Intellectual Property Rights and International Trade with China

Plasmans, J. E. J.[1,2] and Tan, J.[1*]

[1.] Department of Economics and CESIT, University of Antwerp, Belgium
[2.] Department of Econometrics & Operations Research and CentER, Tilburg University, The Netherlands

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Abstract

The perceived weak protection of intellectual property rights (IPRs) and the strong imitation ability in China are considered as barriers to foreign exports to China. We estimate and compare data of China's bilateral trade with those of the U.S. and Japan using a three-country multiple-good trade model by measuring trade distortions related to patenting activity on the industry level. We compute two empirical versions of this model, one based on short-term monthly aggregate data running from 2000.I to 2003.V (before and after China's entering the World Trade Organization (WTO) in November 2001) and the other based on long-term yearly disaggregated data running from 1991 to 2001. We find that strong patent rights enhance foreign exports to China in high-technology and patent-sensitive industries, while more stringent IPRs protection has a negative impact on low-technology and trademark-sensitive industries under the condition that China does have strong ability of imitation. This suggests that different IPRs enforcement policies should be considered in patent-sensitive industry and trademark-sensitive industry.

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[*] Corresponding author: Department of Economics, University of Antwerp, Prinsstraat 13, B-2000 Antwerp, Belgium; *Email*: Jiahua.Tan@ua.ac.be, *Tel*: +32-(0)-3 220-4639, *Fax*: +32-(0)-3 220-4585.

I.   Introduction

Before and after China's entering the World Trade Organization (WTO) in 2001, there has been a heated dispute over the Chinese weak protection of foreign intellectual property, which is included in the WTO agreement through the Trade-Related Intellectual Property Rights (TRIPs) agreement. The perceived weak patent rights and the strong imitation ability in China are considered as barriers to foreign exports, technology transfers and foreign direct investment to China. While most complaints on less efficient enforcement are raised by foreign multinational firms, the conflicts are solved through negotiations with the Minister of Foreign Trade in a government-to-government setting. Undoubtedly, the development of a Chinese legal framework to protect intellectual property rights (IPRs) has been in line with its increasing trading volume with industrial nations. The evolution process of the Chinese IPRs legislation and enforcement policy clearly suggests that the IPRs are trade-related.

To explain how the IPRs are trade-related, several theoretical and descriptive works shed light on IPRs regimes in international economic theory. As strong IPRs protection grants exclusive rights of exploiting the inventions to IPRs holders, this can be seen as a firm-specific asset, which enhances the monopoly power in the market. In order to compensate the expenditure on innovation, IPRs holders have the incentive to broaden the market overseas through exports, licensing and/or direct investment.[1] Therefore, given the characteristics of IPRs, as Maskus and Penubarti (1995) noted, we may consider the strength of IPRs as an additional factor in the relationship between trade and growth.[2] In line with the conceptual thoughts, a few attempts have been made to find empirical evidence of the relationship between IPRs protection and commercial transactions. Maskus and Penubarti (1995) provide the first systematic results on the positive link between patent laws and international trade at industry level, especially in small and large developing economies. Smith (1999) measures the distortion of the U.S. exports related to the IPRs protection level and she finds that weak patent rights are barriers to U.S. exports.

We aim to provide a first look into the relationship between IPRs protection and trade flows using a panel data model from the importing country's perspective. Considering China's recent rapid development in the IPRs protection and the increasing imports of technology-embodied goods, it is interesting to look into the structural change of the IPRs system and its influences on trade flows. Our paper examines the volume and structure in Chinese imports taking the IPRs protection and the ability of imitation into account. We estimate and compare China's bilateral trade data with those of the U.S. and Japan using a three-country multiple-good trade model by measuring the trade distortions related to patenting activity at the ISIC two-digit industry level. Furthermore, we define patent-sensitive industries and trademark-sensitive industries as high- and low-technology industries, respectively. We consider two sample periods for empirical analysis, a short one from 2000 to 2003, covering China's WTO transitional stage, and a relatively-long one from 1991 to 2001.

It is worth mentioning that China joined major international IPRs conventions by the end of 1994 and has set up the legislative framework of IPRs during the early 1990s. However, it is also well-known that *de jure* protection makes a huge difference from *de facto* protection. The perceived weak IPRs protection in China is mainly about the insufficient enactment of IPRs laws rather than about the lack of IPRs laws on paper. In response to this argument, we try to conduct a new proxy for IPRs protection instead of using the Rapp and Rozek (1990) index or the Park and Ginarte (1996) index, which both

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[1] Within the framework of Dunning's (1979) model of OLI (ownership, location, internationalization), there is an extensive literature on IPR holders' entry mode choices of overseas' markets. See Ethier (1986), Horstmann and Markusen (1987) and Ferrantino (1991, 1993).

[2] See Grossman and Helpman (1991) and Helpman (1993).

measure the protection level written only "on the books".[3] The estimated panel data models should help to understand the dynamic picture of the growing trade with the top-two trading partners together with China's efforts in strengthening its IPRs protection system and the growing number of foreign patent applications.

In the following section we start with a review of China's efforts in IPRs legislation and enforcement in the past years and of related theoretical foundations about IPRs and trade flows. Section III presents the modeling framework, while data analysis and descriptions are discussed in Section IV and econometric estimations are presented in Section V. We provide concluding remarks and suggest further studies in the final section.

II.   Review of IPRs in China and the Economics of IPRs

In November 2001, China became a WTO member to fully implement the TRIPs agreement. It was nearly 15 years after China's first application to join the General Agreement on Tariffs and Trade (GATT, the predecessor of WTO), 50 years after the establishment of intellectual property institutions introduced from the USSR, just 20 years after the enactment of modern IPRs laws and systematic management guidelines and only about 7 years after China virtually joined all major international IPRs conventions.[4]

On the one hand, as a developing country with perceived weak protection on IPRs, China has been faced with considerable pressure mounted by the developed countries to upgrade its IPRs-related laws and, more importantly, to strengthen the enforcement during the past decade. An effective IPRs regime is also of strong interest to China as it also protects domestic firms which start to shift to knowledge-based activities associated with their initial labor-intensive production stages. As pointed out by Naughton (1999) with the example of the overwhelming success of the Video CD (VCD) industry in China, higher levels of protection to innovators help position domestic firms to play a pioneering role in manufacturing industries. Therefore, sufficient efforts have been made in the following major aspects:

1) Law framework: improving its legislation to allow for copyright and trademark laws more closely resembling TRIPs, revising patent laws to make it both easier to undergo patent examination and receive protection, setting up specialized IPRs courts to settle IPRs-related cases.
2) Database network: making the electronic version of patent applications dated from 1985 onwards publicly available, providing professional consultancy services and training programs to interested parties.
3) Enforcement action: setting up the State Intellectual Property Office (SIPO) to monitor and enforce IPRs issues, requiring all public entities to only use legitimate software, launching national campaigns against counterfeited products, conducting anti-piracy operations at major customs authorities.[5]

The major gaps and shortfalls in IPRs legislation have been filled in and the importance of protecting exclusive rights on patents, trademarks and copyrights has been reiterated by the government. As the

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[3] Both indices are based on the degree of national compliance with U.S. guidelines for PRs standards proposed by the U.S. Chamber of Commerce (1987).

