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Huiwen Lai, Keith E. Maskus, and Lei Yang

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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 through imitation or licensing. 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 2006 support the model predictions.

Keywords

Intellectual Property Enforcement, Exports, Firm Heterogeneity

JEL Classification: D23, F13, F14, O34

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 goods 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 productivity measures, 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

[*] We acknowledge the financial support from the Hong Kong Government's General Research Fund (Polyu 549513H).

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 database 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 construct two measures as proxies for formal technology transfer: capital-goods imports and new product development. Importation of capital goods is an important form of transferring embodied technology from one country to another (Hoekman et al, 2005). New product development can be considered as the output of international technology transfer to some extent because such transfers provide an important basis for domestic new product development.

We have two measures of cross-province variation in IPRs enforcement. First, 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. Second, we construct a relative measure of settled patent cases, defined as the ratio of the number of judicially decided patent disputes to the cumulative number of patents granted in each province. 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 a 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:

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

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 $\frac{1}{\bar{\lambda}\varphi}$ denote the marginal cost under licensing and we have $\lambda(\theta) < \bar{\lambda}$. 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 two 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 those firms engaging in legal reverse engineering and those 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]

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.

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

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

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[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 development in lower-income OECD economies (Maskus, et al, 2018).

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.

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

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 $\pi_M^E(\varphi_L) = \pi_L^E(\varphi_L)$.

In a manner 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.

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

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

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

2 See Appendix A for the detailed proof.

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

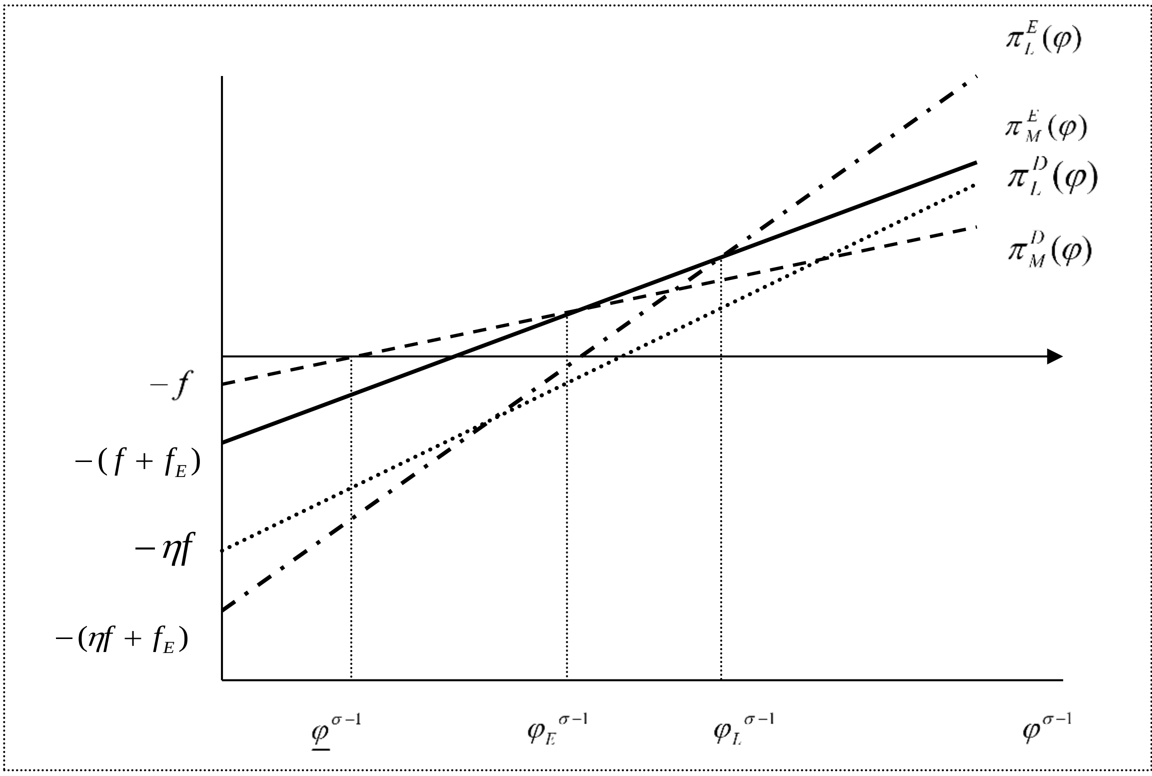
Further, because φ_L is the cutoff productivity above which a firm choosing exporting finds purchasing technology more profitable, we find that $\pi_M^E(\varphi_L) = \pi_L^E(\varphi_L)$. Then we have

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

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 $\underline{\varphi}^{\sigma-1} = \frac{\sigma f}{E(P\rho)^{\sigma-1}\lambda(\theta)^{\sigma-1}}$. It can be shown that

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

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 $\varphi_E^{\sigma-1} = \frac{\sigma f_E(\theta)}{\tau^{1-\sigma}E(P\rho)^{\sigma-1}\lambda(\theta)^{\sigma-1}}$. It can be shown that

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

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

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. If this condition holds, the margin of exporters expands, which is consistent with empirical findings discussed earlier.

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

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

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

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 2006 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 $\frac{df_E(\theta)}{d\theta}\lambda(\theta)^{\sigma-1} - f_E(\theta)(\sigma-1)\lambda(\theta)^{\sigma}\frac{\partial\lambda(\theta)}{\partial\theta} < 0$, 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 it protection of intellectual property, at least on paper, 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 to 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 in enforcement, 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 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 2006. This variable directly measures the probability of IP owners' winning

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3 Note that strength is not necessarily an indicator of optimality in welfare terms.

4 See also Maskus (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.

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).

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 2006 is defined as the number of judgments awarded to rights holders between 2001 and 2006, divided by the total number of such cases over these six years, for each province or special district. 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.

The second measure of cross-provincial variation in IPRs enforcement is the ratio of the number of settled patent disputes to the cumulative number of patents granted in each province, a variable we call the settled patent ratio. We adopt this ratio, rather than the absolute number of settled disputes, for two reasons beyond the obvious need to control for provincial size. First, owners of infringed patents in a province with stronger enforcement are more likely to file cases, suggesting that the ratio helps mitigate the evident endogeneity concerns from absolute numbers. Second, and more directly, a higher number of settled patents reflects the fact that courts in those provinces can work more efficiently to settle such cases. As argued by the World Bank (2008) and Feenstra et al (2013), the efficiency of the court system in each province in China is a good reflection of local institutional quality. Thus, a higher settled patent ratio, presumably arising from enhanced efficiency of the local court system, reflects a stronger enforcement system in that province.

Note that the win rates and the settled patent ratio both capture cross-provincial variation in IPRs enforcement, while the GP index captures overall development of legal provisions at the national level. We therefore multiply the two provincial variables by the GP index, separately, to capture variations in IPRs environment across provinces and over time. The two variables measuring protection of IPRs we use in our analysis are thus defined as the interaction between win rates and the GP index and the interaction between the settled patent ratio and the GP index. For presentation convenience, we refer to these interaction terms, respectively, as the IP cases win rate and the settled patent ratio.

Our intention is to use these variables to explain inter-provincial variations in firm-level trade performance. An obvious difficulty is that win rates and settled patent ratios may be endogenous to the export and import decisions of Chinese enterprises. As noted earlier, higher-income provinces tend to see more IP litigation, and perhaps higher patent settlement rates, because domestic firms and affiliates of international enterprises generate more intellectual property to protect. This factor 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, on the one side, and litigation success and patent adjudication rates, on the other.

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 and settled patent ratio.[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 a mixture of 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

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

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 missionary school enrollment figures as the instrument in their analysis of cross-city income levels. Our study is the first to consider such instruments in explaining firm-level export performance across locations in China.

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 formulate 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.

Appendix Table 1 reports summary statistics for the IP cases win rates, the settled patent ratios, and the instrument variables described above.

4.2 Trade Liberalization in China

The period we analyze, 2000 to 2006, saw both significant legal national reforms in IPRs and tariff liberalization, the latter spearheaded by China's WTO accession in 2001. Clearly, tariff 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 2006, 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, with the latter rates used for the 2006 analysis) and G_i is the number of 8-digit HS products in 4-dight CIC (Chinese Industry Classification) industry *i*. The original 8-digit HS-level import tariff rates were downloaded from the WTO website and assigned to CIC industries using a firm-level matching process mentioned in the next section.[10] Note that these are industry-level computations and do not vary across provinces.

