https://doi.org/10.1016/j.euroecorev.2020.103373



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

Huiwen Lai, Keith E. Maskus, and Lei Yang


## Abstract

We develop and test a model of heterogeneous firms to study how provincial-level enforcement of intellectual property rights affects Chinese firms' decisions regarding exit from the market and entry into exporting, technology adoption through capital imports, and process innovation. In this setting the exit and export cutoff productivities differ from those in the standard environment, leading to a different sorting mechanism. The model also predicts that the highest-productivity firms will implement new technologies and innovate more after stronger enforcement. Empirical tests based on a comprehensive dataset of Chinese firms from 2000 to 2006 support the predictions regarding both the extensive and intensive margins of exports, technology adoption, and innovation.


*JEL Classification*: D23, F13, F14, O34

*Keywords*: Intellectual Property Enforcement, Exports, Firm Heterogeneity

---

Lai: Faculty of Business, Hong Kong Polytechnic University, Kowloon, Hong Kong (Email: huiwen.lai@polyu.edu.hk, Telephone: (852) 2766 7028); Maskus: Department of Economics, UCB 256, University of Colorado at Boulder, USA (Email: keith.maskus@colorado.edu, Telephone: 303-492-7588); Yang: Faculty of Business, Hong Kong Polytechnic University, Kowloon, Hong Kong (Email: aflei.yang@polyu.edu.hk, Telephone: (852) 3400 3457). We acknowledge financial support from the Hong Kong Government's General Research Fund (Polyu 549513H). We are grateful to two referees and the associate editor for valuable comments.

## 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. For example, in the process of joining the World Trade Organization (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). As discussed below, these revisions substantially expanded the national legal scope of various IPRs.

The growing acceptance of IPRs in developing countries is driven primarily by their potential impact on trade and economic development, largely via their influence on technology transfer and innovation. Recent studies suggest that emerging economies see increased exports of goods that intensively use intellectual property (IP) after reforming their IPRs standards (Delgado, et al 2013; Maskus and Yang, 2018). There is evidence also that such reforms are followed by increases in inward technology transfer through high-technology imports, licensing and foreign direct investment (Maskus, 2012). The evidence on innovation responses is mixed.

While this literature is suggestive, it suffers two significant shortcomings. First, empirical studies of IPRs and trade rarely build on a theoretical framework in which local firms may decide to enter export markets or increase exports, purchase foreign technologies, or engage in innovation. In consequence, it is difficult to understand the channels through which policy reforms actually generate more trade. Second, these studies rely primarily on national or industry-level trade data, a setting in which identification is difficult because many confounding factors may not be adequately controlled.

In this paper we aim to address these problems by developing and testing a model of heterogeneous firms, in which variations in patent enforcement affect critical cutoffs, including those delineating firms that purchase technology from abroad and firms that engage in R&D. Thus, such firms face a menu of choices regarding technological activities in the wake of changes in IPRs enforcement. To implement the model empirically, we assemble a comprehensive database of Chinese enterprises during a period of both trade liberalization and policy reforms in IPRs. This database has information on firm-level exports, imports of capital goods, and innovation and production of new products, in addition to other key characteristics. Importantly, these enterprises are located in different Chinese provinces, which varied notably in how strongly IPRs were enforced through the courts in 2000 and 2006. This variation offers a laboratory for studying the microeconomic and trade responses of individual firms to effective changes in enforcement.

Firm heterogeneity has been widely used to analyze the productivity-selection effects of trade liberalization (Bustos, 2011). However, productivity-differentiated firms also may be expected to respond differently to variable IPRs enforcement, a question that has yet to be explored in the literature. Thus, our contribution is to fill this gap by combining an extended theory of heterogeneous firms (Melitz, 2003) with the endogenous choices firms make to adopt international technologies or innovate. In this setting, firms face different exit and export cutoff productivities than in the standard framework, leading to a richer sorting mechanism and altering their productivities and export choices.

While straightforward, our model advances a number of testable predictions. First, stronger IPRs increase the exit cutoff, implying that less productive firms are more likely to shut down. Second, stronger enforcement also reduces the export cutoff, meaning that a margin of strictly domestic firms are more likely to start exporting, while existing exporters expand their trade volumes. Third, more rigorous enforcement reduces the cutoff for technology purchases, which implies that more firms opt for market-based technology acquisition. Finally, the fourth and highest productivity cutoff also is reduced, implying that more firms in that neighborhood undertake R&D. We estimate the impacts of variations in IPRs protection on both the extensive margins and intensive margins using a rich dataset that captures Chinese firms' experience under different degrees of enforcement, finding evidence broadly in support of the model. For this purpose we deploy two measures of cross-province variation in judicial IPRs enforcement. We also control carefully for industry-level and firm-level tariff rates to account for contemporaneous changes in trade policy. Our estimates provide the first evidence in the literature that firms in a major emerging economy respond significantly to the protection of intellectual property rights through expanding technological activities in ways that are consistent with theoretical hypotheses.

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, purchasing foreign technology, and innovating. 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 (Ivus, 2010 and Delgado, et al, 2013), along with foreign direct investment and licensing (Bilir, 2014, Javorcik, 2004, and Nagaoka, 2004). 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, technology transfer, and innovation. 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. 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, in terms of exporting, acquiring international technology, and investing in innovation.

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 export status, technology transfer, and process innovation in the presence of firm heterogeneity. Second, it provides insight into the channels through which IPRs enforcement affects firm-level productivity gains. Finally, 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 model of firm-level choices in technology adoption 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:

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

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 :

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

where *p*(ω*)* 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 Technology Adoption

The market structure is characterized by monopolistic competition. There is a continuum of firms, each producing a different variety using only labor. Firms are heterogeneous in their productivity $\varphi$, which they draw from a known Pareto cumulative distribution function $G(\varphi) = 1-\varphi^{-k}$, after paying a fixed entry cost $\underline{f}$. Note that parameter $k > 1$.

After observing their productivity firms decide whether to exit or stay in the market. Firms then can choose whether to conduct technology adoption or not. A firm produces with old technology if it chooses no technology adoption. Let $\frac{1}{\varphi}$ and $f$ denote the marginal cost and fixed cost, respectively, of a surviving firm in the developing country with productivity $\varphi$ under no technology adoption. Let $\theta$ indicate the level of intellectual property protection in the developing country, where $\theta \in [0,1]$. Parameter $\theta$ 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. There are two ways for firms to undertake technology adoption: importing capital goods from foreign countries and conducting process innovation.

Both capital-goods importation and innovation embody an additional fixed cost beyond *f*. Thus, let $h(\theta)f$ denote the fixed cost for importing capital goods, which arises because the imported machinery must be adapted and implemented in the domestic technology. The total fixed cost then becomes $[1+h(\theta)]f$ when the firm produces with an improved technology under importing capital goods. Note that this additional fixed cost depends on the level of IPRs enforcement. We assume that $\frac{dh(\theta)}{d\theta}<0$ based on the following justifications. Technology adoption through importing capital goods incurs international technology transfer costs. Prior literature demonstrates that such costs involve setting enforceable contract terms and shifting codified knowledge. These costs diminish as IPRs in the developing country are tightened because enforceable patents and trade secrets reduce contracting problems under asymmetric information (Antras, 2003, Yang and Maskus, 2001).

We also posit that marginal production cost falls when capital goods are imported and adopted. Specifically, we assume that marginal cost becomes $\frac{1}{b\varphi}$ with $b>1$. One reason is that such imports support international knowledge spillovers (Grossman and Helpman, 1991). Further, international trade in capital goods is an important form of transferring embodied knowledge across borders (Hoekman, et al, 2005). Xu and Wang (1999) found that capital goods have higher technology content than non-capital goods and hence are a major source of R&D spillovers embodied in trade flows. Acharya and Keller (2009) demonstrated that there could be learning effects generated from imports of capital goods and found evidence of productivity spillovers through such imports.

Next, if the firm chooses to conduct process innovation, its marginal cost under innovation becomes $\frac{1}{a\varphi}$ ($a > b$), which implies a larger cost reduction than available under capital imports. This may be justified by noting that purchasing a capital good may not transfer the tacit knowledge and know-how arising from the experience and experimentation needed to fully utilize the technology. However, a firm that invests in its own successful technological improvement automatically acquires this kind of knowledge, further reducing marginal cost. However, process innovation is available only by paying an R&D cost $\lambda(\theta) f$. Hence, the total fixed cost with innovation is $[1+\lambda(\theta)]f$, where $\frac{d\lambda(\theta)}{d\theta} < 0$.

Note again the assumption that this additional fixed cost falls with stronger IPRs enforcement. We posit that notion because more rigorous enforcement makes it more difficult for competitors to conduct imitation through such channels as reverse engineering and product inspection. Accordingly, stronger enforcement reduces the innovator's need to masque its proprietary knowledge and the associated R&D cost is decreased (Yang and Maskus, 2001). Although own innovation generates a larger reduction in marginal cost than does capital importation, the former requires a higher fixed cost because innovation expenses generally are high compared to input purchases. We capture this situation by assuming that $\lambda(\theta) > h(\theta)$. Moreover, we assume that $-\frac{d\lambda(\theta)}{d\theta} > -\frac{dh(\theta)}{d\theta}$, meaning that the cut in the fixed cost of innovation is greater than the cut in the fixed cost of importing for a given rise in patent enforcement. This reflects the idea that innovation creates knowledge, an asset that is particularly sensitive to IPRs, while the fixed costs of capital inputs are associated with adaptation costs and bear less sensitivity.

To summarize, among the three choices on technology adoption (new technology under process innovation, new technology under importing capital goods, and the old technology), firms with process innovation pay the highest fixed cost but produce at the lowest marginal cost, firms using old technology pay the lowest fixed cost but produce at the highest marginal cost, and firms importing capital goods are in the middle. Note also that the saving in marginal costs increases in the firm's productivity $\varphi$. In this setup, the productivity of each firm depends on both the original random draw and the choice of technology adoption.

After firms make the technology 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 and our justification is based on two observations. First, exporting fixed costs are generally associated with, among other things, the need to establish contracts with input purchasers and wholesalers abroad in various markets and offer surety that products are of unambiguous origin and meet expected quality standards. Enforced patents and trademarks directly reduce the uncertainty about which firms actually produce goods (Maskus, 2012). Enforceable IPRs also reduce asymmetric information problems plaguing procurement contracts and reduce the likelihood that suppliers will ship defective goods (Antras, 2003).

Second, the ability of firms to export is affected by the strength of IPRs in their home country, in part because governments in destination countries may block imports from locations with weak protection. Specifically, products generated by imitation in the developing country could violate the patents and trademarks owned by firms abroad. In turn, these rights holders are empowered by laws, such as Section 337 in the US Tariff Act of 1930, to direct their government to bar such imitative imports (Yang and Maskus, 2009). Evidence that such restrictions diminish exports of high-technology goods from developing economies is provided in Shin, et al (2015). Thus, when an emerging country increases its IPRs protection the exports of its firms are less likely to be blocked, reducing entry costs.[1]

As noted earlier, one inspiration for this model is the logic used by Bustos (2011) in her analysis of endogenous technology upgrading in the presence of trade liberalization. We extend her model in two substantive ways, however. First, in Bustos' model firms choose between using their old technology or investing in an upgrade. Here, we incorporate a third choice, which is importing capital goods, generating a richer menu of potential responses. Second, in Bustos' model the additional fixed cost of upgrading technology is a constant parameter, which does not depend on a policy choice, such as the degree of trade liberalization. Here, the increase in fixed costs of both capital imports and process technology innovation depends on the level of IPRs enforcement, as does the fixed cost of exporting. This structure is new to the literature and lends more complexity to the extensive-margin cutoffs we explore.

### 3.3 Equilibrium Sorting

After firms observe their random productivity draw, those remaining in the market make decisions about technology adoption and exporting. They have six choices in total: make no

[1] It is not possible to test these factors directly with our data. However, in the empirical analysis we show that stronger domestic enforcement induces Chinese enterprises disproportionately to expand exports to more developed markets, which is consistent with the idea that IPRs favor commerce with more technologically advanced countries. Moreover, it is primarily the developed economies that have import-blocking regulations that might be overcome in this way.

investment in technology adoption (whether through capital imports or innovation) while only serving the domestic market; no technology adoption while both selling domestically and exporting; importing capital goods while only serving the domestic market; importing capital goods while selling in both the domestic and foreign markets; conducting process innovation while only serving the domestic market and conducting process innovation while selling in both the domestic and foreign markets.

In Appendix A we provide profit expressions for each choice, along with proofs of several conditions needed to solve for productivity cutoffs and the impacts of IPRs enforcement. Here we describe these results graphically with the aid of Figures 1 and 2.

In Figure 1 we depict the profits of firms with productivity $\varphi$ defined over the relevant range, where the horizontal axis represents $\varphi^{\sigma-1}$ and the vertical axis represents a firm's profits.[2] The upward-sloping lines depict profits under different configurations of no technology adoption versus technology adoption and exporting versus domestic sales.[3]

The sorting pattern in Figure 1 can be summarized in Proposition 1:[4]

***Proposition 1.*** *In equilibrium firms may be sorted into five groups in this model. The least productive firms ($\varphi < \underline{\varphi}$) exit; the low-productivity firms choose no technology adoption and*

[2] In principle, we have two possible cases regarding the cutoff for exporting and the cutoff for importing capital goods: $\varphi_E < \varphi_M$ and $\varphi_E > \varphi_M$. The latter case corresponds to the scenario where all exporters from developing countries import capital goods, which is not consistent with actual behavior in the real world. Thus, we focus on the former case. For the same reason, we focus on the scenario where $\varphi_E < \varphi_I$.

[3] In Figure 1 we focus on the scenario where $\varphi_M < \varphi_I$. As shown in appendix A3, this is true when $\frac{[\lambda(\theta)-h(\theta)]}{(a^{\sigma-1}-b^{\sigma-1})} > \frac{h(\theta)}{(b^{\sigma-1}-1)}$. However, in the model the inequality could go in the opposite direction and either case is possible. Thus, our prediction about these relative cutoffs remains ambiguous, which is one reason we do not attempt a sharp test in the empirical analysis.

[4] The relationships between different cutoffs are shown in Appendix A3. One possibility is that $\varphi_E = \varphi_M$, in which case all firms with $\underline{\varphi} < \varphi < \varphi_M$ choose no technology adoption and only serve the domestic market and firms with $\varphi > \varphi_M$ choose importing capital goods and serve both the domestic and foreign markets.

*only serve the domestic market; the low- to medium-productivity firms choose no technology adoption and sell at home but also export; the medium- to high-productivity firms import capital inputs and sell in both markets; and the most productive firms undertake technology adoption through process innovation and serve both the domestic and foreign markets.*

### 3.4 The Impacts of IPRs Enforcement

In this section we study the effects of a stronger IPRs regime, which we will capture empirically by interprovincial variations in judicial enforcement, on the cutoff productivities for exiting, exporting, importing capital goods and undertaking innovation. Again, the mathematical relationships are derived in Appendix sections A3 and A4. Here, we simply describe the resulting predictions by reference to Figure 2.

First, the exit cutoff increases under strengthened IPRs, implying that more firms with relatively low productivity choose to exit. The reason is that stronger enforcement increases the profitability of more productive firms by reducing the costs of exporting and technology adoption, in turn raising the real wage rate. Therefore, the least productive firms can no longer afford to produce.

We also show that the cutoff productivity for exports falls with greater IPRs enforcement under a plausible condition relating the elasticity of export fixed costs with respect to IPRs to production parameters. Specifically, stronger enforcement reduces the exporting cutoff if its effect on the reduction in fixed exporting cost dominates the increase in expected profit from entry. This is more likely where there is a low substitution elasticity in comparison with productivity dispersion. If this condition holds, the margin of exporters expands.

