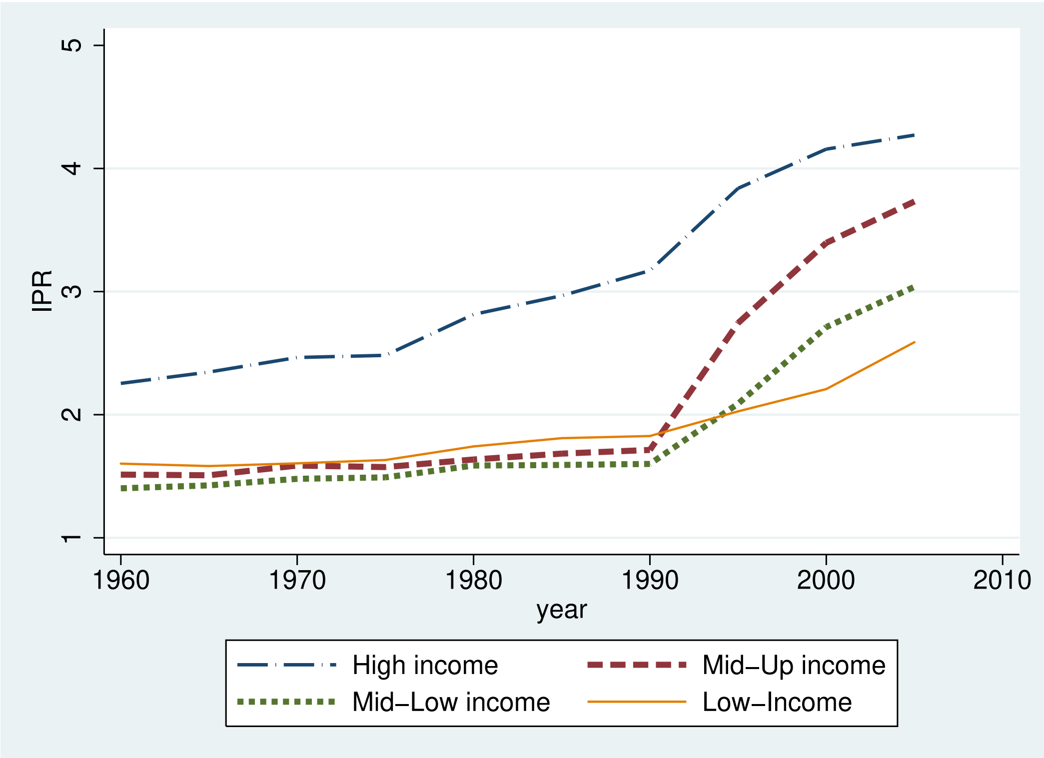
Since both Diwan and Rodrik (1991) and Auriol et al. (2019) are purely theoretical, in this paper we aim to empirically explore the shape of the relationship between IPR, economic development and markets (internal and export) size, in the context of an open economy. To answer this question we need first a proper measure of countries' IPR policy.

2.1 Measuring IPR

Intellectual property policies may be difficult to compare across countries due to the multiple dimensions to consider: specific provisions in national legislations to protect patents or trademarks, the existence of courts able to deal with disputes, adoption of international treaties, etc. A widely used measure is provided by Ginarte and Park (Ginarte and Park, 1997, Park, 2008). They collect information dating back to the 1960s on five categories associated with patent protection. They give scores for each dimension, and summarize them in a composite index for each country, which evolves over time. The resulting index ranges in an almost continuous way from 0 (no protection at all) to 5 (maximum protection). The index is not measuring directly actual enforcement, 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). All in all, this index, which is presented in more details in Section 3, captures the most salient aspects of a country's IPR regime and practice.

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. This hints at the importance of international trade in one country choice of IPR enforcement.

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.

In contrast to the cold war period, when not much happened on the IPR front in the developing world, since the 1990s substantial differences in IPR enforcement emerged among the different groups of countries. Table 1 in the Appendix provides some descriptive statistics of these changes by groups (row a). Although the level of the IPR index in high-income countries almost doubled between 1960 and 2005 (from 2.3 to 4.3), middle-income countries (upper and low) exhibit the highest growth rate, more than doubling the value of the index (from levels of 1.5 and 1.4 to levels of 3.7 and 3.0, respectively). In comparison low-income countries exhibit a lower growth rate of their IPR index at about 60% (from 1.6 to 2.6).

What Figure 1 does not show is the great diversity in the evolution of IPR policies across countries and time. Table 1 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 (1.7). The prospect of enhanced market access associated with the European enlargement provided poor European countries 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 (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 of their IPR index. Their average level is similar to that of African countries (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, reflecting different levels of economic openness and uncoordinated efforts to participate in international export/import markets. This paper aims at documenting and understanding this heterogeneity in countries' willingness to promote IPR.