Again, Appendix Table 1 reports summary statistics of the industry-level tariffs for 2000 and 2006.

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[10] In addition to the tariff measure using this simple average, we constructed a weighted-average version, where the weight was defined as the ratio of imported value of each HS-8 product over the sum of imported values of all the HS-8 products that fall into the same 4-digit CIC code. One argument against using the weighted-average version is that it is dominated by products imported with large volumes. Further, the weights changes over time. Nevertheless, the two tariff measures are very similar in magnitude and subsequent regressions using them lead to similar results. See the summary statistics in Appendix Table 1.

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 transactions 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. Ge et al. (2015) match the Customs trade transactions with the NBS firm data based 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 new products.

The firm-level response variables in our analysis include entry, exit, and volume decisions related to operating, exporting, and importing capital goods, and producing new products. These variables will be further described, along with regression specifications, in the next section. Firm-level attributes capture the status of firms regarding various decisions made under different IPRs and trade-policy environments.

Our measure of formal technology transfer, as opposed to imitation, will be firm-level imports of capital goods. Imports of capital 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.

As a supplemental measure of technology transfer we also use new product development in the analysis. The introduction of new goods, while typically taken as a measure of innovation, also can be considered as the output of international technology transfer to some extent. This is because such transfers induce domestic learning, from which springs new product development by local firms. For example, He and Maskus (2012) argued that learning-by-doing spillovers and expansion of the local technology pool are two important resources for firms in developing countries to invent new products. They found that in large emerging countries, including China, with notable technical capacities to absorb and improve technology, inward technology transfer flows through FDI and licensing were followed by significant increases in technological knowledge generated and growth of patent applications. Baldwin et al (2005) found that local innovators become more efficient by learning new production processes from MNEs. Therefore, we use new product production as a second proxy for formal technology transfer.

Appendix Table 1 reports summary statistics of firm-level attributes, for 2000 and 2006 respectively.

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 2006, 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 and settled patent ratio 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, capital-goods imports, and new products, 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 as proxies for productivity, a firm's relative performance under different IPRs regimes can be tested using the following specification:

$$Y_{fipt'} = \alpha_0 + \beta_1 CE_{fipt'} + \beta_2 DE_{fipt'} + Z_{fipt'}\gamma + FE_{ip} + \varepsilon_{fipt'} \tag{13}$$

for $t' = 2000$ and 2006, respectively. Variable $Y_{fipt'}$ represents firm *f*'s performance measure in industry *i* located in province *p*. These measures include TFP, capital intensity, number of employees, sales, total assets, and wages. Variables CE and DE are the continued-exporter dummy and the discontinued-exporter dummy, where non-exporter (in both 2000 and 2006) 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 $\beta_1 > \beta_2 > 0$, that is, on average the productivity of a continued exporter exceeds that of a discontinued exporter, which is higher than that of a non-exporter. We estimate (13) for $t' = 2000$ and 2006 separately.

We use imported capital goods and production of new products as proxies for technology transfer. Proposition 1 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). Similarly an exporter that also develops new products is more productive than an exporter that does not develop new products, which in turn is more productive than a firm that neither exports nor develops new products. Accordingly, these predictions can be tested using two specifications similar to equation (13):

$$Y_{fipt'} = \alpha_0 + \beta_1 EI_{fipt'} + \beta_2 ENI_{fipt'} + Z_{fipt'}\gamma + FE_{ip} + \varepsilon_{fipt'} \tag{14}$$

and

$$Y_{fipt'} = \alpha_0 + \beta_1 EN_{fipt'} + \beta_2 ENN_{fipt'} + Z_{fipt'}\gamma + FE_{ip} + \varepsilon_{fipt'} \tag{15}$$

where for specification (14), 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 the group of non-exporters (and non-capital

[11] A continued exporter is a firm that exports both before and after the IPRs reform (i.e., in both2000 and 2006), 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 2006), and a non-exporter is a firm that does not export in both periods.

goods importers) is used as the benchmark group of firms. For specification (15), EN is a dummy for firms that both export and develop new products, ENN is a dummy for firms that export but do not develop new products, and the group of non-exporters (and non-new product developers) is used as the benchmark. Our model predicts that $\beta_1 > \beta_2 > 0$ for both (14) and (15). We also estimate (14) and (15) for $t' = 2000$ and 2006 separately.

Note that since we control for firm attributes, such as age and ownership, and include industry-province fixed effects in equations (13) through (15), we are comparing performance among firms of the same age, operating under the same ownership structure, within the same industry, and headquartered in the same province.

Table 1 reports regression results for equation (13), estimated with ordinary least squares.[12] We see that in both 2000 and 2006, continued exporters are more productive, more capital intensive, pay higher wages, and are larger (in terms of work forces, sales, and assets) than discontinued exporters. The latter, in turn, have higher performance measures than non-exporters. 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.

Similarly, Table 2A reports the performance measures of firms that both export and import capital goods relative to firms that export only and, in turn, relative to firms that do neither. The hierarchical patterns are similar to those in Table 1. Firms that both export and import capital goods perform better than firms that export only, which in turn perform better than firms doing neither. Table 2B presents the performance of firms that both export and produce new products relative to firms that export only and firms that do neither. Again, firms that both export and produce new products perform better than firms that export only, which in turn perform better than firms that do neither.

These rankings support the prediction in Proposition 1 that the most productive firms will select into both exporting and formal technology transfer. However, these cross-sectional regressions do not directly link firms' performance indicators with our measures of IPRs protection, the litigation win rates and settled patent ratio. 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 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 2006. Thus, among all non-exporting firms operating in the earlier year, those located in provinces with the greater increases in IPRs protection are more likely to exit. Second, firms with productivities in the range $\varphi_E' < \varphi < \varphi_E$ do not export in 2000 but become exporters by 2006. Thus, among 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 2006. Again, we use firm-level capital goods imports as one proxy for formally buying foreign technology. It follows that among firms that are exporters but not 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 by 2006. Similarly, considering production of new products as another proxy of technology transfer, it

[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 instrumental variables.

follows that among firms who are exporters but did not produce new products in 2000, those located in provinces with the larger increases in protection are more likely to start such production by 2006.

We thus have four testable predictions about shifts in the extensive margins of various activities by Chinese firms induced by the changes in legal and judicial protection of IPRs across provinces and over time. Recall that our two measures of enforcement are the fraction of IP infringement cases won by rights holders and the ratio of the number of settled patent disputes to the cumulative number of patents granted in each province. We use changes between 2000 and 2006 in these two measures in each province to capture relative changes in enforcement.

Moreover, because China engaged in significant trade liberalization in this period, largely associated with WTO accession in 2001, 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 2006 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:

$$Y_{fip\_\Delta t} = \beta_0 + \beta_1 \Delta IPR_p + \beta_2 \Delta TARIFF_i + Z_{fip\_t_0}\gamma + \varepsilon_{fip} \tag{16}$$

Variable $Y_{fip\_\Delta t}$ represents a series of binary choices corresponding to the four predictions: (1) whether a non-exporting firm operating in 2000 chooses to exit i by 2006; (2) whether a non-exporter in 2000 becomes an exporter by 2006; (3) whether an exporter and non-capital goods importer in 2000 starts importing capital goods by 2006; and (4) whether an exporter without new-product production in 2000 starts producing new goods by 2006. Note that Δt in the subscript of $x_{fip\_\Delta t}$ represents the time span from 2000 to 2006. The variable ΔIPR_p captures the change in the strength of IPRs protection (either win rates or settled patent ratio) 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 four 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 equation (16). We therefore modify specification (16) by controlling for industry fixed effects:

$$Y_{fip\_\Delta t} = \beta_0 + \beta_1 \Delta IPR_p + Z_{fip\_t_0}\gamma + FE_i + \varepsilon_{fip} \tag{16'}$$

Here, variable FE_i represents the industry fixed effects that absorb all industry-level policy impacts from 2000 to 2006, including from tariff cuts.

