Do Intellectual Property Rights Matter to Taiwan's Exports? A Dynamic Panel Approach

Chih-Hai Yang*
Department of Industrial Economics
Tamkang University, Taiwan

Yi-Ju Huang
Department of Industrial Economics
Tamkang University, Taiwan

Abstract

This article analyzes whether and how Taiwan's exports are sensitive to national differences in intellectual property rights (IPRs) protection and the degree of threat of imitation from the dynamic perspective. To estimate the trade equations on Taiwan's exports over the 1997-2003 period, we apply a longitudinal IPRs index developed by World Economic Forum (WEF) and employ the technique of generalized method of moments (GMM) on dynamic panel model to control for endogeneity problem and panel unit root. The empirical results show that the strength of importing country's IPRs protection overall has a positive impact Taiwan's exports, supporting the standpoint of market-expansion that stronger IPRs protection will induce more trade. Alternatively, under various classification systems to differentiate the degree of threat-of-imitation across countries, we find that both market expansion and market power do exist in Taiwan's case, while the pattern of threat-of-imitation – trade nexus seems to contradict with theory predictions. Moreover, high-tech exports are found be more IPRs sensitive than non high-tech exports.

Keyword: IPRs, Trade, Dynamic Panel
JEL classification: F13, O24, Q17

---

* Corresponding Author: Department of Industrial Economics, Tamkang University, 151, Ying-Chuan Road, Tamsui 251, Taipei County, TAIWAN. Tel.:+886-2-2622-7774, fax:+886-2-2620-9731. E-mail: chyang@mail.tku.edu.tw. The authors thank the financial support from Tamkang University. The views in this paper are solely the responsibility of the authors.

1. Introduction

Since the Uruguay Round of the General Agreement on Tariffs and Trade (GATT), how to strengthen and harmonize the means for protecting Intellectual Property Rights (hereafter, IPRs) had been placed at the center of the agenda. Although GATT only played as a forum for the negotiation of the declines on international policies to the extent that different levels of IPRs tend to distort trade flows, it did reach an overarching achievement to the conclusion of the Agreement of Trade-Related Intellectual Property Rights (TRIPs), a foundation of the World Trade Organization (WTO).[1] However, IPRs laws and the enforcement of existing laws differ widely across countries due to national differences in economic development and trade policy, the divergence for effects of strengthening IPRs between North and South countries seems to have widened in recent years. Some developing countries argue that an extension of international IPRs harm their technological progress and economic growth. Alternatively, developed countries use the trade policy as a main vehicle for strengthening IPRs across bilateral or multilateral negotiations, implying that stronger IPRs do in fact influence international trade flows.[2]

Do national differences in IPRs affect international trade flows? The importance of the international pattern of IPRs for trade has stimulated wide interest for economists. Despite the practical and conceptual importance of this subject, limited empirical studies on IPRs and trade conclude a mixed result that the trade flow might increase or decrease, depending on two contradictory effects of strengthening IPRs – the market-expansion effect and the market-power effect. Even more importantly, due to the limitation of IPRs indices, there remains little systematic evidence on the dynamic

[1] The issue concerning IPRs and trade was also played on the agenda of regional trade negotiations, e.g., the European economic integration agreements, the North American Free Trade Agreement (NAFTA), and the U.S.-Canadian Free Trade Agreement.

[2] For interrelationships among IPRs, regulatory systems, and economic structure, see Maskus (1998).

relationship between IPRs and trade. From the standpoint of international trade policy, whether the recent WTO-TRIPs agreement to strengthen and harmonize national IPRs can induce a trade growth?

Although several studies have assessed the trade effect of IPRs protection, most of these studies focus on developed economies, while empirical studies investigating the issue for developing countries or newly industrialized economies (NIEs) are quite limited. Indeed, theoretical arguments claim that the degree of threat-of-imitation plays an important role on whether market expansion effect or market power effect exercises. How to group threat-of-imitation usually refers to importing countries' degree of economic development of R&D capability. Because U.S. locates in the world technology-frontier, any importing country in the rest of the world perhaps exhibits some degree of threat of imitation. However, from the view of NIEs, such as Taiwan, it is noteworthy that they might not have any kind of threat of imitation if the importing country is on the technology frontier and has stronger R&D ability than Taiwan (Liu and Lin, 2005). Therefore, compared with developed countries, whether the relation between threat-of-imitation and trade performs a different pattern for NIEs is an interesting issue and it is worth further exploring.

It is well recognized that technological opportunity is an important determinant of technical change and it deeply influences firms' innovation behaviors.[3] In industries of high technological opportunity, the pace of technological change is very rapid, the technological environment faced by firms is relatively fertile, and there are more potential new technologies to patent. Therefore, high-tech exports should rely more on host countries' IPRs protections to appropriate economic rents. Alternatively, driven by a rapid pace of technological change and short product life cycles, high-tech firms

[3] The concept "technological opportunity" has been coined to capture the vitality of the underlying sciences and technologies as the sources of technical progress that firms drawn upon during innovation (Palmberg, 2004).

may tend to rely more heavily on lead time, design secrets, and manufacturing or design capabilities than on patents. A patent could be a less effective mechanism for appropriating returns to R&D as surveyed by Cohen *et al*. (2000), implying that foreign patent rights (FPRs) might play less role on protecting firms' exports. Whether the IPRs-export nexus is different between high-tech and non-high-tech exports is an interesting and important question, while it seems to be less well discussed in previous studies.