2.2 IPR dispersion and trade

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 important step towards a better understanding of the link between IPR enforcement and development. Its main limitation is that it does not take into account the trade dimension of IPR enforcement. 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 GDP and other country-level controls. Yet the stylized facts mentioned above and the theoretical literature, which looks at this problem in the context of an open economy, both stress the importance of trade in countries' incentive to enforce IPR.

The present paper therefore adds the trade dimension to the empirical analysis. In this end, it is necessary to look at the total market size of an economy (i.e., its total GDP) and not solely at its per-capita GDP. Because of the size of its population, a developing economy can indeed be larger than a developed one, although poorer in per capita terms and generally endowed with less efficient R&D technology (e.g., China versus UK). More challenging, it is necessary to find a good proxy for the size of the foreign markets a country might loose while infringing intellectual property rights. The measure of the foreign market potential we use below, denoted $F.MKT$-strong, is a weighted sum of the market sizes of the country's trade partners strictly enforcing IPR (for the details of how it is computed see Section 4). Figure 2 shows how the ratio of internal market (GDP) over this measure of foreign market potential correlates with IPR. Because it is quite demanding in terms of data, it covers a shorter period (1985-2005) than the IPR series (1960-2005).[7] The summary statistics associated with the graph are shown in the bottom of Table 1 (for descriptive statistics of foreign market potential see rows d or e). It is important to note that this ratio covers all type 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 term (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).

We compute for each country the ratio of its internal market divided by the measure of its foreign market. In Figure 2 the magnitude and the dispersion of this ratio is depicted by quartile. The information at the bottom of Table 1 (row f) show 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.[8] This

[7]Over the long run, 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. 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, allows to focus on manufacturing industries, where most of the debate on IPR is concentrated and limits the effects of price volatility.

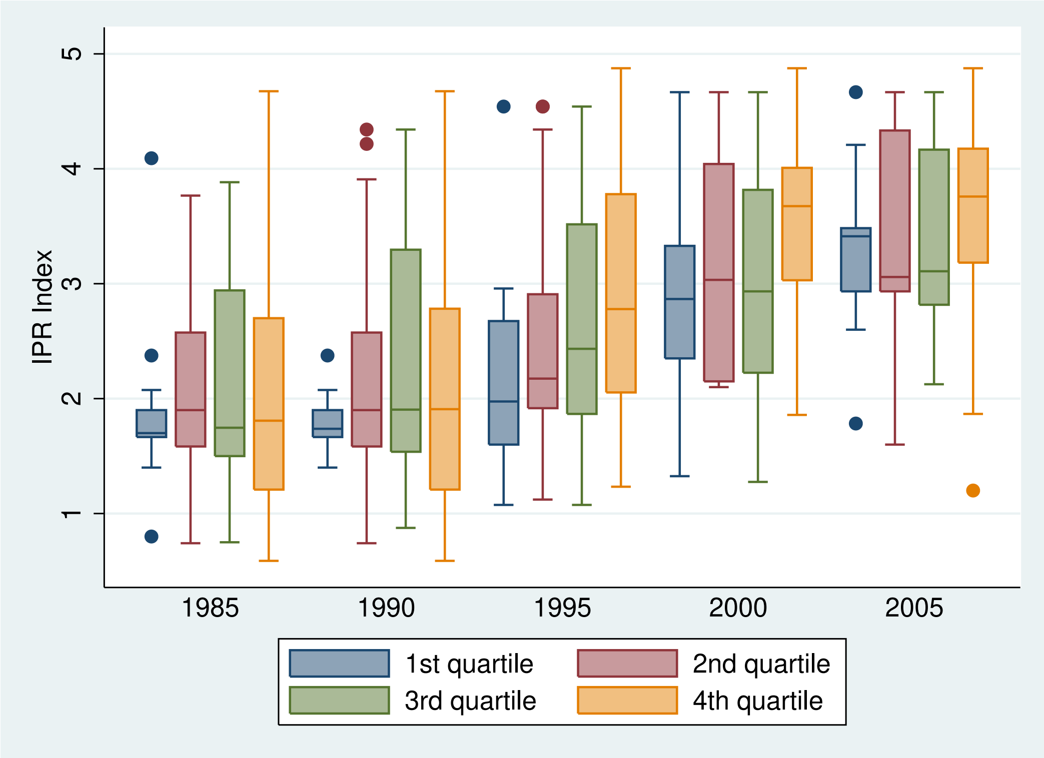
[8]Focusing on internal demand only (GDP row c in Table 1) suggests that countries with a large internal demand increased proportionally less their IPR protection than countries with a smaller demand. This

Table 1: Summary statistics of the IPR index

		Mean			SD		
Groupings		1985	2005	var(%)	1985	2005	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 countries by region	Africa	1.88	2.76	47.2%	0.39	0.54	37.1%
	America	1.44	3.32	130.4%	0.54	0.52	–5.0%
	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 -strong	1st quartile	1.85	2.84	53.5%	0.72	1.01	40.2%
	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 GDP/ F.MKT -strong	1st quartile	1.83	3.17	73.2%	0.67	0.80	20.1%
	2nd quartile	2.09	3.29	57.7%	0.77	0.88	14.5%
	3rd quartile	2.16	3.32	53.2%	0.90	0.80	–11.0%
	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.