Tables 3A – 3D report the linear probability regression results of specifications (16) and (16'). Table 3A lists estimates of the probability that a non-exporting firm operating in 2000 exits by 2006. Specifically, columns (1) - (4) list the results with IPRs protection proxied by the win rates while columns (5) - (8) show the outcomes using the settled patents ratio. Within each grouping the first pair of columns, labeled OLS, include changes over time in sectoral tariff rates while the second pair include industry fixed effects. The OLS specifications suggest that the improvement of IPRs protection, measured both as the increase in the win rate and the ratio of settled patents in the province where a firm is located, raises the probability of the firm failing and exiting by 2006. The tariff results in columns (2) and (6) 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) - (4) and columns (7) – (8) of Table 3A report results of specification (16)', which controls for industry fixed effects. The coefficients corresponding to changes in both forms of IP protection remain highly significant and similar to those of the OLS regressions. Coefficients from columns (4) and (8), corresponding to our preferred specification (16') with the complete set of controls, suggest that a one standard deviation increase in the change of judicial win rates raises the probability of exiting by 3.4 % (0.0427×0.90), while a one standard deviation increase in the change of the settled patent ratio raises the probability of exiting by 6.0% (11.1×0.0054). [13]

Table 3B reports estimates of the probability that a non-exporter in 2000 begins exporting by 2006. The coefficients associated with the changes of IP win rates and settled patents ratio are significantly positive across specifications, suggesting that initial non-exporter are more likely to become exporters in provinces with strengthened enforcement. The coefficient in column (4) implies that a one standard deviation increase in the change of win rates raises the probability of a firm starting to export by 3.3% (0.0367×0.90). Similarly, the coefficient in column (8) indicates that a one standard deviation increase in the change of the settled patent ratio raises that probability by 6.1% (11.17×0.0054).

The negative but insignificant coefficients on tariff changes (column (2) and column (6)) indicate that tariff reductions may raise, though weakly, the likelihood that some initial non-exporters begin to export. This finding is consistent with the positive export-import linkage discussed by Amiti and Konings (2007), Goldberg et al. (2010), and Bas and Strauss-Kahn (2015). They found that higher quality imported inputs induced by tariff reductions allow firms to become more productive and more likely to produce high quality products for export.[14] Finally, we find here that younger firms and firms with higher initial productivity, foreign firms, and firms owned by Hong Kong-Macau-Taiwan are more likely to start exporting.

Table 3C reports the results of the probability that firms that export but do not import capital goods in 2000 begin importing capital goods by 2006. The positive and significant coefficient in column (2) suggests that an increase in provincial win rates raises the probability of starting capital goods importing by 2006. With fixed effects, however, the associated regression coefficient in column (4) becomes only marginally significant (at 10%). The coefficient of 0.00621 suggests that a one standard deviation increase in the change of win rates raises the probability of starting capital goods imports by 0.56% (0.00621×0.9) by 2006, which seems economically insignificant. Using the settled patent ratio as a measure of IPRs protection, the associated coefficients have the expected signs across our regressions, but are insignificant. These outcomes suggest that more rigorous IPRs protection may not have a significant impact on the extensive margins of capital goods imports. One possible explanation is that with improved IPRs protection firms turn more to investing in their own R&D and innovation activities, with relatively little effect on the purchase of foreign technologies through capital goods imports.[15]

The negative but insignificant coefficients on tariff changes in columns (2) and (6) suggest weakly that tariff cuts on own-industry imports encourage firms to start importing capital goods. It should be

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[13] From Appendix Table 1, one standard deviation of the change of the win rates equals 0.9 while one standard deviation of the change of the settled patent ratio equals 0.54%.

[14] This inference should be treated cautiously here, however, for our tariff measure is an average within a 4-digit Chinese industrial category. The sub-sectors from which these averages are computed generally include both within-industry inputs and within-industry outputs at similar stages of production.

[15] This argument is consistent with the evidence of Table 3D, to be presented next, where enhanced IPRs protection makes firms more likely to produce new products.

noted that most capital goods imports are duty free, so tariff cuts in this period provided no direct stimulation to such imports. Moreover, because our measure captures within-sector tariff cuts, any interpretation with respect to capital imports should be treated with caution. Again consistent with our expectations, initially more productive firms were more likely to start importing capital goods in 2006.

Table 3D lists estimates of the probability that an exporter that did not producer new goods in 2000 begins producing them by 2006. The coefficients related to the changes of the IP win rates and the settled patent ratio are significantly positive and consistent across specifications, suggesting that firms with these criteria in 2000 are more likely to become new product producers in provinces with greater strengthening of enforcement. Based on the preferred specification in columns (4) and (8), a one standard deviation increase in the change of win rates raises the probability of starting new product production by 20% (0.22×0.9), while a one standard deviation increase in the settled patent ratio raises that probability by 13% (24.42×0.0054). Both effects are economically large.

Finally, the positive coefficients on tariff changes (columns (2) and column (6)) indicate that tariff reductions make an exporter without new products in 2000 less likely to start manufacturing new products by 2006. It may be that lower tariffs permit imported new goods to substitute for the need of newly developed domestic products, thus lowering the associated probability. Again, firms with higher initial productivity are more likely to start new product production. However, foreign firms and firms owned by investors from Hong Kong, Macau, and Taiwan are less likely to manufacture new goods. The latter evidence is consistent with the finding in Ge et al. (2015) that multinational firms are more likely to conduct R&D and develop new products in their headquarter countries.

In summary, Tables 3A-3D present evidence largely consistent with our model predictions. Improved IPRs protection at the province level: (1) increases the exit probability of initially non-exporters, (2) increases the probability of initially non-exporters becoming exporters, and (3) increases the probability of initially exporters and non-new product producers to start producing new goods. We find weaker evidence that strengthened enforcement increases the probability of firms that were initially exporters and not capital goods importers beginning to import such goods.

5.3 Intensive Margins of Exports, Capital Goods Imports, and New Products Development

Improved IPRs protection also affects the volume decisions of firms that continue to export, import capital inputs, and manufacture new products. As suggested in Melitz (2003), trade liberalization induces changes in cutoff productivities, leading to reallocations of market shares in favor of more productive firms that remain in the exporting markets. Similarly, more rigorous IPRs enforcement induces changes in productivity cutoffs and reallocations of market shares towards firms that continue to trade or firms that continue to purchase foreign technology. Thus, we have the following specification to investigate the impacts of IPRs enforcement on the intensive margins of trade and technology-transfer proxies, pooling across both years:

$$Y_{fipt} = \beta_0 + \beta_1 IPR_{pt} + \beta_2 TARIFF_{it} + Z_{fipt}\gamma + \varepsilon_{fipt} \, , \tag{17}$$

where Y_{fipt} represents log exports, log capital goods imports, and log new products, 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 $TARIFF_{it}$ is the industry-level tariff rate. Again, vector Z_{fipt} captures firm attributes. We again take t=2000 and 2006 to capture the IPRs environment both before and after changes in provincial win rates and settled patents intensity. We restrict the sample to the subset of firms with positive Y values for both years in order to capture continued activities. 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 year fixed effects FE_t :

$$Y_{fipt} = \beta_0 + \beta_1 IPR_{pt} + \beta_2 TARIFF_{it} + Z_{fipt}\gamma + FE_i + FE_t + \varepsilon_{fip} \qquad (17')$$

As discussed earlier, it is important in regressions explaining trade volumes to control for the potential endogeneity of the win rates and settled patents ratio. For this purpose, we use the instruments defined earlier: the origins of former colonial rule by province and the enrollment rates in Christian missionary lower primary schools in 1919. 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.[16] We expect that $\beta_1 > 0$ in both regression specifications.

Table 4A reports regression estimates for log of exports by firm. Columns (1) - (4) and (5) - (8), respectively, report the results when IPRs enforcement is proxied by the win rates or the settled patent ratio. Without controlling for the fixed effects and potential endogeneity, the OLS results in columns (1) - (2) suggest that stronger enforcement, reflected by higher win rates, leads to significantly higher export volume. In contrast, columns (5) and (6) suggest that stronger enforcement, measured by higher settled patent ratio, leads to lower exports. These opposite signs indicate inconsistent estimation that may be due to potential endogeneity of the IPRs enforcement proxies.