[4] The major international conventions are the World Intellectual Property Organization in 1980, the Paris Convention on patents in 1984, the Madrid Protocol and the Washington Convention in 1989, the Bern Convention on copyrights and the Universal Copyright Convention in 1992, the Geneva Phonograms Convention in 1993, and the Patent Cooperation Treaty in 1994. See also La Croix and Konan (2001).

[5] See Sparkman (2001).

legal framework is the fundamental basis of an efficient IPRs protection, the extensive progress in structural and institutional changes in the IPRs system has smoothed the tense situation in executing TRIPs standards.

On the other hand, as a net importer of intellectual property and IPRs-intensive goods, China has also incentives to resist the changes in response to foreign pressures. This may explain why changes in China's IPRs record have been the sticking point in most bilateral trade negotiations with China. The limitations to IPRs protection in China exist in the following aspects:

1) Lack of IPRs protection awareness: some infringers do not have enough legal knowledge to realize their violations to the protected IPRs holders, or right holders do not know how to protect their rights.
2) Reluctances and difficulties in law enforcement: soft punishment in the form of penalty is too light to deter offenders, some productions of pirated or counterfeited goods are fostered by "local protectionism", the strict law enforcement in cracking down on piracy may trigger counterfeiters' shift to "offshore" (e.g., pirated VCDs were smuggled from Macau into China beginning from1997 onwards[6]).
3) Discrepancy between national laws and provincial laws: diversified interpretations on the same terms are made to meet local self-interests, different guideline ranges on sentencing are applied among local courts.[7]

Cohen (1997) asserted that IPRs are a "bellwether of China's adjustment to the West". This adjustment process becomes more complicated while China's cultural tradition itself seemed to be at odds with providing protection to IPRs, because imitation works of master pieces are regarded as showing respect to the original and an art form in its own.[8] This cultural difference in understanding IPRs has been one of the main obstacles to overcome in improving the public's awareness on IPRs protection.

Due to China's rapid improvement in setting up more stringent laws, the tension over IPRs issues have been cooled down. Nevertheless, the complaints on inefficient enforcement keep mounting up. Most of the conflicts are resolved through trade negotiations on the government-to-government level, e.g. Ministry of Foreign Trade and United States Trade Representative (USTR). Looking back into history, modern Chinese IPRs laws and enforcement have been evolving with the development of its trade activity, especially in patent-sensitive industries. Hence, it is clear that IPRs are trade-related in practice. And the implicit trade policy assumption is that the development level of IPRs-related legislation and its enforcement have influences on international trade flows. However, the questions how and to what extent IPRs influence the trade volume remain puzzling.

As the idea of free trade has been widely accepted and continuous efforts are made to harmonize the tariff rates, the share of knowledge-intensive or high-technology products in total world trade has doubled between 1980 and 1994 from 12% to 24%.[9] The importing country has benefited from trading advanced technology-embodied goods through 'learning-by-doing' to catch up with the technology development. Meanwhile, the returns to innovation nourish the further growth. With the fact that IPRs do play a vital role in international trade, the relationship between them seems clear in practice but poorly explained in the theoretical literature. The first issue of interest is how IPRs are linked to trade flows. It is a conventional rationale that IPRs affect economic growth directly by fostering the

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[6] See Zhongguo Dianzi Bao (China Electronic News), March 15, 2000.
[7] Judicial interpretation on IPR cases is under process by the Supreme People's Court and the Supreme People's Procuratorate. It is expected to enact in 2004. See Legal Daily, April 28, 2004.
[8] See Cohen (1997) and Yatsko (2000).
[9] Estimates from Fink and Primo Braga (2000) are based on trade data from the UN Comtrade database.

innovation activity. In a setting of intensively-competitive international markets, IPRs holders may broaden the market to compensate their innovation costs under the condition that their innovations are also under protection abroad. The theoretical studies of IPRs and trade suggest the indeterminate effects of strengthening IPRs protection. From the IPRs-exporting country's viewpoint, the literature concludes that the export volume is simultaneously increased through "market expansion" and decreased through "market power" (see Maskus and Penubarti (1998), pp. 229-230). Market expansion augments the export volume because the technology embodied in imported goods is more difficult to be imitated by local producers under stronger IPRs protection. Meanwhile, monopoly power allows IPRs owners to set monopoly prices for the duration of the intellectual property right (on the average between 10 and 20 years); so, the market power distorts the trade in opposite direction. From the IPRs-importing country's angle, stricter IPRs protection not only makes the acquisition of advanced technology more costly but also restrains the ability of "invention-around-patent" R&D, which may discourage the less developed countries to import from developed countries. Conversely, stronger protection over IPRs induces richer varieties of goods imported to favor domestic needs because it stimulates international innovation to adapt their products to the consumer tastes of the importing country and technological constraints which are often different from those of the exporting country. Setting stricter IPRs-protection levels has more complex influences, interacting with tariff rates and binding quota on the trade volume in the global environment.

To explain the short-run cost and long-run benefits of strengthening IPRs protection, we may refer to the stylized endogenous growth model introduced by Grossman and Helpman (1991). A relaxation of the patent protection laws encourages imitation by reducing the cost to invent around existing patents. Less developed countries are in favor of this in order to accumulate the local knowledge stock. Thus, through this imitating behavior weak IPRs protection in less-developed countries stimulates innovation-around-the-patents and reduces the imports flow from highly-developed countries in the long-run. In contrast, while considering the ongoing process of innovation in Grossman & Helpman's model with a rising product quality, the effects of imitation ability on the growth rate of innovation depend on the efficiency of "catching-up". As a result, the consequences become unclear.

Compared with the growing number of the related literature on IPRs in law, there are a limited number of empirical analyses addressing solely the relationship between IPRs and trade. Ferrantino (1993) provides the first look into the export patterns in relation to national membership in the IPRs treaties by using aggregate U.S. data and finds a weak link. Maskus and Penubarti (1995) made the first attempt in empirical research to measure IPRs along with bilateral trade on industry level. Their most-cited finding is that there is a strong positive correlation (i.e. market expansion effect) between manufacturing exports of OECD countries and the strength of patent rights in large and small developing countries. This has been further proved by Smith (1999) in her paper to explain how and to what extent U.S. exports are sensitive to national differences in patent rights by applying a similar methodology. These three papers offer the needed empirical evidence to support the claim that weak patent rights are a barrier to manufacturing exports to the countries that pose a strong threat of imitation. In the light of this finding, it is of great importance to harmonize IPRs protection standards among countries, mainly to upgrade the protection levels in less developed countries posing strong imitation ability (e.g., China). The empirical findings from cross-sectional data offer the first insight into the static distortion of IPRs protection on the export pattern of the net IPRs exporters (developed countries). Nevertheless, the dynamic influences of IPRs on the importing country's trade flows are rarely explored in empirical studies, due to the difficulty in retrieving a comparable and reliable database for developing countries.

