Intellectual Property Enforcement, Exports and Productivity of Heterogeneous Firms in Developing Countries: Evidence from China

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Abstract

We study how provincial-level enforcement of intellectual property rights (IPRs) affects Chinese firms' decisions regarding exit, export, and the channels through which to receive technology transfer. Our findings provide insights into how variations in IPRs enforcement alter productivity. Our model combines the standard theory of heterogeneous firms with the endogenous choices of those firms concerning how they absorb international technologies. We show that, in this setting, the exit and export cutoff productivities differ from those in the standard environment, leading to a different sorting mechanism. We also predict that stronger IPRs change the decisions firms make concerning their mode of technology transfer, further altering their productivity and export possibilities. Empirical tests based on a comprehensive dataset of Chinese firms from 2000 to 2004 support the model predictions.

JEL Classification: D23, F13, F14, O34

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1. Introduction

Since 1995, many developing countries have reformed their laws governing patents and other forms of intellectual property rights (IPRs) to meet requirements of the World Trade Organization (WTO) or other trade agreements. The growing interest in IPRs is driven by their potential impact on trade and economic development, largely via their influence on technology transfer. Previous studies have found that IPRs reform in emerging economies tends to increase formal technology transfer through high-technology imports, licensing and foreign direct investment (Maskus, 2012).

In the process of joining the WTO in 2001, China strengthened its laws to comply with the minimum standards required by the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) at the WTO. These revisions substantially strengthened the national legal scope of various IPRs. For example, China's GP index, a well-known measure of the comprehensiveness of national patent laws, increased from 2.12 in 1995 to 4.08 in 2005 (Ginarte and Park, 1997; Park, 2008). There also were sweeping changes in the copyright and trademark statutes (Maskus, 2004).

Such extensive reforms should, in principle, have notable impacts on the operations of Chinese enterprises, though this notion has been little studied to date. One exception is Ang, et al (2014), who exploited the fact that, although China's IPRs laws apply to the whole country, the effectiveness with which they are enforced varies markedly across provinces and over time. The authors measured this variation over the years 2001-2005 in IPRs enforcement by the proportion of litigation cases won by IPRs owners in local courts. They found that this variable raised the willingness of Chinese firms to acquire external debts, and invest in R&D.

In this paper we extend this insight to the international trade context by translating it to a world of heterogeneous firms and endogenous technology transfer (TT). Firms of different sizes and productivities may respond differently to variations in local IPRs enforcement regarding international technology adoption. For example, larger and more productive Chinese firms, such as Lenovo and Huawei, mainly purchase capital imports and licensed technologies from foreign firms, relying on their in-house capacity to adapt them to particular needs. In contrast, smaller and less efficient Chinese firms focus more on the development of imitation capacity. These different

TT channels, selected by enterprises of varying ex-ante characteristics, may lead to further differences in ex-post productivities. Hence, an interesting question is how IPRs enforcement affects the choice of technology transfer mode, whether formal licensing agreements or uncompensated imitation. In turn, there should be detectable effects on exports, ex-post productivities, and the reallocation of market shares.

We study these issues by building a model of heterogeneous firms in which variations in patent enforcement affect critical cutoffs, including the mode of TT from abroad. The model also provides insight into how such enforcement drives productivity changes. Firm heterogeneity has been widely used to analyze trade liberalization effects. However, its role in the presence of variable IPRs enforcement has yet to be explored. We fill this gap by combining a standard theory of heterogeneous firms (Melitz, 2003) with the endogenous choices firms make to adopt international technologies. In this setting firms face different exit and export cutoff productivities than in the standard framework, leading to a richer sorting mechanism. Stronger patent protection changes some firms' decisions on TT channels, altering their productivities and export possibilities.

While straightforward, our model advances a number of testable predictions. First, stronger IPRs increase the exit cutoff, implying that less productive firms are more likely to shut down. Second, stronger enforcement also reduces the export cutoff, meaning that a margin of strictly domestic firms are more likely to start exporting. Third, more rigorous enforcement reduces the cutoff for formal technology transfer, which implies that more firms shift from informal learning (i.e., imitation) to market-based technology acquisition. Finally, this shift toward formal TT in locations with stronger IPRs enforcement leads to enhanced productivity gains. We carry out empirical tests using a rich dataset that captures Chinese firms' experience under different degrees of IPRs support, finding evidence in support of these predictions.

To implement our empirical tests, we mainly rely on a comprehensive dataset that matches Chinese firms' financial data to their trade transactions. The sample is for 2000-2006, covering the period when China joined the WTO and implemented major IPRs reforms, including increases in litigation. The dataset contains information that allows us to construct variables needed for our empirical tests, including key firm attributes and decisions regarding market entry, exit, and exporting. We also construct a measure of capital-goods imports as a proxy for formal technology transfer. To measure the IPRs environment, we follow Ang, et al (2014) and calculate, from

original data, the fraction of IPRs infringement cases won by the intellectual property owners in provincial courts over the period. To control for trade liberalization effects in this period, associated primarily with China's WTO accession, we construct industry-level import tariffs.

In the next section we briefly place our analysis into several strands of existing literature. In section 3 we develop the model and demonstrate its theoretical predictions regarding the impacts of stronger IPRs enforcement on cutoff productivities for exit, exporting, and purchasing technology from foreign firms. In section 4 we discuss the institutional background in China and our data sources. We test the model's predictions in section 5 and offer concluding remarks in section 6.

2. Prior Literature

This study is motivated by a number of empirical findings from the trade and innovation literature. First, there is considerable evidence that, at least among emerging and middle-income countries a significant reformulation and strengthening of patent laws is generally followed by increases in inward technology transfer through formal channels. These channels include imports of high-technology goods, as found by Ivus (2010) and Delgado, et al (2013), along with foreign direct investment and licensing, as shown by Smith (2001), Bilir (2010), Javorcik (2004), and Nagaoka (2004). A major study by Branstetter, et al (2006) found that licensing to affiliates of US multinationals, and local R&D expenditures, rose significantly after such reforms in 16 large developing economies. In a later paper, Branstetter, et al (2011) explored theoretically why the technological activities of local firms in reforming economies should expand after patent revisions. Their empirical analysis discovered evidence of increasing sales, employment, physical assets, and R&D, along with growth in the variety of exports. Indeed, significant export growth in high-technology goods after patent reforms in emerging economies was found in Maskus and Yang (2018).

While intriguing, this literature has not yet fully explained why such effects may emerge, or the channels through which that happens. We try to advance this understanding here by casting the problem in terms of heterogeneous firms that must overcome fixed costs of exporting and technology transfer. Specifically, this paper builds on the literature on technology transfer and the productivity of heterogeneous firms. The link between firm productivity and international trade is

well documented. This literature recognizes that individual firms are heterogeneous in important ways, which affects their decisions about engaging in international trade and FDI. It emphasizes the sorting pattern of heterogeneous firms and market share reallocation from lower-productivity to higher-productivity firms as sources of aggregate productivity gains from trade liberalization (Bernard and Jensen, 1999; Melitz, 2003; Bernard et al, 2007; Helpman et al, 2004). Most relevant for our work is the insightful paper by Bustos (2011), who showed that middle-productivity Argentinian exporting firms, facing reduced Brazilian tariffs after those countries joined the trade agreement MERCOSUR, chose endogenously to invest in technology upgrading. We argue here that countries strengthening their IPRs regime may offer similar tradeoffs to differentiated domestic enterprises, both in terms of exporting and acquiring international technology.

We also draw inspiration from the literature on the role of financial constraints in international trade and innovation. Rajan and Zingales (1998) found that in the presence of credit constraints, countries with more developed financial institutions enjoy comparative advantage in sectors with greater need for external financing. Manova (2013) showed that financial market imperfections have detrimental consequences for international trade, while Manova et al. (2015) demonstrated that credit-constrained firms have diminished export capacity. Marrying this logic to the literature showing that enforceable patents serve as a signal that attracts financing to otherwise credit-constrained firms (Conti et al, 2013), we argue that stronger IPRs protection can help enterprises overcome the fixed costs of both exporting their outputs and importing technology, expanding the extensive margins of trade.

Our paper adds to these literatures in the following novel aspects. First, to our knowledge it is the first to show how the strength of IPRs protection affects firms' choices of technology transfer and export status in the presence of firm heterogeneity. Second, it provides insight into the channels through which IPRs affect productivity gains, which may take place both between and within firms. Third, the paper is the first to establish a link between IPRs enforcement and credit constraints. Firms facing binding constraints may choose to acquire technology by imitation alone, whereas IPRs protection can induce them to shift into licensing. Most fundamentally, the study helps unpack the reasons behind the empirical regularities that patent reforms are often followed by increased imports of high-technology inputs and expansion of exports, at both the intensive and extensive margins.

3. Theoretical Framework

In this section we build on Melitz (2003) and Bustos (2011) to develop a simple model of firm-level choices in technology transfer channels and export. We consider the world that consists of a home country and a foreign country. It is useful to think of the home country as a developing nation in which firms receive foreign technology. As in Melitz (2003), each country consists of an industry in which firms produce differentiated products. Firms use labor to manufacture each product under increasing return to scale.

3.1 Demand

The preferences of a representative consumer are represented by the standard constant elasticity of substitution (CES) utility function:

$$U=[\int_0^M q(\omega)^{\rho} d\omega]^{\frac{1}{\rho}} \tag{1}$$

where M is the number of existing varieties, $q(\omega)$ denotes the quantity consumed of variety ω and $\sigma = \frac{1}{1-\rho}$ is the elasticity of substitution across varieties. Then consumer optimization yields the following demand for variety ω:

$$q(\omega) = EP^{\sigma-1}[p(\omega)]^{-\sigma}, \tag{2}$$

where $p(\omega)$ is the price of each variety, P is the price index of the industry, and E is the aggregate level of spending in the country.