To address potential endogeneity we incorporate the instruments with two-stage least squares. In the first-stage, the win rates or settled patent ratio is regressed on the colonial dummies and Christian enrollment, along with the other exogenous variables. In both first-stage regressions, the IVs are highly significant, with the corresponding Stock-Yogo F-test being as high as 1661 for the win rates regression and 670 for the settled patent ratio regression. This suggests that we have strong instruments and that the colonial and Christian influences significantly affect the modern IPRs enforcement environment, consistent with prior literature.

Both the fixed effects and the second-stage IV estimated coefficients, in columns (3) - (4) and columns (7) - (8), respectively, show that the enforcement impacts on exports volumes are positive and significant, with the IV estimates considerably higher. This evidence suggests that exporters in provinces with stronger IPRs protection have significantly higher exports than exporting firms located elsewhere. The estimated coefficient of 0.751 from our preferred model in column (4), for example, suggests that a one standard deviation increase in win rates leads to a 32% (0.751×0.42) average rise in exports across firms. The estimated coefficient of 67.98 from column (8) suggests that a one standard deviation increase in the settled patent ratio generates a 26% (67.98×0.0038) increase in trade. In addition, more productive firms, younger firms, foreign firms, and firms owned by Hong Kong-Macau-Taiwan investors tend to have higher exports. Import tariff reductions lead to less exports for a continued

[16] Notice that these instruments capture cross-province variations in culture through data applied to a fixed time period, which should more accurately reflect on provincial protection than yearly variations of IPRs enforcement. This is why we use IVs for specifications (17) and (17)', which emphasize the level variation in enforcement by province. We do not use IVs for specifications (16) and (16)', which incorporate changes in IPRs and in which first-differencing largely filters out the endogenous component of IPR.

exporter. This is possible, in that lower industry-level import tariffs generate more intensive competition, which could pressure such firms to contract.

Table 4B reports results for log of capital goods import. Similar to the export regressions, our two-stage least squares estimates suggest a significantly positive IPRs impact on the volume of capital imports. The OLS and fixed-effects results are somewhat mixed.[17] Taking the 2SLS coefficients as the preferred models, firms in provinces with stronger IPRs protection import more capital goods. The estimated coefficient of 0.827 from column (4), for example, implies that a one standard deviation increase in win rates leads to a 35% (0.827×0.42) growth in such imports. The coefficient of 257.2 from column (8) implies that a one standard deviation increase in the settled patent ratio leads to a 90% (257.2×0.0038) expansion in capital imports. More productive firms, younger firms, foreign firms, and firms owned by Hong Kong-Macau-Taiwan investors also import more capital goods. Import tariff reductions appear not to directly affect capital goods imports, which again may reflect the largely duty-free treatment of machinery imports even prior to this period in China.

The impacts of enforcing IPRs on developing new products, shown in Table 4C, are somewhat mixed. The IV coefficient on the win rates is negative and significant at 5% (with positive and significant OLS estimates), while coefficients on the settled patent ratio are negative across all specifications. While improvement of IPRs enforcement induces some marginal firms to start producing new products (our extensive-margin outcome), it may not necessarily induce continuing firms to increase their production of such goods. Although trade theory (i.e., Melitz 2003) predicts higher trade volumes for continued traders after trade liberalization, its predictions regarding new products is less straightforward. Similarly, change in IPRs enforcement lead to an unambiguous prediction on trade volumes, but not for manufacture of new products. Table 4C also shows that tariff reductions induce continued firms to reduce new product production, which suggests that cheaper imports induced by lower tariffs may have substituted for the need to develop new products domestically.

In summary, Tables 4A-4C present evidence that is largely consistent with our model predictions about intensive margins. More rigorous IPRs enforcement, measured across provinces and over time, encourages continued exporters and capital goods importers to increase exports and capital goods imports, respectively. The prediction and evidence on new products as a proxy for foreign technology purchasing are less clear-cut.

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 enforcement affects firms' technology transfer channel and exporting decisions in the presence of firm heterogeneity. Second, it provides insights into the channels through which IPRs

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[17] The OLS coefficient using the win rates is significantly negative but the fixed-effects coefficient for the settled patents ratio, though positive, is only marginally significant at 15%.

reform-driven productivity changes occur. Our study also shed light on how stronger intellectual property rights can promote domestic industrial transformation and support both the intensive and extensive margins of trade.

References

Acharya, Ram C. and Wolfgang Keller. Technology Transfer through Imports. *Canadian Journal of Economics* 42, 1411-1448.

Aghion, Philippe, George-Marios Angeletos, Abijit Banerjee, and Kalina Manova. 2010. Volatility and Growth: Credit Constraints and the Composition of Investment. *Journal of Monetary Economics* 57, 246–265.

Amiti, Mary and Jozef Konings. 2007. Trade Liberalization, Intermediate Inputs and Productivity: Evidence from Indonesia. *American Economic Review* 97, 1611-1638.

Ang, James S., Yingmei Cheng, and Chaopeng Wu. 2014. Does Enforcement of Intellectual Property Rights Matter In China? Evidence from Financing and Investment Choices in the High-Tech Industry. *Review of Economics and Statistics* 96, 332-348.

Baldwin, Richard, Henrik Braconier, and Rikard Forslid. 2005. Multinationals, Endogenous Growth, and Technological Spillovers: Theory and Evidence. *Review of International Economics*, 13(5), 945–963.

Bas, Maria and Vanessa Strauss-Kahn. 2015. Input-Trade Liberalization, Export Prices and Quality Upgrading. *Journal of International Economics* 95, 250-262.

Bernard, Andrew B. and Bradford J. Jensen. 1999. Exceptional Exporter Performance: Cause, Effect, or Both? *Journal of International Economics* 47, 1-25.

Bernard, Andrew B., Stephen G. Redding, Peter K. Schott. 2007. Comparative Advantage and Heterogeneous Firms. *Review of Economic Studies* 74, 31-66.

Bhattasali, Deepak, Shantong Li and Will Martin. 2004. China and the WTO Accession, Policy Reform, and Poverty Reduction Strategies. World Bank and Oxford University Press.

Bilir, L. Kamran. 2014. Patent Laws, Product Lifecycle Lengths, and the Global Sourcing Decisions of US Multinationals. *American Economic Review* 104, 1979-2013.Blyde, Juan S. 2003. The Role of Foreign Investment and Imports of Capital Goods in the North-South Diffusion of Technology. *Journal of Economic Integration* 18, 545-562.

Branstetter, Lee G., Ray Fisman, and C. Fritz Foley. 2006. Do Stronger Intellectual Property Rights Increase International Technology Transfer? Empirical Evidence from U.S. Firm-Level Panel Data. *Quarterly Journal of Economics* 121, 321-349.

Branstetter, Lee G., Ray Fisman, C. Fritz Foley, and Kamal Saggi. 2011. Does Intellectual Property Rights Reform Spur Industrial Development? *Journal of International Economics* 83, 27-36.

Bustos, Paula. 2011. Trade Liberalization, Exports, and Technology Upgrading: Evidence on the Impact of MERCOSUR on Argentinian Firm. *American Economic Review* 101, 304-340.

Conti, Annamaria, Jerry Thursby, and Marie C. Thursby. 2013. Patents as Signals for Startup Financing. *National Bureau of Economic Research Working Paper* no. 19191.

Eaton, Jonathan and Samuel Kortum. 2001. Trade in Capital Goods. *European Economic Review* 45, 1195-1235.

Delgado, Mercedes, Margaret Kyle, and Anita M. McGahan. 2013. Intellectual Property Protection and the Geography of Trade. *Journal of Industrial Economics* 61, 733-762.

Fang, Ying and Yang Zhao. 2007. Do Institutions Matter? Estimating the Effects of Institutions on Economic Performance in China. Working paper, available at http://ssrn.com/abstract=957719.

Feenstra, Robert C., Chang Hong, Hong Ma, and Barbara J. Spencer. 2013. Contractual versus Non-Contractual Trade: the Role of Institutions in China. *Journal of Economic Behavior and Organization* 94, 281-294.

Ge, Ying, Huiwen Lai, and Susan Zhu. 2015. Multinational Price Premium. *Journal of Development Economics* 115,181-199.