III. The model

As discussed in the previous section, the influences of IPRs protection are well defined but not yet fully understood from theoretical models. The ambiguity arises when we take the efficiency of imitation activity, the existing gap of technology-development levels between trading partners, and trading factors such as import tariffs and export subsidies into account.[10] Besides, both local and foreign firms may take diversified IPRs strategies in different industry sectors while there are other forms to transfer innovations. In short, there is no clear picture given in a specific theoretical model to answer the questions how strong and to which direction IPRs protection affects the trade flows. Hence, our empirical research interest arises to explore the actual trade flows and the patent regime. Considering a direct approach to measure the influences of IPRs on trade flows implies to take account of variables such as foreign firms' marginal export costs and costs to prevent or trace down imitation. This seems infeasible, as most of the factors are not reported from available data and/or involved a substantial amount of work to tackle the issue of endogeneity. As a result, we intend to estimate the distortion of importing flows caused by different levels of IPRs protection within a more general framework.

As discussed by Maskus and Penubarti (1995), the empirical model should be developed from a general-equilibrium trade theory point of view instead of summing up the variables of interest in an *ad hoc* approach. We start with the Helpman and Krugman (1985) bilateral gross imports equations (from now onwards the HK model). The model estimates the volume of imports in terms of the exporting country's output level. This monopolistic competition model has been widely utilized to examine intra-industry trade flows with increasing returns of scale in the studies on trade structure. The appealing feature of this model is its straightforwardness to predict the trade flows in the absence of any trade-related barriers.[11] Although the alternative gravity approach suggested by Maskus and Penubarti (1995) shares similarities with the HK model, the basic idea to explain trade flows by baseline variables (country size, geographical distance and income levels of trading countries) overlooks the time variations since the population size and geographical distances barely change over time. In contrast, the HK model offers the possibility to add time-varying effects. Consequently, we may write the time series version of the HK model as,

$$m_{ijkt} = \eta_{jt} y_{ikt},$$ (3.1)

where at given time t, m_{ijkt} represents imports of good (industry) i by country j from exporting country k, η_{jt} is country j's share of total world expenditure, and y_{ikt} is country k's output of good (industry) i.

Given disaggregated data on imports and industry output, we observe the issue of endogeneity of these two variables on industry level. Therefore, as suggested by Péridy (2004), we first construct the production model in translog form as a flexible second-order approximation to any concave and at least twice-differentiable production function to estimate the output y_{ikt} by the exogenously-assumed variables labor (L), capital (K), intermediate inputs (INT) and technical change measured by the time index as follows,

$$\ln Y_{ikt} = \omega_0 + \omega_1 t + \omega_2 \ln L_{ikt} + \omega_3 \ln K_{ikt} + \omega_4 \ln INT_{ikt} + \omega_5 \ln L_{ikt} \ln K_{ikt} + \omega_6 \ln L_{ikt} \ln INT_{ikt} + \omega_7 \ln K_{ikt} \ln INT_{ikt}$$
$$+ \frac{1}{2} \omega_8 (\ln L_{ikt})^2 + \frac{1}{2} \omega_9 (\ln K_{ikt})^2 + \frac{1}{2} \omega_{10} (\ln INT_{ikt})^2 + \frac{1}{2} \omega_{11} t^2 + \omega_{12} t \ln L_{ikt} + \omega_{13} t \ln K_{ikt} + \omega_{14} t \ln INT_{ikt} + \varepsilon_{ikt}$$ (3.2)

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[10] See Grossman and Helpman (1991, Chapter 12), in a quality-ladder growth model.
[11] See also Maskus and Penubarti (1995) and Smith (1999) for discussions on empirical modeling.

so that under competitive markets for outputs and the three inputs the necessary conditions for the producer equilibrium are given by the equalities between the cost share of each input and the elasticity of output with respect to that input, i.e. the cost-minimizing factor-cost shares satisfy:

$$S_{L_{ikt}} \equiv \frac{w_{ikt}L_{ikt}}{p_{ikt}Y_{ikt}} = \frac{\partial \ln Y_{ikt}}{\partial \ln L_{ikt}} = \omega_2 + \omega_5 \ln K_{ikt} + \omega_6 \ln INT_{ikt} + \omega_8 \ln L_{ikt} + \omega_{12}t$$

$$S_{K_{ikt}} \equiv \frac{r_{ikt}K_{ikt}}{p_{ikt}Y_{ikt}} = \frac{\partial \ln Y_{ikt}}{\partial \ln K_{ikt}} = \omega_3 + \omega_5 \ln L_{ikt} + \omega_7 \ln INT_{ikt} + \omega_9 \ln K_{ikt} + \omega_{13}t \qquad (3.3)$$

$$S_{INT_{ikt}} \equiv \frac{q_{ikt}INT_{ikt}}{p_{ikt}Y_{ikt}} = \frac{\partial \ln Y_{ikt}}{\partial \ln INT_{ikt}} = \omega_4 + \omega_6 \ln L_{ikt} + \omega_7 \ln K_{ikt} + \omega_{10} \ln INT_{ikt} + \omega_{14}t$$

where w_{ikt} is the unit price of labor (unit wages), r_{ikt} is the unit price of capital (unit capital cost), q_{ikt} is the unit price of intermediate inputs and p_{ikt} is the unit price of output for industry i, exporting country k at time t. The *rate of technical change* is defined as the rate of growth of the quantity of output holding all inputs constant, i.e.

$$S_t \equiv \frac{\partial \ln Y_{ikt}}{\partial t} = \omega_1 + \omega_{11} + \omega_{12} \ln L_{ikt} + \omega_{13} \ln K_{ikt} + \omega_{14} \ln INT_{ikt} \qquad (3.4)$$

The cost-minimizing factor shares should add-up to unity, i.e.:[12]

$$\omega_2 + \omega_3 + \omega_4 = 1 \quad . \qquad (3.5)$$

This adding-up restriction involves zero adding-up restrictions on the other parameters and on the stochastic error terms, that may be superimposed to the individual equations in (3.3-4). Hence, the corresponding disturbance covariance matrix will be singular. The most common procedure for handling this singularity problem is to drop an arbitrary equation, say for the cost share for intermediate inputs, and then estimate the remaining 2 share equations.

It is worth mentioning that labor and capital are more likely to vary over a longer-time period as e.g. on a yearly or quarterly basis rather than on a monthly basis. So, we use this production-function based method to estimate industry outputs for the U.S. and Japan with data available on a yearly basis.