3.2 Production and the Licensing-Imitation Tradeoff

The market structure is characterized by monopolistic competition. There is a continuum of firms, each producing a different variety ω using only labor. Firms are heterogeneous in their

productivity φ , which they draw from a known Pareto cumulative distribution function $G(\varphi)=1-\varphi^{-k}$, after paying a fixed entry cost. Note that parameter $k>1$.

After observing their productivity firms decide whether to exit or stay in the market. We assume that the innovation capacity of the developing country is sufficiently low that some form of technology transfer from foreign firms is the only channel through which firms can gain access to the necessary production technology. If firms remain in the market they choose the preferred channel of international TT. We assume there are two such avenues. First, firms may engage in formal technology transfer, which means purchasing the technology abroad by paying a licensing fee. Second, they instead may choose informal TT, which means imitating foreign firms' technology.

To capture this difference, let f denote the fixed cost of a surviving firm in the developing country under the imitation option. Notice that f captures the fixed costs of both production and imitation. This cost becomes $f\eta$ with $\eta>1$ under licensing.

As noted below, changes in IPRs enforcement will affect this choice, so such rights affect fixed costs through that mechanism. In addition, we postulate that protection of IPRs directly affects marginal production costs. Specifically, consider that imitation may be achieved through product inspection, reverse engineering, or simple trial and error. By increasing the breadth of patent protection, stronger IPRs narrow the scope for legal imitation, raising the cost of informally acquiring foreign technologies. Thus, let θ indicate the level of intellectual property protection in the developing country, where $\theta\in[0,1]$. Parameter θ is 0 when there is no enforcement and 1 when there is full enforcement, though we consider only the effects of marginal changes in the interior of this range. We model the marginal production cost of local firms to be $\frac{1}{\lambda(\theta)\varphi}$ under imitation. Thus, we have $\frac{\partial\lambda(\theta)}{\partial\theta}<0$.

Following Yang and Maskus (2009), we assume that codified knowledge (e.g., blueprints and formulas) is vulnerable to imitation, while tacit knowledge (e.g., know-how and information gained from experience) cannot be imitated. Hence, the marginal production cost under imitation is higher than that under licensing, because the latter process transfers both kinds of knowledge to the licensee. In this context, let $\frac{1}{=}$ denote the marginal cost under licensing and we have

$\lambda(a,\theta) < \bar{\lambda}$. To summarize, the tradeoff between these two different channels of technology acquisition is that firms choosing licensing pay a higher fixed cost but produce at lower marginal cost. Note also that the saving in marginal costs increases in the firm's productivity φ. In this setup, the productivity of each firm depends on both the original random draw and the channel of TT it chooses.

After firms make the latter choice, they decide whether to export or make only domestic sales. Following the typical approach, we assume that firms choosing to export incur iceberg trade costs, such that $\tau > 1$ units of a product need to be shipped for one unit to arrive in the foreign country.

Exporting firms also incur an additional fixed exporting cost $f_E(\theta)$. We posit that this cost is lower under stronger IPRs in the developing country, so that $\frac{df_E(\theta)}{d\theta} < 0$. This is a key assumption for our analysis and our justification is based on three observations. First, the abilities of firms to export, and therefore their costs, are affected by the strength of IPRs in their home country because the developed country may block imports from locations with weak protection. Specifically, products generated by imitation in the developing country could violate the patents owned by firms in the developed country. In turn, these rights holders are empowered by law to direct their government to bar such imitative imports (Yang and Maskus, 2009). Thus, when the developing country increases its IPRs protection the exports of its firms are less likely to be blocked.

A second factor is that the extent of IPRs protection in the developing country could affect the ability of firms to raise capital for meeting fixed export costs. Manova (2013) suggests that, relative to domestic firms, exporting firms face greater credit constraints because exporting involves additional marketing costs associated with product promotion, consumer identification, and development of distribution channels. Stronger IPRs imply that both firms engaged in legal reverse engineering and producing under a license have greater certainty about the scope of their rights, both at home and abroad. As a consequence, such firms are more likely to attract financing from credit providers.[1]

[1] This observation parallels recent empirical findings in the innovation literature that well-defined patent rights attract more risk capital (Conti, et al, 2013) and that stronger patent systems positively interact with financial

3.3 Equilibrium Sorting

After firms observe their random productivity draw, those remaining in the market make decisions about technology acquisition and exporting. They have four choices in total: imitating the technology of the foreign firms while only serving the domestic market; imitating the technology of the foreign firms while both selling domestically and exporting; purchasing technology from foreign firms while only serving the domestic market; and purchasing technology while selling in both the domestic and foreign markets. Profit expressions for each of these choices are listed next.

Denote by $\pi_M^D(\varphi)$ the profit of a firm with productivity φ choosing imitation while only serving the domestic market.

$$\pi_M^D(\varphi) = \frac{1}{\sigma} E(P\rho)^{\sigma-1}[\lambda(a,\theta)\varphi]^{\sigma-1} - f \ . \tag{3}$$

Let $\pi_L^D(\varphi)$ be the profit of a firm with productivity φ choosing licensing from foreign firms while only serving the domestic market.

$$\pi_L^D(\varphi) = \frac{1}{\sigma} E(P\rho)^{\sigma-1}(\bar{\lambda}\varphi)^{\sigma-1} - \eta f \ . \tag{4}$$

Following Melitz (2003) and Bustos (2011), we assume that the home country and the foreign country are identical in size and have symmetric trading costs. Therefore, E and P are assumed to the same in both locations. We take $\pi_M^E(\varphi)$ to be a firm's profit with productivity φ choosing imitation while serving both the domestic and foreign markets.

$$\pi_M^E(\varphi) = (1+\tau^{1-\sigma})\frac{1}{\sigma} E(P\rho)^{\sigma-1}[\lambda(\theta)\varphi]^{\sigma-1} - [f + f_E(\theta)]. \tag{5}$$

development in lower-income OECD economies (Maskus, et al, 2017).

Finally, let $\pi_L^E(\varphi)$ represent profit of a firm with productivity φ choosing licensing while serving both markets.

$$\pi_L^E(\varphi) = (1+\tau^{1-\sigma})\frac{1}{\sigma}E(P\rho)^{\sigma-1}(\bar{\lambda}\varphi)^{\sigma-1} - (\eta f + f_E(\theta)) \tag{6}$$

We now determine the various critical productivity cutoff levels that determine the activity choices of firms. Let $\underline{\varphi}$ represent the cutoff productivity below which a firm decides to exit the market after observing its productivity. We take φ_E to be the cutoff productivity above which an imitating firm finds exporting more profitable than solely domestic sales, determined by the condition $\pi_M^D(\varphi_E) = \pi_M^E(\varphi_E)$. Next, φ_L is the cutoff productivity above which a firm choosing to export finds it more profitable to purchase foreign technology than to imitate, given by the condition $\pi_M^E(\varphi_L) = \pi_L^E(\varphi_L)$.

Similar to Bustos (2011), we can prove that $\pi_L^E(\varphi) > \pi_L^D(\varphi)$ if $\pi_M^E(\varphi) > \pi_M^D(\varphi)$.[2] This implies that a firm purchasing technology will also choose to be an exporter if a firm undertaking imitation selects exporting. Note that a firm with productivity $\varphi > \varphi_E$ undertaking imitation will choose to export. Thus it can be inferred that a firm with $\varphi > \varphi_E$ will always choose export, regardless of its decision between licensing and imitation.

We can also prove that $\pi_L^D(\varphi) < \pi_M^D(\varphi)$ if $\pi_L^E(\varphi) < \pi_M^E(\varphi)$. This implies that if an exporting firm is more profitable under imitation than under licensing, it is also more profitable under imitation when it only serves the domestic market. Notice that φ_L is defined as the cutoff productivity below which an exporting firm is more profitable under imitation than under licensing. It follows that a firm with $\varphi < \varphi_L$ is also more profitable under imitation when only serving the domestic market. Hence, a firm with $\varphi < \varphi_L$ always imitates regardless of whether it enters the foreign market.

[2] See Appendix A for the detailed proof.

As $\underline{\varphi}$ represents the cutoff productivity below which a firm decides to exit the market after observing its productivity, we have $\pi_M^D(\underline{\varphi}) = 0$. Thus we have

$$\underline{\varphi}^{\sigma-1} = \frac{\sigma f}{E(P\rho)^{\sigma-1}\lambda(a,\theta)^{\sigma-1}}. \tag{7}$$

Next, because φ_E denotes the cutoff productivity above which a firm choosing imitation finds exporting more profitable, we have $\pi_M^D(\varphi_E) = \pi_M^E(\varphi_E)$. It follows that

$$\varphi_E^{\sigma-1} = \frac{\sigma f_E(\theta)}{\tau^{1-\sigma}E(P\rho)^{\sigma-1}\lambda(a,\theta)^{\sigma-1}}. \tag{8}$$

Further, because φ_L is the cutoff productivity above which a firm choosing exporting finds purchasing technology more profitable, we find that $\pi_M^E(\varphi_L) = \pi_L^E(\varphi_L)$. Then we have

$$\varphi_L^{\sigma-1} = \frac{\sigma(\eta-1)f}{(1+\tau^{1-\sigma})E(P\rho)^{\sigma-1}[\bar{\lambda}^{\sigma-1} - \lambda(a,\theta)^{\sigma-1}]}. \tag{9}$$

And, because $\pi_M^D(\varphi_E) = \pi_M^E(\varphi_E) \geq 0$ and $\pi_M^D(\underline{\varphi}) = 0$, it follows that $\underline{\varphi} < \varphi_E$.