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. Refer to the bottom of Table 1 for the mean and standard deviation for the beginning and end of the period.

is consistent with the fact that small countries are willing to defend IPR more strictly to get a better access to international markets. Finally consistently with the stylized facts reviewed in the introduction, countries in the fourth quartile have also significantly strengthen 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 happen up to the mid-1990s. Then the median raises in all quartile to become U-shaped in 2005: the median IPR of the first and of the fourth quartile are much larger than the median of the second and third quartile. In Section 4 we explore further this non-monotone

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 shows that this result is not robust to the inclusion of controls.

relationship.

2.3 IPR and innovation

Regarding the impact of IPR enforcement on global innovation, the empirical literature has mostly focused on the pharmaceutical industry. Using a product-level dataset from India, Chaudhuri et al. (2006) estimate the demand and supply characteristics of a segment of the antibiotics market in India (quinolones). They then draw up counterfactual simulations of what prices, profits, and consumer welfare would have been if the relevant molecular formulae had been under patent in India, as they were in the US at the time. Their results suggest that concerns about the potential adverse welfare effects of TRIPS are legitimate. Qian (2007) evaluates the effects of patent protection on pharmaceutical innovations for 26 countries that established pharmaceutical patent laws in the period 1978–2002. She shows that national patent protection alone does not stimulate domestic innovation, but that it does 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) test the hypothesis that, as a consequence of TRIPS, increased patent protection results in greater drug development efforts. They find that 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) focuses on the case of cumulative innovation, when product developments result from incremental inventions. She uses data on the effect of patents on genetic research, following the sequencing of the human genome realized by the public Human Genome Project and by the private firm Celera. While genes sequenced by the public effort fell into the public domain, Celera's sequenced genes was protected by a contract-based form of intellectual property which allowed Celera to charge high fees when selling its data. The protection ensured by this private database was considered by the authors equivalent to strong patent protection. Williams (2013) finds that this strong protection has led to a decline in follow-up scientific research and commercial product development, of the order of 20-30 percent. Sampat and Williams (2019) find a different result on a larger database of patents on gene-sequencing. In this case, when controlling for selection problems (patented genes are often ex-ante more promising than non-patented ones) the authors show that, on average, gene patents have no quantitatively important 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, that the database protection used by Celera was able to partially bypass. They conclude that their estimates may not generalize beyond the case of human gene patents.

The preceding literature shows that the impact of stronger IPR enforcement on innovation tends to be negative in the pharmaceutical industry of developing countries, while it is neutral in the gene-based medical research due to disclosure obligations. Very little is known about the impact of IPR on innovation in other sectors. Our paper complements this literature by looking empirically at the relation between stronger IPR protection and innovation in manufacturing sectors. Contrarily to sector-focused studies, we exploit aggregate country data on manufacturing sectors for longer periods. The drawback of this approach is that we have to work without the fine-grained information of micro-level data. In the case of IPR enforcement this is not such a big concern as we are interested on public policies aimed at promoting IPR at the national level in relation to trade concerns. Macroeconomics considerations are first order to understand the choice of a government 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 macroeconomics 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 in time of IPR protection and therefore miss its long run 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. We propose new empirical evidence that stricter IPR protection impacts negatively patent activity of Southern firms in a wide panel of manufacturing sectors. We also find evidence of a positive effect for non-resident patents, suggesting that stronger national IPR in developing countries favors foreign firms (mostly from developed countries). These results are consistent with the findings of Hudson and Minea (2013), who show that the same level of IPR has a different impact on richer and poorer countries. Comparing countries with a similar level of IPR enforcement, they find that the impact of IPR on innovation (as measured by US patents granted to residents of different countries) is in many cases negative for the poorer countries and positive for the richer. Similarly, we find that strong IPR enforcement 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. Section 4 analyzes countries' choice of the strength of IPR protection. 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. 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). The 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 5 categories are based on weighted scorings of 16 attributes of IPR protection measured as binary subcategories, plus one continuous category for duration of patents, we treat this index as continuous in our regressions, as most of the literature has done since Ginarte and Park (1997) seminal paper.[9] It is also important to mention that, 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 for instance the Happiness scales (see Ferrer-i Carbonell and Frijters, 2004). Finally, as 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 reduce 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).

Trade data is based on COMTRADE, from the United Nations Statistical Department. Although this source contains data from the 1960s to the present, more accurate information is derived from the new release of TradeProd, a cross-country dataset developed at CEPII.[10] This source integrates information from COMTRADE and OECD-STAN and covers the period 1980–2006. A detailed description of the original sources and procedures is available in De Sousa et al. (2012).

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 utilisation raises mea-

[9]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%).