We continue to expand model (3.1) to incorporate other explanatory variables. First, we take the amount of retail sales in China into account as a proxy to domestic demand, which is an exogenous variable to affect the industry imports (so that we can get rid of possible endogeneity also in this manner). Secondly, the ratio of total imports of the importing country divided by total exports of the exporting country is computed to serve as a proxy to the importing country's "openness" relative to its trading partner. In addition, we construct a dummy variable to identify China's WTO status. On China's accession to WTO, the significant tariff cuts and reforms in the administration system have

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[12] An alternative exposition could be in cost functions. In many cases, it is, however, impossible to derive dual cost functions analytically, particularly when the production function becomes mathematically complex. It is even so that the dual cost function of a primal flexible functional form as the transcendental logarithmic (translog) production function has in general not a translog form because of the general second-order approximation (see e.g. Berndt (1991), p. 69, for a simple primal Cobb-Douglas production function (3.10) (first-order approximation to the above (3.6) expression) leading to the dual cost function (3.14-15) with different parameters (so that analytical derivations of dual cost functions from the primal Cobb-Douglas and CES production functions are possible) - see also Berndt (1991) pp. 457-458 and pp. 469-476.
Using highly aggregated economy-wide data (and not firm-level data) Berndt (1991), p. 455, asserts that "it might be more appropriate to assume that prices (rather than quantities) are endogenous and that quantities (rather than prices) are exogenous".

been compiled to meet WTO agreement since late 2001. And this dummy variable should reflect any structural change shock on the bilateral trade flows with China. Last but not least, we introduce a rather primitive proxy to represent the strength of IPRs protection in China and the ability of imitation.

As mentioned in the previous section, the protection level of IPRs in China is recognized as weak, not completely in terms of legislation but mostly in the law enforcement. This implies that China would score considerably high by counting the number of signed international conventions, while the actual enforcement situation remains ineffective for the IPRs holders. There are two widely used proxies for IPRs protection in empirical studies. One is the index of patent-law strength developed by Rapp and Rozek (1990). It is based on surveys of business and government officials and an examination of patent laws by comparing them with the minimum standards put forward by the U.S. Chamber of Commerce Intellectual Property Task Force (1987). The other one is the index constructed by Ginarte and Park (1998) by using a scoring method with similar criteria. So both are based on the degree of national compliance with the U.S. guidelines in the 1980s and remain fairly constant.[13] The potential drawback of both indices is their major focus on the written protection level rather than the actual enacted level. As for the proxy to imitation ability, Smith (1999) suggested the *educational attainment index* published in the Human Development Report by the United Nations. It is a rather general measure because it is constructed from data on adult literacy rates and educational enrollments. Alternatively, the number of patent applications is considered to construct an admittedly primitive proxy to the strength of IPRs protection and the ability of imitation in China. First, as foreign IPRs holders would be reluctant to process patent applications in China if they are not satisfied with the current status of the local IPRs law enforcement, we may expect that the number of foreign patent applications (*FP*) is positively influenced by the trust of IPRs holders in China's IPRs protection. Second, the number of patent applications made by Chinese individuals and domestic firms (*DP*) indicates the innovation capacity in China. It is reasonable to believe that the more active Chinese innovators are in technology development, the stronger imitation ability they possess to replicate foreign technology. The combined force of these two factors can be explained in the following manner.

Figure 1. Explanation of threat of imitation and its impact on trade flows[14]

FP ⟍ DP	High DP (Strong Imitation Ability)	Low DP (Weak Imitation Ability)
High FP (Strong IPRs Protection)	undetermined effect (+/-)	weak threat (+)
Low FP (Weak IPRs Protection)	strong threat (-)	undetermined effect (+/-)

where the sign of (+/-) denotes the expected influences of the combined force on the importing trade flows from the exporting country. We can only determine that a country poses strong imitation threat if it has strong imitation ability and its IPRs protection level is low, while the combination of weak imitation ability and strong IPRs protection is considered a weak threat to foreign exporting firms. If we construct the ratio (*PI*) of *FP* to *DP* for each manufacturing industry, we have

$$PI_{ijkt} = \frac{FP_{ikt}}{DP_{ijt}}$$
(3.6)

Based on the explanation given in Figure 1, intuitively, a smaller value of PI ratio suggests a relatively strong imitation threat while a higher value implies the opposite. In order to examine the impact of this *PI* ratio more specifically, we include interaction terms *ln(PI)DTech* between this ratio and the dummy variable for technology classification. So, the estimated coefficient of *ln(PI)* alone explains the elasticity change of the *PI* ratio in low-technology industries. The sum of estimated coefficients of both *ln(PI)* and *ln(PI)DTech* interprets the change of the *PI* ratio in high-technology industries.

Combining all the remarks mentioned above, we arrive at the empirical version of the HK model (3.1) including the variables listed above as follows,

$$\ln(m_{ijkt}) = \alpha_{ijk} + \beta_k \ln(MO_{kt}) + \gamma_j \ln(RS_{jt}) + \lambda_{jk} \ln(IE_{jkt}) + \theta_{ijk} \ln(PI_{ijkt}) + \tau_{ijk} \ln(PI_{ijkt})DTech_i + \psi_{ij}DWTO_j + \mu_{ijkt} \quad (3.7)$$

$$\ln(m_{ijkt}) = \alpha_{ijk} + \beta_{ik} \ln(MO_{ikt}^*) + \gamma_j \ln(RS_{jt}) + \lambda_{ijk} \ln(IE_{ijkt}) + \theta_{ijk} \ln(PI_{ijkt}) + v_{ijkt} \quad (3.8)$$

Equation (3.7) is the empirical model to estimate the short-term effects of IPRs on trade flows from 2000 to 2003 on a monthly basis and equation (3.8) is used to test the long-term influences of IPRs from 1991 to 2001 on a yearly basis. In equation (3.7) MO_{kt} is the manufacturing output of the exporting country, RS_{jt} is the amount of retail sales of the importing country, IE_{jkt} is the ratio of total imports of the importing country divided by total exports of the exporting country, PI_{ijkt} is the ratio of foreign patent applications to domestic patent applications, $DWTO_j$ is the step dummy variable to identify the status whether China entered WTO which is given a value 1 from November 2001 onwards and $DTech_i$ is the dummy variable for technology classification to assign a value 1 to patent-sensitive industries and 0 to trademark-sensitive industries. And in equation (3.8), MO_{ikt}^* is the estimated industrial production of exporting country k computed from production function (3.2).

IV. Data descriptions

We estimate equation (3.7) with the U.S. and Japan datasets, respectively, covering the time period from January 2000 to May 2003. The observed variables are the bilateral trade volumes of the U.S. and Japan with China, manufacturing outputs of the U.S. and Japan, the amount of retail sales of China, the ratio of total imports of China divided by total exports of the U.S./Japan, the number of patent applications of the U.S., Japan and of domestic patent applications in China.[15] We take manufacturing production on the aggregate level as an alternative proxy for the industrial output, because it is reasonable to consider the business cycle effect to influence the general output level of the exporting country when we examine the bilateral trade flows between a specific pair of countries during the last 4 years. Additionally, the endogeneity of imports and output on industry level should be significantly weakened by introducing the output on aggregate level, which still accounts for the conceptual idea to explain imports as proportional to the exporting country's industrial output and also the business cycle effects in general. Manufacturing output, retail sales and total exports and imports data are on aggregate level, while the other variables are either retrieved or grouped on industry level. We estimate equation (3.8) with the U.S. dataset from 1991 to 2001 on a yearly basis. The observed variables are the bilateral trade flows of the U.S. with China, the ratio of sectoral imports of China divided by sectoral exports of the U.S., the retail sales of China. The industrial output is estimated from production function (3.2) by

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[15] For data consistency, we retrieve data for China Mainland, which means that Hong Kong SAR, Macao SAR and Taiwan are not included in our analysis.