In principle, we have two possible cases regarding the exporting and licensing cutoffs: $\varphi_E < \varphi_L$ and $\varphi_E > \varphi_L$. The latter case corresponds to the scenario where no exporters from developing countries undertake imitation, which is not consistent with actual behavior in the real world. Thus, we focus on the former case. In Figure 1 we depict the profits of firms with productivity φ defined over the relevant range, where the horizontal axis represents $\varphi^{\sigma-1}$ and the vertical axis represents a firm's profits. The upward-sloping lines depict profits under different configurations of imitation versus licensing and exporting versus domestic sales. Note that the possibility of licensing and purely domestic sales, given by $\pi_L^D(\varphi)$,does not appear as a potential equilibrium.

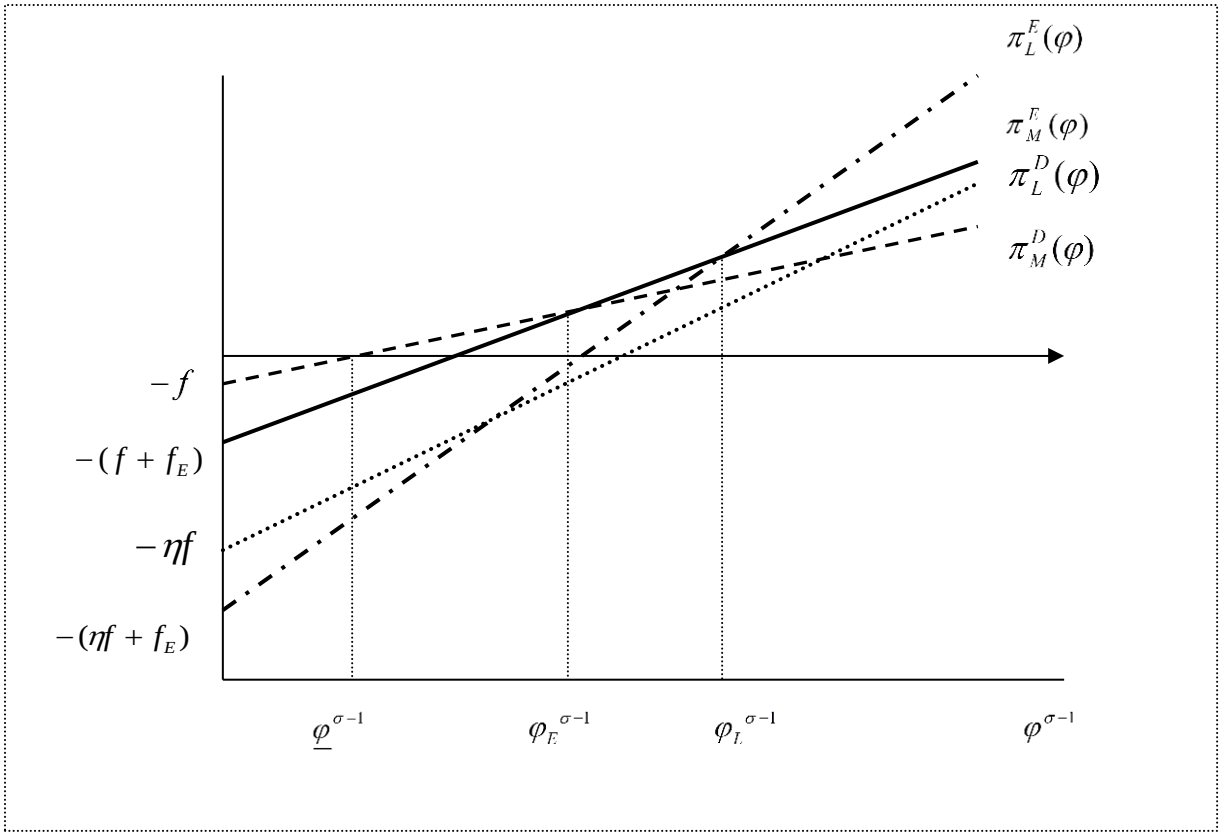

Figure 1. Profits under Different Regimes before Patent Reform

The sorting pattern in Figure 1 can be summarized in Proposition 1:

Proposition 1. In equilibrium firms may be sorted into four groups. The least productive firms ($\varphi < \underline{\varphi}$) exit; the low-productivity firms ($\underline{\varphi} < \varphi < \varphi_E$) choose imitation and only serve the domestic market; the medium-productivity firms ($\varphi_E < \varphi < \varphi_L$) imitate and sell at home but also export; and the most productive firms ($\varphi > \varphi_L$) purchase technology from foreign firms and serve both the domestic and foreign markets.

3.4 The Impact of IPRs Enforcement

In this section we study the effect of a stronger IPRs regime, which we will capture empirically by interprovincial variations in judicial enforcement, on the cutoff productivities for exiting, exporting, and purchasing foreign technology.

From equation (7), we have $\underline{\varphi}^{\sigma-1} = \frac{\sigma f}{E(P\rho)^{\sigma-1}\lambda(a,\theta)^{\sigma-1}}$. It can be shown that

$$\frac{\partial \underline{\varphi}^{\sigma-1}}{\partial \theta} = -(\sigma-1)\frac{\sigma f}{E(P\rho)^{\sigma-1}}\lambda(a,\theta)^{-\sigma}\frac{\partial \lambda(a,\theta)}{\partial \theta} > 0. \quad (10)$$

Therefore, the exit cutoff increases under strengthened IPRs, implying that more firms with relatively low productivity choose to exit. The reason is that the increase in imitation costs makes the firms at this margin uncompetitive.

From equation (8), we have $\varphi_E^{\sigma-1} = \frac{\sigma f_E(\theta)}{\tau^{1-\sigma}E(P\rho)^{\sigma-1}\lambda(a,\theta)^{\sigma-1}}$. It can be shown that

$\frac{\partial \varphi_E^{\sigma-1}}{\partial \theta} = \frac{\sigma}{\tau^{1-\sigma}E(P\rho)^{\sigma-1}\lambda(a,\theta)^{2\sigma-2}}[\frac{df_E(\theta)}{d\theta}\lambda(a,\theta)^{\sigma-1} - f_E(\theta)(\sigma-1)\lambda(a,\theta)^{\sigma}\frac{\partial \lambda(a,\theta)}{\partial \theta}]$. As $\frac{df_E(\theta)}{d\theta} < 0$ and $\frac{\partial \lambda(a,\theta)}{\partial \theta} < 0$, we have

$$\frac{\partial \varphi_E^{\sigma-1}}{\partial \theta} < 0 \text{ if } \frac{df_E(\theta)}{d\theta}\lambda(a,\theta)^{\sigma-1} - f_E(\theta)(\sigma-1)\lambda(a,\theta)^{\sigma}\frac{\partial \lambda(a,\theta)}{\partial \theta} < 0. \quad (11)$$

This implies that the exporting cutoff productivity will be lower under strengthened IPRs if the impact on facilitating exports is larger than that on reducing the benefit from imitation. In the first case, the margin of exporters expands, which is consistent with empirical findings discussed earlier.

From equation (9) we have $\varphi_L^{\sigma-1} = \frac{\sigma(\eta-1)f}{(1+\tau^{1-\sigma})E(P\rho)^{\sigma-1}[\bar{\lambda}^{\sigma-1} - \lambda(a,\theta)^{\sigma-1}]}$. Therefore, we have

$\frac{\partial \varphi_L^{\sigma-1}}{\partial \theta} = \frac{\sigma(\eta-1)(\sigma-1)f}{(1+\tau^{1-\sigma})E(P\rho)^{\sigma-1}[\bar{\lambda}^{\sigma-1} - \lambda(a,\theta)^{\sigma-1}]^2}\lambda(a,\theta)^{\sigma-2}\frac{\partial \lambda(a,\theta)}{\partial \theta}$. As $\frac{\partial \lambda(a,\theta)}{\partial \theta} < 0$, we have

$$\frac{\partial \varphi_L^{\sigma-1}}{\partial \theta} < 0 . \qquad (12)$$

Thus, the cutoff productivity for licensing from foreign firms will be lower under more rigorous enforcement of intellectual property rights. In consequence, more firms in this high-productivity margin choose to purchase the rights to use foreign technologies, again consistent with the empirical findings discussed earlier.

Let $\underline{\varphi}'$, φ_E' and φ_L' represent the new cutoff productivities for entry, exporting and licensing, respectively. From the analysis above it follows that $(\underline{\varphi}')^{\sigma-1} > \underline{\varphi}^{\sigma-1}$, $(\varphi_E')^{\sigma-1} < \varphi_E{}^{\sigma-1}$ and $(\varphi_L')^{\sigma-1} < \varphi_L{}^{\sigma-1}$, as depicted in Figure 2. In this diagram we use 2000 to refer to the period prior to such strengthening and 2004 to the period after. Thus, the theory demonstrates that, other things equal, an increase in rights enforcement should generate more exit of low-productivity firms, while expanding the range of exporters and inducing more licensing among high-productivity enterprises. Hence, we have the following proposition about the impact of IPRs reform:

Proposition 2. An exogenous increase in IPRs protection will have the following market effects. It increases the exit cutoff productivity, lowers the exporting cutoff productivity if $\frac{df_E(\theta)}{d\theta}\lambda(a,\theta)^{\sigma-1} - f_E(\theta)(\sigma-1)\lambda(a,\theta)^{\sigma}\frac{\partial\lambda(a,\theta)}{\partial\theta} < 0$, and reduces the cutoff productivity for purchasing technology from foreign firms.