[10]In particular, this dataset takes advantage of 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).

surement error issues (see Griliches, 1979).[11] R&D expenditure also has shortcomings, because expenditure is an input for R&D rather than an output.[12] 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 applications 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. Patents applications are generally preferable to patent grants when considering international comparison, because processing practices varies largely across countries and can take from 2 to 10 years after application (see Ang and Madsen, 2015). Even if the number of patent applications is a good proxy of the level of a country R&D activity, this measure is not perfect either. First of all, not all patents represent innovation, nor all innovations are patented. Second, the raw counts of patents generates a purely quantitative measure, while the quality of patents also matter. 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

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

[12]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 3 observations.

patents 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, measures of patent breadth, among others. We are therefore confident in using the number of patents to assess the innovation activity of countries.

Finally we also rely on cross-country human capital levels from Barro and Lee (2010). This widely used dataset reports levels of education attainment in periods of 5 years. All other data are from the OECD and the World Bank.

4 IPR enforcement

This section empirically assesses the role of export opportunities on the determinants of IPR enforcement. 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' IPRs to serve its domestic market and the cost it yields in term of trade. Consistently with these contributions, we assume that a developing country j that respects the IPRs of developed countries enjoys greater export opportunities F_j, compared to a country that violates these IPRs and has reduced export opportunities $f_j < F_j$. The benefits of IPR infringement come from the 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 countries respects IPRs 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 summarized the payoffs in function of the policy implemented.

Table 2: Developing Country's Payoffs When Choosing IPR Policy

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

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

$$(F_j - f_j) - N_j \Delta_j > 0 \tag{1}$$

It is easy to see that in the absence of trade opportunity concern (i.e., $F_j = f_j$) no country enforce IPRs, while in the absence of internal demand concern (i.e., $N_j \Delta_j = 0$) all countries enforce them. It implies that a country will have no incentive to respect IPRs if it trades mainly with other developing or emerging countries which do not enforce IPRs strictly. Indeed, in this case f_j is not very different from F_j, $f_j \simeq F_j$, which implies that (1) is violated since $N_j \Delta_j > 0$.

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

$$F_j - N_j\Delta_j > 0 \tag{2}$$

Equation (2) implies that the decision of a developing country to enforce IPRs depends on its export opportunities relative to its internal market: the larger the gap between F_j and $N_j\Delta_j$, the bigger its incentives to enforce them. Since advanced economies are already enforcing strictly IPR, the willingness of a country to enforce IPRs should then be U-shaped: Poor countries with a small population and relatively large export opportunities are willing to enforce IPRs to be able to trade. Developing and emerging countries with large population and relatively lower export opportunities are more reluctant to do so. Finally high income countries with large GDP relative to their export market enforce IPRs to protect their innovations. This result is a new proposal in the empirical literature, which until now has focused on a country per-capita GDP to explain its willingness to enforce IPR. Yet an empirical assessment of IPRs determinant 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.

In Table 3 we take a first look at the relationship between IPR regimes and measures of economic development and 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 describing the economic development or market size are lagged by one period (i.e., 5 years).[13] These

[13]Strong IPR protection could possibly stimulate new investment and/or FDI and in turn affect GDP. However, this channel would take some time. To avoid, as far as possible, residual endogeneity problems, we therefore lag the variables 5 years.

specifications are based on the implications of the previous empirical literature on IPR (i.e., Ginarte and Park, 1997; Maskus, 2000; Chen and Puttitanun, 2005).

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
R^2	0.68	0.62	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. In all regressions, GDP is in constant values. In regressions (b), (d), (e) and (f), GDP per capita or GDP are PPP-deflated. R^2 is the Adjusted R^2 for pooled regressions (a to d) and within-R^2 for the panel regressions (e and f). 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 virtually no effect on the values and statistical significance.

Results (a) to (d) in Table 3 confirm non-linear relationships in all cases. Many observable and unobservable country characteristics may confound this relationship. For example, institutional aspects crucial to growth may also influence the adoption of stricter IPR regulations. Consequently, we exploit the panel dimension of our data to better control for unobservable characteristics.

The results of the regressions are presented in columns (e) and (f) in Table 3. We fully exploit the panel dimension of our database, including in these regressions 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 GATT, or, later, the WTO, $gatt/wto$.[14] 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 the size of GDP and its square, with time, country fixed effects, and controls. This last regression confirms that IPR enforcement is a U-shaped function of a country's total wealth (i.e., 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

[14]The WTO commenced operations in 1995, replacing the GATT agreements. Our dummy takes a value of one, for a given country, starting from the year it joined the either the GATT (if before 1995) or the WTO (if after).

1965–2005. These different robustness checks are presented in Table 8 in the Appendix.

These preliminary 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 enforcement and a 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 is not yielding robust results. IPR enforcement is U-shaped with respect to total GDP (national market size). According to the theoretical literature reviewed earlier this is because total GDP is a better measure of a country's relative weight in the global economy than per-capita wealth (see for instance Diwan and Rodrik, 1991; Auriol et al., 2019).