Next, we show that the productivity cutoff at which firms undertake capital importing also falls with stronger IPRs. This occurs under the similar condition that stronger enforcement reduces the fixed cost of importing capital goods by more than the increase in expected profit from entry. We also show that the cutoff for innovation falls with IPRs if the policy generates a relatively large cut in fixed innovation costs. In consequence, more firms in this highest-productivity margin choose technology adoption through process innovation.

To summarize, let $\underline{\varphi}'$, $\varphi_E'$, $\varphi_M'$ and $\varphi_I'$ represent the new cutoff productivities for entry, exporting, importing capital goods and innovation, respectively, under more rigorous enforcement of IPRs. From the analysis above it follows that $(\underline{\varphi}')^{\sigma-1} > \underline{\varphi}^{\sigma-1}$, $(\varphi_E')^{\sigma-1} < \varphi_E^{\sigma-1}$, $(\varphi_M')^{\sigma-1} < \varphi_M^{\sigma-1}$ and $(\varphi_I')^{\sigma-1} < \varphi_I^{\sigma-1}$ as depicted in Figure 2. Thus, the theory demonstrates that, other things equal, an increase in patent enforcement should generate more exit of low-productivity firms, while expanding the range of exporters and inducing more technology adoption through importing capital goods or innovation among high-productivity enterprises. Hence, we have the following proposition:

***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 stronger IPRs lead to a large reduction in exporting cost, reduces the cutoff productivity for technology adoption through importing capital goods, and diminishes the cutoff productivity for process innovation, where the final two impacts emerge if stronger IPRs lead to large reduction in the cost of importing capital goods or engaging in R&D.*

At this point we note a practical difficulty in testing one element of this theory. Although the model offers sharp predictions about separation between capital-goods importers (those firms with medium- to high-productivities) and innovators (those with highest productivities), our firm-level data on these decisions are inadequate to test for that separation. Specifically, as explained below, the sample does not permit precise matching of firms that both export and enter in the later year solely into capital imports as a form of technology acquisition, as opposed to exporters that may enter both capital imports and introduction of new goods. Thus, in the empirical work below regarding extensive-margin effects we test only for exit, entry into exporting, and entry into technology adoption through new product releases. We do, however, analyze the effects of enforcement on the volume of capital-goods imports.

## 4. Institutional Background and Data

In this section we discuss the evolution of Chinese IPRs policy and two province-level IPRs measures. Following that we present firm-level and industry-level variables for the analysis.

### 4.1 China's IPRs and Proxies for Enforcement

China began to establish modern patent laws in 1984, mainly to facilitate new technology diffusion through narrow claims, utility models and design patents (Liang and Xue, 2010). These laws were revised in 1992, partially to comply with a memorandum of understanding with the United States, in legislation extending protection to 20 years and covering foods and pharmaceutical products (Maskus, 2012). The country's patent laws were further strengthened before China joined the WTO in 2001. In particular, a major revision made in 2000 substantially enhanced the scope of eligibility, patent breadth, and judicial procedures for litigating patent claims. The country's legal system was also significantly upgraded. Consequently, China's Ginarte-Park (GP) index rose from 2.12 in 1995 to 4.21 in 2010.[5] Indeed, by his measure the

[5] This index, assembled by Ginarte and Park (1997), captures the presence or absence of particular elements in patent law. These elements are aggregated into five broad categories: duration of protection, coverage (e.g., which technologies are eligible for patents), membership in international IPRs treaties, legal enforcement mechanisms (such as preliminary injunctions), and limitations on patent breadth (such as compulsory licensing). The components in each category are summed to get a figure between zero and one, and then the categories are equally weighted to achieve an overall patent-rights index that varies between zero and five.

country's legal reforms converged to those of many advanced countries and exceeded those of many middle-income countries. [6]

The GP index measures national patent reforms but not inter-provincial differences in IPRs enforcement. Mertha (2005) describes how administrative and judicial enforcement of IP laws is different across provinces. First, provinces with higher per-capita income, technological orientation of industry and the labor force, and registration of patents and trademarks by local enterprises likely invest more in enforcement (Maskus, 2012). Second, regions located far from the central government are less likely to support IPRs. Third, provinces with different historical experiences in colonization may respect patent laws differently (Feenstra, et al, 2013). Finally, local officials often have different attitudes towards IPRs enforcement (Wang, et al, 2014).

Variations in IPRs enforcement could have notable impacts on Chinese firms' performance, but this possibility rarely has been studied. One exception is Ang, et al (2014) who find that stronger IPRs enforcement induces Chinese firms to acquire more debt and invest more in R&D. We thus follow that paper in constructing our first measure of IPRs enforcement as the fraction of IP infringement cases won by rights owners in provincial courts between 2000 and 2006. We compute a win-rate measure using data from the China PKULAW judicial database. 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 cases in these years for each province. Similarly, the win rate in 2006 is defined as the number of IP cases won from 2001 to 2006, divided by the total number of such cases over these years for each province. This variable is used to measure the

[6] See also Maskus (2004) and Joyce (2009). Despite the changes, the Chinese government remains heavily criticized for implicit mandates that force transfers of technologies and intellectual property rights from foreign to domestic joint-venture partners. Our results suggest that if China moderates these polices then additional legal enforcement will encourage local firms to engage in more compensated technology acquisition and more innovation.

IPRs enforcement for different regions corresponding to the situation before and after the 2000 major revision in national IPRs laws (Maskus, 2012).

Our second IPRs enforcement measure is defined as the ratio of the number of settled patent disputes to the cumulative number of patents granted in each province. We adopt this settled-patent ratio, rather than the absolute number of settled patent disputes, for two reasons. First, owners of infringed patents in a province with stronger enforcement are more likely to file cases. Second, a higher ratio of settled patent disputes may capture that courts in those provinces work more efficiently to resolve such cases.[7] Thus, the use of the ratio as an enforcement measure may mitigate the endogeneity concerns of directly using the number of cases as a measure. A higher settled-patent ratio arising from enhanced efficiency of the local court system reflects a stronger enforcement system in that province.

The win rate and the settled-patent ratio mainly capture cross-provincial variation in IPRs enforcement, while the GP index captures overall development of legal provisions at the national level. We define two IPRs enforcement measures as the interaction between the win rate and the GP index and the corresponding interaction between the settled-patent ratio and the GP index. To illustrate, after multiplying by the GP index a province with a one-percent win rate in both 2000 and 2006 will have interaction values of 3.09 and 4.08 for each year, respectively. For presentational convenience, we continue to refer these transformed variables as the win rate and the settled-patent ratio. Note, however, that multiplying the raw enforcement data by the GP index only leads to parallel shifts of the win rate and settled-patent ratio. It does not change their

[7] According to 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.

relative magnitudes across provinces, meaning that our estimated IPRs impacts are mainly driven by the cross-provincial variation of the untransformed measures.

Figures 3 and 4 present histograms of the cross-provincial win rate and settled-patent ratio for 2000 and 2006.[8] The measures for some provinces are noisy, likely due to the small number of cases. For example, the settled-patent ratio of Xinjiang in 2006 is far larger than those of other provinces. Further, this ratio for some provinces decreased from 2000 to 2006, likely due to a considerably larger number of issued patents, raising the denominator. In contrast, the pattern for the win rates seems more reasonable. Guangdong, Jiangsu, and Zhejiang, three provinces accounting for a large share of firms in our sample, have win rates significantly larger than the sample average of 3.43 for 2006. This accords with the notion that more developed provinces have stronger IPRs enforcement. The correlation between the two IPRs measures is low at 0.113, suggesting they capture different elements of enforcement. The correlation between the 2000 and 2006 levels of the settled-patent ratio is 0.59 and that of the win rate is 0.14. The low two-year correlation of the win rates likely reflects the noisiness of the 2000 data due to a low number of cases.

A further difficulty is that these two measures may be endogenous to firms' decisions. More developed provinces tend to have more IP litigation and higher patent-settlement rates, perhaps because firms in those provinces generate more intellectual property. There may also exist provincial-level omitted variables that correlate with both firm performance and these two enforcement measures. To address the endogeneity problem, we construct two instruments following Feenstra, et al (2013), Lu, et al (2013), and Fang and Zhao (2007).[9] The first

[8] We exclude Neimengu, Ningxia, Qinghai, Xizang (Tibet), and Guangxi provinces in constructing these charts, since they account for very few firms in our sample.
[9] Feenstra, et al (2013) used these instruments to analyze export patterns at the provincial level, distinguishing

instrument is the origin country of formal colonial rule. These origins are Great Britain, France, Russia, or a mixture of several countries. 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. We construct several dummy variables indicating each possibility. For example, the Great Britain indicator takes the value one if a province is a former British colony and zero otherwise. The benchmark case, taking zero values for all indicator variables, 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. 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.

Table 1 reports summary statistics for the win rate, the settled-patent ratio, and the instrumental variables described above.

### 4.2 Firm-Level Data

To test the model predictions about firms' behaviors under different levels of IPRs enforcement, we construct variables of firm-level attributes and decisions based on two data sources used in Ge, et al (2015). The first source is the National Bureau of Statistics (NBS)

---

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 trade and production performance across locations in China.

Enterprise Dataset for 1998-2007, which includes information from annual surveys of all state enterprises and large- and medium-sized non-state enterprises (with sales above 5 million RMB) in the manufacturing sector. We derive key firm attributes, including ownership, industry affiliation, establishment year, total factor productivity (TFP), capital intensity, employment, sales, total assets, wages, exports, and new products. We define variables representing both extensive margins, such as exit, entry into exporting, and entry into producing new products, and intensive margins, such as the logarithm of exports or new products. Again, we use the development of new products as our proxy for process innovation in the model.[10]

For a subset of NBS firms that participate in international trade, we can define additional intensive-margin variables by exploring a second data source, available from Chinese Customs, which includes disaggregated trade transactions at the 8-digit HS level. These data cover monthly import and export transactions of all Chinese trading firms for 2000-2006. The relevant variables include trade type (e.g., processing trade or ordinary trade), product code (8-digit HS), trading partners, and the value and quantity of trade. Ge, et al (2015) aggregate the monthly transactions data to annual frequency and match them to the NBS firms using contact information shared by both datasets.[11] For matched firms, attributes from NBS and detailed trade transactions from Customs are combined. These include exports (or imports) for different categories of products (e.g., processing vs. ordinary trades; intermediate inputs vs. capital goods) and exports sent to different types of partners (e.g., developed or developing countries). Among the constructed variables, imports of capital goods are our proxy for inward technology transfer.

[10] This approach is reasonable to the extent that new products correlate highly with R&D spending. Hitt, et al (1996) found a substantial correlation between the R&D intensity of companies and their new product intensity. Brouwer and Kleinknecht (1999) showed a positive correlation between patent applications and sales of innovative products. Hagedoorn and Cloodt (2003) demonstrated statistical evidence that new product announcements are a useful indicator of the innovative performance of firms.

[11] The trading firms in the Customs data include both producing firms and trade intermediaries. Among the producing firms reported in the NBS surveys, only those that trade directly can be matched with the Customs data.

Since it is observed only in the matched NBS-Customs dataset, not all capital-goods importers are captured due to potential mismatch and the existence of trade intermediaries. For this reason we cannot measure decisions to enter into capital importation. Nonetheless, we can calculate the intensive margin of capital-goods imports.[12]

Table 1 reports summary statistics for 2000 and 2006 firm-level attributes of all firms from the full NBS sample. As suggested by Ge, et al (2015) and the empirical evidence from the next section, exporters in the matched subsample on average are similar to those in the NBS sample.

### 4.3 Trade Liberalization in China

Our empirical study tests the impact of IPRs enforcement on extensive and intensive margins of firms' activities, defined in the last subsection, from 2000 to 2006. This period also experienced significant trade liberalization surrounding China's WTO accession in 2001. Among trade-related policies implemented during this period, import-tariff reductions played the central role. Clearly, it is important to control for tariff reductions.

While our theory provides predictions on the impacts of IPRs enforcement on the performance of firms operating at different stages, the effects of tariff reductions on those firms may not be straightforward.[13] Tariff reductions have a direct impact on firms that import capital

[12] Besides potential mismatches, some firms conduct exports and imports through trade intermediaries, which are not captured in the matched dataset. Thus, it is impossible to define a precise measure of extensive margins, though we can derive reliable intensive margins for the sub-sample of the matched firms. See Ann, et al (2011) for the role of intermediaries.

[13] There is a large literature on the effects of tariff reductions. For example, Amiti and Konings (2007), Goldberg, et al (2010), and Bas and Strauss-Kahn (2015) emphasized 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. Brandt, et al (2017) found that Chinese industries with the greatest tariff cuts attracted relatively larger entry of productive domestic enterprises, demonstrating a link between liberalization and sectoral competition. Fan, et al (2015) found that tariff cuts on intermediate inputs induce Chinese firms to upgrade the quality of their exports. Yu (2015) noted that tariff cuts on imported inputs and final goods have positive impacts on the productivity of large Chinese trading firms.

goods and intermediate inputs for ordinary trade, but only indirect impacts on firms that import for processing trade, firms that export only, and domestic firms (i.e., firms that neither import nor export).[14] We thus construct industry-level tariffs and several firm-level tariffs. The industry-level tariff is an approximate measure of the average tariff applied to all firms within a 4-digit Chinese Industry Classification (CIC) sector. A firm-level tariff is the average duty on goods directly charged to a firm that imports them. To disentangle the impact of IPRs protection from that of trade liberalization, we control for the industry-level tariffs in all regressions where enforcement measures are included. We further control for specific firm-level tariffs in regressions applied to different subsamples of firms where those tariffs are applied.

Details of the industry-level tariffs and three firm-level tariffs are given in Appendix B. Table 1 reports summary statistics of these tariffs for 2000 and 2006. All tariffs were reduced significantly during this period. The three firm-level tariffs have similar means and standard deviations, which are somewhat lower than those of the industry-level tariffs.

## 5. Empirical Analysis

In this section we use the datasets described above to test our model predictions. Technology transfer is proxied by information about capital-goods imports and innovation is captured by the introduction of new products. The analysis comes in three parts. First, we consider patterns of firm performance determined by the different productivity cutoffs described in Proposition 1, using cross-sectional firm-level data in separate regressions for 2000 and 2006. This is essentially a descriptive exercise to discover if the data support the basic model. Second, we exploit the inter-provincial variation of IPRs litigation measured by the win rate and settled-

[14] One feature of China's trade policy is a "dual track" procedure in which intermediate inputs imported for purposes of processing exports are duty-free. Hence, decreasing formal import barriers has no direct impacts on processing imports, though there may be indirect effects. We thus exclude processing importers in the firm-level tariffs construction. See Yu (2015) for a detailed treatment of processing imports.

patent ratio to isolate the impacts of different levels of enforcement on the productivity cutoffs, in turn determining the extensive-margins effects in terms of exit, export, and introduction of new products. Third, we analyze the impacts of IPRs enforcement on the intensive margins in terms of volumes of exports, capital-goods imports, and new products. To address potential endogeneity, we control for firm characteristics, industry fixed effects, and use instrumental variables in different regression specifications. We also calculate appropriate clustered standard errors applied to different specifications.