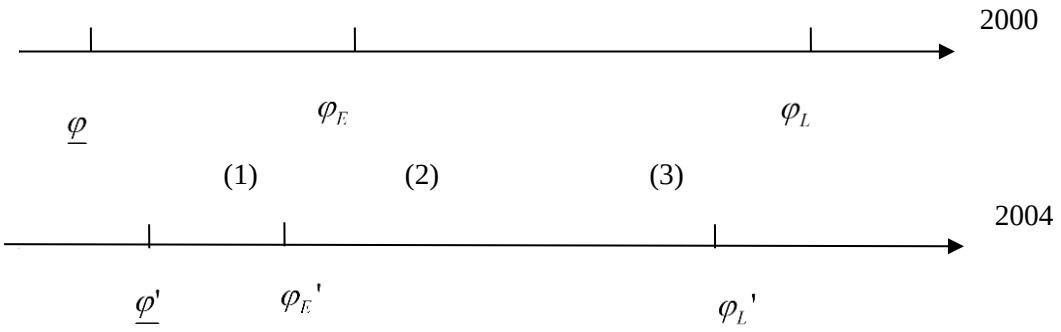

Figure 2. Effects of More Rigorous IPRs Enforcement

4. Institutional Background and Data

In this section we discuss the evolution of Chinese IPRs policy in recent decades and the situation regarding litigation of IPRs cases across the country's provinces. Following that we present data sources and the construction of variables for the analysis.

4.1 China's IPRs and a Proxy for IPRs Enforcement

China has a short history with IPRs. It started to establish patent laws in 1984 mainly to facilitate diffusion of new technologies through narrow claims, utility models and design patents (Liang and Xue, 2010). These patent laws were later revised, in 1992, partially to comply with a memorandum of understanding with Washington, which extended the length of patents to 20 years and covered foods and pharmaceutical products (Maskus, 2012). In preparation for joining the WTO in 2001, China engineered a strengthening of patent laws. For example, a major revision in 2000 substantially strengthened the country's patent eligibility, breadth, and judicial procedures). In this period the country also focused on improving administrative and judicial standards and procedures to comply with the TRIPS rules, which had mandated significant policy changes (Maskus, 2012).

The strength of a country's IPRs regime depends on both its legal provisions and the rigor of its enforcement.[3] China significantly upgraded its legal framework for protecting patents, as reflected in the well-known Ginarte-Park (GP) index, which measures the components of patent laws across countries (Ginarte and Park, 1997). China's GP index rose from 2.12 in 1995 to 3.09 in 2000, 4.08 in 2005, and 4.21 in 2010. Using the GP index of the United States, which remained at 4.88 from 1995 through 2010, as a benchmark, China's legal reforms converged considerably on those of major advanced countries and now markedly exceeds that of most middle-income emerging nations.[4]

The rigor with which countries enforce their IPRs, whether through seizures of counterfeit products, raids of illicit enterprises, the extent of fines or criminal penalties, or access to courts and the frequency of litigation, has not been indexed comparably. Some recent studies have taken, as a proxy for enforcement, components of the Fraser Institute's various indexes of legal systems and property rights because they account for the general efficacy of administrative and judicial enforcement mechanisms (Hu and Png, 2013; Maskus and Yang, 2018). As used by these authors, the index, which ranges in principle from zero to ten, is based on three aspects of protection: legal security from confiscation of property rights, viability of contracts, and rule of law.[5] The index value for China was 5.5 in 1995, changed 4.9 in 2000, 5.8 in 2005, and 6.2 in 2010. Comparable figures for the United States were 8.8 in 1995 and 9.2 in 2000, though these fell to 7.5 in 2005 and 7.3 in 2010. On this basis, the system of property rights and contracts, one proxy for IPRs enforcement, remains relatively weak in China.[6]

Despite this national weakness, there are important inter-provincial differences that offer scope for analysis. Specifically, although national laws and regulations apply to the whole country, the administrative and judicial enforcement of the IPRs laws is quite different across provinces, as discussed initially by Mertha (2005). Several complex factors contribute to these differences in local enforcement efforts. First, provinces vary widely in their economic characteristics, including

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[3] Note that strength is not necessarily an indicator of optimality in welfare terms.
[4] See also Bhattasali, et al (2004).
[5] These components are compiled from surveys of international business executives published in the *International Country Risk Guide*.

[6] Joyce (2009) offers a broader discussion.

per-capita income, technological orientation of industry and the labor force, and registration of patents and trademarks by local enterprises (Maskus, 2012). Richer provinces and regions, such as Beijing and Shanghai, invest relatively greater amounts in enforcement activities. Next, provinces lie at different geographical and cultural distances from the central government, with more remote locations less likely to support IPRs effectively.[7] Third, provinces had different historical experiences regarding the origins of colonial rule, a factor that persists in trade and investment patterns (Feenstra et al, 2013). Finally, local officials often have different attitudes towards the importance of enforcing national legislation and administrative priorities (Wang et al, 2014).

As described by Ang, et al (2014), one measure of this cross-province variation in enforcement is the relative success of intellectual property owners in enforcing their rights through local courts. We follow those authors and construct the fraction of IP infringement cases won by rights owners in provincial courts between 2000 and 2004. This variable directly measures the probability of IP owners' winning a court case and is, therefore, a good proxy for enforcement of such rights across provinces over the period. We compute this measure of the "win rate" based on data collected from the China PKULAW judicial database.[8] In our sample the win rate in 2000 is defined as the number of IP cases won in 1999 and 2000, divided by the total number of such lawsuits in these two years, for each province or special district. Similarly, the win rate in 2004 is defined as the number of judgments awarded to rights holders between 2001 and 2004, divided by the total number of such cases over these four years. Note that this variable captures the IPRs environment for different regions corresponding to the situation before and after the major revision in national IPRs laws in 2000 (Maskus, 2012). We therefore have these measures defined for two separate years sandwiching the reform date.

Our intention is to use these variables to explain inter-provincial variations in firm-level trade performance. An obvious difficulty is that win rates may be endogenous to the export and import decisions of Chinese enterprises. As noted earlier, higher-income provinces tend to see

[7] The venerable Chinese proverb "the mountains are high and the emperor is far away" continues to hold water in China, in that locations further from Beijing and Shanghai tend to pursue less rigorous contract enforcement, perhaps to favor local interests. See also Mertha (2005).

[8] See http://www.pkulaw.cn/case.

more IP litigation because domestic firms and affiliates of international enterprises generate more intellectual property to protect, which may be particularly the case for firms engaged in international trade. There may also be provincial-level omitted variables that correlate both with international trade and litigation success.

We thus follow Feenstra et al. (2013), Lu, et al, (2013), and Fang and Zhao (2007) in using two variables to instrument for the IP cases win rate.[9] The first instrument is the origin country of formal colonial rule in each province. These origins may have been, for example, Great Britain, France, Russia, or several countries. Note that each colonizer implemented its own legal traditions in specific provinces, while groups of colonizers mixed these traditions, generating a mélange of legal forms across provinces. To capture colonial management, we construct several dummy variables indicating each possibility. For example, the Great Britain indicator takes the value 1 if a province is a former British colony and 0 otherwise. The benchmark case, involving no indicator variable, comprises the group of provinces that were never colonized. The second instrument is the enrollment rates (students per 100,000 persons) in Christian missionary lower primary schools in 1919. As suggested by previous authors, we expect that the formal origins of colonial rule, and the extent of enrollment in Christian schools, helped form the local cultures regarding respect for law and order and attitudes toward misappropriation of property rights. These instruments, which in prior studies seem to have persistent effects on institutional quality, are likely correlated with the current inter-provincial environments for IPRs enforcement, while not necessarily correlated with current trade and investment patterns.

The construction of these two instrumental variables is discussed in the Appendix (not yet written). Further, Appendix Table B1 reports summary statistics for the win rates of IPRs cases.

4.2 Trade Liberalization in China

The period we analyze, 2000 to 2004, saw both significant legal national reforms in IPRs and tariff liberalization, the latter spearheaded by China's WTO accession in 2001. Clearly, tariff

[9] Feenstra, et al (2013) used these instruments to analyze export patterns at the provincial level, distinguishing between contract-intensive trade and other goods. Lu, et al (2013) introduced usage of the provincial colonial origins in their study of firm-level productivity across Chinese cities, while Fang and Zhao (2007) used the enrollment figures as the instrument in their analysis of cross-city income levels. Our study is the first to consider firm-level export performance across locations in China.

cuts bear considerable potential to affect both trade performance and technology acquisition by Chinese enterprises. Regarding the latter, Amiti and Konings (2007), Goldberg et al. (2010), and Bas and Strauss-Kahn (2015), emphasize that import tariff reduction allows firms to have better access to cheaper and higher-quality foreign inputs, including capital goods and high-technology products, in turn supporting production of higher quality products for export.