Since the economic development of Taiwan overwhelmingly relies on international trade and the export-led growth indeed has played as a successful strategy during the past decades (Chu, 1988), the impact of foreign IPRs protection on exports is an important concern. This paper aims to provide empirical evidence on how Taiwan's high-tech and non-high-tech exports are sensitive to national difference in IPRs protection and their changes. Furthermore, the study attempts to contribute in line with the empirical literature by providing the following three distinct types of empirical evidence.

First, this study uses longitudinal data of Taiwan's exports to 51 countries during the 1997-2003 period and employ a longitudinal and consistent IPRs index surveyed by World Economic Forum (WEF) to investigate the dynamic process between IPRs and trade. Indeed, the protection of IPRs is inherently a dynamic process, involving both a secular evolution within one country over time and the need for new standards of protection (Maskus, 1998). However, previous empirical studies, except for Al-Mawali (2005) and Yang and Woo (2006), use only cross- sectional and pre-1990 data. This empirical analysis can provide a clearer and more dynamic portrait, yielding to an insightful viewpoint on the importance of IPRs on trade after the implementation of TRIPs Agreement in 1995.

Second, most previous studies assume that the strength of IPRs is exogenous, ruling

out countries' behavior when they decide the strength of IPRs protection. If a country's imports are simultaneously determined with the strength of IPRs protection, then the coefficient of the IPRs variable may encounter a downward bias.[4] To deal with the endogeneity problem and control for the potential problem of panel unit root, two potential sources of bias which was not well dealt with in most of previous studies, this study employs the econometric technique of Generalized Method of Moments (GMM) for dynamic panel data model to execute the estimation.

Third, one of the features differentiating our study from existing works on the IPRs-trade nexus is focusing on NIEs, Taiwan, rather than developed countries. This work enables us to investigate the IPRs-trade nexus from an alternative perspective and reexamine the role of threat-of-imitation on affecting trade. Moreover, this study separates Taiwan's exports into high-tech and non high-tech exports and then examine whether there is difference on IPRs-trade nexus between high-tech and non high-tech exports. Taiwan's high-tech products has accounted for an extremely large share in the global market. Due to the rapid pace of technological change and short product life cycles, high-tech products would be more or less IPRs-sensitive than non high-tech products in international trade is explored in this study. In addition, the degree of imitation threat encountered by high-tech and non high-tech exports might vary across/within countries and therefore we also discuss the potential differences on the relation between threat-of-imitation and trade for high-tech and non-high exports.

The paper is organized as follows: Section 2 reviews the theoretical and empirical literature on IPRs and trade to describe the channels through which a variation in IPRs could influence trade flow. The essential point of this review is the inconclusive prediction that the amount of trade flow could increase or decrease with the

[4] On exploring the relationship between enforcement of IPRs and economic growth, Gould and Gruben (1996) argue that a country's membership in an international convention may qualify for lowering this endogeneity problem.

imposition of stronger IPRs. Given the ambiguity, we go on in the third section to specify an econometric model of bilateral trade, borrowing from the Gravity model, and describe the data. Section 4 presents the empirical results of panel data model. We proceed to adopt the GMM approach for dynamic panel data model to conduct an estimate to investigate the dynamic IPRs-trade nexus in section 5. In section 6, we discuss the role of imitation threat on the relation between IPRs and trade for both high-tech and non high-tech exports. Concluding remarks and policy implication are provided in the final section.

2. Intellectual Property Rights and Trade

The theoretical literature discussing IPRs-trade nexus is ever-increasing. Recent theoretical articles, such as Brown (1991), Schwartz (1991), and Taylor (1993), have used more sophisticated modeling or descriptive frameworks to explore this issue and yielded different results, but they did provide some guidance: the strengthening of IPRs has two simultaneously contradicting powers on trade: trade might be increased through the market expansion effect and decreased through the market power effect (Maskus and Penubarti, 1995).[5]

The market expansion effect increases the demand curve facing the foreign firm and increases trade flow toward countries with relatively stronger patents, because the strengthening on IPRs reduces the ability of importing countries' firms to imitate technologies embodied in imported products. This expectation is clearly supported when importers have the resources to imitate the technologies. If the importing countries impose stronger IPRs, then this means that the costs associated with preventing a loss of the technologies will decrease. Thus, strong IPRs might increase

[5] Taylor (1993) argues that there is a cost-reduction effect in larger markets that raises exports if a stronger patent reduces the need for foreign firms to undertake R&D to deter local imitation.

exports to such markets. Alternatively, the market power effect reduces the elasticity of demand facing the foreign firm and decreases exports toward countries with strong patents, arising from the holder of the patent is ensured the exclusive rights to technologies by stronger patents. Due to strong IPRs protection, firms that own patented technologies or products in a foreign market may execute their monopoly power by restricting export volumes and raising prices.