Ginarte, Juan C. and Walter G. Park. 1997. Determinants of Patent Rights: A Cross-National Study. *Research Policy* 26, 283-301.

Glass, Amy J. and Kamal Saggi. 1999. Intellectual Property Rights and Foreign Direct Investment. *Journal of International Economics* 56, 387–410.

Goldberg, Pinelopi Koujianou, Amit Kumar Khandelwal, Nina Pavcnik, and Petia Topalova. 2010. Imported Intermediate Inputs and Domestic Productivity Growth: Evidence from India. *Quarterly Journal of Economics* 125, 1727-1767.

Grossman, Gene M. and Elhanan Helpman. 1991. Innovation and Growth in the Global Economy. Cambridge, MA: MIT Press.

He, Yin and Keith E. Maskus. 2012. Southern Innovation and Reverse Knowledge Spillover: A Dynamic FDI Model. *International Economic Review* 53, 279-302.

Helpman, Elhanan. 1993. Innovation, Imitation, and Intellectual Property Rights. *Econometrica* 61, 1247-1280.

Helpman, Elhanan, Marc J. Melitz and Stephen R. Yeaple. 2004. Exports versus FDI with Heterogeneous Firms. *American Economic Review* 94, 300-316.

Hoekman, Bernard M., Keith E. Maskus, and Kamal Saggi. 2005. Transfer of Technology to Developing Countries: Unilateral and Multilateral Policy Options. *World Development* 33, 1587-1602.

Hu, Albert G. Z. and Ivan P. L. Png. 2013. Patent Rights and Economic Growth: Evidence from Cross-Country Panels of Manufacturing Industries. Oxford Economic Papers 65, 675—698.

Ivus, Olena. 2010. Do Stronger Patent Rights Raise High-Tech Exports to the Developing World? *Journal of International Economics* 81, 38-47.

Javorcik, Beata Smarzynska. 2004. The Composition of Foreign Direct Investment and Protection of Intellectual Property Rights: Evidence from Transition Economies. *European Economic Review* 48, 39-62.

Joyce, James A. 2009. Chinese patent law reform: Sharpening the Dragon's Teeth. Wisconsin Technology Network. http://wtnnews.com/articles/6245/.

Liang, Zheng and Lan Xue. 2010. The Evolution of China's IPR System and Its Impact on the Patenting Behaviors and Strategies of Multinationals in China. *International Journal of Technology Management* 51, 469-496.

Lu, Yi, Ivan P. L. Png, and Zhigang Tao. 2013. Do Institutions Not Matter in China? Evidence from Manufacturing Enterprises. *Journal of Comparative Economics* 41, 74-90.

Manova, Kalina. 2013. Credit Constraints, Heterogeneous Firms, and International Trade. *Review of Economic Studies* 80, 711-744.

Manova, Kalina, Shang-Jin Wei, and Zhiwei Zhang. 2015. Firm Exports and Multinational Activity under Credit Constraints. *Review of Economics and Statistics* 97, 574-588.

Maskus, Keith E. 2004. Intellectual Property Rights in the WTO Accession Package: Assessing China's Reforms. In Deepak Bhattasali, Shantong Li, and William J. Martin, eds, *China and the WTO:*

Accession, Policy Reform, and Poverty Reduction Strategies. Oxford: Oxford University Press, 49-68.

Maskus, Keith E. 2012. *Private Rights and Public Problems: the Global Economics of Intellectual Property in the 21st Century*. Washington DC: Peterson Institute for International Economics.

Maskus, Keith E., Sahar Milani, and Rebecca Neumann. 2018. The Impact of Financial Development and Patent Protection on Industrial R&D. University of Colorado Boulder, Manuscript.

Maskus, Keith E., Rebecca Neumann, and Tobias Seidel. 2012. How National and International Financial Development Affect Industrial R&D. *European Economic Review* 56, 72-83.

Maskus, Keith E. and Mohan Penubarti. 1995. How Trade-related are Intellectual Property Rights? *Journal of International Economics* 39, 227-248.

Maskus, Keith E. and Lei Yang. 2018. Patent Reforms and Export Specialization. *Canadian Journal of Economics* 51, 483-509.

Melitz, Marc J. 2003. The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity. *Econometrica* 71, 1695-1725.

Mertha, Andrew C. 2005. *The Politics of Piracy: Intellectual Property in Contemporary China*. Ithaca NY: Cornell University Press.

Nagaoka, Sadao. 2004. Do Intellectual Property Rights Protection and Ownership Control Facilitate International Licensing? Some Evidence from Licensing Contracts of Japanese Firms. Hitotsubashi University, Manuscript.

Park, Walter G. 2008. International Patent Protection: 1960-2005. *Research Policy* 37, 761-766.

Rajan, Raghuram G. and Luigi Zingales. 1998. Financial Dependence and Growth. *American Economic Review* 88, 559-586.

Smith, Pamela J. 2001. How Do Foreign Patent Rights Affect U.S. Exports, Affiliate Sales, and Licenses? *Journal of International Economics* 5, 411-440.

Wang, Yongjin, Yanling Wang and Kunwang Li. 2014. Judicial Quality, Contract Intensity and Exports: Firm-Level Evidence. *China Economic Review* 31, 32-42.

Xu, Bin and Jianmao Wang. 1999. Capital Goods Trade and R&D Spillovers in the OECD. *Canadian Journal of Economics* 32, 1258-1274.

Yang, Guifang and Keith E. Maskus. 2001. Intellectual Property Rights and Licensing: An Econometric Investigation. *Weltwirtschaftliches Archiv* 137, 58-79.

Yang, Guifang and Keith E. Maskus. 2001. Intellectual Property Rights, Licensing, and Innovation in an Endogenous Product-Cycle Model. *Journal of International Economics* 53, 169-187.

Yang, Lei and Keith E. Maskus. 2009. Intellectual Property Rights, Technology Transfer and Exports in Developing Countries. *Journal of Development Economics* 90, 231-236.

Yeaple, Stephen R. 2005. A Simple Model of Firm Heterogeneity, International Trade, and Wages. *Journal of International Economics* 65, 1-20.

World Bank. 2008. Doing Business in China 2008. Available at: www.doingbusiness.org/china.

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

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

Table 1: Firm Performance under Different Exporting Status

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Variables	log(tfp)		log(capital/labor)		log(labor)		log(sale)		log(total asset)		log(wage)	
	2000	2006	2000	2006	2000	2006	2000	2006	2000	2006	2000	2006
Continued exporter dummy	0.477***	0.437***	0.0605***	0.0715***	0.752***	0.775***	0.767***	0.740***	0.740***	0.775***	0.773***	0.764***
	(0.0183)	(0.0193)	(0.0181)	(0.0177)	(0.0178)	(0.0183)	(0.0220)	(0.0251)	(0.0249)	(0.0270)	(0.0213)	(0.0250)
Discontinued exporter dummy	0.271***	0.0221	0.0901***	0.105***	0.472***	0.221***	0.452***	0.123***	0.507***	0.319***	0.466***	0.136***
	(0.0168)	(0.0198)	(0.0197)	(0.0200)	(0.0184)	(0.0188)	(0.0198)	(0.0229)	(0.0235)	(0.0240)	(0.0198)	(0.0227)
log(age)	0.0852***	-0.0275***	0.0388***	0.0637***	0.324***	0.167***	0.165***	0.0295***	0.335***	0.216***	0.184***	0.0388***
	(0.00635)	(0.00881)	(0.00698)	(0.00864)	(0.00607)	(0.00791)	(0.00704)	(0.0102)	(0.00759)	(0.00960)	(0.00679)	(0.0101)
Foreign firm dummy	0.361***	0.392***	0.906***	0.447***	-0.0278	0.137***	0.512***	0.508***	0.791***	0.568***	0.477***	0.476***
	(0.0183)	(0.0222)	(0.0269)	(0.0219)	(0.0174)	(0.0180)	(0.0223)	(0.0272)	(0.0239)	(0.0256)	(0.0221)	(0.0266)
HK-Macau-Taiwan dummy	0.136***	0.142***	0.536***	0.169***	0.00347	0.0513***	0.265***	0.195***	0.532***	0.286***	0.249***	0.176***
	(0.0171)	(0.0190)	(0.0248)	(0.0198)	(0.0169)	(0.0171)	(0.0192)	(0.0224)	(0.0221)	(0.0226)	(0.0189)	(0.0223)
Constant	6.180***	7.147***	3.291***	3.528***	4.235***	4.509***	9.295***	10.26***	8.818***	9.547***	9.140***	10.07***
	(0.0163)	(0.0232)	(0.0182)	(0.0231)	(0.0153)	(0.0211)	(0.0182)	(0.0274)	(0.0202)	(0.0267)	(0.0177)	(0.0274)
Observations	67,325	65,868	68,623	68,798	68,936	68,943	68,780	68,697	69,245	69,101	68,836	68,840
R-squared	0.432	0.472	0.330	0.303	0.409	0.348	0.361	0.337	0.391	0.341	0.362	0.334
Industry-province fixed effects	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes

In parentheses are standard errors clustered at industry-province level. *** p<0.01, ** p<0.05, * p<0.1

Table 2A: Firm Performance under Different Exporting and Capital Goods Importing Status

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
VARIABLES	log(tfp)		log(capital/labor)		log(labor)		log(sale)		log(total asset)		log(wage)	
	2000	2006	2000	2006	2000	2006	2000	2006	2000	2006	2000	2006
Export & capital goods importer dummy	0.828***	0.764***	0.431***	0.497***	1.130***	1.115***	1.309***	1.243***	1.305***	1.316***	1.299***	1.243***
	(0.0266)	(0.0159)	(0.0234)	(0.0155)	(0.0190)	(0.0158)	(0.0279)	(0.0192)	(0.0270)	(0.0209)	(0.0271)	(0.0190)
Export & non capital goods import dummy	0.460***	0.286***	-0.0253*	-0.042***	0.692***	0.501***	0.712***	0.461***	0.641***	0.416***	0.739***	0.469***
	(0.0158)	(0.0110)	(0.0151)	(0.0151)	(0.0137)	(0.0118)	(0.0195)	(0.0148)	(0.0209)	(0.0178)	(0.0193)	(0.0149)
log(age)	-0.042***	0.135***	0.074***	-0.0153**	0.264***	0.243***	0.030***	0.196***	0.305***	0.231***	0.051***	0.202***
	(0.00619)	(0.00527)	(0.00562)	(0.00596)	(0.00482)	(0.00457)	(0.00670)	(0.00630)	(0.00613)	(0.00577)	(0.00643)	(0.00621)
Foreign firm dummy	0.315***	0.276***	0.768***	0.441***	-0.0226	0.193***	0.461***	0.404***	0.730***	0.637***	0.440***	0.388***
	(0.0185)	(0.0124)	(0.0236)	(0.0192)	(0.0149)	(0.0118)	(0.0214)	(0.0169)	(0.0229)	(0.0194)	(0.0211)	(0.0168)
HK-Macau-Taiwan dummy	0.0981***	0.143***	0.470***	0.258***	-0.002	0.257***	0.240***	0.269***	0.512***	0.536***	0.232***	0.271***
	(0.0187)	(0.0125)	(0.0267)	(0.0148)	(0.0131)	(0.0101)	(0.0214)	(0.0146)	(0.0235)	(0.0153)	(0.0205)	(0.0142)
Constant	6.144***	6.517***	3.166***	3.576***	4.092***	3.968***	9.164***	9.552***	8.550***	9.056***	8.993***	9.366***
	(0.0156)	(0.0105)	(0.0158)	(0.0109)	(0.0117)	(0.00953)	(0.0170)	(0.0128)	(0.0170)	(0.0128)	(0.0164)	(0.0127)
Observations	136,801	265,527	142,260	276,809	144,102	277,390	141,664	276,985	143,640	274,697	142,763	277,138
R-squared with FE	0.360	0.423	0.247	0.239	0.349	0.322	0.346	0.263	0.362	0.301	0.343	0.260
Industry-province fixed effects	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes

In parentheses are standard errors clustered at the industry-province level. *** p<0.01, ** p<0.05, * p<0.1

Table 2B: Firm Performance under Different Exporting and New Product Producing Status

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
VARIABLES	log(tfp)		log(capital/labor)		log(labor)		log(sale)		log(total asset)		log(wage)	
	2000	2006	2000	2006	2000	2006	2000	2006	2000	2006	2000	2006
Export & new product dummy	1.142***	0.687***	0.461***	0.247***	1.418***	0.882***	1.653***	1.010***	1.764***	1.033***	1.658***	0.999***
	(0.0237)	(0.0218)	(0.0177)	(0.0173)	(0.0226)	(0.0295)	(0.0283)	(0.0320)	(0.0286)	(0.0383)	(0.0278)	(0.0341)
Export & non-new product dummy	0.391***	0.264***	-0.0365**	-0.0204	0.628***	0.511***	0.634***	0.455***	0.537***	0.413***	0.659***	0.467***
	(0.0145)	(0.0101)	(0.0155)	(0.0158)	(0.0119)	(0.0110)	(0.0167)	(0.0136)	(0.0171)	(0.0163)	(0.0164)	(0.0136)
log(age)	-0.0516***	0.135***	0.0672***	-0.0137**	0.254***	0.245***	0.0164**	0.198***	0.290***	0.233***	0.0377***	0.204***
	(0.00614)	(0.00528)	(0.00564)	(0.00607)	(0.00474)	(0.00461)	(0.00662)	(0.00634)	(0.00600)	(0.00586)	(0.00635)	(0.00626)
Foreign firm dummy	0.413***	0.359***	0.874***	0.525***	0.0898***	0.292***	0.613***	0.534***	0.902***	0.785***	0.583***	0.515***
	(0.0183)	(0.0131)	(0.0237)	(0.0197)	(0.0145)	(0.0119)	(0.0213)	(0.0180)	(0.0219)	(0.0202)	(0.0209)	(0.0179)
HK-Macau-Taiwan dummy	0.174***	0.196***	0.546***	0.308***	0.0822***	0.317***	0.354***	0.350***	0.642***	0.628***	0.340***	0.350***
	(0.0183)	(0.0122)	(0.0263)	(0.0147)	(0.0135)	(0.0103)	(0.0204)	(0.0145)	(0.0222)	(0.0154)	(0.0195)	(0.0141)
Constant	6.161***	6.506***	3.174***	3.563***	4.108***	3.953***	9.186***	9.533***	8.577***	9.033***	9.014***	9.347***
	(0.0151)	(0.0104)	(0.0156)	(0.0109)	(0.0114)	(0.00958)	(0.0163)	(0.0127)	(0.0160)	(0.0127)	(0.0157)	(0.0125)
Observations	136,801	265,527	142,260	276,809	144,102	277,390	141,664	276,985	143,640	274,697	142,763	277,138
R-squared	0.365	0.422	0.246	0.235	0.356	0.315	0.352	0.257	0.372	0.293	0.349	0.254
Industry-province fixed effects	yes	yes	yes	yes	Yes	yes	yes	yes	yes	yes	yes	Yes

In parentheses are standard errors clustered at the industry-province level. *** p<0.01, ** p<0.05, * p<0.1

Table 3A: Change of IPRs on Exit Decision

	dependent=exit dummy							
Variables	(1) OLS	(2) OLS	(3) Fixed Effects	(4) Fixed Effects	(5) OLS	(6) OLS	(7) Fixed Effects	(8) Fixed Effects
Change of IP cases win rates	0.0208***	0.0411***	0.0200**	0.0427***				
	(0.0131)	(0.0112)	(0.00771)	(0.00856)				
Change of settled patent ratio					20.08***	15.27***	16.43***	11.10***
					(2.545)	(2.366)	(1.734)	(1.796)
change of tariffs		-0.253***				-0.238***		
		(0.0377)				(0.0355)		
log(tfp_{2000})		-0.0637***		-0.0654***		-0.0635***		-0.0649***
		(0.00181)		(0.00143)		(0.00169)		(0.00137)
log(age_{2000})		-0.00296		0.00301		-0.00306		0.00298
		(0.00223)		(0.00204)		(0.00212)		(0.00196)
		0.00383		0.0115		0.00689		0.0128
Foreign firm dummy		(0.00927)		(0.00866)		(0.00908)		(0.00852)
		0.0175***		0.00899		0.0171**		0.00735
HK-Macau-Taiwan dummy		(0.00864)		(0.00750)		(0.00848)		(0.00786)
Constant	0.638***	0.985***	0.638***	1.003***	6.183***	5.207***	5.177***	4.073***
	(0.00585)	(0.0121)	(0.00368)	(0.0103)	(0.702)	(0.368)	(0.479)	(0.495)
Observations	103,886	90,286	103,886	94,497	110,434	96,140	110,434	100,589
R-squared	0.000	0.039	0.0414	0.0732	0.002	0.041	0.0421	0.0733
Industry fixed effects	no	no	yes	yes	no	no	yes	Yes