Thus, it is important to control for changes in trade policy, which we do in some regression specifications, to separate the impact of IPRs reform from that of trade liberalization. To summarize its commitments in the WTO accession, China agreed to lower its average tariff levels on industrial products to 8.9 percent and to eliminate all quotas, licenses, tendering requirements and other non-tariff barriers to imports of manufactured goods by 2005. The motivation to join the WTO was not only to integrate further into the global economic system, but also to advance the domestic reform agenda and speed the country's transition into a market economy. Among the directly trade-related policies implemented during this period, import tariff reduction played the central role.

To build an appropriate control, we construct a measure of industry-level import tariffs, applied to 2000 and 2004, respectively. This variable captures the impacts of tariff cuts during this period of IPRs reform. We compute industry-level tariffs as simple average rates, built up from the 8-digit level to the 4-digit industry classification. Specifically, $\tau_{it} = \sum_{g=1}^{G_i} \tau_{gt} / G_i$, where τ_{gt} is the applied MFN tariff rate at the 8-digit HS level in year *t* (2000 or 2004) and G_i is the number of 8-digit HS products in 4-dight CIC (Chinese Industry Classification) industry *i*. Tariff rates are taken from the Chinese customs office and we assigned them to CIC industries using a firm-level matching process mentioned in the next section. Note that these are industry-level computations and do not vary across provinces.

Appendix B2 (not yet included) reports summary statistics of the industry-level tariffs for 2000 and 2004. Also drawn there is a time-series graph of aggregate tariffs between 2000 and 2006 (not done as yet).

4.3 Firm-Level Data

To test the model predictions about firms' behaviors under different levels of IPRs strength, we construct variables capturing enterprise-level attributes and decisions based on a matched firm-trade dataset used in Ge, et al, (2015). This dataset comes from two sources. The first is the

disaggregated trade transaction data at the 8-digit HS level from Chinese Customs. It covers monthly import and export of all Chinese trading firms for 2000-2006. The variables include trade type (e.g., processing trade or ordinary trade), value, quantity, and contact information for firms (e.g., company name, telephone, zip code, and contact person).

The second source is the National Bureau of Statistics Enterprise Dataset for 1998-2007. The National Bureau of Statistics of China (NBS) obtains annual reports from all state enterprises and large- and medium-sized non-state enterprises (with sales above 5 million RMB) in the manufacturing sector for all the covered years. However, 2004 is an exceptional year in which NBS conducted a census, so information for all firms including small non-state enterprises with sales below 5 million RMB is also available. The annual reports contain information on financial statements and nonfinancial variables, such as contact information, age, location, industry, ownership structure and main products of the enterprises. Ge, et al, (2015) matched the Customs trade transactions with the NBS firm data based on carefully matching the firm contact information. We construct from this dataset key firm attributes for our analysis, including establishment year, total factor productivity (TFP), capital intensity, employment, sales, total assets, wages, and development of new products.

The firm-level response variables in our analysis include entry, exit, and volume decisions related to operating, exporting, and capital goods importing. These variables will be further described, along with regression specifications, in the next section. Firm-level attributes in 2000 and 2004 capture the status of firms regarding various decisions made under different IPRs and trade environments for these two years. Note that while 2000 is the first year when our matched dataset was available, a practical consideration in choosing 2004as the ending year for our study is to explore the fuller information available in the census year. Because the 2004 database covers all manufacturing firms, it is the only year in which a firm's exit or continued exporting and or importing status after the 2000 IPRs revisions, taken to comply with TRIPS, may be completely captured. [10]

[10] A non-state enterprise operating in 2000 can be taken as an example. If it continued to operate but with revenue falling below 5 million RMB in later years, only its 2004 status can be precisely tracked because only then are all firms included in the census. For other years, we cannot distinguish whether the firm has exited or is still operating with revenue below the survey threshold.

Our measure of formal technology transfer, as opposed to imitation, will be firm-level imports of capital goods. Such goods are often assumed to support international knowledge spillovers (Grossman and Helpman, 1991). Further, international trade in capital goods is an important form of transferring embodied technology from one country to another (Hoekman et al, 2005). Xu and Wang (1999) found that capital goods have higher content of technology than non-capital goods and hence are the major source of R&D spillovers embodied in trade flows. Eaton and Kortum (2001) and Blyde (2003) showed that capital goods imports may be used as a sound proxy for formal channel of technology transfer from technologically more advanced countries. Acharya and Keller (2009) demonstrated that there could be learning effect generated from imports of capital goods and found evidence of productivity spillovers through such imports.

Appendix B3 reports summary statistics of firm-level attributes by ownership, for 2000 and 2004, respectively (not done as yet).

5. Empirical Analysis

In this section we test the predictions of the model developed in Section 3, using the microeconomic data sets described above. The analysis comes in three parts. First, we consider basic propositions about productivity cutoffs, using cross-sectional firm-level data in separate regressions for 2000 and 2004, without reference to trade decisions. This is essentially a descriptive exercise to discover if the data support the basic model. Second, we exploit changes over this period in the inter-provincial IPRs litigation win rates to isolate the impacts of different levels of enforcement on the productivity cutoffs, in turn determining the extensive-margin effects. Third, we analyze impacts of IPRs enforcement on the intensive-margin volumes of imports, exports, and capital-goods imports, accounting for endogeneity of patent protection.

5.1 Firm Performance and Exporting Status

Proposition 1 predicts that in equilibrium exporters have higher productivity than non-exporters. This suggests that a continued exporter is more productive than a discontinued exporter,

which in turn has a higher productivity than a non-exporter.[11] Using different firm-level performance measures (TFP, capital intensity, wages, and size) as proxies for productivity, a firm's relative performance under different IPRs regimes can be tested using the following specification:

$$y_{fipt'} = \theta_0 + \theta_1 CE_{fipt'} + \theta_2 DE_{fipt'} + Z_{fipt'}\gamma + FE_{ip} + \varepsilon_{fipt'} \quad (13)$$

for $t' = 2000$ and 2004 respectively. Variable $y_{fipt'}$ represents firm *f*'s performance measures in industry *i* located in province *p*. Variables *CE* and *DE* are the continued-exporter dummy and the discontinued-exporter dummy, where non-exporter (in both 2000 and 2004) is used as the benchmark. Vector Z denotes a series of firm attributes, such as age and ownership, while FE_{ip} represents industry-province fixed effects. Finally, $\varepsilon_{fipt'}$ is the error term. Our model predicts that $\theta_1 > \theta_2 > 0$, that is, that the productivity of continued exporters exceeds that of discontinued exporters, which is higher than that of non-exporters. We estimate (13) for $t' = 2000$ and 2004 separately.

Proposition 1 also predicts that an exporter that also imports capital goods is more productive than an exporter that does not import capital goods, which in turn is more productive than a non-exporter (who is also a non-capital goods importer). Accordingly, this prediction can be tested using a specification similar to equation (13):

$$y_{fipt'} = \alpha_0 + \alpha_1 EI_{fipt'} + \alpha_2 ENI_{fipt'} + Z_{fipt'}\gamma + FE_{ip} + \varepsilon_{fipt'} \quad (14)$$

where *EI* is a dummy for firms that both export and import capital goods, *ENI* selects firms that export but do not import capital goods, and where the group of non-exporters is used as the benchmark. Our model predicts that $\alpha_1 > \alpha_2 > 0$. We also estimate (14) for $t' = 2000$ and 2004 separately.

Since we control for firm attributes, such as age and ownership, and include industry-province fixed effects in (13) and (14), we are comparing performance among firms of the same age, operating under the same ownership structure, within the same industry and headquartered in

[11] A continued exporter is a firm that exports both before and after the IPRs reform (i.e., in both years), a discontinued exporter is a firm that exports before the reform but exits the export market afterward (i.e., it exported in 2000 but not in 2004), and a non-exporter is a firm that does not export in both periods.

the same province. Table 1 reports regression results for equation (13), estimated with ordinary least squares.[12] We see that in both 2000 and 2004, continued exporters are more productive, more capital intensive, pay higher wages, and are larger (in terms of worker forces, sales, and assets) than discontinued exporters. The latter, in turn, have higher performance measures than non-exporters. Recall that the NBS dataset reports information on new products issued in year 2000 but not in 2004. The final column of the first part shows that this performance measure demonstrates a similar hierarchy pattern.

It is also notable that foreign firms have better overall performance measures than firms controlled by investors from Hong Kong, Macau, and Taiwan, which in turn have superior performance than Chinese domestic firms. However, foreign firms and firms owned by Hong Kong-Macau-Taiwan interests produce fewer new products in comparison with Chinese domestic firms. This is consistent with the findings in Ge, et al, (2015) that these internationally owned firms tend to conduct their R&D and new product development in their headquarter countries and thus produce relatively fewer new products in their affiliates in China.

Similarly, Table 2 reports the performance measures of firms that both export and import capital goods relative to firms that export only and firms that do neither for the years 2000 and 2004. The hierarchy patterns are similar to those in Table 1. Firms that both export and import capital goods perform better than firms that only export, which in turn perform better than firms doing neither. These rankings support our model prediction that the highest-productivity firms will select into both exporting and formal technology transfer. However, these cross-sectional regressions do not directly link firms' performance indicators with our measure of IPRs protection, the litigation win rates. We turn to that question next, by linking activities to changes in provincial-level enforcement.