including the total number of employees, gross capital stock and intermediate inputs in each industry as observed variables.[16]

All the aggregate data used in equation (3.7), including manufacturing outputs of the U.S. and Japan, retail sales of China, total imports of China and total exports of the U.S. and Japan, are taken as seasonally adjusted from the OECD Statistical Compendium database on a monthly level. Doing so provides us with the aggregate variables corrected for seasonal effects. The bilateral trade flows between the U.S. and China from 1991 to 2001 are taken from International Trade by Commodity Statistics (ITCS), OECD Statistics. The statistical source of the total number of employees, the gross capital stock and the intermediate inputs of the U.S. is the OECD Statistical Compendium. All the values expressed in local currencies are converted into current U.S. dollars at the exchange rates computed by the OECD Statistics Directorate. Due to the availability of monthly data, we retrieve China's imports volume from the U.S. and Japan trade statistics in the form of their exports to China. The U.S. exports to China are reported in thousands of current U.S. dollars by the Foreign Trade Division in the U.S. Bureau of the Census, and are detailed at the 3-digit SITC (Standard International Trade Classification) level and the Japanese exports to China are initially constructed in thousands of Japanese Yen by Japanese statistics on foreign trade at complete HS (Harmonized System) code. Both trading volumes on commodity codes are aggregated to industry sector at the two-digit ISIC (the International Standard Industrial Classification) level by using the correspondence tables provided by the EUROSTAT classification server.[17]

The data of patent applications of the U.S., Japan and China are retrieved from the China Patent Office (CPO). We sum up the total number of monthly patent applications submitted during January 2000 to May 2003 with the U.S., Japan and China as the assignee country in each International Patent Classification (IPC) code.[18] Our research interest in patents lies in the number counted by industry sector, while the IPC system categorizes inventions by product or process. This makes patent data of very limited use together with other variables. There have been many efforts made to deliver an accurate concordance table between the patent classification IPC code and the industrial classification code ISIC. The one released in 1994 and named after its institution MERIT (Maastricht Economic Research Institute on Innovation and Technology) contains 22 different aggregate manufacturing sectors defined by ISIC Rev. 2. Inasmuch as it is simple to apply with pooled patent data, it has been widely used to group patent counts. Also because of its simplicity, the MERIT table could not distinguish the difference of likelihood between assigning a specific patent to the corresponding industry of manufacture (IOM) or the sector of use (SOU). The OECD concordance table made by Johnson (2003) is a recent contribution to group patents into industry sectors according to ISIC Rev. 3 within the OECD patent project framework in 2003. The table computes the probability that a patent with a specific IPC has a particular IOM-SOU combination. In so doing, it maps the patent product or process categories into the economic sectors responsible for their creation and subsequent use. In particular, we recalculate the likelihood of a specific patent in IOM since it is the sector that executes innovation and files the patent applications.[19] We multiply the number of patent applications in each IPC class with the likelihood in one specific industry sector to compute the patent counts in corresponding industry.

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[16] Intermediate inputs are calculated by taking the difference between production and value added.

[17] See EUROSTAT RAMON classification server (http://europa.eu.int/comm/eurostat/ramon/).

[18] Most patent applications from Chinese individuals and domestic firms have the provincial address as assignee country rather than "China". As a result, we first retrieve the raw data for all coded provinces and cities, excluding Hong Kong, Macau and Taiwan applications.

[19] We are indebted to Wim Depreter for providing the OECD concordance table and software.

To provide a general picture of bilateral trade flows and the patent applications, we present China's manufacturing imports from the U.S. and Japan together with their patent applications in the CPO.

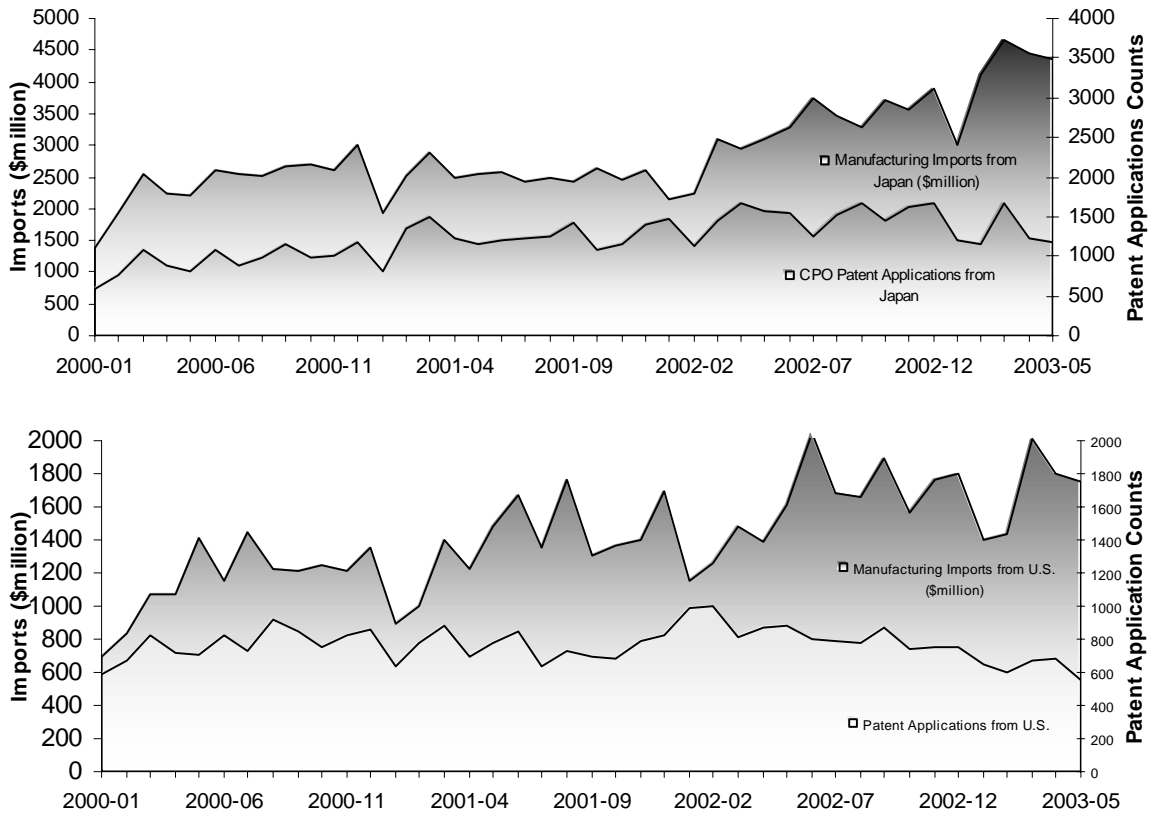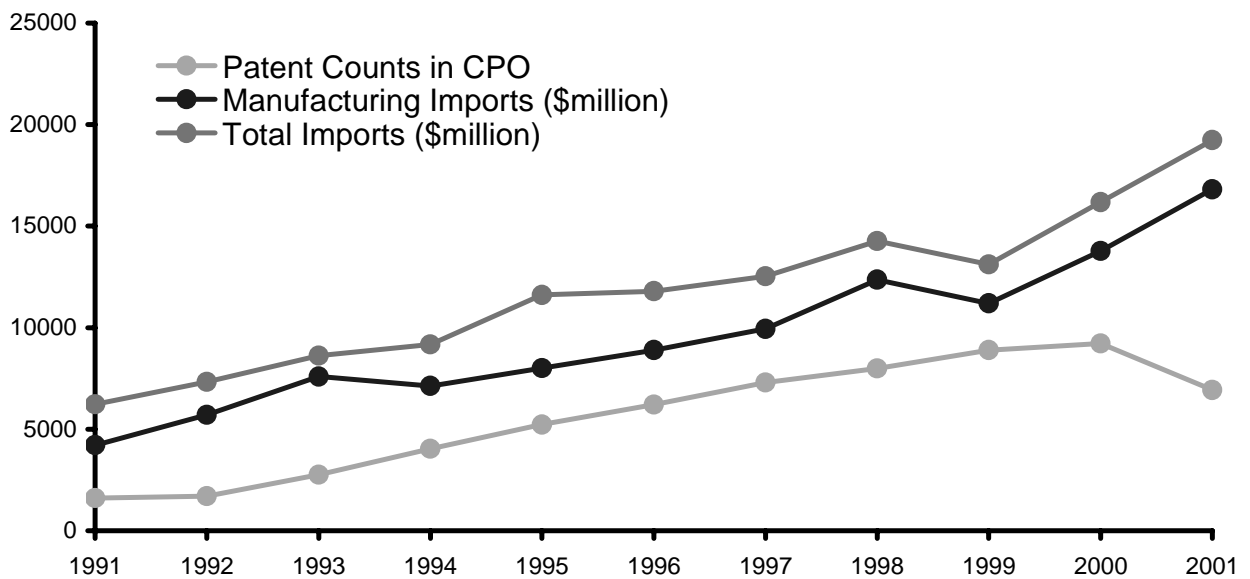*Chart 1. Manufacturing Imports and CPO Patent Applications Counts from the U.S. and Japan*