### 5.1 Firm Performance and Status Measures

Proposition 1 predicts that an exporter purchasing foreign technology or introducing new goods is more productive than an exporter that does not do those things, which in turn is more productive than a non-exporter that does not implement a new technology. Then a firm's relative performance under different IPRs regimes can be tested using the following specification:

$$P_{fipt'} = \alpha_0 + \beta_1 X\_TI_{fipt'} + \beta_2 X\_NTI_{fipt'} + Z_{fipt'}\gamma + FE_{ip} + \varepsilon_{fipt'}, \quad (1)$$

where $t' = 2000$ and 2006, respectively. Variable $P_{fipt'}$ represents firm *f*'s performance in industry *i* located in province *p*. We choose six performance measures, including TFP, capital intensity, number of employees, sales, total assets, and wages per worker. The variable *X_TI* is an indicator dummy, with value 1 for firms that both export and either import capital goods or produce new products, and 0 otherwise. Thus, it captures technology implementers. Similarly, the variable *X_NTI* identifies firms that export but neither import capital goods nor produce new products. The group of firms that neither export nor implement a new technology 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 $\beta_1 > \beta_2 > 0$, i.e., the productivity of an exporter and new technology implementer exceeds that of an exporter and non-implementer, which exceeds that of a non-exporter and non-implementer. Note that since we control for firm attributes and include industry-province fixed effects, we are comparing performance among firms of the same age, operating under the same ownership structure, within the same industry, and located in the same province. We estimate equation (1) for $t' = 2000$ and 2006 separately and cluster the standard errors at the industry-province level.

Table 2A reports estimates of firm performance under different exporting and capital-goods importing status.[15] The table captures relative performance of firms that both export and import capital goods relative to firms that export only and, in turn, relative to firms that do neither.[16] In five of the six performance measures, firms that both export and import capital goods significantly outperform firms that only export, which significantly outperform firms that do neither. The only exception is that exporting firms that do not import capital goods have slightly lower average capital intensity than firms that do neither. One possible explanation is that the group of exporting firms that do not import capital goods includes a large number of firms that import intermediate inputs for processing exports. Such exporters typically hire many workers and have low capital intensity. Table 2B presents estimates of firm performance under

[15] To conserve space, we suppress the coefficients on firm attributes beyond those in *X_TI* and *X_NTI*.

[16] Note that information on exports and new products are directly observed from the NBS dataset, but information on imports of capital goods can only be observed when a firm in the NBS dataset is matched to a Customs firm that imports capital goods. Not all importers of capital goods can be matched due to imperfect identification and the existence of intermediary traders. Nevertheless, the predictive patterns using the imperfect definition still hold because, as long as capital-goods importers perform better than non-capital goods importers, on average, the subsample of the capital-goods importers should perform better than its counterpart, which includes both non-capital-goods importers and some unmatched capital-goods importers.

different exporting and new-products status. The table captures relative performance of firms that both export and produce new products relative to firms that export only and in turn, relative to firms that do neither. Again, the performance rankings are consistent with expectations.

These estimates support the prediction of Proposition 1 that the most productive firms will select into exporting and either purchasing foreign technology or innovating new goods. However, these regressions do not directly link firms' performance indicators with our measures of IPRs protection. We turn to that question next, by relating activities to provincial-level IPRs enforcement.

### 5.2 IPRs Protection and Extensive Margins (EM)

More direct connections between firms' performance and IPRs protection are predicted by Proposition 2. From Figure 2, the proposition suggests that in comparing a province with a weaker IPRs environment to a province with a stronger one, those firms in the latter with productivity between $\underline{\varphi}$ and $\underline{\varphi}^{'}$ exit, those firms with productivity between $\varphi_E^{'}$ and $\varphi_E$ export, and those firms with productivity between $\varphi_I^{'}$ and $\varphi_I$ innovate. This suggests, first, that among all the originally non-exporting firms, those located in provinces with stronger IPRs are on average more likely to exit. Second, among all the originally non-exporting firms, those located in provinces with stronger IPRs are on average more likely to start exporting. Third, by using new products as a proxy for innovation, the proposition also suggests that among all the originally exporting firms that do not produce new products, those located in provinces with stronger IPRs are on average more likely to start doing so.[17]

[17] From Figure 2, the proposition also suggests that in the stronger IPRs environment, those firms with productivity between the new and old import cutoffs begin to undertake technology transfer, proxied by capital-goods imports. Thus, we also estimated an EM regression for capital-goods importing but found an insignificant IPRs impact. One

We test predictions about three extensive margins of related activities by Chinese firms induced by the variation in cross-provincial IPRs enforcement. Recall that our two measures of enforcement are the interaction of the IP cases win rate with the GP index and the corresponding interaction of the settled-patent ratio. Multiplying by the GP index values in each year leads to parallel shifts of the original enforcement measures but does not change their relative rankings across provinces. We use the 2006 levels in our regressions because authorities put greater emphasis on IPRs-related data collection after the WTO-based reforms. Accordingly, the measures in the later year better capture IPRs enforcement.[18]

Since trade liberalization surrounding China's WTO accession in our sample period is another important factor that affects firms' decisions, we must control for tariff cuts to isolate the impact of IPRs protection. We include changes in industry-level tariffs from 2000 to 2006, along with the other firm-level variables, as controls.[19] We thus have the following specification to test our model predictions, using linear probability models on dichotomous dependent variables:

$$EM_{fip\_2006} = \beta_0 + \beta_1 IPR_{p\_2006} + \beta_2 \Delta TARIFF_i + Z_{fip\_2000}\gamma + \varepsilon_{fip}, \quad (2)$$

where $EM_{fip\_2006}$ represents a series of binary choices corresponding to the three predictions: exit by 2006 of original non-exporters, entry into exports by non-exporters, and entry into new

potential explanation for the insignificance is that, as suggested in footnotes 11 and 16, the matched NBS-Customs dataset could exclude a significant number of capital-goods importers. The omitted importers lead to an imprecise sample in defining the EM measure. Accordingly, we do not report these results.

[18] Section 4.1 shows that the correlations between the 2000 and 2006 levels of the win rate and the settled-patent ratio are 0.14 and 0.59 respectively. The low correlations, especially for the win rate, are likely due to the small number of cases captured in the earlier year, which leads to noisier measures.

[19] Industry-level tariffs capture the average impact of import competition faced by all firms within an industry. Note that within many sectors there may be firms operating at different stages of vertical production and there may be no clear prediction on the signs of the associated tariff coefficients. In this sense, industry-level tariffs primarily serve as a control to isolate the IPRs impact. We also construct firm-level tariffs for subsets of matched firms importing capital goods and intermediate inputs and use them in the next section to control further for tariff liberalization in analyzing impacts of IPRs enforcement on intensive margins.

products by exporting firms that were not innovators. The variable $IPR_{p\_2006}$ represents the GP-interacted 2006 win rate or settled-patent ratio, which captures the relative strength of IPRs enforcement across provinces. The cross-sectional variable appropriately captures the logic of Figure 2, in which we compare behavior of firms across provinces. The idea is that entry into exporting and innovation is more likely in provinces with stronger enforcement, as opposed to greater relative increases in enforcement.[20] Firms seeking to protect their IPRs are more likely to expand technological activities where there is greater access to courts. Our model predicts that $\beta_1 > 0$ for all three regressions.

The variable $\Delta TARIFF_i$ is the change in import tariffs in industry *i*. We use first differences to account for how substantial tariff cuts would affect exit and entry decisions between 2000 and 2006. Finally, $Z_{fip\_2000}$ is a vector that captures the initial firm attributes, including year 2000 productivity, age, and ownership status.

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 (2). We therefore modify the specification by controlling for industry fixed effects:

$$EM_{fip\_2006} = \beta_0 + \beta_1 IPR_{p\_2006} + Z_{fip\_2000}\gamma + FE_i + \varepsilon_{fip}, \qquad (2)'$$

[20] In an earlier version we used changes of our IPRs measures from 2000 to 2006 as the primary independent variable but the estimated coefficients were insignificant. This outcome is unsurprising because first differences over time in the enforcement measures do not yield enough useful variation to generate precise estimates under province-level clustering.

where $FE_i$ represents industry dummies, which absorb all industry-level policy impacts, including from tariff cuts.

As discussed in Section 4.1, it is important to control for the potential endogeneity of the win rate and settled-patent ratio. For this purpose, we use the origins of former colonial rule by province and the enrollment rates in Christian missionary primary schools in 1919 as instruments. We expect these pre-determined variables to condition local cultures regarding attitudes toward law and order, which may still significantly affect the 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 20$^{th}$ century, these instruments are unlikely to affect current economic outcomes such as trade, beyond their impacts through the channel of IPRs and contract enforcement.

Finally, since $IPR_{p\_2006}$ varies across provinces and has the same value across industries, the standard errors are clustered at the province level for both specifications (2) and (2)'.

Tables 3A through 3C report the regression results. Table 3A presents estimates of the probability that a non-exporting firm in 2000 exits by 2006. Specifically, columns (1)-(4) list the coefficients obtained by using the win rate as a proxy for IPRs protection, while columns (5)-(8) do the same for the settled-patent ratio. Columns (1)-(2) and (5)-(6), labeled OLS, control for industry-level tariffs. The regressions in (1) and (5) suggest that firms in provinces with stronger IPRs protection are more likely to fail and exit by 2006, which is consistent with our model prediction. Those in (2) and (6) also suggest that firms in industries with greater exposure to import competition through tariff cuts are more likely to exit. Firms with lower initial productivity have a higher propensity to exit, consistent with prior expectations.

Columns (3) and (7) report regression results of specification (2)', which controls for industry fixed effects. The coefficients corresponding to both forms of IPRs protection remain highly significant and with magnitudes comparable to those of the OLS regressions. Coefficients for other firm attributes are also similar to those of the OLS regressions, suggesting that the OLS coefficients on tariff reductions may be robust even without controlling for the industry fixed effects.

Columns (4) and (8) present the 2SLS estimates, modeled in parallel with the fixed-effects cases. In the first stage the win rate or the settled-patent ratio is regressed on the colonial dummies and Christian enrollment, along with the other exogenous variables. In both first-stage regressions (not shown), the IVs are highly significant, with the corresponding Stock-Yogo F-test being as high as 1,661 for the win-rate 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. However, the second-stage coefficients suggest mixed results. While the estimate for the settled-patent ratio indicates a marginally significant and positive impact on exit, the estimate for the win rate is insignificant.[21] Despite the weak IV results, overall the findings in Table 3A are consistent with our model prediction about firms' exit decision under different levels of IPRs enforcement.

Table 3B reports estimates of the probability that a non-exporter in 2000 starts exporting by 2006. The coefficients associated with the two IPRs measures are all positive as expected, but some are marginally significant and some are insignificant. In particular, the OLS

---

[21] The standard errors of the IPRs coefficients are substantially increased with the use of IVs and provincial clustering. Note that the two IPRs measures are weakly correlated, suggesting that they may capture different forces. It is thus not surprising that the same IVs could generate significance for one endogenous variable and not the other.

coefficients associated with the win rate are significant but those associated with the settled-patent ratio are not. Overall, these results offer some indication that non-exporters are more likely to become exporters in provinces with stronger IPRs enforcement.

The negative and marginally significant coefficients on tariff changes (columns (2) and (6)) suggest that tariff reductions may raise 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 imported inputs induced by tariff reductions allow firms to become more productive and more likely to produce high-quality products for export. In this context, easier access to high-quality imported inputs enhances productivities of non-exporters, permitting more of them to enter export markets at the margin. Finally, we find that younger firms, firms with higher initial productivity, foreign firms, and firms owned by Hong Kong-Macau-Taiwan are more likely to start exporting.

Table 3C reports estimates of the probability that an exporter not producing new products in 2000 starts to do so by 2006. Across the specifications the coefficients related to the settled-patent ratio are all positive, while significant for the fixed-effects and 2SLS cases. However, those related to the win rate are positive but only marginally significant at best. These findings broadly support the notion that non-innovative firms are more likely to become new-product developers in provinces with stronger IPRs protection.

Finally, the regressions suggest that cuts in industry-level tariffs do not significantly affect exporters' new-products decisions. Firms with higher initial productivity are more likely to innovate. Compared with domestic firms, foreign firms and firms owned by investors from

Hong Kong, Macau, and Taiwan are less likely to manufacture new products. This 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-3C present evidence broadly consistent with our key predictions from Proposition 2. The results are not always strongly significant, which is perhaps unsurprising given the province-level clustering and that the probabilities are determined only by firms near certain thresholds.

### 5.3 IPRs Protection and Intensive Margins (IM)

In the prior sections we tested Propositions 1 and 2, which offer clear predictions about EM effects. The model is also consistent with the idea that stronger IPRs enforcement may affect the volume decisions of firms that continue to export and purchase foreign technology. As suggested in Melitz (2003), trade liberalization reallocates market shares in favor of more productive firms that remain in export markets, expanding trade volumes for continuing exporters. Similarly, in the present model Figure 2 suggests that more rigorous IPRs enforcement reduces the cutoff productivities of exports, capital-goods imports, and production of new products, suggesting analogous volume impacts.

However, in our applied empirical setting it is not possible to draw sharp hypotheses about intensive margins. One reason is that our data incorporate firm-level exports to multiple markets, rather than a single foreign destination. For example, if new exporters, induced by stronger IPRs, directly compete in existing exporters' markets, the export volumes of the latter could decrease. However, if new exporters enter other markets instead, the export volume of existing exporters could well increase, particularly if they sell higher-quality goods in the wake of IPRs enforcement. Similar comments apply to capital-goods imports and the introduction of new goods. Thus, we treat the IM effects as an empirical question. We use the following specification to investigate the impacts of IPRs enforcement on the various IMs, pooling across the years 2000 and 2006:

$$IM_{fipt} = \beta_0 + \beta_1 IPR_{pt} + \beta_2 TARIFF_{it} + Z_{fipt}\gamma + \varepsilon_{fipt} , \quad (3)$$

where $IM_{fipt}$ represents log of exports, log of capital-goods imports, or log of new products, for firm *f* operating in industry *i* located in province *p* in year *t*. To focus on continuous activities, we restrict the sample to the subset of firms with positive values of each activity for both years. The variable $IPR_{pt}$ measures the strength of IPRs protection in province *p* in year *t*. The variable $TARIFF_{it}$ is industry tariffs. Again, vector $Z_{fipt}$ captures firm attributes. This specification identifies the average impact of IPRs protection on volumes across provinces over these two years, controlling for the variation of industry-level tariffs and firm-level attributes. To control for other policy changes that may correlate with both the IPRs environment and import tariffs, such as non-tariff barriers and macroeconomic conditions, we modify specification (3) by adding industry fixed effects and year fixed effects:

$$IM_{fipt} = \beta_0 + \beta_1 IPR_{pt} + \beta_2 TARIFF_{it} + Z_{fipt}\gamma + FE_i + FE_t + \varepsilon_{fip} \quad (3)'$$

Unlike regressions for the extensive margins, we do not predict the sign of $\beta_1$ *ex ante* and let the data speak for themselves.

It is also important to control for the potential endogeneity of the win rate and the settled-patent ratio when examining their impacts on IMs. As in our treatment of EM effects earlier, we use the origins of former colonial rule by province and the enrollment rates in Christian missionary lower primary schools in 1919 as instruments.

Table 4 reports estimates for the various intensive-margin effects, organized in three panels. All regressions include firm-level TFP, age, and ownership dummies but these coefficients are not reported. Panel A contains the export regressions. Columns (1)-(4) and (5)-(8), respectively, report the results when IPRs enforcement is proxied by the win rate 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, measured by higher win rate, leads to significantly higher export volumes. In contrast, columns (5)-(6) suggest that stronger enforcement, measured by higher settled-patent ratio, is associated with lower exports. In this context, the two measures may capture different aspects of IPRs enforcement influencing export volumes. Perhaps more likely, the OLS estimation is problematic due to potential endogeneity of these measures.