5.2 Extensive Margins of Exporting and Capital Goods Importing

More direct connections between firms' performance and IPRs enforcement are predicted by Proposition 2. Specifically, it demonstrates that improved IPRs protection increases the exit cutoff productivity but lowers the cutoff productivities of both exporting and purchasing

[12] The regressions in this sub-section and the next do not involve trade volumes as dependent variables and so we do not use the instrument variables.

technology abroad, as depicted above. Referring back to Figure 2, we translate its results into the following empirical hypotheses. First, firms with productivities in the range $\underline{\varphi} < \varphi < \underline{\varphi}'$ operate in 2000 but exit by 2004. Thus, among all firms operating in the earlier year, those located in provinces with the greater increases in IPRs protection are more likely to exit. Second, operating firms with productivities in the range $\varphi_E' < \varphi < \varphi_E$ do not export in 2000 but become exporters in 2004. Thus, among all operating non-exporters in 2000, those located in provinces with the most improved protection over the period are more likely to become exporters. Third, firms with productivities in the range $\varphi_L' < \varphi < \varphi_L$ do not buy foreign technology through the formal channel in 2000 but choose to do so in 2004. Again, we use firm-level capital goods imports as a proxy for formally buying foreign technology. It follows that among all non-capital goods importers in 2000, those located in provinces with the larger increases in the rigor of IPRs protection are more likely to begin importing such machinery. These are testable predictions about changes in various extensive margins of activity by Chinese firms over the period.

Recall that our basic measure of enforcement is the computed fraction of IP infringement cases won by rights holders in provincial courts, with these win rates instrumented in the first stage by colonial origins and primary enrollments. To capture relative increases in enforcement we use changes between 2000 and 2004 in these win rates in each province.

Moreover, because China engaged in significant trade liberalization in this period, there are two basic reforms at play, both of which affect firms' decisions. Thus, it is important to control for the impact of tariff cuts to isolate the impact of patent enforcement in the regressions. We use changes in industry-level tariffs between 2000 and 2004 for this purpose, along with the other firm-level controls.

We thus have the following estimation specification to test the model, using linear probability models on dichotomous dependent variables:

$$x_{fip\_\Delta t} = \beta_0 + \beta_1 \Delta IPR_p + \beta_2 \Delta TARIFF_i + Z_{fip\_t_0}\gamma + \varepsilon_{fip} \tag{15}$$

Variables $x_{fip\_\Delta t}$ represent binary choices corresponding to the three predictions: (1) whether a

firm operating in 2000 chooses to exit in 2004; (2) whether a non-exporter in 2000 becomes an exporter in 2004; and (3) whether a non-capital goods importer in 2000 becomes a capital goods importer. Note that Δt in the subscript of $x_{fip\_\Delta t}$ represents the time span from 2000 to 2004. Variable ΔIPR_p is the change in the strength of IPRs protection (win rates) in province *p* over this period, while $\Delta TARIFF_i$ is the change of import tariffs in industry *i*. Finally, $Z_{fip\_t_0}$ is a vector that captures the initial firm attributes, including year 2000 productivity, age, and ownership status. Our model predicts that $\beta_1 > 0$ for all the three regressions.

While import tariff reductions capture a major WTO accession measure, the liberalization of non-tariff barriers and implementation of other trade-promoting policies also affect firms' decisions and are potentially correlated with tariff cuts. Omitting these factors in the regression may bias the estimation of (15). We thus modify specification (15) by controlling for industry fixed effects:

$$x_{fip\_\Delta t} = \beta_0 + \beta_1 \Delta IPR_p + Z_{fip\_t_0}\gamma + FE_i + \varepsilon_{fip} \qquad (15)'$$

Here, variable FE_i represents the industry fixed effects that absorb all industry-level policy impacts from 2000 to 2004, including from tariff cuts.

Table 3 reports the linear probability regression results of specifications (15) and (15)'. Panel A reports the probability that a firm operating in 2000 exits by 2004. Without controlling for the industry fixed effects, columns (1) and (2) suggest that the improvement of IPRs protection, measured by the increase in the win rate of the province where a firm is located, raises the probability of the firm failing and exiting in 2004. The tariff results in column (2) suggest that greater exposure to imports through tariff cuts increases the probability of exiting, capturing the enhanced competition effect. Younger firms and firms with lower initial productivity are more likely to fail and exit, consistent with prior expectations.

Columns (3) and (4) report results of the specification (15)', controlling for industry fixed effects. The coefficient corresponding to changes in the IP cases win rate remains highly significant and similar to those of columns (1) and (2). Overall, the findings suggest that a one-

point increase in the average win rate raises the probability of exiting by between three and six percent.

Panel B of Table 3 reports the results for cases in which a non-exporter in 2000 begins to export in 2004. The coefficients related to the changes of IP win rates are positive and consistent across specifications, suggesting that originally did not export is more likely to become an exporter under strengthened enforcement. Quantitatively, a marginal rise in the win rate increases the extensive-margin probability of exporting by between 1.5 and 3 percent. The consistently positive and significant coefficients on IPRs litigation also suggest that the coefficient on tariff changes in column (2) is well identified. The negative coefficient indicates that tariff reduction induces some initially non-exporters to start exporting at this extensive margin. This finding is consistent with the positive export-import linkage of Amiti and Konings (2007), Goldberg et al. (2010), and Bas and Strauss-Kahn (2015). Finally, note that younger firms and firms with higher initial productivity are more likely to start exporting.

Panel C of Table 3 reports the regressions examining whether non-capital goods importers in 2000 begin importing such inputs by 2004. The positive and significant coefficient in column (2) suggests that a marginal increase in win rates raises the probability of capital importation by close to one percent, again a notable extensive-margin impact. However, this significance disappears in the fixed effects regression in column (4), implying that more rigorous IPRs protection may not affect the margin of capital inputs. One possible explanation is that with improved IPRs protection firms turn more to investing in their own R&D and innovation activities, with little effect on the purchase of foreign technologies, a factor we cannot test here. The negative coefficient on tariff changes in column (2) is marginally significant but suggests that tariff cuts on own-industry outputs encourage firms to start importing capital goods. It should be noted that capital-goods imports were duty free before the WTO accession, so there was no direct stimulation on that end and the output-tariff result should be interpreted with caution. Consistent with our expectations, initially more productive firms were more likely to start importing capital goods in 2004.

In summary, Table 3 presents evidence largely consistent with our model predictions: improved IPRs protection at the province level increases both the exit probability of initially producing firms and the probability that a firm that was not exporting entered the international

market. On the other hand, we do not find strong evidence that improved IPRs protection raises the probability that a firm that was not initially importing machinery would shift toward such imports.

5.3 Intensive Margins of Exporting and Capital Goods Importing

Improved IPRs protection also affects the trade volumes of firms that continue to exporters and firms that continue to import capital inputs. As suggested in Melitz (2003), trade liberalization induces changes in cutoff productivities, leading to reallocations of market shares in favor of the more productive firms, which remain in the exporting markets. Similarly, more rigorous IPRs protection induces changes in cutoff productivities and reallocates market shares to firms continuing to trade. Thus, we have the following specification for firm-level volumes of exports and capital goods imports, pooling across both years:

$$v_{fipt} = \phi_0 + \phi_1 IPR_{pt} + \phi_2 TARIFF_{it} + Z_{fipt}\gamma + \varepsilon_{fipt} \tag{16}$$

where v_{fipt} represents either the log export volume or the log capital goods import volume for a firm *f* operating in industry *i* located in province *p* in year *t*. Variable IPR_{pt} captures the strength of IPRs protection of a province in each year, while $TARIFF_{it}$ captures the industry-level tariff rate.. Again, vector Z_{fipt} captures firm attributes. We again take t=2000 and 2004 to capture the IPRs environment both before and after changes in litigation rates. This specification identifies the average intensive-margin impact of provincial-level IPRs improvement between these two years, controlling for the variation in industry-level tariffs and firm-level attributes. To control for other policy changes that may correlate with both IPRs environment and import tariffs, e.g., non-tariff barriers and macroeconomic conditions, we modify specification (16) by adding industry fixed effects FE_i and time fixed effects FE_t :

$$V_{fipt} = \phi_0 + \phi_1 IPR_{pt} + \phi_2 TARIFF_{it} + Z_{fipt}\gamma + FE_i + FE_t + \varepsilon_{fip} \tag{16}'$$

As discussed earlier, it is important in regressions explaining trade volumes to control for the potential endogeneity of IP cases win rates to trade. For this purpose, we use two instruments defined earlier: the origins of former colonial rule by province and the enrollment rates in Christian

missionary lower primary schools in 1919. Again, we expect these clearly pre-determined variables to condition local cultures regarding attitudes toward law and order, which may still significantly affect IPRs enforcement environment via contract litigation in courts. At the same time, because of dramatic changes in China's political and social systems since the early 20th century, these instruments are unlikely to affect current economic outcomes such as trade, beyond their impacts through the channel of IPRs and contract enforcement. We expect that $\phi_1 > 0$.

Table 4 initially reports ordinary least squares estimates of specifications (16) and (16)', which directly link firms' intensive margins with IPRs enforcement, in the top panel. Columns (1) through (3) show the determinants of continued-exporters' log export volumes. Without controlling for the fixed effects and potential endogeneity, OLS results from columns (1) and (2) suggest that stronger IPRs protection, reflected by the higher level of IPRs cases win rates across provinces and over years, generates significantly higher export volumes. Younger firms, firms with higher productivity, foreign firms, and firms owned by Hong Kong-Macau-Taiwan investors tend to have higher export volumes. The significantly positive tariff coefficient from column (2) suggests that import tariff reduction leads to lower export volume for a continued exporter. This is possible, in that lower output tariffs could pressure such firms to contract. However, the OLS tariff coefficient loses its significance in column (3), which shows estimation results after industry and year fixed effects are accounted for. Importantly, IPRs enforcement remains highly significant, suggesting that its positive impact is robust.