One of our main contribution is to show that a developing country willingness to trade impacts its incentives to adopt western style IPR legislation. To be more specific, we test that a country's willingness to enforce IPR is U-shaped in the size of its internal market *relative* to the size of its export opportunity. The empirical challenge is therefore to find a good proxy for a country's export opportunities. We use gravity models, a methodology developed in the new economic geography literature (see Head and Mayer, 2004, and Redding and Venables, 2004), to compute a suitable measure of the foreign market potential.

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 their accessibility. To be more specific, we define the foreign market potential of country i at time t as

$$F.MKT_{it} = \sum_{j \neq i} \hat{\Phi}_{ijt} GDP_{it}, \tag{3}$$

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.[15] Of course, these bilateral variables are not the only components of trade costs. There are also variables specific to the exporter or the importer, like 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 Gravity Dataset. We concentrate our analysis on manufacturing data.[16] We estimate for each period the following cross-country regressions:

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

[15] 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).

[16] CEPII developed a dataset based on BACI-COMTRADE called TRADEPROD, specifically for the manufacturing sector. This is the version we use. De Sousa et al. (2012) describe the dataset in detail and make it available through the CEPII website.

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:

$$\hat{\Phi}_{ijt} = distance_{ij}^{\hat{\delta}_t} \exp\left(\widehat{\lambda}_{1t} Contiguity_{ij} + \widehat{\lambda}_{2t} Language_{ij} + \widehat{\lambda}_{3t} Colony_{ij}\right) \tag{4}$$

In the recent literature, gravity equations are increasingly used to get 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 result of our estimations are displayed in Table 4. 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 (3) 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 we want to test depend on the size of the internal market relative to export opportunities (see equation 2): we expect the coefficient of $F.MKT$ and $F.MKT^2$ in the regressions to have opposite signs with respect to the domestic market variables, GDP and GDP^2. This is confirmed by the estimation. The coefficients of GDP and its square are still significant and of similar size as in Table 3 column (f). In other words, IPR enforcement is shown to be U-shaped in a country's

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. ***, ** and * represent respectively statistical significance at the 1%, 5% and 10% levels. All regressions include country fixed effects and time effects. Regressions (c) and (d) include continent-time effects and regressions (e) and (f) include grouped-fixed effects using the method by Bonhomme and Manresa (2015). All variables describing the market size are lagged one period.

market size relative to the aggregated market size of its trade partners.

The role of trade, as captured by $F.MKT$ can be understood considering the cost and benefits of protecting IPR in developing countries. For the vast majority of these countries, which do not invest in R&D, passing laws and regulations to protect IPR is costly internally.[17] 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 be able to export there as 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).

The effect of export opportunities, as measured by $F.MKT$, 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 (it was still the cold war 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.[18] Similarly, Korea, which already had a higher level of $F.MKT$ in 1980 (6% higher than Colombia and Chile) significantly increased its IPR index from

[17] Innovative activities are concentrated in a handful of countries, with the top seven countries (i.e. US, China, Japan, Germany, France, the UK and South Korea) accounting for 71 % of the total R&D worldwide expenses. See WIPO Publication No. 941E/2011 ISBN 978-92-805-2152-8 at www.wipo.int

[18] 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.

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.

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 market is indeed the main driving force behind changes in a country IPR index, it is useful to distinguish between trade partners who strongly enforce IPR and those who do not. If a country trades only with countries that do not enforce 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 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 (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 have also performed 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 detail of these robustness checks are presented in Table 9 in the Appendix. They show that the result in Table 4 column (b), which is one of the main contribution of the paper, is qualitatively preserved.

We conclude the analysis with additional robustness tests that confirm the role of trade motives in IPR policies. One could be concerned that changes in institutional quality over time (not measured by 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 reduces considerably 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.[19] However, despite the stringency of the test, the measures of foreign market size remain significant.

[19] We also re-run the regressions in Table 3 with similar controls. The GDP coefficients are no longer significant for the same reason (see Table 10 in the appendix).

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,[20] we define four groups of countries that are used in our regressions in addition to all the other controls. Although these new tests, which are presented in columns (e) and (f), may help explore the effect of possible unobserved heterogeneity, they are probably overkill 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 reduce 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.[21] 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.

Finally, to confirm the hypothesis of existence of a U-shape, we perform a last test, using the Sasabuchi-test (Sasabuchi, 1980). The test is performed for the specifications in column (b) of Table 2, which is our main result. It directly tests for the existence of an inverse U-shape with respect to $F.MKT$-strong and a U-shape with respect to GDP. In both cases the test supports the U-shape hypothesis (i.e., the test does reject the null hypothesis of non-existence of a U-shape).

[20]The authors propose an algorithm of Variable Neighborhood Search that iteratively "re-assign" countries in the groupings if the objective function decreases. We set the parameters of this heuristic method to the values proposed by the authors. For details, see section S1.1 in the appendix of the Bonhomme and Manresa (2015) paper. They provide a Stata code and the Fortran file to perform the calculations as supplementary material.