Because the market expansion and market power effects are countervailing, the predicted effect of IPRs on trade, ceteris paribus, depends on the relative importance of these two enhancements. These two effects might act simultaneously, while Maskus and Penubarti (1995) argued that it seems possible that the market expansion effect tends to be more dominant in larger countries with highly competitive local imitative firms. However, the market power effect is stronger in small countries with limited imitation capacity.

Despite the link between IPRs and trade being important, the empirical literature on this issue is limited. Empirical studies of the IPRs-trade relationship began in the 1990s and concentrated on cross-sectional studies: Ferrantino (1993) used a gravity approach to examine aggregate U.S. export patterns in relation to national membership in IPRs treaties and suggests that arm's-length trade is unaffected by variations in IPRs. Maskus and Penubarti (1995) explored the relationship between the manufacturing exports of OECD countries and the strength of patent rights in large and small developing economies. The results indicate that increasing patent protection has a positive impact on bilateral trade. Smith (1999) assessed whether, how, and to what extent U.S. exports are sensitive to national differences in patent rights. She found that the stronger patent rights of importing countries increase U.S. exports to these high-threat markets. Alternatively, a strengthening of patents in weak threat-of-imitation countries reinforces monopoly power and reduces U.S. exports to

these markets. Smith (2001) analyzed how foreign IPRs affect US exports, affiliate sales and license. Empirical findings show that stronger foreign IPRs increase US exports, especially across countries with stronger imitative abilities, through the market expansion effect. Alternatively, stronger foreign IPRs decrease US exports to countries with weak imitative abilities through market power effect. Rafiquzzaman (2002) took the exports of ten provinces in Canada to 76 countries in 1990 as a sample to analyze the relationship between IPRs protection and exports and found that exports increase with improvement of in IPRs no matter what degree of development of the importing countries.

Smith (2002) analyzed the effect of foreign patent rights on U.S. bilateral exports upon three highly-disaggregated drug industries during the 1970-90s. The findings show that strong patent rights enhance the market power of U.S. drug exporters across countries with weak imitative abilities, while stimulating the market expansion across countries with strong imitative abilities. However, her study adopts the pooling estimation rather than panel data model. This situation applies in Liu and Lin's (2005) study that employing the technique of pooling estimation to investigate the relation between foreign patent rights (FPRs) and the exports of three high-tech industries in Taiwan during the 1989 to 2000 period. They found that both market expansion and market power effects do exist in Taiwan's case.

Panel data studies on IPRs-trade nexus were emerging in more recent years. Different from previous studies, Al-Mawali (2005) provided evidence on the effect of IPRs protection on bilateral intra-industry trade flow rather than one-way trade. The findings suggest that IPRs and imitation abilities separately are not important factors in determining intra-industry trade flow, while the interaction between them is important. Despite the panel data model is applied in this study, this two-period panel analysis can provide little insight for the dynamic IPRs-trade nexus. Yang and Woo

(2006) firstly extended this research line to agro-trade. Their panel data study showed that whether a country adheres to IPRs agreements has no discernible impact on planting seeds that are imported from the U.S., implying that the strengthening of IPRs would not induce more agro-trade.

Table 1 presents the list of relevant studies that have been conducted. It can be seen clearly that these studies on the relationship between IPRs and trade have generated unambiguous results, depending on the imitation threat of importing countries. And one more important point drawn from the literature, we find few empirical panel data studies on discussing the IPRs-trade nexus, indicating that the dynamics of IPRs-trade relation is not well understood. The few panel data studies don't find a significant trade effect of IPRs, while their estimates might be biased, attributing to the limitation on IPRs variable, such as the data viability of Ginarte and Park's (1997) IPRs index or using a binary variable of IPRs index.[6] In an attempt to bridge this gap in the existing literature, this study adopts a consecutive and consistent IPRs index measured by WEF to analyze the dynamic relation between IPRs and trade.

[Insert Table 1 about Here]

3. Empirical Model and Data

To investigate the effects of IPRs on exports, we apply the commodity version of gravity model that is widely adopted in previous related studies, because it provides a flexible general equilibrium framework consistent with a variety of general equilibrium trade models.[7] The gravity model expresses bilateral trade flow as a function of exporter and importer characteristics, including income per capita, population (market size), distance (transportation cost), (non)trade barriers, and

[6] The Ginarte and Park (1997) IPRs index are only available for years of pre-1990, 1995, and 2000.
[7] Detailed theoretical foundations of the gravity model and nesting of trade theories, see Anderson (1979) and Bergstrand (1985).

factors that augment or distort trade. Of course, the national differences in IPRs is the main factor we concern that might increase or decrease trade flow. Adopting the specification by indexing the Taiwan as the source country to examine bilateral trade from the Taiwan perspective, the empirical model is specified as:

$$EXP_{it} = \beta_0 (PGDP_{it})^{\beta_1} (POP_{it})^{\beta_2} (DIS_{it})^{\beta_3} (OPEN_{it})^{\beta_4} (TB)^{\beta_5} (NTB)^{\beta_6} (IPR_{it})^{\beta_7} u_{it} \quad (1)$$

where EXP_{it} represents Taiwan's exports to country *i* in year *t*.