In parentheses are standard errors clustered at the industry-province level. *** p<0.01, ** p<0.05, * p<0.1

Table 3B: Change of IPRs on Export Decision

	dependent=start exporting dummy							
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	OLS	Fixed Effects	Fixed Effects	OLS	OLS	Fixed Effects	Fixed Effects
Change of IP cases win rates	0.0382***	0.0545***	0.0293***	0.0367***				
	(0.0134)	(0.0137)	(0.00859)	(0.00873)				
Change of settled patent ratio					11.31***	12.83***	8.923***	11.17***
					(3.315)	(3.428)	(2.168)	(2.277)
change of tariffs		-0.0797				-0.0634		
		(0.0562)				(0.0524)		
log(tfp_{2000})		0.0129***		0.0322***		0.0121***		0.0323***
		(0.00293)		(0.00177)		(0.00280)		(0.00171)
log(age_{2000})		-0.0229***		-0.0160***		-0.0229***		-0.0160***
		(0.00233)		(0.00203)		(0.00221)		(0.00193)
		0.181***		0.163***		0.180***		0.161***
Foreign firm dummy		(0.0115)		(0.0102)		(0.0113)		(0.01000)
		0.139***		0.110***		0.137***		0.108***
HK-Macau-Taiwan dummy		(0.0111)		(0.00926)		(0.0109)		(0.00911)
Constant	0.139***	0.0745***	0.142***	-0.0505***	3.467***	3.861***	2.765***	3.233***
	(0.00642)	(0.0184)	(0.00427)	(0.0119)	(0.579)	(1.006)	(0.635)	(0.668)
Observations	43,773	40,198	43,773	42,114	46,386	42,646	46,386	44,652
R-squared	0.001	0.034	0.0686	0.100	0.001	0.033	0.0681	0.0990
Industry fixed effects	no	no	yes	yes	no	no	yes	yes

In parentheses are standard errors clustered at the industry-province level. *** p<0.01, ** p<0.05, * p<0.1

Table 3C: Change of IPRs on Capital Goods Import Decision

	dependent=start capital goods importing dummy							
Variables	(1) OLS	(2) OLS	(3) Fixed Effects	(4) Fixed Effects	(5) OLS	(6) OLS	(7) Fixed Effects	(8) Fixed Effects
Change of IP cases win rates	0.00546	0.0129***	0.00228	0.00621**				
	(0.00434)	(0.00455)	(0.00321)	(0.00312)				
Change of settled patent ratio					0.979***	1.329***	0.161	1.206***
					(0.285)	(0.294)	(0.324)	(0.317)
change of tariffs		-0.00426				-0.00242		
		(0.0123)				(0.0115)		
$\log(tfp_{2000})$		0.0127***		0.0190***		0.0122***		0.0185***
		(0.000973)		(0.000931)		(0.000933)		(0.000902)
$\log(age_{2000})$		-0.00178**		-0.00301***		-0.00169*		-0.00291***
		(0.000908)		(0.000873)		(0.000863)		(0.000832)
		0.0960***		0.0889***		0.0964***		0.0891***
Foreign firm dummy		(0.00618)		(0.00594)		(0.00607)		(0.00584)
		0.0573***		0.0501***		0.0559***		0.0485***
HK-Macau-Taiwan dummy		(0.00434)		(0.00401)		(0.00429)		(0.00396)
Constant	0.0369***	-0.0580***	0.0381***	-0.0913***	0.325	0.339	0.0853	0.267
	(0.00201)	(0.00633)	(0.00151)	(0.00623)	(0.370)	(0.374)	(0.308)	(0.295)
Observations	57,980	53,765	57,980	56,154	61,078	56,666	61,078	59,167
R-squared	0.000	0.029	0.0306	0.0599	0.000	0.028	0.0304	0.0588
Industry fixed effects	no	no	yes	yes	no	no	yes	yes

In parentheses are standard errors clustered at the industry-province level. *** p<0.01, ** p<0.05, * p<0.1

Table 3D: Change of IPR on New Products Decision

	dependent=start new products dummy							
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	OLS	Fixed Effects	Fixed Effects	OLS	OLS	Fixed Effects	Fixed Effects
Change of IP cases win rates	0.266***	0.222***	0.261***	0.220***				
	(0.0289)	(0.0279)	(0.0243)	(0.0244)				
Change of settled patent ratio					25.69***	23.76***	27.13***	24.42***
					(6.157)	(5.625)	(5.054)	(4.777)
change of tariffs		0.212***				0.200***		
		(0.0728)				(0.0361)		
$\log(tfp_{2000})$		0.0248***		0.0265***		0.0255***		0.0280***
		(0.00286)		(0.00285)		(0.00200)		(0.00280)
$\log(age_{2000})$		0.00263		0.00226		0.00376		0.00213
		(0.00388)		(0.00346)		(0.00307)		(0.00337)
		-0.0496***		-0.0529***		-0.0601***		-0.0628***
Foreign firm dummy		(0.00756)		(0.00668)		(0.00591)		(0.00677)
		-0.0554***		-0.0515***		-0.0771***		-0.0713***
HK-Macau-Taiwan dummy		(0.00658)		(0.00651)		(0.00537)		(0.00660)
Constant	0.00362	-0.0986***	0.00554	-0.131***	7.632***	6.950***	8.054***	7.107***
	(0.00940)	(0.0239)	(0.00825)	(0.0228)	(1.805)	(1.652)	(1.483)	(1.400)
Observations	19,159	18,181	19,159	18,803	19,559	18,549	19,559	19,192
R-squared	0.021	0.039	0.0745	0.0877	0.003	0.028	0.0607	0.0791
Industry fixed effects	no	no	yes	yes	no	no	yes	yes

In parentheses are standard errors clustered at the industry-province level. *** p<0.01, ** p<0.05, * p<0.1

Table 4A: IPRs Impact on Export Volume

	Dependent=log(export)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Variables	OLS	OLS	Fixed Effects	2nd-stage IV	OLS	OLS	Fixed Effects	2nd-stage IV
IP cases win rates	0.458***	0.223***	0.159***	0.751***				
	(0.0215)	(0.0273)	(0.0236)	(0.0542)				
Settled patent ratio					-0.541***	-0.254***	29.41***	67.98***
					(0.0202)	(0.0394)	(5.447)	(13.22)
Tariffs		0.662**	1.563***	1.560***		0.675**	1.541***	1.578***
		(0.311)	(0.309)	(0.214)		(0.338)	(0.307)	(0.211)
log(tfp)		0.565***	0.829***	0.833***		0.562***	0.828***	0.829***
		(0.0159)	(0.0115)	(0.00627)		(0.0162)	(0.0115)	(0.00619)
log(age)		-0.0609***	-0.0346**	-0.0349***		-0.0662***	-0.0338**	-0.0303***
		(0.0189)	(0.0139)	(0.0101)		(0.0189)	(0.0136)	(0.00995)
		0.472***	0.362***	0.334***		0.482***	0.379***	0.389***
Foreign firm dummy		(0.0359)	(0.0269)	(0.0176)		(0.0361)	(0.0267)	(0.0177)
		0.471***	0.365***	0.281***		0.508***	0.389***	0.386***
HK-Macau-Taiwan dummy		(0.0376)	(0.0251)	(0.0186)		(0.0390)	(0.0247)	(0.0169)
Constant	8.641***	5.113***	3.293***	1.873***	8.033***	4.865***	94.46***	213.5***
	(0.0645)	(0.151)	(0.142)	(0.145)	(0.0787)	(0.176)	(16.80)	(40.80)
Observations	36,300	34,413	34,413	34,338	36,734	34,826	34,826	34,717
R-squared	0.030	0.255	0.438	0.453	0.031	0.254	0.439	0.442
Industry fixed effects	no	no	yes	yes	no	no	yes	yes