[21]If we follow the recommendation of Bonhomme and Manresa (2015), GDP squared, $F.MKT$ and its squared are significant in a regression like (e) using their method but excluding country fixed effects or using random fixed effects.

Taken together, these results show that the measure of foreign market potential is critical in explaining IPR protection, and the outcome is largely determined by export opportunities to countries that strictly enforce IPRs. To our knowledge, this empirical result, which sheds light on the relationship between national policy regarding IPR strength and trade, is novel. It is consistent with theoretical papers by Diwan and Rodrik (1991) and Auriol et al. (2019). Very rich countries with a large GDP relative to their export market apply IPR to protect their innovations. Poor countries with small populations and, therefore, low GDP relative to their export market, apply IPRs to trade. Developing countries with a large population and an intermediate GDP relative to their export market prefer to infringe IPRs to serve their domestic market

5 IPR and innovation

The fact that some developing countries are coerced into adopting western style IPR protection to be able to trade with advanced economies has presumably consequences on these countries ability to develop autonomous research capacity. We now turn to the exploration of the relation between stricter IPR protection and innovation. 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 variables regressions, based on two original instruments for IPR. Both instruments are based on exploiting spatial and temporal lags of 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 3 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 IPRs) but are uncorrelated through other mechanisms with the outcome (in our case, innovation).[22] Similar identification strategies have been employed in different contexts.[23] As explained in Acemoglu and Restrepo (2020), choosing an important 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.[24]

[22]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).

[23]For instance Persson and Tabellini (2009) and Acemoglu et al. (2019) use in a similar way 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.

[24]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 information from the 1970s.

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 total number of tractors available in the country (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.[25] 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 important 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 country i and j, for all j.[26] The good data avail-

[25]According to the FAO (2019), roughly 2.5 billion of 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.

[26]The information is provided by Comin and Hobijn (2009) in their Cross-country Historical Adoption

ability allows us to introduce the instrument lagged by 3 periods (15 years) to eliminate any further endogeneity concerns.

The second instrument is the lagged number of students leaving the 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 spent time abroad can influence the development of institutions in their home country.[27] 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).[28] Again, to eliminate endogeneity problems, we do not consider the number of migrant students leaving a given country i, but 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 correspond to the variable $Students(FH)$, the number of students studying in foreign democratic countries (as defined by Freedom House).[29] This second instrument is also lagged by 3 periods

of Technology (CHAT) dataset.

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

[28]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.

[29]All alternative specifications give very similar results but they are more exposed to weak-instrument problems (tested using the Kleibergen-Paap statistic). To avoid the related biases, we retain the presented

(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 students 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 are controlling for these potential economic linkages through a spatial weighted measure of neighbors' GDPs.[30] In our regression we already control for these effects, because the $F.MKT$ is included in all specifications.[31] We also control for local human capital in the innovation regression.

As a dependent variable, we use data on patent applications as a proxy for innovation. We focus on the subsample of less developed countries (i.e., excluding the highest income quintile)[32] and we measure domestic innovation as the number of patent applications

specifications. For example, using only the *tractor* instrument gives similar results, but does not allow to apply a Hansen test of exogeneity, and using only the *student* instrument result in invalid first-stage regressions. These cases are presented in Table 13 in the Appendix. Other alternative specifications and related tests are available upon request.

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

[31]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: 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.

[32]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 developing to 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. The list of countries is depicted in Table 7 in the Appendix.

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. 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.

made by resident firms. Innovations made by foreign firms (i.e., mainly from developed countries) are measured by the number of patent applications made by non-resident firms.[33]

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. We first show in columns (a), (b), (c) of Table 5, the result of the regressions when we do not correct for the endogeneity of IPR,[34] and next, in columns (d), (e), (f), IPR is instrumented using Students(FH), the lagged flows of students in neighboring countries going to study in democratic countries, and N. of tractors, the lagged number of tractors 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 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 level.[35]

[33]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.

[34]In the Appendix 6, we provide a robustness check for these estimations by performing negative binomial regressions. Results are shown in Table 12.

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

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. All 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 coherent 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 like 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) show that increasing IPR strength decreases on-the-frontier innovation of resident firms in developing countries (resident patents), but increases innovation of nonresident firms (which are mostly firms based in developed countries).[36] 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 enforce IPR more strictly is not affected: there seems to be a substitution between domestic and foreign patents. This result is consistent with Kyle and McGahan (2012) who find that, in the pharmaceutical industry, the introduction of patents in developing countries has not been followed by more R&D investment in the diseases that are most prevalent there.

Our empirical results suggest that increased IPRs in developing countries have a negative effect on the level of innovation produced in these countries. According to their opponents, this is because universally strong IPRs reduce technology transfer. By preventing developing countries from closing their initial technology gap through imitation and reverse engineering, IPRs undermine their ability to truly 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

[36]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.