The basic gravitational variables that appear as independent variables in this study include the per capita GDP of country *i* in US dollars (*PGDP*) and the population of the importing country in thousands (*POP*) that is used to capture the notional economies of scale. Both the *PGDP* and *POP* are obtained from the IMF World Economic Outlook Database and are expected to have a positive impact on trades. Term *DIS* is the geographical distance between country *i* and Taiwan. It represents a natural rather than a policy-driven distortion, because the transport cost increases as the distance is longer. The term *OPEN* denotes the degree of trade openness of county *i*, and it is measured as the trade volume to GDP ratio and it is expected to exhibit a positive coefficient. The trade barriers variable (*TB*) is measured by the average tariff rate and was obtained from the Global Competitiveness Report of World Economic Forum (WEF). Tariff is widely recognized as the main distorting force of trade flows and then a higher tariff is expected to induce a decrease on imports. As for the non-tariff barrier (*NTB*) is the degree of hidden import barriers of importing countries as measured by WEF. One point worth pointing out is that the index ranges from one to seven points and a lower value represents a higher degree of non-tariff barrier. Therefore, the estimated coefficient for the *NTB* variable is expected to be positive. Lastly, *IPR* represents the importing country's strength of IPRs protection. It is the main factor we concern that it might reduces or augments trades, depending on the

contradicting forces of market expansion and market power effects; u_{it} is assumed to be a log normally-distributed error term.

How does one measure the notional differences in IPRs? Rapp and Rozek (1990) and Ginarte and Park (1997) developed indices to measure the degree of patent protection. Unfortunately, these indices cannot be adopted in this study, because the dataset we use is the 1997-2003 period, while these indices are only available as late as in 1990 and for years 1995 and 2000. The lack of a consecutive and consistent IPRs index prevents the insightful analyses on the dynamic relation between IPRs and trade. The IPRs protection index measured by World Economic Forum serves as an excellent alternative index, because this comprehensive index of IPRs is a consecutive and consistent index for a larger pool of countries.

Taking natural logs of Eq. (1), the resulting econometric specification is:

$$\begin{aligned}\ln EXP_{it} = {} & \beta_0 + \beta_1 \ln PGDP_{it} + \beta_2 \ln POP_{it} + \beta_3 \ln DIS_{it} + \beta_4 \ln OPEN_{it} \\ & + \beta_5 \ln TB_{it} + \beta_6 \ln NTB_{it} + \beta_7 \ln IPR_{it} + \varepsilon_{it}\end{aligned} \tag{2}$$

The IPRs index of WEF is constructed by the survey results. The WEF survey is related IPRs protection in general. The question of the WEF survey is that whether IPRs protection is “weak or nonexistence” (score1) or “equal to the world’s most stringent” (score 7). Thus, this index ranges from 1 to 7 and a higher value of the index indicates a stronger level of protection. The estimates on the coefficient for the IPR variable can provide insights on the incidence of market expansion and market power, and so there are no priori expectations as to whether IPRs increase or decrease trade flows. Moreover, in order to investigate whether there are differences on the IPRs-trade nexus between high-tech and non high-tech export, equation 2 can be modified as equations 3 and 4 for high-tech exports and non high-tech exports, separately

$$\begin{aligned}\ln HIGH_{it} = {} & \beta_0 + \beta_1 \ln PGDP_{it} + \beta_2 \ln POP_{it} + \beta_3 \ln DIS_{it} + \beta_4 \ln OPEN_{it} \\ & + \beta_5 \ln TB_{it} + \beta_6 \ln NTB_{it} + \beta_7 \ln IPR_{it} + \varepsilon_{it}\end{aligned} \tag{3}$$

$$\ln NHIGH_{it} = \beta_0 + \beta_1 \ln PGDP_{it} + \beta_2 \ln POP_{it} + \beta_3 \ln DIS_{it} + \beta_4 \ln OPEN_{it} + \beta_5 \ln TB_{it} + \beta_6 \ln NTB_{it} + \beta_7 \ln IPR_{it} + \varepsilon_{it} \quad (4)$$

where terms *HIGH* and *NHIGH* represents high-tech exports and non high-tech exports. The high-tech industries include Electronic Components, Chemical Materials, Information, Communication, Visual Electronics, Machinery, Transport Equipment, Electric & Electronic Machinery, Chemical Products, and Precision Instrument.[8]

The trade flow we focus on in this study is Taiwan's exports to 51 countries during 1997-2003. Taiwan is a small open economy that is highly exposed to international markets, revealing the potential importance of trades on the Taiwan economy. Therefore, the export-led strategy of growth was adopted as the main driving force for the island's economic growth as long as the 1960 and it was widely recognized as a successful strategy for Taiwan's economic development (Chu, 1988). Figure 1 displays the time trend of Taiwan's exports, high-tech exports, and non high-tech exports since the 1990. The value of Taiwan's exports increased steadily, except for years 1998 and 2001, from US$ 67.214 billion in 1990 to US$ 189.393 billion in 2005, experiencing an average export growth of 7.25% per year. The amount of exports decreased in 1998 and 2001 were mainly influenced by the Asian financial crisis and the 911 terror attack, respectively. The increasing trend of exports shows the great effort for promoting exports in Taiwan, which indeed plays as the major attribute of economic growth. At the same time, much of the recent increase comes from the high-tech exports. The amount of high-tech exports has increased more than four times - that is, from US$ 29.144 billion in 1990 to US$ 120.179 billion in 2005. In terms of the share of high-tech exports as a percentage of total exports, it rose steadily