In parentheses are standard errors clustered at the industry-province level. *** p<0.01, ** p<0.05, * p<0.1

Table 4B: IPRs Impact on Capital Goods Import Volume

	Dependent=log(capital goods import)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Variables	OLS	OLS	Fixed Effects	2nd-stage IV	OLS	OLS	Fixed Effects	2nd-stage IV
IP cases win rates	0.00784	-0.360***	0.519***	0.827***				
	(0.0528)	(0.0785)	(0.107)	(0.181)				
Settled patent ratio					0.105**	0.820***	17.96	257.2***
					(0.0492)	(0.0987)	(14.52)	(45.03)
Tariffs		-1.939***	0.121	0.0912		-2.930***	-0.0247	-0.0345
		(0.685)	(0.775)	(0.688)		(0.698)	(0.729)	(0.689)
log(tfp)		0.614***	0.830***	0.833***		0.637***	0.826***	0.824***
		(0.0296)	(0.0280)	(0.0212)		(0.0310)	(0.0278)	(0.0214)
log(age)		-0.386***	-0.199***	-0.207***		-0.184***	-0.181***	-0.176***
		(0.0681)	(0.0603)	(0.0542)		(0.0675)	(0.0594)	(0.0544)
		0.486***	0.974***	0.972***		0.636***	0.994***	1.084***
Foreign firm dummy		(0.145)	(0.130)	(0.101)		(0.143)	(0.129)	(0.103)
		0.422***	0.875***	0.850***		0.518***	0.923***	0.921***
HK-Macau-Taiwan dummy		(0.143)	(0.132)	(0.105)		(0.143)	(0.131)	(0.105)
Constant	7.123***	4.245***	-0.520	-1.277**	7.527***	5.532***	56.20	794.5***
	(0.149)	(0.240)	(0.413)	(0.516)	(0.183)	(0.262)	(44.82)	(139.0)
Observations	9,505	8,909	8,909	8,893	9,566	8,964	8,964	8,943
R-squared	0.000	0.121	0.316	0.320	0.000	0.131	0.313	0.340
Industry fixed effects	no	no	yes	yes	no	no	yes	yes

In parentheses are standard errors clustered at the industry-province level. *** p<0.01, ** p<0.05, * p<0.1

Table 4C: IPRs impact on New Products Volume

Variables	Dependent=log(new products)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	OLS	Fixed Effects	2nd-stage IV	OLS	OLS	Fixed Effects	2nd-stage IV
IP cases win rates	0.593***	0.344***	0.107	-0.799**				
	(0.0440)	(0.0594)	(0.0749)	(0.407)				
Settled patent ratio					-0.802***	-0.470***	-0.372	-59.13
					(0.0472)	(0.0734)	(10.82)	(47.26)
Tariffs		1.540**	1.779***	1.934***		1.872***	1.731***	1.766***
		(0.624)	(0.532)	(0.604)		(0.612)	(0.494)	(0.573)
log(tfp)		0.642***	1.072***	1.069***		0.626***	1.072***	1.075***
		(0.0357)	(0.0290)	(0.0237)		(0.0378)	(0.0284)	(0.0229)
log(age)		-0.0439	-0.0414	-0.0358		-0.0432	-0.0420	-0.0472
		(0.0416)	(0.0313)	(0.0304)		(0.0410)	(0.0314)	(0.0293)
		0.239**	0.0160	0.0399		0.250**	0.0232	0.00216
Foreign firm dummy		(0.118)	(0.0809)	(0.0797)		(0.117)	(0.0802)	(0.0776)
		0.0573	0.0653	0.104		0.0763	0.0692	0.0613
HK-Macau-Taiwan dummy		(0.117)	(0.0913)	(0.0946)		(0.117)	(0.0907)	(0.0904)
Constant	8.995***	4.427***	1.617***	3.763***	7.820***	3.810***	0.725	-180.7
	(0.132)	(0.336)	(0.313)	(0.992)	(0.172)	(0.363)	(33.42)	(145.9)
Observations	3,729	3,480	3,480	3,473	3,830	3,578	3,578	3,568
R-squared	0.031	0.258	0.612	0.625	0.040	0.257	0.610	0.612
Industry fixed effects	no	no	yes	yes	no	no	yes	yes

In parentheses are standard errors clustered at the industry-province level. *** p<0.01, ** p<0.05, * p<0.1

Appendix Table 1: Summary Statistics

Variables	year	mean	SD	Minimum	25th Percentile	Median	75th Percentile	Maximum	observations
A: Firm Attributes									
log(tfp)	2000	6.228	1.427	-8.365	5.495	6.280	7.087	13.589	137,165
	2006	6.925	1.311	-4.502	6.124	6.885	7.724	15.229	265,661
log(capital/labor)	2000	3.471	1.334	-6.992	2.702	3.517	4.296	13.271	142,650
	2006	3.638	1.337	-6.858	2.834	3.703	4.508	11.909	276,976
log(labor)	2000	4.898	1.234	0.000	4.094	4.868	5.663	11.993	144,529
	2006	4.649	1.102	0.000	3.912	4.554	5.298	11.816	277,608
log(sale)	2000	9.517	1.546	0.000	8.772	9.503	10.389	17.314	142,046
	2006	10.167	1.296	0.000	9.239	10.002	10.903	18.872	277,129
log(total asset)	2000	9.571	1.530	0.000	8.592	9.467	10.480	18.067	144,036
	2006	9.529	1.425	0.000	8.562	9.350	10.339	18.082	256,487
log(wage)	2000	9.394	1.536	0.000	8.659	9.388	10.259	17.062	143,151
	2006	9.991	1.288	0.000	9.099	9.834	10.715	18.838	277,286
log(age)	2000	2.302	0.934	0.000	1.609	2.197	3.045	4.595	147,135
	2006	1.896	0.806	0.000	1.386	1.946	2.398	4.595	278,835
new product indicator	2000	0.076	0.264	0.000	0.000	0.000	0.000	1.000	147,627
	2006	0.104	0.305	0.000	0.000	0.000	0.000	1.000	279,135
log(new product)	2000	8.963	2.117	0.000	7.683	9.048	10.333	17.069	11,155
	2006	9.105	2.114	0.000	7.720	9.053	10.449	18.516	28,969
B: Industry Level Import Tariffs									
tariffs: weighted average	2000	0.182	0.140	0.000	0.110	0.150	0.220	1.138	396
	2006	0.091	0.079	0.000	0.046	0.078	0.113	0.570	396
tariffs: simple average	2000	0.181	0.124	0.000	0.110	0.150	0.230	0.893	396
	2006	0.095	0.077	0.000	0.050	0.082	0.120	0.570	396
C: IPR Measures									
IP cases win rates	2000	2.52	0.67	0.52	2.21	2.63	3.09	3.09	25
	2006	3.43	0.42	2.42	3.24	3.48	3.69	4.15	31
Settled patent ratio	2000	0.41%	0.66%	0.00%	0.10%	0.23%	0.58%	3.72%	31
	2006	0.36%	0.38%	0.00%	0.09%	0.30%	0.42%	1.51%	31
change of IP cases win rates	2006-2000	0.85	0.90	-0.67	0.20	0.84	1.28	3.08	25
change of settled patents ratio	2006-2000	-0.05%	0.54%	-2.20%	-0.16%	-0.01%	0.14%	1.16%	31
D: Instrumental Variables for IPR Measures									
Christian School		0.50	0.52	0.00	0.13	0.37	0.73	2.47	28
British Settlement		0.26	0.44	0.00	0.00	0.00	1.00	1.00	31
Britian Dummy		0.39	0.50	0.00	0.00	0.00	1.00	1.00	31
France Dummy		0.13	0.34	0.00	0.00	0.00	1.00	1.00	31
Russia Dummy		0.16	0.37	0.00	0.00	0.00	1.00	1.00	31
Multi-country Dummy		0.06	0.25	0.00	0.00	0.00	1.00	1.00	31

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