Estimation with industry fixed effects or instrumental variables mitigate this concern. The fixed-effects estimated coefficients on IPRs enforcement from columns (3) and (7) are positive, albeit either insignificant (the win rate) or marginally significant (the settled-patent ratio). The second-stage IV estimated coefficients from columns (4) and (8), on the other hand, are positive with that of the win rate highly significant and that of the settled-patent ratio insignificant. This evidence suggests overall that competition from new exporters in stronger IPRs provinces does not generate substantial pressure on existing exporters and the average volumes of continuing exporters go up. The estimated coefficient of 0.751 from column (4), for example, suggests that a one-standard deviation increase in the win rate leads to 32 percent ($0.751 \times 0.42$) more exports in 2006.

It is notable that the 2SLS estimate in column (4) markedly exceeds the OLS coefficient in column (2). This situation pertains in several cases regarding both EM and IM effects, as may be seen in other tables. It raises the question of why OLS may be biased downward in regressions of exports or other activities on win rates or settled-patent ratios. One basic possibility is that win rates and settled-patent ratios capture only a fraction of actual enforcement efforts, which would include the scope of "cease-and-desist" letters, the likelihood of preliminary injunctions, the time required to settle litigation, and the extent of fines issued. These avenues are more available in locations where effective enforcement is greater, suggesting that win rates may be biased downward particularly in such areas.

Another possibility is that some firms may file lawsuits only when they are confident of prevailing, suggesting that missing from the sample are complex but winnable cases that were not filed but likely would raise provincial win rates if they were. Indeed, this factor could bias win rates downward by more in provinces where IPRs are more professionally enforced if such enforcement raised the likelihood of a positive court ruling. Similarly, patent cases may be settled more frequently where they do not involve this middle range of complex lawsuits. In both situations the measured enforcement rates may be biased downward, with the relative effect being larger in provinces with greater actual enforcement.

Returning to Panel A, the results also suggest that continuing exporters in industries with lower tariffs have lower exports. This may seem puzzling, especially in the context of export-import linkages mentioned above. This is possible, however, because our sample includes firms conducting mixed activities. Note that we use the sample of exporters reported in the NBS surveys, where such firms include both non-importers and importers. The latter include firms that import inputs for ordinary purpose and firms that import inputs for processing purpose.[22] Exporters that use purely domestic inputs in production could be pressured to contract by import competition from tariff cuts favoring those that do import. Processing exporters, reliant on duty-free imports, could also contract because they do not benefit from input-tariff cuts in comparison with firms that were paying pre-liberalization duties on imported inputs. Indeed, tariff cuts facing exporters who import inputs for ordinary purpose could permit them to increase export volumes. On balance, it is possible that industry-level tariff cuts could lead to lower average exports in our sample.

Panel B reports results for the log of capital-goods imports for continuing capital-goods importers that are matched between the NBS and Customs databases. Figure 2 predicts that more firms in provinces with stronger IPRs protection should start to import capital goods. As with exports, the empirical impact on the average volumes of existing capital-goods importers can rise or fall. The OLS results are mixed, with a significantly negative coefficient on the win rate but a significantly positive coefficient on the settled-patent ratio. Due to potential endogeneity concerns, we focus on the fixed-effects and the second-stage IV estimates. Similar to the exports regressions, our fixed-effects and 2SLS estimates suggest a positive, though sometimes insignificant, IPRs impact on the volumes of capital imports. Taking 2SLS as the preferred approach, firms in provinces with stronger IPRs protection import more capital goods. The coefficient of 206.3 from column (8), for example, implies that a one-standard deviation increase in the settled-patent ratio leads to a 78 percent ($206.3 \times 0.0038$) expansion in capital-goods imports.

[22] Firms that import for ordinary purpose pay import tariffs and use the imported inputs to manufacture products for either export or domestic sale. Firms that import for processing purpose pay no tariffs and use the imported inputs to manufacture products for export only.

From the OLS regressions, import-tariff reductions appear to have the expected positive impact on imports of capital goods, but this impact disappears in the cases with industry fixed effects and instrumental variables, where the coefficients are insignificant. This is not surprising, for industry-level tariffs may not well capture the tariffs on capital-goods imports a specific firm faces. In the following section, we revisit this issue by controlling for firm-level tariffs.

The impacts of enforcing IPRs on the volume of new products, shown in Panel C, are again mixed. The fixed-effects and 2SLS coefficients on the win rate are insignificant (with positive and significant OLS estimates), while coefficients on the settled-patent ratio are negative across all specifications (and insignificant for the fixed effects and IV estimation). This result is interesting, for it suggests that while stronger IPRs enforcement induces some marginal firms to start developing new products (our extensive-margin result from Table 3C), continuing firms may not increase their production of such products. Put differently, firms may be encouraged to become innovators by IPRs enforcement, but that policy may not incentivize higher production of existing goods. Indeed, stronger protection may reduce the incentive to ramp up production of new products because the risk of imitation goes down.

Panel C also suggests that lower industry-level tariffs push continuing firms to reduce their output of new products, which suggests that cheaper imports may substitute for the need to use new products developed domestically.

In summary, Panels A through C of Table 4 present empirical evidence that the volume effects of IPRs enforcement are variable across cases. However, there is weak evidence that stronger enforcement, measured across provinces and over time, encourages continued exporters and capital-goods importers to increase the amounts of those activities. There is essentially no impact on the volume of output of new products, as opposed to entry into such development.

### 5.4 IPRs Protection and Intensive Margins: Further Results

The regressions presented so far control for industry-level tariffs to separate the impact of IPRs enforcement from those of trade liberalization. To the extent that individual firms within an industry face different tariffs, the use of industry-level measures likely does not fully capture their effects. We therefore run additional regressions in which we control for firm-level tariffs for subsets of firms where these tariffs apply, focusing on IM effects.[23]

First, we investigate the impact of adding firm-level tariffs to the capital-goods imports regressions, using a subset of such importers that exclude processing firms. Panel A in Table 5 reports the IV results, though we suppress the coefficients on other control variables. Columns (1) and (4) are copied from columns (4) and (8) of Table 4, Panel B and used as benchmarks. Using this restricted sample, the coefficients on the settled-patent ratio remain significantly positive (columns (5)-(6)), but those on the win rate remain insignificantly positive (columns (3)–(4)). Across specifications, lower firm-level tariffs on capital-goods imports significantly increase such imports, indicating that our more precisely defined tariffs capture the expected impact.

Panel B of Table 5 reports additional regressions using capital-goods imports from rich countries and the proportion of these imports from rich countries as dependent variables. The results are consistent with our expectation that stronger IPRs, at least as reflected in the settled-patent ratio, encourage more capital-goods imports from rich countries. However, we find

---

[23] Since firm-level tariffs can only be computed for subsets of firms, the relevant extensive margins cannot be properly constructed for such regressions.

significantly negative coefficients of IPRs protection on the proportion of such imports from rich countries. This finding is intriguing, for it suggests that with stronger IPRs protection, Chinese firms may shift the mix of their greater imports of capital goods toward sources in emerging countries with notable technological capacities. In our data several such countries have higher per-capita GDP than China, indicating that such a pool is available. In this context, our finding suggests that as Chinese provincial IPRs enforcement is strengthened, local firms increase their demand for imported capital goods from all sources, but by relatively more from locations that offer machinery that may more readily be incorporated into production techniques.

The last supplemental regressions are reported in Appendix C. Briefly, Table C.1 estimates export-volume regressions with the sample restricted to manufacturing exporters matched between the NBS and Customs databases, while continuing to use industry tariffs. This approach produces estimates that are quite similar to those in Table 4, Panel A. Having established this consistency, we next estimate in Table C.2 a full series of second-stage IV regressions that incorporate both industry and firm-level tariffs, including only exporting firms that import inputs for uses other than processing exports. Firm-level tariffs are constructed using both total imports and intermediate imports. We find again that the coefficients on IPRs enforcement and firm attributes are similar to those of our primary specifications and remain stable with various tariff-measure inclusions. In summary, the matched exporters and the subset of the matched exporters importing for ordinary purpose experience similar and in some cases significantly positive impacts from IPRs protection on export volumes.

Next, we explore characteristics of the detailed export data to investigate whether IPRs protection affects the quality of exports. We construct from the Customs data four additional variables: export volume to rich countries, export volume of differentiated products, the proportion of exports going to rich countries, and the proportion of exports that are differentiated products. Rich countries are those with above-average per capita GDP in 2006, while a differentiated product is one with a below-average elasticity of substitution estimated by Broda and Weinstein (2006). Table C.3 reports the results of these regressions, using the larger matched sample with industry tariffs included. We find that the IPRs coefficients for the win rate on exports to rich countries and on exports of differentiated goods are significantly larger than those related to total exports. Further, firms in provinces with stronger IPRs export relatively more to rich countries but such protection does not affect the export mix between differentiated and homogenous products.

## 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 enforcement should force 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 levels at which firms will implement newer technologies, whether through capital-goods imports or their own process innovation. The ideas that both exports and technology imports should rise in the wake of more enforcement comports well with prior empirical findings that did not attempt to study the reasons for such effects. 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 broadly 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 adoption and exporting decisions in the presence of firm heterogeneity. Second, it provides insights into the channels through which IPRs reform-driven productivity changes occur. Our study also sheds 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.

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.

Ann, Jaebin, Khandelwal, Amit K., Wei, Shang-Jin. 2011. The Role of Intermediaries in Facilitating Trade. *Journal of International Economics* 84, 73-85.

Antras, Pol. 2003. Firms, Contracts, and Trade Structure. *Quarterly Journal of Economics* 118, 1375-1418.

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.

Bilir, L. Kamran. 2014. Patent Laws, Product Lifecycle Lengths, and the Global Sourcing Decisions of US Multinationals. *American Economic Review* 104, 1979-2013.

Brandt, Loren, Johannes Van Biesebroeck, Luhang Wang, and Yifan Zhang. 2017. WTO Accession and Performance of Chinese Manufacturing Firms. *American Economic Review* 107, 2784-2820.

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.

Broda, Christian and David E. Weinstein. 2006, Globalization and the Gains from Variety. *Quarterly Journal of Economics* 118, 541-585.

Brouwer, Erik and Alfred Kleinknecht. 1999. Innovative Output and a Firm's Propensity to Patent: An Exploration of CIS micro data. *Research Policy* 28, 615–624.

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

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

Fan, Haichao, Yao Amber Li, and Stephen R. Yeaple. 2015. Trade Liberalization, Quality, and Export Prices. *Review of Economics and Statistics* 97, 1033-51051.

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.

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.

Hagedoorn, John and Myriam Cloodt. 2003. Measuring Innovative Performance: Is there an Advantage in Using Multiple Indicators? *Research Policy* 32, 1265-1379.

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

Hitt, Michael A., Robert E. Hoskisson, Richard A. Johnson, and Douglas D. Moesel. 1996. The Market for Corporate Control and Firm Innovation. *Academy of Management Journal* 39, 1084–1119.

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.

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.

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. 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.

Shin, Wonkyu, Keun Lee, and Walter G. Park. 2015. When an Importer's Protection of IPR Interacts with an Exporter's Level of Technology: Comparing the Impacts on the Exports of the North and South. *The World Economy* 39, 772-802.

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, 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.

Yu, Miaojie. 2015. Processing Trade, Tariff Reductions and Firm Productivity: Evidence from Chinese Firms. *Economic Journal* 125, 943-988.

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

**Figure 1. Profits under Different Regimes before the Strengthening of IPRs**

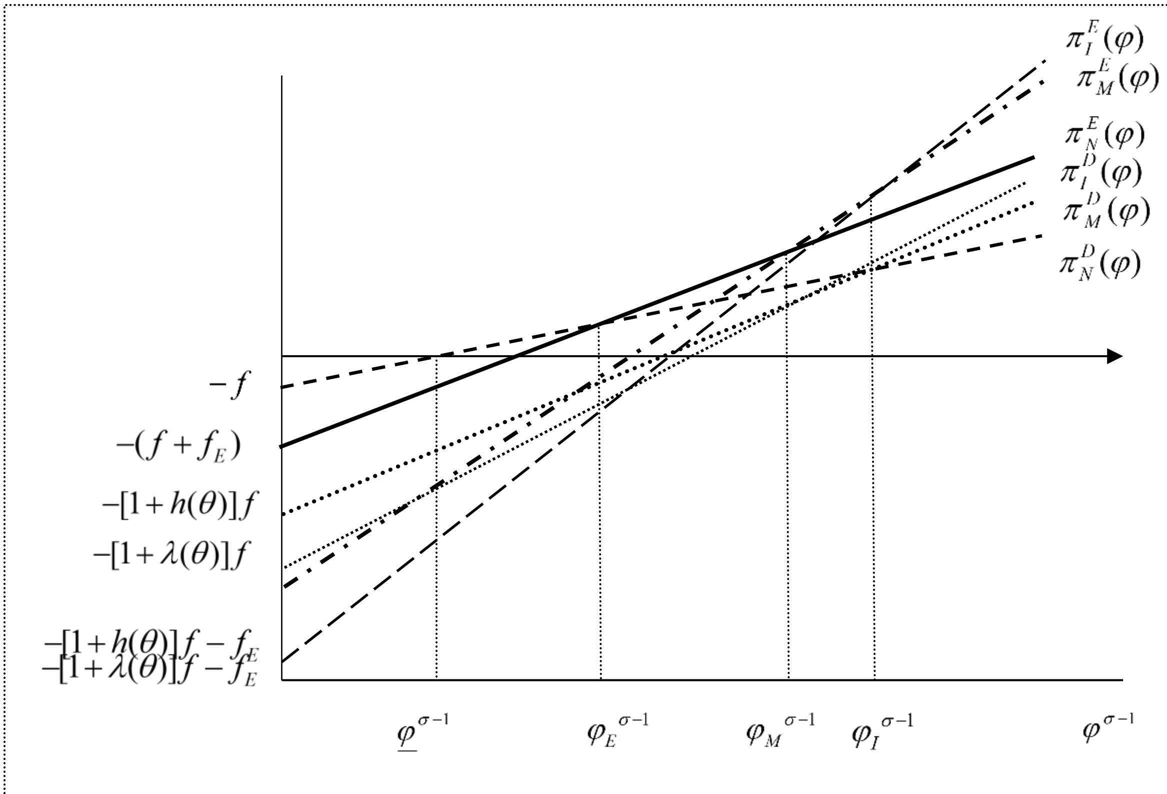
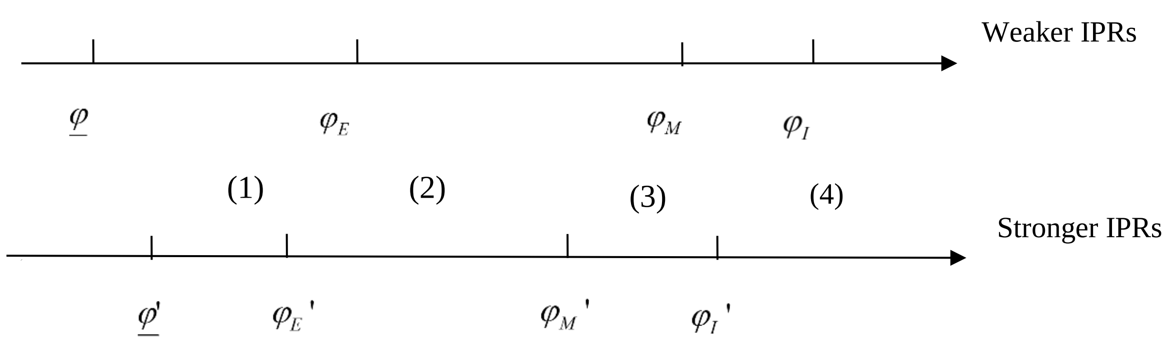