[8] This definition of high tech industries used here is (1) high value added; (2) complexity of technique; (3) high ratio of technical staff and R&D inputs, and is constructed by the Ministry of Finance of Taiwan.

from 43.36% in 1990 to about 64% in 2000 and then kept this weight stably. One point worth noting is that the ratio of high-tech exports outpaced the non high-tech export ratio since 1995, meaning that the exports contribution by high-tech industries is emerging important for Taiwan. Therefore, whether there are differences on the IPRs – trade nexus between high-tech and non high-tech exports is also entering as a main issue to be examined in this study.

[Insert Figure 1 about Here]

As for the definition, basic statistics, and data sources of the right-hand side variables used in this paper, they are summarized in Table2.

[Insert Table 2 about here]

Before plugging into the econometric analysis, it is useful for us to have a rough understanding about the relationship between IPRs and trades through a simple graphical analysis. If stronger IPRs, measured by the WEF index, indeed induce more trade through market expansion effect, then it can be expected that the time path of Taiwan's exports to a country should show a similar trend as that country's IPRs protection strength. Alternatively, if the market power effect dominates, the time path of IPRs index will exhibit an opposite trend to that of importing countries imports.

To illustrate the potential impact of IPRs protection on trades, the trends of imports for some Taiwan's major trade partners are shown in Figure 2. The upper panel of Figure 2 shows that the time trend of import amount for U.S. and Japan appears to have the similar trend that steadily increased from 1997 to 2000 and then decreased, while the time trend of IPRs seems to be a random walk. As for China and Korea, both their import from Taiwan appears an ascending trend, while the time trend of their IPRs index seems not to have a similar trend. Drawing from the graphical analysis, the degree of IPRs protection overall seems to have less influence on trade when other factors are not controlled for. In order to further investigate the IPRs –

trade nexus, a more comprehensive econometric analysis is carried out in following sections.

[Insert Figure 2 about Here]

4. Panel Data Model Analysis

The panel data contain both cross-sectional and time-serial features. Thus, to estimate equation 2, the relationship between IPRs and trade flow, this study considers two types of models: pooling and within models. The pooling data estimates presents the cross-sectional characteristics and the within model allows for the existence of individual effects which are potentially correlated with the right-hand side regressors. Using a "within" panel estimator, the random effect (RE) or fixed effect (FE) technique, to eliminate the individual effect is a standard estimation method.[9]

The estimates of the pooling data model are shown in Table 3. Comparing the results obtained from total, high-tech, and non high-tech exports equations, one can clearly find that the sign and impact of the estimated coefficients are quite similar. The coefficients of per-capita GDP and population are both positive and significant at the 1% statistical level in all specifications, implying that one country that has a higher per capita income and larger population relative to other countries imports more products from Taiwan. The distance by contrast has a negative and significant impact on imports from the Taiwan, consistent with the prediction of the gravity model. Increased shipping distance represents a higher transportation cost of trade, and so it might decrease the volume of imports from Taiwan for country *i*. The impacts of *OPEN* are significantly positive in all estimates, indicating that the more open the importing country, the more the exports. Moreover, the effects of tariff and non tariff barriers are statistically significant and exhibits a sign as expected, while the

[9] For details on the panel data model, please refer to Hsiao (1986).

impact of non-tariff barrier seems to be less influential for non high-tech trade.

[Insert Table 3 about Here]

The main concern of this study is to determine whether Taiwan's exports are sensitive to the national differences in IPRs protection and whether the IPRs effects vary between high-tech and non high-tech exports. The estimated regression results in Table 3 reveal that the estimated coefficient of the IPR variable is positive and statistically significant in all regression when the degree of imitation threat is not controlled for. Since the signs are positive, this result tends to confirms that the market expansion effect is prevailing as argued by Maskus and Penubarti (1995) and it is consistent with most of previous cross-sectional studies summarized in Table 1. Moreover, we cannot find a significant difference in the trade effect of IPRs between high-tech and non high-tech exports. The elasticity of IPRs on high-tech and non high-tech exports are 1.819 and 1.701, respectively, meaning importing country's IPRs protection increases 1% will induce about 1.8% increase on Taiwan's exports, no matter high-tech or non high-tech exports, to that country.

The estimates in Table 4, whereby with overall country means removed ($y_{it} - y_{i\bullet}$), yield the within-firm estimations. The within-firm estimations can be separated into a random effect model and a fixed effect model. The χ^2 values of Hausman tests are significant at the 1% statistical level, implying that the FE model is more appropriate. Due to the fact that both RE and FE models have their potential bias, we report both these estimates while focus on discussing the FE estimates.

[Insert in Table 4 about Here]

Before finding out whether the IPRs regimes of countries have a substantial impact on Taiwan's exports from the point of time dimension, there are two points worth noting drawing from Table 4. First, the coefficient for population turns to be negative but not statistically significant in FE estimates. The possible interpretations are

twofold: the importing country that has a large population perhaps is a more domestic-market-oriented economy as well as a poorer country, such as China and India. Second, the tariff seems to exhibit an insignificant influence on Taiwan's non high-tech exports.