For the IV estimation, the bottom panel of Table 4 reports the first-stage regression results, where the IP cases win rate is regressed on the colonial dummies and Christian enrollment along with the other exogenous variables. All the IVs are highly significant, and the corresponding Stock-Yogo F-test is as high as 1046, suggesting that they are strong. Thus, the colonial and Christian influences significantly affect the IPRs enforcement environment, consistent with prior literature.

Column (4) of the top panel in Table 4 reports the second-stage IV estimation of log export volume. The IV (including fixed effects) estimated coefficient of the IPRs impact is notably larger than the estimated impact from the OLS regressions. Relative to the fixed effects results reported in column (3), the coefficients of tariff and other firm-level attributes largely remain unchanged.

The consistent IV estimation thus suggests a highly significant impact of IPRs enforcement on the intensive margin of exports in China.

Columns (5) through (8) of the top panel from Table 4 report the corresponding determinants of log capital goods import volumes. Similar to the export patterns, the OLS, fixed effects, and IV regressions all report significantly positive IPRs impact on the log of capital goods import. While the IV coefficient on the win rate is somewhat lower than the OLS estimate, it is markedly higher than the fixed effect coefficient. These results suggest that existing importers located in provinces with stronger IPRs protection import more capital goods. We also find that younger firms, more productive firms, foreign firms, and firms owned by Hong Kong-Macau-Taiwan investors import more capital goods. Import tariff reductions at the industry level do not directly affect capital goods import, which again may reflect the largely duty-free treatment of machinery imports even prior to this period in China.

In summary, Table 4 presents evidence that is highly consistent with our model predictions about intensive margins: a more rigorous IPRs environment helps continued exporters and capital goods importers to increase exports and capital goods imports, respectively. This evidence is robust to different specifications, including controlling for industry and year fixed effects.

6. Summary and Conclusions

In this paper we build on the work of Melitz (2003) and Bustos (2011) to develop a theoretical model that predicts several key impacts of IPRs protection in developing countries. First, stronger IPRs protection should force more of the less productive firms out of the market. Second, better access to IPRs litigation reduces the minimum productivity needed for exports, which implies that firms in the intermediate margin are more likely to start exporting. Third, IPRs enforcement reduces the productivity at which firms will shift from imitation to more formal channels of acquiring foreign technologies, a finding that comports well with prior empirical findings. We carry out empirical tests using Chinese firms' experience during a period of both legal reforms and greater judicial enforcement, taking advantage of differences in the latter across provinces. The evidence consistently supports the hypotheses derived from the theory.

This paper departs from previous literature in several dimensions. First, to our knowledge it is the first to show how IPRs reform affects firms' technology transfer channel and exporting decisions in the presence of firm heterogeneity. Second, it provides insights into the channels through which IPRs reform-driven productivity changes occur. Third, it establishes a link between IPRs protection and the credit costs of heterogeneous firms. Our study also shed light on how stronger intellectual property rights can promote domestic industrial transformation and support both intensive and extensive margins of trade.

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Appendix A

The proof that $\pi_L^E(\varphi) > \pi_L^D(\varphi)$ if $\pi_M^E(\varphi) > \pi_M^D(\varphi)$ is as follows.

Proof: From $\pi_M^E(\varphi) > \pi_M^D(\varphi)$, we have

$$(1+\tau^{1-\sigma})\frac{1}{\sigma}E(P\rho)^{\sigma-1}[\lambda(a,\theta)\varphi]^{\sigma-1} - (f + f_E) > \frac{1}{\sigma}E(P\rho)^{\sigma-1}[\lambda(a,\theta)\varphi]^{\sigma-1} - f \ .$$

Therefore, we have

$$\tau^{1-\sigma}\frac{1}{\sigma}E(P\rho)^{\sigma-1}[\lambda(a,\theta)\varphi]^{\sigma-1}-f_E>0.$$

Thus we have

$$\begin{aligned}&\pi_L^E(\varphi)>\pi_L^D(\varphi)\\&=(1+\tau^{1-\sigma})\frac{1}{\sigma}E(P\rho)^{\sigma-1}(\bar{\lambda}\varphi)^{\sigma-1}-(\eta f+f_E)-[\frac{1}{\sigma}E(P\rho)^{\sigma-1}(\bar{\lambda}\varphi)^{\sigma-1}-\eta f]\\&=\tau^{1-\sigma}\frac{1}{\sigma}E(P\rho)^{\sigma-1}(\bar{\lambda}\varphi)^{\sigma-1}-f_E)\\&>\tau^{1-\sigma}\frac{1}{\sigma}E(P\rho)^{\sigma-1}[\lambda(a,\theta)\varphi]^{\sigma-1}-f_E>0\end{aligned}.$$

The proof that $\pi_L^D(\varphi)<\pi_M^D(\varphi)$ if $\pi_L^E(\varphi)<\pi_M^E(\varphi)$ is as follows.

Proof: From $\pi_L^E(\varphi)<\pi_M^E(\varphi)$, we have

$(1+\tau^{1-\sigma})\frac{1}{\sigma}E(P\rho)^{\sigma-1}(\bar{\lambda}\varphi)^{\sigma-1}-(\eta f+f_E)<(1+\tau^{1-\sigma})\frac{1}{\sigma}E(P\rho)^{\sigma-1}[\lambda(a,\theta)\varphi]^{\sigma-1}-(f+f_E)$ .Hence we have

$$(1+\tau^{1-\sigma})\frac{1}{\sigma}E(P\rho)^{\sigma-1}\left\{(\bar{\lambda}\varphi)^{\sigma-1}-[\lambda(a,\theta)\varphi]^{\sigma-1}\right\}-(\eta-1)f<0.$$

Thus we find that

$$\pi_L^D(\varphi) - \pi_M^D(\varphi)$$
$$= \frac{1}{\sigma} E(P\rho)^{\sigma-1} (\bar{\lambda}\varphi)^{\sigma-1} - \eta f - \left\{ \frac{1}{\sigma} E(P\rho)^{\sigma-1} [\lambda(a,\theta)\varphi]^{\sigma-1} - f \right\}$$
$$= \frac{1}{\sigma} E(P\rho)^{\sigma-1} \left\{ (\bar{\lambda}\varphi)^{\sigma-1} - [\lambda(a,\theta)\varphi]^{\sigma-1} \right\} - (\eta - 1) f$$
$$< (1 + \tau^{1-\sigma}) \frac{1}{\sigma} E(P\rho)^{\sigma-1} \left\{ (\bar{\lambda}\varphi)^{\sigma-1} - [\lambda(a,\theta)\varphi]^{\sigma-1} \right\} - (\eta - 1) f < 0$$

Table 1A: Firm Performance under Different Exporting Statuses (year=2000)

(1) log(tfp)	(2) log(capital/labor)	(3) log(labor)	(4) log(sale)	(5) log(total asses)	(6) log(wage)	(7) new product dummy

Continued exporter	0.487***	0.0406**	0.746***	0.770***	0.721***	0.780***	0.122***
	(0.0180)	(0.0178)	(0.0166)	(0.0221)	(0.0241)	(0.0214)	(0.00545)
Discontinued exporter	0.332***	0.120***	0.514***	0.530***	0.595***	0.559***	0.108***
	(0.0192)	(0.0196)	(0.0204)	(0.0219)	(0.0252)	(0.0223)	(0.00648)
log(age)	0.0458***	0.0510***	0.306***	0.122***	0.327***	0.138***	0.0343***
	(0.00681)	(0.00656)	(0.00571)	(0.00732)	(0.00714)	(0.00721)	(0.00162)
foreign firm dummy	0.371***	0.888***	-0.0170	0.517***	0.792***	0.490***	-0.0345***
	(0.0184)	(0.0254)	(0.0167)	(0.0216)	(0.0226)	(0.0212)	(0.00447)
HK-Macau-Taiwan Dummy	0.145***	0.536***	0.00544	0.272***	0.536***	0.261***	-0.0388***
	(0.0168)	(0.0239)	(0.0164)	(0.0186)	(0.0209)	(0.0184)	(0.00399)
Constant	6.200***	3.268***	4.234***	9.311***	8.795***	9.157***	-0.00844**
	(0.0171)	(0.0176)	(0.0143)	(0.0185)	(0.0191)	(0.0182)	(0.00425)
Observations	77,722	79,612	80,028	79,514	79,976	79,797	79,515
R-squared	0.049	0.057	0.141	0.095	0.138	0.097	0.041
Industry and Province Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	yes

Table 1B: Firm Performance under Different Exporting Statuses (year=2004)