**Figure 2. Effects of More Rigorous IPRs Enforcement**



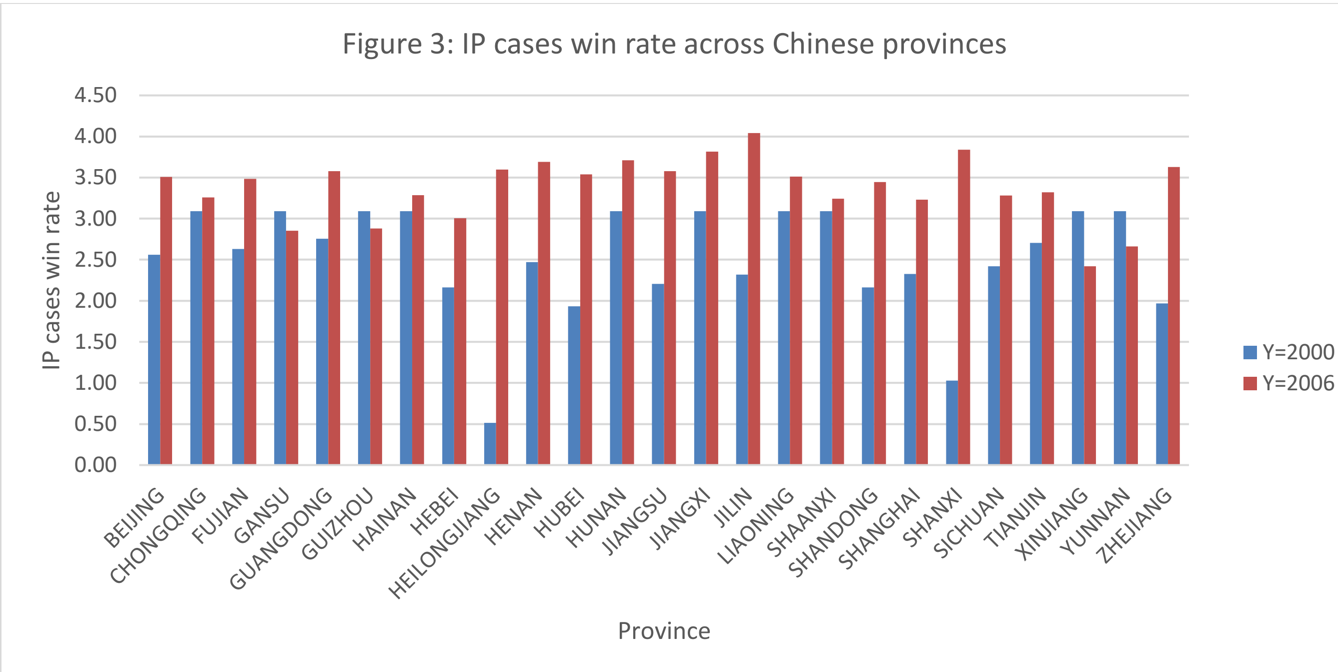


Figure 3: IP cases win rate across Chinese provinces
IP cases win rate
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
BEIJING
CHONGQING
FUJIAN
GANSU
GUANGDONG
GUIZHOU
HAINAN
HEBEI
HEILONGJIANG
HENAN
HUBEI
HUNAN
JIANGSU
JIANGXI
JILIN
LIAONING
SHAANXI
SHANDONG
SHANGHAI
SHANXI
SICHUAN
TIANJIN
XINJIANG
YUNNAN
ZHEJIANG
Province
Y=2000
Y=2006

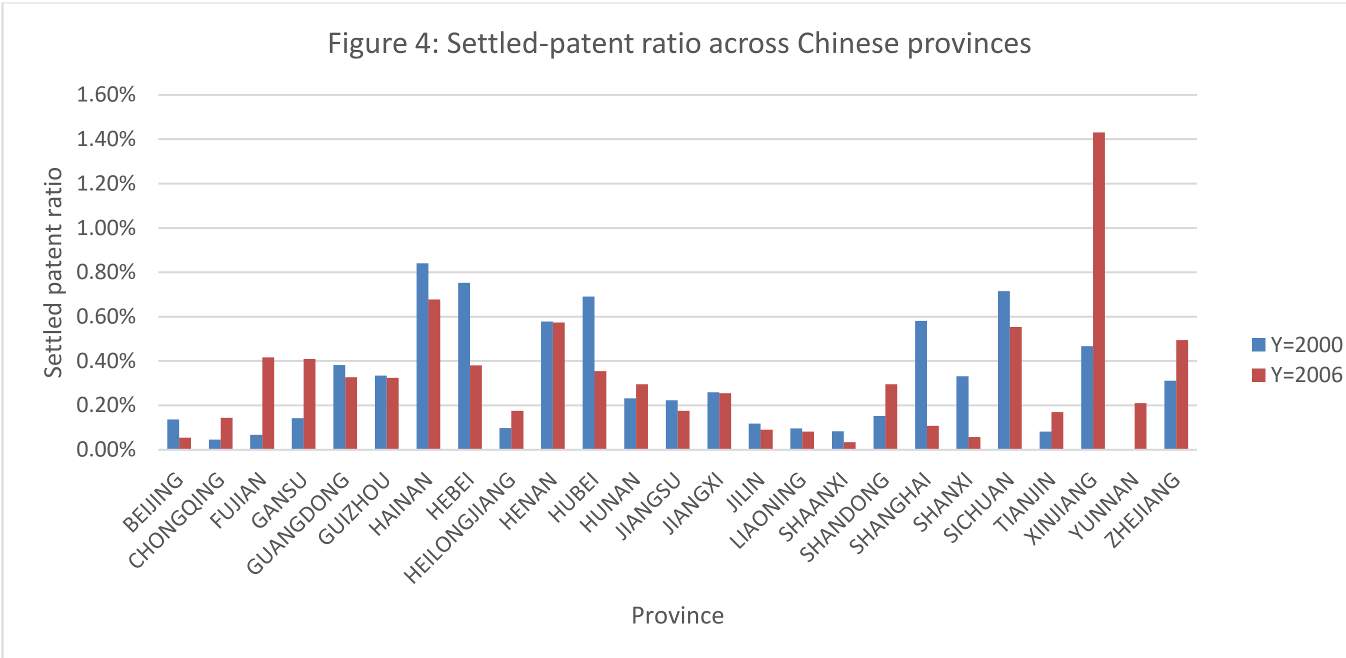


Figure 4: Settled-patent ratio across Chinese provinces
Settled patent ratio
1.60%
1.40%
1.20%
1.00%
0.80%
0.60%
0.40%
0.20%
0.00%
BEIJING
CHONGQING
FUJIAN
GANSU
GUANGDONG
GUIZHOU
HAINAN
HEBEI
HEILONGJIANG
HENAN
HUBEI
HUNAN
JIANGSU
JIANGXI
JILIN
LIAONING
SHAANXI
SHANDONG
SHANGHAI
SHANXI
SICHUAN
TIANJIN
XINJIANG
YUNNAN
ZHEJIANG
Province
Y=2000
Y=2006

**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: Import Tariffs | | | | | |
| tariffs - industry: 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 - industry: 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 |
| tariffs - firms | 2000 | 0.149 | 0.077 | 0.000 | 0.101 | 0.140 | 0.180 | 1.140 | 4,879 |
| | 2006 | 0.075 | 0.051 | 0.000 | 0.050 | 0.071 | 0.095 | 0.650 | 5,501 |
| tariffs - firms: intermediates | 2000 | 0.140 | 0.076 | 0.000 | 0.097 | 0.128 | 0.170 | 1.140 | 4,490 |
| | 2006 | 0.073 | 0.049 | 0.000 | 0.050 | 0.070 | 0.089 | 0.650 | 5,049 |
| tariffs - firms: capital goods | 2000 | 0.142 | 0.037 | 0.030 | 0.120 | 0.140 | 0.160 | 0.493 | 1,873 |
| | 2006 | 0.062 | 0.040 | 0.000 | 0.030 | 0.065 | 0.087 | 0.350 | 1,873 |
| | | | | C: IPR Measures | | | | | |
| IP cases win rate | 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 |
| D: Instrumental Variables for IPR Measures | | | | | | | | | |
| Christian School | | 0.50 | 0.52 | 0.00 | 0.13 | 0.37 | 0.73 | 2.47 | 28 |
| 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 |

This table presents the summary statistics of variables used in our analysis. Panel A: Firm Attributes. Panel B: Industry Level Import Tariffs. Panel C: IPR Measures. Panel D: Instrumental Variables for IPR Measures.

## 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 |
| | 0.828*** | 0.764*** | 0.431*** | 0.497*** | 1.130*** | 1.115*** | 1.309*** | 1.243*** | 1.305*** | 1.316*** | 1.299*** | 1.243*** |
| Export & capital goods importer dummy | (0.0266) | (0.0159) | (0.0234) | (0.0155) | (0.0190) | (0.0158) | (0.0279) | (0.0192) | (0.0270) | (0.0209) | (0.0271) | (0.0190) |
| | 0.460*** | 0.286*** | -0.0253* | -0.0418*** | 0.692*** | 0.501*** | 0.712*** | 0.461*** | 0.641*** | 0.416*** | 0.739*** | 0.469*** |
| Export & non-capital goods import dummy | (0.0158) | (0.0110) | (0.0151) | (0.0151) | (0.0137) | (0.0118) | (0.0195) | (0.0148) | (0.0209) | (0.0178) | (0.0193) | (0.0149) |
| 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 |

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

## Table 2B: Firm Performance under Different Exporting and New-Product 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 |
| | 1.142*** | 0.687*** | 0.461*** | 0.247*** | 1.418*** | 0.882*** | 1.653*** | 1.010*** | 1.764*** | 1.033*** | 1.658*** | 0.999*** |
| Export & new products dummy | (0.0237) | (0.0218) | (0.0177) | (0.0173) | (0.0226) | (0.0295) | (0.0283) | (0.0320) | (0.0286) | (0.0383) | (0.0278) | (0.0341) |
| | 0.391*** | 0.264*** | -0.0365** | -0.0204 | 0.628*** | 0.511*** | 0.634*** | 0.455*** | 0.537*** | 0.413*** | 0.659*** | 0.467*** |
| Export & non-new products dummy | (0.0145) | (0.0101) | (0.0155) | (0.0158) | (0.0119) | (0.0110) | (0.0167) | (0.0136) | (0.0171) | (0.0163) | (0.0164) | (0.0136) |
| 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 |

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

**Table 3A: IPRs Protection and Exit Decision**

| | **Dependent variable = exit** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | (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 rate (2006) | 0.0498** | 0.0417** | 0.0398** | -0.0788 | | | | |
| | (0.0211) | (0.0176) | (0.0155) | (0.157) | | | | |
| Settled-patent ratio (2006) | | | | | 6.712** | 6.790** | 5.395** | 13.44* |
| | | | | | (2.962) | (3.119) | (2.755) | (7.968) |
| change of tariffs | | -0.249*** | | | | -0.234*** | | |
| | | (0.0294) | | | | (0.0295) | | |
| $\log(tfp_{2000})$ | | -0.0631*** | -0.0647*** | -0.0669*** | | -0.0638*** | -0.0650*** | -0.0650*** |
| | | (0.00481) | (0.00525) | (0.00623) | | (0.00463) | (0.00519) | (0.00483) |
| $\log(age_{2000})$ | | -0.00299 | 0.00294 | 0.00351 | | -0.00309 | 0.00301 | 0.00293 |
| | | (0.00359) | (0.00366) | (0.00410) | | (0.00357) | (0.00359) | (0.00374) |
| Foreign firm dummy | | -0.000456 | 0.00816 | 0.0127 | | 0.0131 | 0.0174 | 0.0268* |
| | | (0.0215) | (0.0188) | (0.0156) | | (0.0181) | (0.0163) | (0.0139) |
| HK-Macau-Taiwan dummy | | 0.0126 | 0.00447 | 0.00803 | | 0.0207 | 0.00986 | 0.0136 |
| | | (0.0270) | (0.0232) | (0.0237) | | (0.0246) | (0.0218) | (0.0186) |
| Constant | 0.487*** | 0.862*** | 0.886*** | 1.404** | 27.99** | 28.66** | 22.99** | 55.90* |
| | (0.0721) | (0.0605) | (0.0586) | (0.514) | (12.08) | (12.71) | (11.22) | (32.45) |
| Observations | 109,012 | 94,921 | 99,314 | 98,381 | 110,434 | 96,140 | 100,589 | 98,618 |
| R-squared | 0.003 | 0.041 | 0.0740 | 0.057 | 0.004 | 0.044 | 0.0750 | 0.072 |
| Industry fixed effects | no | no | yes | yes | no | no | yes | yes |

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

**Table 3B: IPRs Protection and Export Decision**

| | Dependent variable = start exporting | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | (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 rate (2006) | 0.152** | 0.159** | 0.131* | 0.107 | | | | |
| | (0.0774) | (0.0799) | (0.0748) | (0.0859) | | | | |
| Settled-patent ratio (2006) | | | | | 6.72 | 8.508 | 8.450* | 22.23* |
| | | | | | (5.395) | (5.698) | (4.917) | (11.78) |
| change of tariffs | | -0.0583* | | | | -0.0571* | | |
| | | (0.0328) | | | | (0.0302) | | |
| $\log(tfp_{2000})$ | | 0.0119*** | 0.0309*** | 0.0313*** | | 0.0119*** | 0.0326*** | 0.0321*** |
| | | (0.00384) | (0.00351) | (0.00361) | | (0.00386) | (0.00404) | (0.00389) |
| $\log(age_{2000})$ | | -0.0218*** | -0.0154*** | -0.0161*** | | -0.0227*** | -0.0159*** | -0.0155*** |
| | | (0.00492) | (0.00336) | (0.00324) | | (0.00485) | (0.00326) | (0.00331) |
| Foreign firm dummy | | 0.183*** | 0.164*** | 0.163*** | | 0.190*** | 0.171*** | 0.188*** |
| | | (0.0294) | (0.0237) | (0.0249) | | (0.0268) | (0.0219) | (0.0175) |
| HK-Macau-Taiwan dummy | | 0.137*** | 0.109*** | 0.108*** | | 0.143*** | 0.113*** | 0.120*** |
| | | (0.0341) | (0.0274) | (0.0282) | | (0.0323) | (0.0255) | (0.0207) |
| Constant | -0.377 | -0.453 | -0.488* | -0.400 | 27.53 | 34.77 | 34.39* | |
| | (0.246) | (0.270) | (0.253) | (0.275) | (22.00) | (23.23) | (20.04) | |
| Observations | 46,386 | 42,646 | 44,652 | 43,903 | 46,386 | 42,646 | 44,652 | 43,903 |
| R-squared | 0.013 | 0.046 | 0.107 | 0.108 | 0.006 | 0.040 | 0.107 | 0.101 |
| Industry fixed effects | no | no | yes | yes | no | no | yes | yes |