Turning to focus on the estimates of the IPRs variables, the sign and significance of the coefficients of the IPRs variables in the within estimates can be used to identify the time-dimensional IPRs-trade nexus that is less well analyzed in previous studies. The estimates obtained from both RE and FE models show that the coefficients for the IPRs variable are positive and significant at a conventional statistical level, tending to provides the evidence that Taiwan's export to the importing countries increased as the strength of importing countries' IPRs protection increased during the 1997-2003 period, after controlling for other influences. Moreover, the estimated IPRs impact for high-tech exports is higher than that of non high-tech exports, revealing that high-tech exports seem to be more IPRs sensitive relative to non high-tech exports. This finding is very important to Taiwan's trade policy, because high-tech exports account for a large share of 64% of Taiwan's exports as noted previous.

It is noteworthy that the estimates for the trade effect of IPRs might be inconsistent when the importing country's IPRs protection is assumed to be an exogenous rather than endogenous variable. Moreover, the Durbin-Watson statistics shown in the button of table 4 seems to reveal that there exists a first-order autocorrelation problem. We then would like to deal with the possible econometric problems that might generate biased estimators.

5. GMM for the Dynamic Panel Model

Do stronger IPRs protections really stimulate trade flows of Taiwan's exports? Two econometric problems emerge with regard to the traditional panel data model. First,

the time dimension of the panel data might be non-stationary due to the existence of a unit root. Second, the potential of an endigeneity between trade and flows and the measure of IPRs protection may exist because the enforcement of IPRs is probably influenced by other factors such as economic development and technological specialization.

Concerning the first problem, the Durbin-Watson tests obtained in table 4 seem to reveal that there exists the first-order autocorrelation problem. We now resort to the formal panel unit root test developed by Im *et al.* (2003) and the ADF-Fisher test. Table 5 show that the statistics for both the two tests are smaller than the critical value at the 10% statistical level, indicating that the null hypothesis that there is a panel unit root is not rejected.

[Insert Table 5 about Here]

To control for the panel unit root problem and get rid of the possible endogeneity for IPRs degree, this study employs a within-firm estimate obtained by the GMM method for the panel dynamic model developed by Anderson and Hsiao (1982), Arellano and Bover (1995), and Ahn and Schmidt (1995). Using the setting of linear regression models with predetermined rather than exogenous right-hand side variables, this approach provides asymptotically efficient estimators even under a weak assumption on the disturbance and it is robust in the presence of heteroscedasticity across countries and shows a correlation of disturbances within countries over time.

Table 6 presents the estimates of the GMM estimates of dynamic panel data model that might provide the most plausible estimates. We first look at the p-value of the Sargan statistic (also know as Hansen's J-statistic) in the button of Table 6, which tests the joint null hypothesis that the model is correctly specified and that the

instruments are valid.[10] The value of Sargan statistics is lower than 10% critical value for all estimates, indicating that GMM estimates for dynamic panel data model are well-behaved.

[Insert Table 6 about Here]

Compared the estimates obtained by GMM technique for dynamic panel and that in Table 4, it can be seen clearly that the results are quite similar. Turning to the IPRs effect we concern, the coefficients for IPRs variable are all positive and statistically significant at 1% statistical level in all estimates, indicating that a stronger IPRs protection would induce more exports from Taiwan to that importing country. This result overall supports the market expansion effect from the dynamic standpoint and it contributes new insights on the dynamic relation between IPRs and trade, because previous panel studies found that IPRs protection has no discernible impact on trade, e.g. Al-Mawali (2005) and Yang and Woo (2006).

To determine the dynamic trade effect of strengthening IPRs, we can calculate IPRs elasticities with respect to the trade growth. In case of total exports, when the degree of IPRs protection increases 1% and keeps other variables at the means, it will induce a growth of 11.85% for Taiwan's exports. One important point worth noting is that this trade effect of strengthening IPRs for high-tech and non high-tech exports are substantially different. The calculated elasticities are 11.64% for high-tech and 7.51% for non high-tech, revealing that the IPRs effect for high-tech is about 55% higher than that for non high-tech exports. From the standpoint of trade dynamic, Taiwan's exports structure has changed gradually from labor-intensive products toward high-tech products. Drawn from the higher estimated IPRs elasticity of high-tech

[10] Formally, the Sargan statistic is a test that the over-identification restrictions are asymptotically distributed $\chi^2_{(n-p)}$, where n is the number of instruments and p is the number of parameters. In this study, we adopt lagged IPRs variables as instruments.

exports, it indicates that the WOT-TRIPs agreement to strengthen and harmonize national IPRs seems to be beneficial for Taiwan's trade and then contributes to Taiwan's long-run economic growth.

In sum, the empirical findings show that the strengthening IPRs of importing countries indeed increase Taiwan's exports to those countries in cross-sectional, time-dimensional, and dynamic estimates, strongly supporting the market expansion hypothesis. This result is consistent with the previous study on Taiwan's high-tech exports carried out by Liu and Lin (2005).