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 and the gatt/wto variable are lagged one period. First-stage regressions include all controls shown in Table 4. Instruments are lagged three periods. F-stat is the Angrist and Pischke version.

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.[37] 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 and BACI-CEPII. Measuring export discoveries requires a strict set of criteria to avoid the inclusion of temporary 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 BACI-COMTRADE data for the period 1980–2005, the available classification is SITC Rev 2, which allows for 1836 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 exceed temporarily 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

[37]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 suggests that diversification may be an important channel to understand the role of innovation and IPR in development, specially for middle-income countries.

4, but using "inside-the-frontier" innovation (discoveries) as the endogenous variable. We use the same instrumentation strategy to address the endogeneity of IPR. We focus the analysis on less developed countries, excluding, for each year in our sample, the highest quintile in terms of GDP per capita. The results are presented in Table 6. Fixed effects and time dummies are included in all specifications. For the sake of comparison we show in column (a) 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 3. 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.[38] 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 enforcement slows down innovation in developing countries because it makes it harder for them to close their initial technology gap.

Combined with the analysis in section 4, the results in Table 5 and Table 6 highlight the conflict between advanced and developing countries regarding universally strong IPR. Developing countries face a trade-off between the benefit of free-riding on advanced economies' innovations to develop their internal markets, and the cost it yields for them in

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

term of reduced export opportunities. As shown in section 4, they are compelled to protect IPRs when they rely heavily on exports, and they prefer to copy foreign technologies when their domestic market is relatively large. Finally, our results show that universally strong IPRs are not necessarily conducive to more innovation globally. Asymmetric enforcement of IPRs, stronger in developed countries and weaker in large developing countries, may be desirable from the perspective of both the welfare of developing countries 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. Consistent with the international balance of power, our empirical analysis shows that the strength of patent protection is a U-shaped function of the size of countries' domestic market relative to their export opportunities. Small developing countries are forced to adopt Western-style legislation, while large emerging countries are able to resist pressure from advanced economies.

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 IPRs. An interesting question for further research would be to study the enforcement of IPRs. 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) quantifies 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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Table 7: Appendix.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).

Appendix: additional tables

Table 8 presents some robustness checks. Column (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. Column (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 (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 $GDPpc$, GDP and $F.MKT$ 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.

Table 8: IPR Equation - Robustness Checks

	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)
GDPpc	–0.48		–0.61*		–0.25			
	(0.31)		(0.34)		(0.49)			
GDPpc^2	0.06***		0.07***		0.04			
	(0.02)		(0.02)		(0.03)			
GDP		–2.24***		–2.42***		–3.13***	–1.99	–2.07*
		(0.40)		(0.43)		(0.64)	(1.30)	(1.21)
GDP^2		0.05***		0.06***		0.07***	0.05*	0.05**
		(0.01)		(0.01)		(0.01)	(0.03)	(0.02)
F.MKT							2.91**	
							(1.24)	
F.MKT^2							–0.07**	
							(0.03)	
F.MKT-strong								2.56***
								(0.78)
F.MKT-strong^2								–0.06***
								(0.02)
freedom					0.67***	0.70***	0.59*	0.60*
					(0.24)	(0.22)	(0.31)	(0.31)
gatt/wto					0.29**	0.31***	0.43***	0.45***
					(0.13)	(0.12)	(0.15)	(0.16)
No. of obs	907	906	711	711	709	709	511	511
N. countries	118	118	79	79	112	112	112	112
Within R^2	0.74	0.75	0.77	0.78	0.75	0.76	0.71	0.71

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. 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.

Finally, columns (g) and (h) present the same regression as in Table 4 column (a) and (b), except that the GDP, $F.MKT$ and $F.MKT$-strong 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 importance of the total GDP and of the foreign market potential are confirmed, in particular when considering the size of markets of foreign countries strongly enforcing IPR ($F.MKT$-strong).

Table 9: IPR equation - Robustness Checks

	(a)	(b)	(c)	(d)
GDP	–2.14*	–2.26**	–2.07*	–2.09*
	(1.15)	(1.10)	(1.18)	(1.19)
GDP^2	0.05**	0.05**	0.05**	0.05**
	(0.02)	(0.02)	(0.02)	(0.02)
F.MKT-strong	2.36***		2.26**	2.69***
	(0.79)		(0.96)	(0.76)
F.MKT-strong^2	–0.06***		–0.06**	–0.06***
	(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)
freedom	0.56*	0.58*	0.57*	0.54*
	(0.31)	(0.31)	(0.31)	(0.31)
gatt/wto	0.41***	0.43***	0.41***	0.37**
	(0.16)	(0.16)	(0.15)	(0.15)
No. of obs	511	511	511	511
N. countries	112	112	112	112
Within R^2	0.72	0.71	0.72	0.72

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. GDP is in constant dollars.