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

## Table 3C: IPRs Protection and New-Products Decision

| | Dependent variable = start new products | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | (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 rate (2006) | 0.131 | 0.137* | 0.125* | 0.154 | | | | |
| | (0.0799) | (0.0804) | (0.0760) | (0.103) | | | | |
| Settled-patent ratio (2006) | | | | | 24.64* | 25.03* | 25.23** | 36.85** |
| | | | | | (13.58) | (13.67) | (12.72) | (15.75) |
| change of tariffs | | 0.00675 | | | | 0.0231 | | |
| | | (0.0156) | | | | (0.0181) | | |
| $\log(tfp_{2000})$ | | 0.0173*** | 0.0246*** | 0.0246*** | | 0.0158*** | 0.0246*** | 0.0243*** |
| | | (0.00392) | (0.00556) | (0.00545) | | (0.00351) | (0.00544) | (0.00549) |
| $\log(age_{2000})$ | | -0.00177 | -0.00220 | -0.00220 | | -6.66e-05 | -0.000243 | 0.000305 |
| | | (0.00316) | (0.00236) | (0.00218) | | (0.00291) | (0.00231) | (0.00216) |
| Foreign firm dummy | | -0.0313 | -0.0399** | -0.0393** | | -0.0146 | -0.0260* | -0.0206** |
| | | (0.0207) | (0.0176) | (0.0169) | | (0.0140) | (0.0132) | (0.00985) |
| HK-Macau-Taiwan dummy | | -0.0505* | -0.0498** | -0.0508** | | -0.0425** | -0.0449*** | -0.0467*** |
| | | (0.0252) | (0.0200) | (0.0203) | | (0.0203) | (0.0158) | (0.0151) |
| Constant | -0.358 | -0.473* | -0.472* | -0.543 | 102.3* | 103.8* | 104.6* | 152.8** |
| | (0.255) | (0.269) | (0.260) | (0.350) | (56.33) | (56.70) | (52.75) | (65.36) |
| Observations | 62,470 | 57,955 | 60,457 | 59,663 | 62,470 | 57,955 | 60,457 | 59,663 |
| R-squared | 0.011 | 0.020 | 0.0537 | 0.056 | 0.027 | 0.034 | 0.0707 | 0.088 |
| Industry fixed effects | no | no | yes | yes | no | no | yes | yes |

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

## Table 4: IPRs Protection and the Volumes of Exports, Capital-Goods Imports, and New Products

| Variables | (1) OLS | (2) OLS | (3) Fixed Effects | (4) 2nd-stage IV | (5) OLS | (6) OLS | (7) Fixed Effects | (8) 2nd-stage IV |
|---|---|---|---|---|---|---|---|---|
| **Panel A: log(exports)** | | | | | | | | |
| IP cases win rate | 0.458*** | 0.223*** | 0.159 | 0.751*** | | | | |
| | (0.0396) | (0.0355) | (0.0986) | (0.236) | | | | |
| Settled patent ratio | | | | | -0.541*** | -0.254*** | 29.41* | 67.98 |
| | | | | | (0.0442) | (0.0822) | (15.35) | (65.09) |
| tariffs - industry | | 0.662** | 1.563*** | 1.560*** | | 0.675 | 1.541*** | 1.578*** |
| | | (0.321) | (0.252) | (0.261) | | (0.412) | (0.271) | (0.282) |
| 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 | 0.439 | 0.031 | 0.254 | 0.439 | 0.448 |
| **Panel B: log(capital-goods imports) - matched sample** | | | | | | | | |
| IP cases win rate | -0.0276 | -0.342*** | 0.544** | 0.561 | | | | |
| | (0.0834) | (0.109) | (0.217) | (0.467) | | | | |
| Settled patent ratio | | | | | 0.139* | 0.827*** | 8.519 | 206.3** |
| | | | | | (0.0755) | (0.114) | (21.09) | (77.07) |
| tariffs - industry | | -1.973*** | 0.390 | 0.338 | | -3.024*** | 0.139 | 0.150 |
| | | (0.478) | (0.935) | (0.930) | | (0.466) | (0.876) | (0.946) |
| Observations | 8,598 | 8,052 | 8,052 | 8,036 | 8,648 | 8,097 | 8,097 | 8,076 |
| R-squared | 0.000 | 0.126 | 0.324 | 0.322 | 0.001 | 0.136 | 0.322 | 0.305 |
| **Panel C: log(new products)** | | | | | | | | |
| IP cases win rate | 0.593*** | 0.344*** | 0.107 | -0.799 | | | | |
| | (0.0762) | (0.104) | (0.0916) | (0.938) | | | | |
| Settled patent ratio | | | | | -0.802*** | -0.470*** | -0.372 | -59.13 |
| | | | | | (0.0949) | (0.135) | (14.74) | (42.11) |
| tariffs - industry | | 1.540** | 1.779*** | 1.934*** | | 1.872*** | 1.731*** | 1.766*** |
| | | (0.634) | (0.498) | (0.507) | | (0.575) | (0.478) | (0.506) |
| 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 | 0.595 | 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 province level. *** p<0.01, ** p<0.05, * p<0.1

## Table 5: IPRs Protection and Capital-Goods Imports with Control for Firm-Level Tariffs

**Panel A: log(capital-goods imports) - matched sample**

| Variables | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| IP cases win rate | 0.561 | 0.265 | 0.291 | | | |
| | (0.467) | (0.752) | (0.834) | | | |
| Settled patent ratio | | | | 206.3** | 243.9*** | 280.7*** |
| | | | | (77.07) | (67.24) | (73.21) |
| tariffs - industry | 0.338 | | 2.221 | 0.150 | | 1.710 |
| | (0.930) | | (1.573) | (0.946) | | (1.588) |
| tariffs of capital goods - firm | | -2.100* | -2.396* | | -2.260* | -2.619* |
| | | (1.278) | (1.391) | | (1.237) | (1.359) |
| Observations | 8,036 | 4,539 | 4,384 | 8,076 | 4,564 | 4,408 |
| R-squared with FE | 0.322 | 0.390 | 0.390 | 0.305 | 0.372 | 0.365 |
| Industry fixed effects | yes | yes | yes | yes | yes | yes |

**Panel B: log(capital-goods imports from rich countries) - matched sample**

| Variables | log(capital goods imports) - rich countries | % capital goods imports - rich countries | log(capital goods imports) - rich countries | % capital goods imports - rich countries |
|---|---|---|---|---|
| IP cases win rate | 0.145 | -0.134 | | |
| | (0.780) | (0.151) | | |
| Settled patent ratio | | | 198.0** | -46.19*** |
| | | | (79.41) | (9.057) |
| tariffs - industry | 1.738 | -0.101 | 1.467 | -0.0522 |
| | (1.305) | (0.139) | (1.326) | (0.141) |
| tariffs - firm level: capital goods import | -2.920** | 0.0155 | -3.061*** | 0.0393 |
| | (1.117) | (0.0688) | (1.062) | (0.0737) |
| Observations | 4,051 | 4,051 | 4,075 | 4,075 |
| R-squared with FE | 0.388 | 0.232 | 0.376 | 0.185 |
| Industry fixed effects | yes | yes | yes | yes |

2nd-Stage IV estimates, in parentheses are standard errors clustered at the province level. *** p<0.01, ** p<0.05, * p<0.1

# Appendix A. Theoretical Results

## Appendix A1. Profit Expressions and Productivity Cutoffs

Denote by $\pi_N^D(\varphi)$ the profit of a firm with productivity $\varphi$ choosing no technology adoption while only serving the domestic market.

$$\pi_N^D(\varphi) = \frac{1}{\sigma} E(P\rho)^{\sigma-1} \varphi^{\sigma-1} - f \ .$$

Let $\pi_M^D(\varphi)$ be the profit of a firm with productivity $\varphi$ importing capital goods while only serving the domestic market.

$$\pi_M^D(\varphi) = \frac{1}{\sigma} E(P\rho)^{\sigma-1} (b\varphi)^{\sigma-1} - [1 + h(\theta)] f \ .$$

Let $\pi_I^D(\varphi)$ be the profit of a firm with productivity $\varphi$ undertaking innovation while only serving the domestic market.

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

Following Melitz (2003) and Bustos (2011), we assume that the home country and the foreign country are identical in size and have symmetric trading costs. Therefore, E and P are assumed to the same in both locations. We take $\pi_N^E(\varphi)$ to be a firm's profit with productivity $\varphi$ choosing no technology adoption while serving both domestic and foreign markets.

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

Let $\pi_M^E(\varphi)$ represent the profit of a firm with productivity $\varphi$ importing capital goods while serving both markets.

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

Finally, let $\pi_I^E(\varphi)$ represent the profit of a firm with productivity $\varphi$ undertaking innovation while serving both markets.

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

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 $\varphi_E$ to be the cutoff productivity above which a firm choosing no technology adoption finds exporting more profitable than solely domestic sales, determined by the condition $\pi_N^D(\varphi_E) = \pi_N^E(\varphi_E)$. Next, $\varphi_M$ is the cutoff productivity above which a firm choosing to export finds it more profitable to import capital goods, given by the condition $\pi_N^E(\varphi_M) = \pi_M^E(\varphi_M)$. Finally, $\varphi_I$ is the cutoff productivity above which an exporting firm that had chosen to import capital goods finds process innovation more profitable, given by $\pi_M^E(\varphi_I) = \pi_I^E(\varphi_I)$.

In a manner similar to Bustos (2011), we prove in Appendix A2 that $\pi_M^E(\varphi) > \pi_M^D(\varphi)$ and $\pi_I^E(\varphi) > \pi_I^D(\varphi)$ if $\pi_N^E(\varphi) > \pi_N^D(\varphi)$. This implies that a firm undertaking technology adoption through importing capital goods or innovation will also choose to be an exporter if a firm choosing no technology adoption selects exporting. Note that a firm with productivity $\varphi > \varphi_E$ choosing no technology adoption will choose to export. Thus, it can be inferred that a firm with $\varphi > \varphi_E$ will always choose export, regardless of its decision on technology adoption.

We also prove that $\pi_M^D(\varphi) < \pi_N^D(\varphi)$ if $\pi_M^E(\varphi) < \pi_N^E(\varphi)$ and $\pi_I^D(\varphi) < \pi_N^D(\varphi)$ if $\pi_I^E(\varphi) < \pi_N^E(\varphi)$. This implies that if an exporting firm is more profitable choosing no technology adoption, it is also more profitable choosing no technology adoption when it only serves the domestic market. Notice that $\varphi_M$ is defined as the cutoff productivity below which an exporting firm is more profitable under the old technology than under importing capital goods. It follows that a firm with $\varphi < \varphi_M$ is also more profitable with the old technology when only serving the domestic market. Hence, a firm with $\varphi < \varphi_M$ always chooses no technology adoption regardless of whether it enters the foreign market.

**Appendix A2. Proof of Ranking Conditions**

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

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

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

Therefore, we have

$$\tau^{1-\sigma}\frac{1}{\sigma}E(P\rho)^{\sigma-1}\varphi^{\sigma-1} - f_E > 0 .$$

It follows that

$$\begin{aligned}
&\pi_M^E(\varphi) - \pi_M^D(\varphi) \\
&= (1+\tau^{1-\sigma})\frac{1}{\sigma}E(P\rho)^{\sigma-1}(b\varphi)^{\sigma-1} - [1+h(\theta)]f - f_E(\theta) - \left\{\frac{1}{\sigma}E(P\rho)^{\sigma-1}(b\varphi)^{\sigma-1} - [1+h(\theta)]f\right\} \\
&= \tau^{1-\sigma}\frac{1}{\sigma}E(P\rho)^{\sigma-1}(b\varphi)^{\sigma-1} - f_E \\
&> \tau^{1-\sigma}\frac{1}{\sigma}E(P\rho)^{\sigma-1}\varphi^{\sigma-1} - f_E > 0
\end{aligned} .$$

The proof that $\pi_I^E(\varphi) > \pi_I^D(\varphi)$ if $\pi_N^E(\varphi) > \pi_N^D(\varphi)$ is similar to the above analysis.

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

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

$$(1+\tau^{1-\sigma})\frac{1}{\sigma}E(P\rho)^{\sigma-1}(b\varphi)^{\sigma-1} - [1+h(\theta)]f - f_E(\theta) < (1+\tau^{1-\sigma})\frac{1}{\sigma}E(P\rho)^{\sigma-1}\varphi^{\sigma-1} - [f + f_E(\theta)]$$ Hence,

we have

$$(1+\tau^{1-\sigma})\frac{1}{\sigma}E(P\rho)^{\sigma-1}[(b\varphi)^{\sigma-1} - \varphi^{\sigma-1}] - h(\theta)f < 0.$$

Thus, we find that

$$\begin{aligned}
&\pi_M^D(\varphi) - \pi_N^D(\varphi) \\
&= \frac{1}{\sigma}E(P\rho)^{\sigma-1}(b\varphi)^{\sigma-1} - [1+h(\theta)]f - [\frac{1}{\sigma}E(P\rho)^{\sigma-1}\varphi^{\sigma-1} - f] \\
&= \frac{1}{\sigma}E(P\rho)^{\sigma-1}[(b\varphi)^{\sigma-1} - \varphi^{\sigma-1}] - h(\theta)f \\
&< (1+\tau^{1-\sigma})\frac{1}{\sigma}E(P\rho)^{\sigma-1}[(b\varphi)^{\sigma-1} - \varphi^{\sigma-1}] - h(\theta)f < 0
\end{aligned}.$$

The proof that $\pi_I^D(\varphi) < \pi_N^D(\varphi)$ if $\pi_I^E(\varphi) < \pi_N^E(\varphi)$ is similar to the above analysis.

**Appendix A3. Relationship between Different Cutoffs.**

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

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

Next, because $\varphi_E$ denotes the cutoff productivity above which a firm choosing no technology adoption finds exporting more profitable, we have $\pi_N^D(\varphi_E) = \pi_N^E(\varphi_E)$. It follows that

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

We also have $$\varphi_E = \underline{\varphi}\tau[\frac{f_E(\theta)}{f}]^{\frac{1}{\sigma-1}}.$$

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

Further, because $\varphi_M$ is the cutoff productivity above which a firm choosing exporting finds importing capital goods more profitable, we find that $\pi_N^E(\varphi_M) = \pi_M^E(\varphi_M)$. Then we have

$$\varphi_M^{\sigma-1} = \frac{\sigma h(\theta) f}{(1+\tau^{1-\sigma})E(P\rho)^{\sigma-1}(b^{\sigma-1}-1)}.$$

It can also be derived that $$\varphi_M = \underline{\varphi}\frac{1}{(1+\tau^{1-\sigma})^{\frac{1}{\sigma-1}}}[\frac{h(\theta)}{b^{\sigma-1}-1}]^{\frac{1}{\sigma-1}}.$$

Finally, as $\varphi_I$ is the cutoff productivity above which a firm choosing to export finds innovation more profitable, we have $\pi_M^E(\varphi_I) = \pi_I^E(\varphi_I)$. Then we have

$$\varphi_I^{\sigma-1} = \frac{[\lambda(\theta) - h(\theta)] f}{(1+\tau^{1-\sigma})\frac{1}{\sigma}E(P\rho)^{\sigma-1}(a^{\sigma-1} - b^{\sigma-1})}.$$

It can also be derived that $$\varphi_I = \underline{\varphi}\frac{1}{(1+\tau^{1-\sigma})^{\frac{1}{\sigma-1}}}[\frac{\lambda(\theta)-h(\theta)}{a^{\sigma-1}-b^{\sigma-1}}]^{\frac{1}{\sigma-1}}.$$

Therefore, we have $\varphi_I > \varphi_M$ when $\frac{[\lambda(\theta)-h(\theta)]}{(a^{\sigma-1}-b^{\sigma-1})} > \frac{h(\theta)}{(b^{\sigma-1}-1)}$ and $\varphi_I < \varphi_M$ if the opposite inequality holds.