6. Threat-of-imitation and (Non) High-tech Trade

The imitation cost may vary substantially between high-tech and non high-tech products, implying that the effect of market expansion and market power may differ for high-tech and non high-tech exports when they suffer the same degree of imitation threat. The theoretical literature has emphasized the role of threat-of-imitation on trade. The relationship between threat of imitation and market expansion and market power is summarized in table 7. As shown in table 7, a strong threat of imitation occurs when the importing country's IPRs protection is weak and its imitative ability is strong, while the situation that the importing country's IPRs protection is strong and its imitative ability is weak is regarded as a weak threat of imitation. When both IPRs protection and imitative ability are strong or weak, the threat of imitation is unclear and resulting in an ambiguous effect on trade. This section investigates the relation between threat-of-imitation and Taiwan's exports, high-tech, and non high-tech exports

[Insert Table 7 about Here]

Smith (1999) argued that the effects of patent laws on trade flow could vary, depending on the importing nation's economic development level and related

threat-of-imitation might to be correlated to the degree of economic development. She defines a set of development dummy variables to assess IPRs' interactions by classifying the level of development of countries into four categories.[11] Moreover, Smith (1999) also adopted a R&D intensity of 0.5% as the critical value to group high and imitative abilities. Most existing studies investigating the IPRs–trade nexus concentrate on developed countries, such as U.S. From the standpoint of U.S. that is the technology frontier country, how to define the importing country's imitative ability seems to be ambiguous. Because the exporting country we study is Taiwan, a newly industrialized economy, it seems to be plausible to group importing countries into strong and weak imitative abilities by comparing their degree of economic development or R&D intensity with Taiwan.[12]

How to classify groups of threat-of-imitation might affect the estimated threat-of-imitation effect substantially, we therefore use various classifications to categorize threat-of-imitation groups, in order to obtain robust estimates for the relation between threat-of-imitation and trade. We divide the importing countries into two groups according to their degree of economic development or R&D intensity. The 'strong imitative ability' is defined as GDP per capita is higher than US$8,356, GDP per capita is higher than Taiwan, R&D intensity is high than 0.5%, or R&D intensity is high than Taiwan. Alternatively, we classify the importing countries into 'strong IPRs protection' and 'weak IPRs protection' groups by IPRs index that whether the value is higher than score 4 or the mean. And then we have eight classificatory methods to group the importing countries into four categories as suggested by Smith (1999): weak imitative ability and strong IPRs protection, weak imitative ability and weak

[11] The classification is based on the World Bank categorization of income (in U.S. dollars) per capita as follows: High income: above 8356; Upper middle income: 2,696-8,355; Lower middle income: 675-2,695, and the low income (below 675) group.

[12] Liu and Lin (2005) define the importing country' imitative ability by that whether it R&D intensity is higher or lower than that in Taiwan.

IPRs protection, strong imitative ability and strong IPRs protection, and strong imitative ability and weak IPRs protection. These four groups are denoted by threat-of imitation dummies G1, G2, G3, and G4, respectively. The countries we select and the degree of threat-of-imitation are summarized in the Appendix.

To examine the relationship between threat-of-imitation and trade, the following equation is the empirical model and is modified from equations 2-4 by replacing the IPRs variable by four threat-of-imitation dummies and their interactive terms with IPRs variable.

$$\begin{aligned}\ln Y_{it} = {} & \alpha_0 + \alpha_1 G_{1it} + \alpha_2 G_{2it} + \alpha_3 G_{3it} + \alpha_4 \ln Y_{i,t-1} + \beta_1 \ln PGDP_{it} \\ & + \beta_2 \ln POP_{it} + \beta_3 \ln DIS_{it} + \beta_4 OPEN_{it} + \beta_5 TB_{it} + \beta_6 NTB_{it} \\ & + \beta_7 G1_{it} IPR_{it} + \beta_8 G2_{it} IPR_{it} + \beta_9 G3_{it} IPR_{it} + \beta_{10} G4_{it} IPR_{it} + \varepsilon_{it}\end{aligned} \tag{5}$$

where *Y* denotes total exports, high-tech exports, or non high-tech exports. Note that the constant term has been divided into four parts and the later three terms are known as the intercept shift term, representing the difference among different groups of threat-of-imitation. Does the difference in threat-of-imitation affect exports volume through market expansion and market power effects? The four interaction variables indicate the sensitivity of the Taiwan exports to the strength of national IPRs within each threat of imitation group. Positive values of the parameters of these interaction terms confer market expansion and negative parameters indicate the IPRs confer market power. According to Smith's (1999) predictions, the sign for coefficient β_7 should be negative and the sign for coefficient β_{10} should be positive. While the estimated interaction effects for groups 2 and 3 (β_8 and β_9) are indeterminant, depending on the relative strength of market expansion and market power effects.

Now we consider the link between threat of imitation and export sensitivity to IPRs and examine whether there are differences in the trade effect of threat-of-imitation between high-tech and non high-tech exports. To explore whether the market

expansion (power) effect of IPRs applies across countries that pose strong (weak) imitative threats, we implement similar econometric techniques of GMM for dynamic panel model used in obtaining table 6 and report the estimates on the new interaction variables in table 8.[13]

[Insert Table 8 about Here]

The results in table 8 are ordered from left to right to reflect an increasing threat of imitation of the average country in each group. The estimated coefficients indicate the effect of national differences in IPRs across importers within each threat-of-imitation group.