Chart 2. Imports from the U.S. and the Patent counts of the U.S. in CPO 1991-2001


As is clear from Chart 1, the number of foreign patent applications and the manufacturing imports share similar variation patterns both for the U.S. and Japan. Especially from early 2000 to late 2001, we see simultaneous increase and decrease co-movements between patenting and trading activities, which

imply the patent applications are trade-linked. While in the longer term as shown in Chart 2, the number of patent counts of the U.S. also increases along with the manufacturing and total imports from the U.S. until 2001.

As we discussed before, the *PI* ratio is designed to interpret the compound influences of imitation ability and patent protection levels. It is of great interest to see whether it varies cross industry lines and the pattern of its variation. Here we report the average *PI* ratio's of 22 manufacturing industries defined on ISIC 2-digit level of the U.S. and Japan.

Chart 3. PI Ratio's of the U.S. and Japan in the Manufacturing Industries
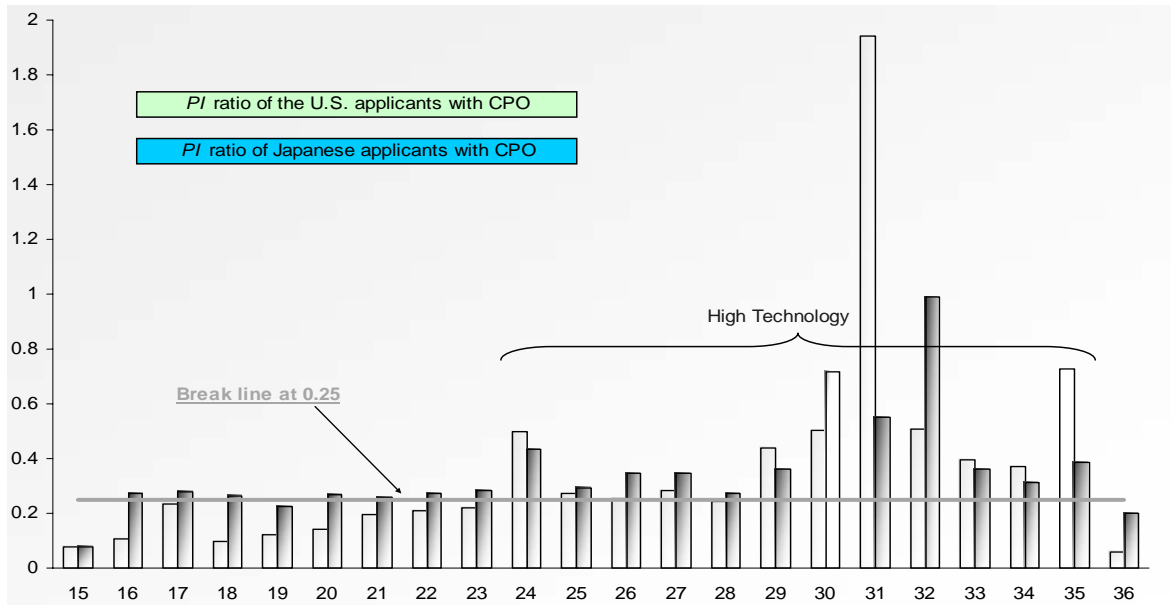
There are several interesting findings worth mentioning. First, the *PI* ratios between the U.S. and Japan are close to each other in most industry lines. The major difference between these two countries occurs where Japan exceeds the U.S. in basic metals, office machinery and communication equipment and the U.S. is more active in chemical products, electrical machinery and transport equipment (excluding motor vehicles and trailers). Secondly, there are two *PI* ratios in ISIC 31 (Manufacture of electrical machinery) and ISIC 32 (Manufacture of radio, television and communication equipment) more than one, which simply means foreign patent applications exceeding domestic applications. Thirdly, according to the statistics report from the Intellectual Property Office of China, the yearly domestic patent applications reach around 80% of total applications. As a result, the average *PI* ratio among all foreign countries and all industries is about 0.25. We draw a break line at 0.25 to divide manufacturing industries into two groups. A country's *PI* ratio in a particular industry going beyond this break line point should be considered a relatively high value. We notice the *PI* ratios of the U.S. and Japan in most industry lines are above average level. The *PI* ratio does not necessarily reflect the actual level of innovation development in the U.S. and Japan, but the innovations of these countries which are commercialized in China. Since the IPRs protection policy is indiscriminative among countries, Japan is in general more active in patenting wtih CPO than the U.S. If we pay attention to the industries where the *PI* ratios of both foreign countries are relatively high, the list of 12 manufacturing industries (from ISIC 24 to ISIC 35) coincides with the OECD Science, Technology and Industry Scoreboard released in 2003.[20] These 12 industries above the 0.25 threshold line are all considered as belonging to either a

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[20] See Appendix *I* for the complete classification list of classification of manufacturing industries.

high-technology or a medium-technology class, while most of the other industries situate in a low-technology class. The industries in the low-technology class, such as food products and textiles, are mainly trademark-sensitive industries. We may expect industries in high- and medium-technology classes are more patent-sensitive. It also suggests that at present China is still at the stage of catching up the technology development in patent-sensitive industries and the foreign patent holders are more active in these industries because the enforcement of IPRs protection in these industries may be regarded relatively more efficient. Furthermore, this finding also supports the rationale of our introduction of the technology dummy variable interacting with the *PI* ratio in the empirical model.