**Appendix A4. Proofs of the Impacts of IPRs Enforcement**

**A4.1. Per-period expected profit of surviving firms**

Let $\bar{\pi}$ denote the per-period expected profit of surviving firms. Following Busto (2011), we have $\bar{\pi} = \bar{\pi}_d(\varphi_d) + p_E \bar{\pi}_E(\varphi_E)$. Here $\bar{\pi}_d(\varphi_d)$ denote the expected profits from domestic market, $\bar{\pi}_E(\varphi_E)$ denote the expected profit from exporting market, $\varphi_d$ represents the expected productivity of home surviving firms and $p_E$ is the probability of exporting. We then have

$$\bar{\pi}_d(\varphi_d) = \frac{1}{\sigma} E(P\rho)^{\sigma-1} \varphi_d^{\ \sigma-1} - f\frac{G(\varphi_M) - G(\underline{\varphi})}{1-G(\underline{\varphi})} - h(\theta) f \frac{G(\varphi_I) - G(\varphi_M)}{1-G(\underline{\varphi})} - \lambda(\theta) f \frac{1-G(\varphi_I)}{1-G(\underline{\varphi})}$$. And

$$\begin{aligned}\varphi_d^{\ \sigma-1} &= \int_{\underline{\varphi}}^{\varphi_M} \frac{k\varphi^{\sigma-k-2}}{1-G(\underline{\varphi})} d\varphi + \int_{\varphi_M}^{\varphi_I} b^{\sigma-1}\frac{k\varphi^{\sigma-k-2}}{1-G(\underline{\varphi})} d\varphi + \int_{\varphi_I}^{\infty} a^{\sigma-1}\frac{k\varphi^{\sigma-k-2}}{1-G(\underline{\varphi})} d\varphi \\ &= \frac{k}{1-G(\underline{\varphi})}\frac{1}{\sigma-k-1}[\varphi^{\sigma-k-1}|_{\underline{\varphi}}^{\varphi_M} + b^{\sigma-1}\varphi^{\sigma-k-1}|_{\varphi_M}^{\varphi_I} + a^{\sigma-1}\varphi^{\sigma-k-1}|_{\varphi_I}^{\infty}] \\ &= \frac{k}{1-G(\underline{\varphi})}\frac{1}{\sigma-k-1}[(1-b^{\sigma-1})\varphi_M^{\sigma-k-1} - \underline{\varphi}^{\sigma-k-1} + (b^{\sigma-1}-a^{\sigma-1})\varphi_I^{\sigma-k-1}]\end{aligned}$$

From the free entry condition, we have

$$E\left(P\rho\right)^{\sigma-1} = \frac{f}{\underline{\varphi}^{\sigma-1}}\sigma.$$

Also note that $1-G(\underline{\varphi}) = \underline{\varphi}^{-k}$.

Denote $\beta_M = [\frac{h(\theta)}{(1+\tau^{1-\sigma})(b^{\sigma-1}-1)}]^{\frac{1}{\sigma-1}}$, $\beta_I = [\frac{\lambda(\theta)-h(\theta)}{(1+\tau^{1-\sigma})\left(a^{\sigma-1}-b^{\sigma-1}\right)}]^{\frac{1}{\sigma-1}}$ and $\beta_E = \tau\left[\frac{f_E(\theta)}{f}\right]^{\frac{1}{\sigma-1}}$. We then have

$$\varphi_M = \underline{\varphi}\beta_M,\ \varphi_I = \underline{\varphi}\beta_I \text{ and } \varphi_E = \underline{\varphi}\beta_E.$$

Therefore, it can be derived that

$$\begin{aligned}\bar{\pi}_d(\varphi_d) &= \frac{1}{\sigma} E(P\rho)^{\sigma-1} \varphi_d^{\ \sigma-1} - f\frac{G(\varphi_M) - G(\underline{\varphi})}{1-G(\underline{\varphi})} - h(\theta) f \frac{G(\varphi_I) - G(\varphi_M)}{1-G(\underline{\varphi})} - \lambda(\theta) f \frac{1-G(\varphi_I)}{1-G(\underline{\varphi})} \\ &= \frac{fk}{\sigma-k-1}[(1-b^{\sigma-1})\beta_M^{\sigma-k-1} - 1 + (b^{\sigma-1}-a^{\sigma-1})\beta_I^{\sigma-k-1}] - f\left(1-\beta_M^{-k}\right) - h(\theta) f\left(\beta_M^{-k} - \beta_I^{-k}\right) - \lambda(\theta) f \beta_I^{-k}\end{aligned}$$

Note that

$$1-G(\varphi_E) = \varphi_E^{-k} = \left(\underline{\varphi}\beta_E\right)^{-k}.$$

Thus, we get

$$\varphi_E^{\ \sigma-1} = \int_{\varphi_E<\varphi<\varphi_M} \varphi^{\sigma-1}\frac{g(\varphi)}{1-G(\varphi_E)}d\varphi + \int_{\varphi_M<\varphi<\varphi_I} \varphi^{\sigma-1}b^{\sigma-1}\frac{g(\varphi)}{1-G(\varphi_E)}d\varphi + \int_{\varphi_I<\varphi} \varphi^{\sigma-1}a^{\sigma-1}\frac{g(\varphi)}{1-G(\varphi_E)}d\varphi$$

$$= \int_{\varphi_E}^{\varphi_M}\frac{k\varphi^{\sigma-k-2}}{1-G(\varphi_E)}d\varphi + \int_{\varphi_M}^{\varphi_I} b^{\sigma-1}\frac{k\varphi^{\sigma-k-2}}{1-G(\varphi_E)}d\varphi + \int_{\varphi_I}^{\infty} a^{\sigma-1}\frac{k\varphi^{\sigma-k-2}}{1-G(\varphi_E)}d\varphi$$

$$= \frac{k}{\sigma-k-1}\beta_E^{\ k}[(1-b^{\sigma-1})\beta_M^{\sigma-k-1} - \beta_E^{\ \sigma-k-1} + (b^{\sigma-1}-a^{\sigma-1})\beta_I^{\sigma-k-1}]\underline{\varphi}^{\sigma-1}$$

Hence, we have

$$\bar{\pi}_E(\varphi_E) = \frac{1}{\sigma}E(P\rho)^{\sigma-1}\tau^{1-\sigma}\varphi_E^{\ \sigma-1} - f_E$$

$$= \frac{fk}{\sigma-k-1}\tau^{1-\sigma}\beta_E^{\ k}[(1-b^{\sigma-1})\beta_M^{\sigma-k-1} - \beta_E^{\ \sigma-k-1} + (b^{\sigma-1}-a^{\sigma-1})\beta_I^{\sigma-k-1}] - f_E$$

Note that $p_E = \frac{1-G(\varphi_E)}{1-G(\underline{\varphi})} = \beta_E^{-k}$. Accordingly, we have

$$p_E\bar{\pi}_E(\varphi_E) = \frac{fk\tau^{1-\sigma}}{\sigma-k-1}[(1-b^{\sigma-1})\beta_M^{\sigma-k-1} - \beta_E^{\ \sigma-k-1} + (b^{\sigma-1}-a^{\sigma-1})\beta_I^{\sigma-k-1}] - \beta_E^{-k}f_E$$

Therefore, we obtain

$$\bar{\pi} = \bar{\pi}_d(\varphi_d) + p_E\bar{\pi}_E(\varphi_E)$$

$$= \frac{fk}{k-(\sigma-1)}\left(1+\tau^{1-\sigma}\right)(a^{\sigma-1}-b^{\sigma-1})\beta_I^{\sigma-1-k} + \frac{f(\sigma-1)}{k-(\sigma-1)}\frac{1}{(1+\tau^{1-\sigma})^{\frac{-k}{\sigma-1}}}(b^{\sigma-1}-1)^{\frac{k}{\sigma-1}}h(\theta)^{1-\frac{k}{\sigma-1}}$$

$$+ f\beta_M^{-k} + f\left[h(\theta)-\lambda(\theta)\right]\beta_I^{-k} + \frac{f(\sigma-1)}{k-\sigma+1} + \frac{f(\sigma-1)}{k-\sigma+1}\tau^{-k}\left(\frac{f_E}{f}\right)^{1-\frac{k}{\sigma-1}}$$

Plugging in the expressions of $\beta_M$ and $\beta_I$, we have

$$\bar{\pi}$$

$$= \frac{f(\sigma-1)}{k-(\sigma-1)}\frac{\left[\lambda(\theta)-h(\theta)\right]^{1-\frac{k}{\sigma-1}}}{\left[\left(1+\tau^{1-\sigma}\right)\left(a^{\sigma-1}-b^{\sigma-1}\right)\right]^{-\frac{k}{\sigma-1}}} + f\left[\frac{h(\theta)}{\left(1+\tau^{1-\sigma}\right)\left(b^{\sigma-1}-1\right)}\right]^{-\frac{k}{\sigma-1}} + \frac{f(\sigma-1)}{k-\sigma+1} + \frac{f(\sigma-1)}{k-\sigma+1}\tau^{-k}\left(\frac{f_E}{f}\right)^{1-\frac{k}{\sigma-1}}$$

$$+ \frac{f(\sigma-1)}{k-(\sigma-1)}\frac{h(\theta)^{1-\frac{k}{\sigma-1}}}{\left[(1+\tau^{1-\sigma})(b^{\sigma-1}-1)\right]^{-\frac{k}{\sigma-1}}}$$

Denote

$$u(\theta)=\frac{f(\sigma-1)}{k-(\sigma-1)}\frac{\left[\lambda(\theta)-h(\theta)\right]^{1-\frac{k}{\sigma-1}}}{\left[\left(1+\tau^{1-\sigma}\right)\left(a^{\sigma-1}-b^{\sigma-1}\right)\right]^{-\frac{k}{\sigma-1}}}+f\left[\frac{h(\theta)}{\left(1+\tau^{1-\sigma}\right)\left(b^{\sigma-1}-1\right)}\right]^{-\frac{k}{\sigma-1}}+\frac{f(\sigma-1)}{k-\sigma+1}+\frac{f(\sigma-1)}{k-\sigma+1}\tau^{-k}\left(\frac{f_E}{f}\right)^{1-\frac{k}{\sigma-1}}$$

$$,\ v(\theta)=\frac{f(\sigma-1)}{k-(\sigma-1)}\frac{h(\theta)^{1-\frac{k}{\sigma-1}}}{\left[(1+\tau^{1-\sigma})(b^{\sigma-1}-1)\right]^{-\frac{k}{\sigma-1}}}.$$

Thus, we have $\overline{\pi}=u(\theta)+v(\theta)$.

$$\frac{du(\theta)}{d\theta}$$

$$=\frac{f(\sigma-1)[1-\frac{k}{\sigma-1}]}{k-(\sigma-1)}\frac{\left[\lambda(\theta)-h(\theta)\right]^{-\frac{k}{\sigma-1}}}{\left[\left(1+\tau^{1-\sigma}\right)\left(a^{\sigma-1}-b^{\sigma-1}\right)\right]^{-\frac{k}{\sigma-1}}}[\frac{d\lambda(\theta)}{d\theta}-\frac{dh(\theta)}{d\theta}]-f(1+\tau^{1-\sigma})^{\frac{k}{\sigma-1}}(b^{\sigma-1}-1)^{\frac{k}{\sigma-1}}\frac{k}{\sigma-1}[h(\theta)]^{\frac{-k}{\sigma-1}-1}\frac{dh(\theta)}{d\theta}$$

$$+\frac{f(\sigma-1)}{k-\sigma+1}\tau^{-k}f^{\frac{k}{\sigma-1}-1}(1-\frac{k}{\sigma-1})f_E^{-\frac{k}{\sigma-1}}\frac{df_E}{d\theta}$$

Note that $-\frac{d\lambda(\theta)}{d\theta}>-\frac{dh(\theta)}{d\theta}$, we have $\frac{d\lambda(\theta)}{d\theta}-\frac{dh(\theta)}{d\theta}<0$. Also we have $\frac{df_E}{d\theta}<0$ and $k>\sigma-1$.

Therefore, we have $\frac{du(\theta)}{d\theta}>0$.

We also have

$$\frac{dv(\theta)}{d\theta}=\frac{f(\sigma-1)\left[(1+\tau^{1-\sigma})(b^{\sigma-1}-1)\right]^{\frac{k}{\sigma-1}}}{k-(\sigma-1)}(1-\frac{k}{\sigma-1})h(\theta)^{-\frac{k}{\sigma-1}}\frac{dh(\theta)}{d\theta}.$$

As $\frac{dh(\theta)}{d\theta}<0$, we get $\frac{dv(\theta)}{d\theta}>0$.

Accordingly,

$$\frac{d\overline{\pi}}{d\theta}=\frac{du(\theta)}{d\theta}+\frac{dv(\theta)}{d\theta}>0.$$

Therefore, the above analysis shows that $\frac{d\overline{\pi}}{d\theta}>0$.

**A4.2. Exit cutoff**

Given that $\underline{f} = [1 - G(\underline{\varphi})]\frac{1}{\delta}\bar{\pi}$, we have

$\underline{\varphi} = (\frac{1}{\delta \underline{f}}\bar{\pi})^{\frac{1}{k}}$. Therefore, we obtain

$$\frac{d\underline{\varphi}}{d\theta} = \frac{1}{k}\delta^{\frac{-1}{k}} \underline{f}^{\frac{-1}{k}} \bar{\pi}^{\frac{1}{k}-1} \frac{d\bar{\pi}}{d\theta} > 0 .$$

**A4.3. Exporting cutoff**

Note that

$$\begin{aligned} \varphi_E &= \underline{\varphi}\tau[\frac{f_E(\theta)}{f}]^{\frac{1}{\sigma-1}} \\ &= \tau\delta^{-\frac{1}{k}} \underline{f}^{-\frac{1}{k}} f^{-\frac{1}{\sigma-1}} [f_E(\theta)]^{\frac{1}{\sigma-1}} \bar{\pi}^{\frac{1}{k}} \end{aligned} .$$

We obtain

$$\begin{aligned} \frac{d\varphi_E}{d\theta} &= \frac{\partial\varphi_E}{\partial f_E}\frac{df_E}{d\theta} + \frac{\partial\varphi_E}{\partial\bar{\pi}}\frac{d\bar{\pi}}{d\theta} \\ &= \tau\delta^{-\frac{1}{k}} \underline{f}^{-\frac{1}{k}} f^{-\frac{1}{\sigma-1}} \bar{\pi}^{\frac{1}{k}} [f_E(\theta)]^{\frac{1}{\sigma-1}} [\frac{1}{(\sigma-1) f_E}\frac{df_E}{d\theta} + \frac{1}{k\bar{\pi}}\frac{d\bar{\pi}}{d\theta}] \end{aligned} .$$

The first term in the parenthesis is negative while the second term is positive. Therefore, we get

$$\frac{d\varphi_E}{d\theta} < 0 \quad \text{when} \; -\frac{\frac{df_E}{d\theta}}{f_E(\theta)} \Bigg/ \frac{\frac{d\bar{\pi}}{d\theta}}{\bar{\pi}} > \frac{\sigma-1}{k}.$$

This implies that stronger IPRs enforcement reduces the exporting cutoff when the impacts of stronger IPRs enforcement on the reduction in fixed exporting cost dominates the increase in expected profit from entry.