	(1) log(tfp)	(2) log(capital/labor)	(3) log(labor)	(4) log(sale)	(5) log(total assets)	(6) log(wage)
Continued exporter	0.459***	0.0534***	0.782***	0.745***	0.767***	0.797***
	(0.0189)	(0.0176)	(0.0168)	(0.0241)	(0.0252)	(0.0244)
Discontinued exporter	0.0407**	0.145***	0.255***	0.143***	0.399***	0.171***
	(0.0206)	(0.0226)	(0.0212)	(0.0227)	(0.0247)	(0.0243)
log(age)	-0.0542***	0.113***	0.120***	-0.0132	0.202***	-0.0469***
	(0.00794)	(0.00736)	(0.00678)	(0.00853)	(0.00822)	(0.00989)
foreign firm dummy	0.413***	0.520***	0.106***	0.535***	0.598***	0.527***
	(0.0212)	(0.0230)	(0.0169)	(0.0256)	(0.0238)	(0.0259)
HK-Macau-Taiwan Dummy	0.177***	0.249***	0.0542***	0.255***	0.353***	0.254***
	(0.0180)	(0.0201)	(0.0153)	(0.0200)	(0.0207)	(0.0204)
Constant	6.800***	3.318***	4.560***	9.995***	9.340***	9.871***
	(0.0198)	(0.0192)	(0.0169)	(0.0219)	(0.0218)	(0.0247)
Observations	75,757	79,049	80,087	78,965	80,427	80,052
R-squared	0.042	0.024	0.085	0.074	0.093	0.075
Industry and Province Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 2A: Firm Performance under Different Exporting and Capital Good Importing Statuses (year=2000)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)

	log(tfp)	log(capital/labor)	log(labor)	log(sale)	log(total asset)	log(wage)	new product dummy
Export capital import dummy	0.828***	0.431***	1.130***	1.309***	1.305***	1.299***	0.126***
	(0.0266)	(0.0234)	(0.0190)	(0.0279)	(0.0270)	(0.0271)	(0.00622)
Export non-capital import dummy	0.460***	-0.0253*	0.692***	0.712***	0.641***	0.739***	0.112***
	(0.0158)	(0.0151)	(0.0137)	(0.0195)	(0.0209)	(0.0193)	(0.00445)
Foreign firm dummy	0.315***	0.768***	-0.0226	0.461***	0.730***	0.440***	-0.0305***
	(0.0185)	(0.0236)	(0.0149)	(0.0214)	(0.0229)	(0.0211)	(0.00349)
HK-Macau-Taiwan Dummy	0.0981***	0.470***	-0.00226	0.240***	0.512***	0.232***	-0.0333***
	(0.0187)	(0.0267)	(0.0131)	(0.0214)	(0.0235)	(0.0205)	(0.00300)
Log(age)	-0.0418***	0.0738***	0.264***	0.0297***	0.305***	0.0505***	0.0249***
	(0.00619)	(0.00562)	(0.00482)	(0.00670)	(0.00613)	(0.00643)	(0.00113)
Constant	6.144***	3.166***	4.092***	9.164***	8.550***	8.993***	-0.00236
	(0.0156)	(0.0158)	(0.0117)	(0.0170)	(0.0170)	(0.0164)	(0.00309)
Observations	136,801	142,260	144,102	141,664	143,640	142,763	141,712
R-squared	0.044	0.046	0.120	0.085	0.135	0.086	0.036
Industry and Province Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 2B: Firm Performance under Different Exporting & Capital Good Importing Statuses (year=2004)

	(1) log(tfp)	(2) log(capital/labor)	(3) log(labor)	(4) log(sale)	(5) log(total asset)	(6) log(wage)
Export capital import dummy	0.740***	0.577***	1.116***	1.239***	1.363***	1.270***
	(0.0164)	(0.0163)	(0.0157)	(0.0196)	(0.0211)	(0.0195)
Export non-capital import dummy	0.298***	-0.0440***	0.558***	0.500***	0.467***	0.543***
	(0.0123)	(0.0155)	(0.0119)	(0.0151)	(0.0185)	(0.0152)
Foreign firm dummy	0.248***	0.503***	0.102***	0.360***	0.602***	0.355***
	(0.0121)	(0.0208)	(0.0123)	(0.0150)	(0.0180)	(0.0150)
HK-Macau-Taiwan Dummy	0.116***	0.344***	0.191***	0.239***	0.530***	0.247***
	(0.0140)	(0.0152)	(0.0112)	(0.0148)	(0.0145)	(0.0144)
Log(age)	0.0970***	0.0815***	0.210***	0.158***	0.282***	0.125***
	(0.00494)	(0.00541)	(0.00453)	(0.00562)	(0.00527)	(0.00651)
Constant	6.213***	3.202***	4.001***	9.293***	8.695***	9.163***
	(0.00987)	(0.00986)	(0.00915)	(0.0115)	(0.0110)	(0.0126)
Observations	242,427	251,578	255,584	253,657	256,321	255,554
R-squared	0.050	0.039	0.131	0.112	0.155	0.105
Industry and Province Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 3: exit exporting, start exporting, and start importing capital goods

	(1)	(2)	(3)	(4)
	Panel A: exiting in 2004			

change of win rate in IP cases	0.0324***	0.0577***	0.0330***	0.0590***
	(0.00534)	(0.00573)	(0.00610)	(0.00630)
change of tariffs		-0.269***		
		(0.0199)		
log(tfp_{2000})		-0.0631***		-0.0628***
		(0.00113)		(0.00204)
Foreign firm dummy		0.0310***		0.0311***
		(0.00811)		(0.0113)
Hong Kong-Macau-Taiwan dummy		0.0488***		0.0312***
		(0.00681)		(0.00914)
log(age_{2000})		-0.0177***		-0.00991***
		(0.00177)		(0.00327)
Constant	0.563***	0.945***	0.563***	0.946***
	(0.00154)	(0.00860)	(1.48e-05)	(0.0135)
Observations	103,886	90,286	103,886	94,497
R-squared	0.000	0.037	0.000	0.028
Number of industries			424	422
	Panel B: start exporting in 2004			
change of win rate in IP cases	0.0217***	0.0296***	0.0150***	0.0189***
	(0.00497)	(0.00518)	(0.00502)	(0.00574)
change of tariffs		-0.0617***		
		(0.0190)		
log(tfp_{2000})		0.00711***		0.0254***
		(0.00115)		(0.00186)
Foreign firm dummy		0.218***		0.191***
		(0.00659)		(0.0132)
Hong Kong- Macau- Taiwan dummy		0.181***		0.141***
		(0.00585)		(0.00974)
log(age_{2000})		-0.0261***		-0.0168***
		(0.00162)		(0.00212)
Constant	0.124***	0.110***	0.124***	-0.0202*
	(0.00145)	(0.00858)	(3.26e-05)	(0.0119)
Observations	51,812	47,130	51,812	49,365
R-squared	0.000	0.054	0.000	0.046
Number of industries			422	420
	Panel C: start importing capital goods in 2004			
change of win rate in IP cases	0.00442	0.00982***	0.000174	0.00291
	(0.00273)	(0.00286)	(0.00209)	(0.00218)
change of tariffs		-0.0188*		
		(0.0105)		
log(tfp_{2000})		0.0127***		0.0179***
		(0.000606)		(0.00108)
Foreign firm dummy		0.120***		0.112***
		(0.00310)		(0.00595)
Hong Kong-Macau-Taiwan dummy		0.0764***		0.0679***
		(0.00255)		(0.00460)
log(age_{2000})		0.000336		8.72e-05
		(0.000833)		(0.000862)
Constant	0.0385***	-0.0608***	0.0384***	-0.0911***
	(0.000738)	(0.00449)	(5.85e-06)	(0.00767)
Observations	67,968	62,513	67,968	65,297
R-squared	0.000	0.042	0.000	0.040

Table 4: Decisions in volumes of export and capital goods importing

Model	Dependent=log(export)				Dependent=log(capital goods import）			
	OLS	**OLS**	**Fixed Effects**	**IV second stage**	**OLS**	**OLS**	**Fixed Effects**	**IV second stage**
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
win rate of IP cases	0.424***	0.227***	0.193***	1.283***	0.816***	1.296***	0.713***	1.099***
	(0.0549)	(0.0510)	(0.0692)	(0.0923)	(0.193)	(0.189)	(0.205)	(0.312)
Tariff		0.428***	0.513	0.418		-2.215***	0.571	0.563
		(0.0861)	(0.446)	(0.254)		(0.258)	(1.059)	(0.730)
log(tfp)		0.550***	0.797***	0.802***		0.619***	0.810***	0.812***
		(0.00571)	(0.0188)	(0.00608)		(0.0168)	(0.0352)	(0.0192)
Foreign firm dummy		0.526***	0.397***	0.355***		0.409***	0.890***	0.882***
		(0.0182)	(0.0509)	(0.0170)		(0.0899)	(0.149)	(0.0890)
Hong Kong-Macau-Taiwan		0.534***	0.390***	0.312***		0.266***	0.808***	0.792***
		(0.0178)	(0.0471)	(0.0175)		(0.0922)	(0.149)	(0.0925)
log(age)		-0.0638***	-0.0400**	-0.0445***		-0.327***	-0.184***	-0.185***
		(0.00999)	(0.0181)	(0.00915)		(0.0442)	(0.0509)	(0.0456)
Constant	9.910***	5.847***	4.124***	4.436***	7.294***	3.536***	0.936***	1.025***
	(0.0163)	(0.0514)	(0.172)	(0.0725)	(0.0512)	(0.196)	(0.343)	(0.246)
Observations	42,282	39,922	39,922	39,871	11,774	11,049	11,049	11,039
R-squared	0.001	0.213	0.329		0.002	0.122	0.149	
Industry fixed effects	No	No	Yes	Yes	No	No	Yes	Yes
Year fixed effects	No	No	Yes	Yes	No	No	Yes	Yes

First stage regression, dependent=win rate of IP cases	
Christian Schools	0.036***
	(0.0019)
Britain	-0.078***
	(0.0045)
France	0.0945***
	(0.0045)
Russia	0.1406***
	(0.0061)
Multi-countries	0.0073**
	(0.0046)
Partial F-test of IVs	1046
Observations	11,015
R-squared	0.347
Industry fixed effects	Yes
Year fixed effects	Yes

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1