V.   Estimation results

We estimate the empirical model specified as equation (3.7) with the U.S. and Japan panel data, respectively.[21] We have run the model with both the fixed and random effects estimation methods. Because the Hausman (1978) specification test rejects the null hypothesis of no correlation between the independent variables and the latent individual effects for both countries' estimations, it is reasonable to believe that the fixed effects estimation is the more appropriate estimation technique.[22] As a result, here we focus on the fixed effects results and the comparisons between the U.S. and Japan. The estimation results are presented in Table 1[23]:

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[21] Due to multicollinearity between foreign and domestic patent applications, we also estimate the model of fixed effects with foreign patent applications and domestic patent applications separately. Neither of the variables is significant in the U.S. or Japan estimation. This leads us to construct an alternative proxy for threat of imitation.

[22] Hausman (1978) shows that under the null hypothesis of no correlations (incompatibility) the test statistic:

$m = (\hat{\beta}_{aFE} - \hat{\beta}_{sRE})'(M_1 - M_0)^{-1}(\hat{\beta}_{sFE} - \hat{\beta}_{sRE})$ is asymptotically distributed as $\chi^2_{(K-1)}$, where K is the number of variables,

M_0 is the (asymptotic) covariance matrix of the GLS estimator $\hat{\beta}_{sRE}$ and M_1 is the (asymptotic) covariance matrix of the dummy variables estimator $\hat{\beta}_{sFE}$.

[23] We also run the empirical estimation with GLS method to correct for potential heteroskedasticity and autocorrelation. The results provide similar coefficients and significance levels. So at this stage, we take brevity to focus on the fixed effects results.

Table 1 Estimation results of the Chinese bilateral imports from the U.S. and Japan

	U.S.	Japan
ln(MO)	4.53862	3.00587
	(2.496)*	(0.4517)***
ln(RS)	1.24171	3.31345
	(0.5269)**	(0.5557)***
ln(IE)	0.269419	-0.201558
	(0.1018)***	(0.1050)*
ln(PI)	-0.0258262	-0.0857139
	(0.06694)	(0.04153)**
ln(PI)Dtech	0.0994146	0.0836465
	(0.04534)**	(0.04967)***
DWTO	0.696891	-0.0177528
	(0.06282)***	(0.05835)
Observations:	902 (Balanced Panel)	902 (Balanced Panel)
R^2	0.4069011	0.3494135
χ^2 -statistic Hausman Test	307.7	293.1

***p<..01; **p<..05; *p<..1 (Standard errors in parentheses).

The coefficients of most variables show expected signs and the significance levels of most estimated results are consistent between the U.S. and Japan. The U.S. and Japan estimations yield R^2 values between 0.35 and 0.41. As shown in the model, all the observed variables are taken in natural logarithms, except for the dummy variables. In so doing, the coefficients explain the elasticity change on the importing trade flows. In general, a 1% increase in manufacturing output in the U.S. and Japan augments their exports volume to China with 4.5% and 3%, respectively. Different from the original notion of the HK model, both coefficients are significantly higher than unity. It implies that there is an increasing proportion of exports in exporters' manufacturing output. And the difference between increasing levels of the U.S. and Japan may be due to their current shares of China's total imports, which are, for instance, 18% for Japan and 8% for the U.S. in 2003.[24] We use retail sales in China as a proxy for domestic demand. The coefficients for the U.S. and Japan are both highly significant. Also similar to the case we described for manufacturing output, the coefficients of retail sales suggest an increasing share of imported goods from foreign countries. China seems to prefer imported goods from Japan to those from the U.S. given the same increase in domestic demand. It may be due to the cultural similarities and the long history of trading between China and Japan. The ratio of total imports of China to total exports of the U.S./Japan (*IE*) serves as a measure of China's relative "openness" to the exporting country. We observe a positive sign in the U.S. results and it is highly significant. This finding is consistent with the sign of the other "openness" dummy *DWTO*. On the contrary, the coefficient of *IE* in the Chinese imports from Japan is negative sign and is also consistent with its dummy variable *DWTO*. This seems puzzling since it implies that China's accession to WTO and the improvement in trade openness may abate the imports from Japan. Nevertheless, we can also understand this as a fact that China's relative openness to Japan has already reached a comparatively

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[24] From Ministry of Commerce of the People's Republic of China.

high level and the entry of WTO provides China with more opportunities to increase trade activity with other countries and regions (e.g. European Union).

Most of our interest lies in the estimated results for the *PI* ratio and its interaction with the technology dummy *DTech*. As we assign 1 to patent-sensitive industries and 0 elsewhere, the coefficient of the *PI* ratio stands for the impact of imitation threat on China's imports in trademark-sensitive and low-technology industries. We may recall Chart 2 to stress China's relatively strong imitation threat in low-technology industries. Although the negative impact of the *PI* ratio on imports is reported in both the U.S. and Japan results, only the Japan case is statistically significant. In other words, the U.S. exports of low-technology embodied goods are not significantly influenced by China's relatively strong imitation threat. The estimated coefficients of patent-sensitive industries for the U.S. and Japan are highly statistically significant. The coefficient 0.07 in the U.S. model means that the increase in IPRs protection level in high-technology industries will lead to the increase in imports from the U.S. However, in Japan's estimations, the stricter IPRs protection level in patent-sensitive industries has much less sizable effects on the importing flow from Japan. This can be explained by the business cycle (and real estate) recession of Japan during the last few years which are selected as the sample period in our model.

We continue our analysis by including the production function (3.2) to compute the estimated industrial production on industry level. We estimate the production function (3.2) together with (3.3) for 22 manufacturing industries (ISIC-2 digits) with the U.S. dataset, using FIML, over the period of 1991-2001. All parameters are significant at 15%. The estimated coefficients are subsequently used to compute the estimated industrial production on industry level for the estimation of equation (3.8). We present the results in Table 2.

Table 2. Estimation results of China's imports from the U.S. 1991-2001

	U.S.
In(MO*)	0.851421 (0.5043)*
In(RS)	1.19111 (0.2411)***
In(IE)	0.233830 (0.1660)
In(PI)	1.28291 (0.8592)
Industry Dummies	
Low Technology	**High Technology**
Food	Chemicals*
Tobacco	Rubber*
Textiles	Mineral
Wearing apparel	Basic metals*
Leather	Fabricated metal***
Wood	Machinery
Paper	Office machines***
Publishing	Electrical machinery*
Coke	Radio,Television**
	Medical instruments
	Motor vehicles***
	Transport equipment**
Observations:	242 (Balanced Panel)
R^2	0.9207291
χ^2-statistic Hausman Test	199.6

***p<..01; **p<..05; *p<..1 (Standard errors in parentheses).

Because most variables estimated in equation (3.8) are industry specific and the result of Hausman test also suggests individual effects, we focus on the fixed effects results here. First, all the coefficients show expected signs. The coefficients of manufacturing output and retails sales suggest positive influences of domestic demand and industrial production of the U.S. on China's bilateral imports with the U.S. Secondly, it is worth mentioning that both *IE* ratio and *PI* ratio are significant on 15%. The coefficient 1.2829 of *PI* ratio means that increasing IPRs protection level in general has positive effects on China's imports from the U.S in the long run. We also report the industry dummies in the table. All the industry dummy variables of low-technology industries are insignificant, while most of high-technology industries are statistically significant. This supports our finding in equation (3.7) that China's efforts in improving IPRs protection level positively influence its bilateral imports from the U.S. in high-technology patent-sensitive industries both in short-term and long-term.