**A4.4. Importing capital-goods cutoff**

Given that $\varphi_M = \underline{\varphi}\frac{1}{(1+\tau^{1-\sigma})^{\frac{1}{\sigma-1}}}[\frac{h(\theta)}{b^{\sigma-1}-1}]^{\frac{1}{\sigma-1}}$, we get

$$\varphi_M = (\delta \underline{f})^{-\frac{1}{k}}[(1+\tau^{1-\sigma})(b^{\sigma-1}-1)]^{-\frac{1}{\sigma-1}}[h(\theta)]^{\frac{1}{\sigma-1}}\bar{\pi}^{-\frac{1}{k}}.$$

Thus, we have

$$\begin{aligned}\frac{d\varphi_M}{d\theta} &= \frac{\partial\varphi_M}{\partial h(\theta)}\frac{dh(\theta)}{d\theta}+\frac{\partial\varphi_M}{\partial\bar{\pi}}\frac{d\bar{\pi}}{d\theta} \\ &= [(\delta \underline{f})^{-\frac{1}{k}}[(1+\tau^{1-\sigma})(b^{\sigma-1}-1)]\bar{\pi}^{-\frac{1}{k}}[h(\theta)]^{\frac{1}{\sigma-1}}[\frac{1}{\sigma-1}\frac{dh(\theta)}{d\theta}+\frac{1}{k\bar{\pi}}\frac{d\bar{\pi}}{d\theta}]\end{aligned}.$$

As $\frac{dh(\theta)}{d\theta}<0$ and $\frac{d\bar{\pi}}{d\theta}>0$, the first term in the parenthesis is negative while the second term is positive. Therefore, we have

$$\frac{d\varphi_M}{d\theta}<0 \text{ when } -\frac{\frac{dh(\theta)}{d\theta}}{h(\theta)}\bigg/\frac{\frac{d\bar{\pi}}{d\theta}}{\bar{\pi}}>\frac{\sigma-1}{k}.$$

This implies that stronger IPRs enforcement decreases the cutoff for importing capital goods when the its impacts on the reduction in the cost of importing capital goods dominates the increase in expected profit from entry.

**A4.5. Process innovation cutoff**

Given that $\varphi_I = \underline{\varphi}\frac{1}{(1+\tau^{1-\sigma})^{\frac{1}{\sigma-1}}}[\frac{\lambda(\theta)-h(\theta)}{a^{\sigma-1}-b^{\sigma-1}}]^{\frac{1}{\sigma-1}}$, we get

$\varphi_I = (\delta \underline{f})^{-\frac{1}{k}}[(1+\tau^{1-\sigma})(a^{\sigma-1}-b^{\sigma-1})]^{-\frac{1}{\sigma-1}}[\lambda(\theta)-h(\theta)]^{\frac{1}{\sigma-1}}\bar{\pi}^{-\frac{1}{k}}$. Hence, we have

$\frac{d\varphi_I}{d\theta} = (\delta \underline{f})^{-\frac{1}{k}}[(1+\tau^{1-\sigma})(a^{\sigma-1}-b^{\sigma-1})]^{-\frac{1}{\sigma-1}}\bar{\pi}^{-\frac{1}{k}}[\lambda(\theta)-h(\theta)]^{\frac{1}{\sigma-1}}[\frac{1}{\sigma-1}\frac{\frac{d\lambda(\theta)}{d\theta}-\frac{dh(\theta)}{d\theta}}{\lambda(\theta)-h(\theta)}+\frac{1}{k\bar{\pi}}\frac{d\bar{\pi}}{d\theta}]$.The first term in the parenthesis in the above expression is negative while the second term is positive. Therefore, we have

$$\frac{d\varphi_I}{d\theta}<0 \text{ when } \frac{-\frac{d[\lambda(\theta)-h(\theta)]}{d\theta}}{[\lambda(\theta)-h(\theta)]}\bigg/\frac{\frac{d\bar{\pi}}{d\theta}}{\bar{\pi}}>\frac{\sigma-1}{k}.$$

The above analysis shows that stronger IPRs enforcement reduces the innovation cutoff when its impacts on the reduction in R&D cost dominates the increase in expected profit from entry.

### Appendix B. Construction of Industry-level and Firm-level Tariffs

To build appropriate controls for trade liberalization, we first construct a measure of industry-level import tariffs, applied to 2000 and 2006, respectively. This variable captures the average impact of tariff cuts on all firms operating in an industry during this period of IPRs reform. We compute the industry-level tariffs as simple average rates, built up from the 8-digit level to the 4-digit CIC codes. Specifically, $\tau_{it} = \sum_{g=1}^{G_i} \tau_{gt} / G_i$ , where $\tau_{gt}$ is the applied MFN tariff rate at the 8-digit HS-level in year *t* and $G_i$ is the number of 8-digit HS products in 4-digit CIC industry *i*. The 8-digit HS-level import tariff rates were downloaded from the WTO website and assigned to CIC industries using a firm-level matching process.[24] Note that these are industry-level computations and do not vary across provinces.

Note that industry-level tariffs may mask large variations in tariff reductions effectively facing different firms within an industry. We can observe, for a subset of exporting firms in our sample, details of the product-level import and export activities recorded by Chinese Customs. For the subset of exporting firms that also import intermediate inputs and capital goods from different countries, we construct measures of firm-specific tariffs suggested by early studies (Fan, et al 2015; Yu 2015). The firm-level tariffs are defined as

---

[24] In addition to the tariff measure using this simple average, we also constructed a weighted-average version, with the weights being the ratios of the imported value of each HS-8 product over the sum of the 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 and that the weights change 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 Table 1.

$\tau_{ft} = \sum_{c,g} v_{fcgt} \tau_{gt} / \sum_{c,g} v_{fcgt}$ , where $\tau_{gt}$ is the applied MFN tariff rate of product g imported by firm f and $v_{fcgt}$ is firm f's import of product g from country c. The simple-average version of the firm-level tariffs can be similarly defined. Since not all of these firms import both intermediates and capital goods, we construct three versions of the value-weighted average tariffs $\tau_{ft}$ : (1) using all imports by firm; (2) using imports of intermediate inputs by firm; and (3) using capital-goods imports by firm. Notice that intermediate inputs and capital goods are identified by the 3-digit product codes under the United Nation's Broad Economic Categories (BEC) classification, and those codes are linked to the HS 8-digit product codes. We exclude firms that import intermediate inputs for processing exports, since processing trade is duty-free.

## Appendix C: Further Empirical Results

**Table C.1: IPRs Protection and Export Volume - Matched Sample**

| | Dependent variable = log(exports) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | (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 rate | 0.662*** | 0.462*** | 0.447*** | 0.756*** | | | | |
| | (0.0458) | (0.0669) | (0.147) | (0.243) | | | | |
| Settled-patent ratio | | | | | -0.709*** | -0.468*** | 25.77 | 81.91 |
| | | | | | (0.107) | (0.152) | (22.13) | (89.15) |
| tariffs – industry | | 0.737** | 1.497*** | 1.450*** | | 0.765* | 1.653*** | 1.655*** |
| | | (0.352) | (0.440) | (0.462) | | (0.383) | (0.448) | (0.452) |
| log(tfp) | | 0.420*** | 0.662*** | 0.666*** | | 0.415*** | 0.656*** | 0.658*** |
| | | (0.0357) | (0.0349) | (0.0346) | | (0.0393) | (0.0350) | (0.0359) |
| Foreign firm dummy | | 0.936*** | 0.931*** | 0.917*** | | 0.960*** | 0.963*** | 0.984*** |
| | | (0.130) | (0.123) | (0.128) | | (0.114) | (0.106) | (0.0998) |
| HK-Macau-Taiwan dummy | | 0.675*** | 0.667*** | 0.624*** | | 0.746*** | 0.731*** | 0.728*** |
| | | (0.0829) | (0.0745) | (0.0774) | | (0.0815) | (0.0572) | (0.0544) |
| log(age) | | 0.0255 | 0.0584 | 0.0579 | | 0.0161 | 0.0556 | 0.0601 |
| | | (0.0591) | (0.0481) | (0.0492) | | (0.0500) | (0.0447) | (0.0441) |
| Constant | 14.45*** | 11.25*** | 9.427*** | 6.348*** | 13.85*** | 10.95*** | 90.04 | 261.0 |
| | (0.167) | (0.208) | (0.449) | (0.736) | (0.459) | (0.410) | (68.25) | (275.6) |
| Observations | 20,641 | 19,514 | 19,514 | 19,463 | 20,830 | 19,692 | 19,692 | 19,617 |
| R-squared | 0.034 | 0.126 | 0.287 | 0.291 | 0.032 | 0.124 | 0.284 | 0.288 |
| Industry fixed effects | no | no | Yes | yes | no | no | yes | yes |

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

**Table C.2: IPRs Protection and Export Volume - Matched Sample with Control for Firm-Level Tariffs**

| | Dependent variable = log(exports) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Variables | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
| IP cases win rate | 0.745* | 0.773* | 0.746* | 0.773* | 0.739* | | | | | |
| | (0.399) | (0.424) | (0.401) | (0.429) | (0.407) | | | | | |
| Settled-patent ratio | | | | | | 161.4 | 176.7 | 163.8 | 199.7 | 189.3 |
| | | | | | | (143.6) | (148.4) | (144.3) | (150.2) | (146.4) |
| tariffs – industry | 0.473 | | 0.316 | | 0.166 | 0.644 | | 0.472 | | 0.356 |
| | (0.715) | | (0.679) | | (0.702) | (0.695) | | (0.660) | | (0.688) |
| tariffs – firm | | 0.638 | 0.619 | | | | 0.745* | 0.720** | | |
| | | (0.390) | (0.364) | | | | (0.365) | (0.336) | | |
| tariffs of intermediates - firm | | | | 0.280 | 0.277 | | | | 0.378 | 0.354 |
| | | | | (0.493) | (0.469) | | | | (0.443) | (0.415) |
| log(tfp) | 0.648*** | 0.657*** | 0.649*** | 0.657*** | 0.649*** | 0.634*** | 0.643*** | 0.635*** | 0.639*** | 0.632*** |
| | (0.0384) | (0.0359) | (0.0383) | (0.0392) | (0.0417) | (0.0375) | (0.0352) | (0.0375) | (0.0385) | (0.0408) |
| Foreign firm dummy | 0.648*** | 0.626*** | 0.649*** | 0.585*** | 0.608*** | 0.735*** | 0.721*** | 0.737*** | 0.675*** | 0.694*** |
| | (0.131) | (0.130) | (0.131) | (0.113) | (0.114) | (0.118) | (0.113) | (0.117) | (0.101) | (0.102) |
| HK-Macau-Taiwan dummy | 0.407*** | 0.406*** | 0.408*** | 0.368*** | 0.370*** | 0.472*** | 0.475*** | 0.474*** | 0.422*** | 0.422*** |
| | (0.0938) | (0.0935) | (0.0941) | (0.0924) | (0.0903) | (0.0781) | (0.0716) | (0.0776) | (0.0720) | (0.0747) |
| log(age) | 0.0397 | 0.0448 | 0.0405 | 0.0389 | 0.0371 | 0.0472 | 0.0514 | 0.0485 | 0.0505 | 0.0487 |
| | (0.0581) | (0.0598) | (0.0579) | (0.0540) | (0.0532) | (0.0559) | (0.0575) | (0.0556) | (0.0527) | (0.0519) |
| Constant | 8.734*** | 8.594*** | 8.546*** | 8.729*** | 8.776*** | 508.5 | 555.8 | 515.7 | 627.0 | 594.8 |
| | (1.126) | (1.391) | (1.185) | (1.422) | (1.224) | (443.3) | (458.1) | (445.5) | (463.7) | (452.0) |
| Observations | 9,662 | 9,939 | 9,662 | 9,134 | 8,891 | 9,709 | 9,987 | 9,709 | 9,177 | 8,933 |
| R-squared | 0.319 | 0.320 | 0.319 | 0.326 | 0.324 | 0.308 | 0.308 | 0.308 | 0.310 | 0.310 |
| Industry fixed effects | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes |

2nd-Stage IV estimates, in parentheses are standard error clustered at the province level. *** p<0.01, ** p<0.05, * p<0.1

## Table C.3: IPRs Protection and Export Volume - Matched Sample (Rich Destinations and Differentiated Products)

| Variables | (1) Log(exports) | (2) Log(exports to rich countries) | (3) Log(exports differentiated goods) | (4) % of exports to rich country | (5) % exports differentiated goods | (6) Log(exports) | (7) Log(exports to rich countries) | (8) Log(exports differentiated goods) | (9) % of exports to rich country | (10) % exports differentiated goods |
|---|---|---|---|---|---|---|---|---|---|---|
| IP cases win rate | 0.756*** | 1.017*** | 0.850** | 0.134** | -0.00418 | | | | | |
| | (0.243) | (0.289) | (0.320) | (0.0497) | (0.0337) | | | | | |
| Settled-patent ratio | | | | | | 81.91 | 99.38 | 115.5 | 21.13 | -7.676 |
| | | | | | | (89.15) | (123.5) | (82.02) | (18.26) | (6.357) |
| tariffs – industry | 1.450*** | 1.031** | 1.088* | -0.176*** | -0.122* | 1.655*** | 1.266*** | 1.286** | -0.145** | -0.136* |
| | (0.462) | (0.422) | (0.595) | (0.0574) | (0.0685) | (0.452) | (0.425) | (0.585) | (0.0573) | (0.0719) |
| log(tfp) | 0.666*** | 0.663*** | 0.548*** | -0.00681*** | -0.0207*** | 0.658*** | 0.653*** | 0.541*** | -0.00819*** | -0.0203*** |
| | (0.0346) | (0.0374) | (0.0417) | (0.00209) | (0.00319) | (0.0359) | (0.0388) | (0.0427) | (0.00180) | (0.00332) |
| Foreign firm dummy | 0.917*** | 1.083*** | 0.559*** | 0.103*** | -0.0348*** | 0.984*** | 1.168*** | 0.640*** | 0.117*** | -0.0404*** |
| | (0.128) | (0.122) | (0.101) | (0.0136) | (0.00774) | (0.0998) | (0.0848) | (0.0787) | (0.0185) | (0.00715) |
| HK-Macau-Taiwan dummy | 0.624*** | 0.751*** | 0.453*** | 0.0853*** | -0.0198 | 0.728*** | 0.890*** | 0.567*** | 0.103*** | -0.0225** |
| | (0.0774) | (0.0745) | (0.0793) | (0.0103) | (0.0117) | (0.0544) | (0.0502) | (0.0559) | (0.0188) | (0.00951) |
| log(age) | 0.0579 | 0.0905* | 0.0569 | 0.00899 | -0.000502 | 0.0601 | 0.0945** | 0.0597 | 0.00962 | -0.000666 |
| | (0.0492) | (0.0462) | (0.0529) | (0.00907) | (0.00415) | (0.0441) | (0.0422) | (0.0456) | (0.0102) | (0.00410) |
| Constant | 6.348*** | 6.118*** | 8.201*** | 0.608*** | 0.427*** | 261.0 | 105.6 | 366.6 | 66.15 | -23.27 |
| | (0.736) | (0.834) | (1.131) | (0.122) | (0.132) | (275.6) | (381.5) | (252.9) | (56.35) | (19.67) |
| Observations | 19,463 | 18,975 | 15,777 | 18,975 | 15,777 | 19,617 | 19,115 | 15,901 | 19,115 | 15,901 |
| R-squared with FE | 0.291 | 0.283 | 0.224 | 0.153 | 0.319 | 0.288 | 0.280 | 0.226 | 0.139 | 0.317 |
| Industry fixed effects | yes | yes | yes | yes | yes | yes | yes | yes | yes | yes |

2nd-Stage IV estimates, in parentheses are standard error clustered at the province level. *** p<0.01, ** p<0.05, * p<0.1