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

Table 10: IPR Equation Further Robustness Checks

	(a)	(b)	(c)	(d)
GDPpc	1.23		0.52	
	(1.07)		(0.71)	
GDPpc^2	–0.06		–0.01	
	(0.07)		(0.04)	
GDP		–1.31		–1.58*
		(1.44)		(0.89)
GDP^2		0.04		0.03*
		(0.03)		(0.02)
freedom	0.36	0.45	0.48**	0.35
	(0.27)	(0.27)	(0.20)	(0.22)
gatt/wto	0.33**	0.36**	0.30**	0.41***
	(0.16)	(0.16)	(0.13)	(0.12)
No. of obs	511	511	511	511
N. countries	112	112	112	112
W. R^2	0.75	0.76	0.82	0.82

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. Regressions (a) to (d) include continent-time effects and regressions (e) to (h) include grouped-fixed effects using the method by Bonhomme and Manresa (2015). All variables describing the market size are lagged one period.

Table 10 presents additional robustness checks of the results presented in Table 3. We rerun 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 (a) and (b). This is a very strong test that comes at the cost of reducing considerably the variation to identify the impact of our variables of interest. Unsurprisingly, *GDPpc* and *GDP* are no longer significant, suggesting some role for unobserved heterogeneity in determining IPR adoption.

In column (c) and (d) we reproduce the results of (a) and (b) but this time using the method by Bonhomme and Manresa (2015) (as described i the main text to run the regressions in column (e) and (f) of Table 4). Overall, we confirm our results, although this time *GDP* and squared are sugnificant at the 10% level. Since we also control for

Table 11: Appendix. IPR equation - Robustness Checks

	(a)	(b)	(c)	(d)
GDP	–2.71**	–2.34**	–2.07*	–1.98*
	(1.11)	(1.04)	(1.16)	(1.09)
GDP^2	0.06***	0.05***	0.05**	0.05**
	(0.02)	(0.02)	(0.02)	(0.02)
F.MKT	3.49***		2.40*	
	(1.28)		(1.26)	
F.MKT^2	–0.07**		–0.06*	
	(0.03)		(0.03)	
F.MKT-strong		2.76***		2.30***
		(0.81)		(0.74)
F.MKT-strong^2		–0.06**		–0.05***
		(0.02)		(0.02)
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			–0.01	–0.02
			(0.10)	(0.10)
freedom	0.62**	0.62**	0.68**	0.70**
	(0.31)	(0.30)	(0.29)	(0.29)
gatt/wto	0.43***	0.44***	0.45***	0.46***
	(0.16)	(0.16)	(0.16)	(0.16)
No. of obs	493	493	503	503
N. countries	106	106	112	112
Within R^2	0.72	0.72	0.72	0.72

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. GDP is in constant dollars.

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.

In Table 11, we present the results of augmenting our benchmark IPR regressions (regressions (a) and (b) in Table 4) with the human capital variable used in the patent equations. We also explored a potential non-linear effect between education and our variables of interest. Regressions (a) and (b) reject any direct impact of educational levels on IPR enforcement and market-size variables remain significant. The next two regressions (c) and (d) 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. Although not significant, it shows some correlation with our $F.MKT$ and $F.MKT-strong$ variables. This is not surprising, since all this variables are reflecting the influence of international trade. Nevertheless, it has negligible effect for the coefficients, reflecting that taking into account the trade costs is crucial to explain the countries' strategies on IPR enforcement.

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 includes 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 the IPR enforcement variable. There is no effect of IPR enforcement when the dependent variable is either the number of non-resident patents or the total number of patents.

A last 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 three periods. The first instrument is significant and the coefficient for the instrumented IPR enforcement is

Table 12: Patents Negative binomial

Patent type	(Resid)	(Non-Resid)	(All)
	(a)	(b)	(c)
ipr	–0.35***	0.12	–0.01
	(0.08)	(0.07)	(0.06)
GDP	–3.79***	–4.51***	–4.72***
	(0.53)	(0.92)	(0.88)
GDP^2	0.09***	0.09***	0.10***
	(0.01)	(0.02)	(0.02)
F.MKT-strg	–0.44	4.00*	2.55
	(1.81)	(2.16)	(1.96)
F.MKT-$strg^2$	0.01	–0.12**	–0.08
	(0.05)	(0.06)	(0.05)
gatt/wto	0.20	0.04	0.31**
	(0.17)	(0.16)	(0.13)
freedom	0.27	–0.41	–0.04
	(0.33)	(0.28)	(0.27)
hcap	–2.25**	0.90	–0.31
	(0.97)	(0.81)	(0.79)
$hcap^2$	0.08*	–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. ***, ** 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.

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 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.

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[39]. 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 serious doubts of 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 enforcement affects negatively 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 temporal and spatially lagged. Alternatively, we propose a combination with a second instrument that

[39]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.

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.

Agence française
de développement
5, rue Roland Barthes
75012 Paris l France
www.afd.fr

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