To summarize, in trademark-sensitive and low-technology industries under the condition that China poses a stronger imitation threat, the increase of the IPRs protection level has either no significant impact or even a negative influence on foreign exports to China. The improvement in the IPRs protection level enhances high-technology and patent-sensitive industries where China has relatively weak imitation ability. These findings elaborate the general argument that China's perceived weak IPRs protection and strong ability imitation are barriers to foreign exports.

VI.   Conclusions

We first reviewed the theoretical studies about the relation between IPRs and trade to explain the indeterminate influences of IPRs protection on international trade. Based on the monopolistically competitive trade model and relating to China's recent accession to WTO and its rapid convergence with OECD nations on IPRs enforcement, we develop an empirical model to examine the change in China's imports from developed nations in relation to IPRs protection and its ability of imitation.

Our major findings from fixed effects panel data estimations are meant to illustrate the link between IPRs and trade flows between the U.S., Japan and China in more detail. First, instead of taking most manufacturing industries as IPRs-sensitive, we define patent-sensitive industries and trademark-sensitive industries based on our statistical analysis and the OECD Science, Technology and Industry Scoreboard 2003. Secondly, we construct the ratio of foreign patent applications to domestic patent applications in CPO. Lastly, we deliver comparable results for the U.S. and Japan which are the top two trading partners with China. In our empirical results, we find no significant or, rather, even a negative impact of improving IPRs protection level on imports volume from the U.S. and Japan in low-technology and trademark-sensitive industries. In these industry lines, China provides less efficient IPRs protection in terms of minimal punishment and meanwhile poses very strong ability of imitation. Considering the fact that China is mainly regarded as the production base of labor-intensive industries due to its comparative advantage in cheaper production cost, this suggests that different IPRs policies should be applied. In patent-sensitive industries, we find that strong patent rights augment the U.S. exports to China both in short-term and long-term. The influence of strengthening IPRs protection on imports from Japan is much less sizeable and this may due to the recession cycle in Japan during the past few years. Our research shows that the positive enforcement of IPRs in China, especially in highly patent-sensitive technologies, should be taken into effect for both China and foreign exporters' interest, because foreign IPRs holders can nourish their R&D activity by expanding overseas' markets and China can receive economic and technological benefits by importing technology embodied goods. Last but not least, the comparative results between the U.S. and Japan show similar trading characteristics in highly patent-sensitive industries. Furthermore, because of the cultural similarities and longer trading history, the influences of domestic demand are larger to imports from Japan than from the U.S.

To the authors' knowledge, this is the first paper to examine how trading activity and policies on IPRs interact and nourish in manufacturing industries given the definition of patent-sensitive and trademark-sensitive industries with Chinese data during the WTO transitional and IPRs reinforcement period. We attempt to apply equation. (3.2) to estimate industrial production of Japan on industry level instead of the aggregate manufacturing production we use at present when the related data is available on yearly basis. In so doing, we may provide comparative results of both Japan and the U.S. in long-term and short-term panel data models. Further research is also suggested on extending the analysis to include European Union data in the light of its increasing importance to China as a trading partner in IPRs-sensitive goods.

Appendix I. OECD Classification of manufacturing industries based on Technology (Science, Technology and Industries Scoreboard 2003)

	ISIC Rev. 3	1999				1991			
		R&D divided by production		R&D divided by value added		R&D divided by production		R&D divided by value added	
		Aggregate intensity[2]	Median intensity	Aggregate intensity[2]	Median intensity	Aggregate intensity[2]	Median intensity	Aggregate intensity[2]	Median intensity
High-technology industries									
Aircraft and spacecraft	353	10.3	10.4	29.1	27.5	13.9	12.9	34.7	32.1
Pharmaceuticals	2423	10.5	10.1	22.3	25.8	9.4	8.7	20.6	19.7
Office, accounting and computing machinery	30	7.2	4.6	25.8	15.1	10.9	6.4	29.4	15.2
Radio, TV and communications equipment	32	7.4	7.6	17.9	22.4	7.9	8.2	17.0	21.5
Medical, precision and optical instruments	33	9.7	5.6	24.6	11.9	6.6	6.1	15.6	12.5
Medium-high-technology industries									
Electrical machinery and apparatus, n.e.c.	31	3.6	2.3	9.1	6.7	4.2	2.6	9.3	5.9
Motor vehicles, trailers and semi-trailers	34	3.5	2.8	13.3	11.7	3.7	3.0	14.3	11.9
Chemicals excluding pharmaceuticals	24 excl. 2423	2.9	2.2	8.3	7.1	3.4	2.8	9.8	8.0
Railroad equipment and transport equipment, n.e.c.	352 + 359	3.1	2.8	8.7	7.9	2.9	2.1	7.6	5.4
Machinery and equipment, n.e.c.	29	2.2	2.1	5.8	5.3	1.9	2.0	4.6	4.7
Medium-low-technology industries									
Building and repairing of ships and boats	351	1.0	1.0	3.1	2.9	0.9	0.9	2.8	2.6
Rubber and plastics products	25	1.0	1.1	2.7	3.0	1.0	0.6	2.6	1.5
Coke, refined petroleum products and nuclear fuel	23	0.4	0.3	1.9	2.7	1.2	0.7	5.4	3.8
Other non-metallic mineral products	26	0.8	0.6	1.9	1.3	1.0	0.6	2.4	1.5
Basic metals and fabricated metal products	27-28	0.6	0.5	1.6	1.4	0.7	0.6	2.0	1.6
Low-technology industries									
Manufacturing, n.e.c.; Recycling	36-37	0.5	0.5	1.3	1.2	0.5	0.4	1.2	0.9
Wood, pulp, paper, paper products, printing and publishing	20-22	0.4	0.1	1.0	0.3	0.3	0.1	0.8	0.3
Food products, beverages and tobacco	15-16	0.3	0.3	1.1	1.0	0.3	0.3	1.1	1.0
Textiles, textile products, leather and footwear	17-19	0.3	0.4	0.8	1.0	0.2	0.3	0.7	0.7
Total manufacturing	15-37	2.6	2.2	7.2	6.5	2.5	2.0	7.0	5.7

1. Based on data for 12 OECD countries: United States, Canada, Japan, Denmark, Finland, France, Germany, Ireland, Italy, Spain, Sweden, United Kingdom

2. Aggregate R&D intensities calculated after converting countries' R&D expenditures, value added and production using GDP PPPs

Source: OECD: ANBERD and STAN databases, May 2003

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