According to the theoretical predictions, the market expansion effect should increase gradually when the degree of threat-of-imitation increases. That is, β_7 should be negative and β_{10} should be positive. As shown in table 8, the estimates among total, high-tech and non high-tech equations are quite similar, indicating the effect of threat-of-imitation does not vary for Taiwan's high-tech and non high-tech exports. The parameter sign for the strong threat-of-imitation group (G4) appears opposite sign in different classifications. This inconsistent result is attributed to the fact that there are few countries being classified into group 4 and the samples vary across different classification system,[14] suggesting that both the classification system of importing countries and estimated trade effect of threat-of-imitation should be dealt with and interpreted more carefully when the sample countries are limited.

Now we turn to focus on the Taiwan export sensitivity to differences in IPRs across countries within a given group. It is noteworthy that all estimates lead to puzzling asymmetries in the sign of elasticities with respect to the degree of threat-of-imitation compared with theory predictions. Suggested by theory literature and evidence from

[13] To save space, the estimates on other variables are not reported here. The value of Sargan statistics are lower than 10% critical value in all estimates.
[14] There are usually only two countries being classified into this category. See the appendix table.

developed countries, such as Smith (1999, 2001), the estimated coefficient for the interaction terms should tend to be negative in groups 1 and 2. That is, one may expect Taiwan's export to be biased against those importers with "relative" strongest IPRs within the group that poses a weak imitative threat (group 1). In other word, the market power effect of IPRs applies across low-threat importers. However, our estimates on the interaction terms for groups 1 and 2 appear a statistically positive impact on Taiwan's exports to those importing countries, meaning that the market power effect dominates the market expansion effect in weak imitative abilities groups when their strength of IPRs protection is enhanced. This result indicates that the market expansion strategy might be widely applied by Taiwanese firms to sell their products in countries with weakest and moderate threat of imitation (usually developing countries), contradicting with previous studies.

Theory predictions also suggest that the market expansion effect applies across countries with the strongest threat of imitation (group 4), implying that the coefficient for the interaction term G4*IPR should be positive. Drawn from the results in table 8, the estimate confirm remarkably well with the interpretations suggested by the theory literature in classification 1 that categorizes strongest threat-of-imitation as the one similar to that suggested by Maskus and Penubarti (1995). In contrast, the estimates obtained from classifications 4-8 exhibit a significant negative coefficient for the G4*IPR variable. Why the estimated trade effect for the group with strongest threat of imitation differs when we adopt different classification standards and which one is correct? Indeed, the inconsistent results arise from the fact that here are few countries being classified into group 4 (usually 2 countries) and the samples vary across different classification system, resulting in a sensitive result. Therefore, we cannot obtain an affirmative answer whether market expansion applies across countries with strongest threat of imitation for Taiwan's exports.

Concerning group 3 that poses strong imitative ability and strong IPRs protections (usually developed countries), how their enhancement of IPRs protection affects Taiwan's exports toward them? Among the classification systems, our estimates obtain a consistent result of significant negative impact. Despite one can expect the effect of IPRs to be more ambiguous for importers in group 3, since either the market power or market expansion effect may apply. For group 3, when IPRs protection is sufficiently stringent to protect against infringements by importers with strong imitative abilities, then Taiwanese firms that own patented technologies or products in a foreign market may execute their monopoly power by restricting export volumes. This study also finds that elasticity for high-tech exports is higher than that of non high-tech in all estimates. This result is reasonable because the high ranking of Taiwan's patents in developed countries is composed of high share of high-tech patents.[15]

In sum, both market expansion and market power effects exist in Taiwan's exports, while the market expansion effect seems to be predominate. Moreover, the connection between the threat of imitation and market expansion and power is stronger for high-tech exports.

7. Concluding Remarks and Policy Implications

The theoretical literature suggests that the impact of patent laws on trade is ambiguous. Several empirical works have contributed evidence on the sensitivity of exports to national differences in IPRs for developed countries, while there are few studies discussing the experiences of developing countries. More importantly, the

[15] However, the negative coefficient can be interpreted from an alternative point. Since most group3 members are developed countries that have a higher GDP per capita or R&D intensity than that of Taiwan (such as classifications 3, 4, 7, and 8), the enhancement of IPRs might stimulate their domestic innovations and lower fake goods imported from developing countries.

protection of IPRs is inherently a dynamic process, meaning that the clarification about the dynamic relation between IPRs and trade is worth exploring while is never well investigated due to the availability of a longitudinal IPRs index. By applying the IPRs index developed by World Economic Forum (WEF) and employing the technique of GMM on dynamic panel model, this work contributes the empirical evidence on the relationship between IPRs and trade for NIEs, Taiwan, attempting to shed some light on the issue.

Based on the data of high-tech and non high-tech imports from Taiwan for 51 countries during 1997-2003 and employing the technique of GMM on dynamic panel model, the dynamic nature of our estimates could control for potential endogeneity and panel unit root, helping place these results into a better perspective. The empirical results find that overall the national differences in IPRs protection do exist a significant positive influence on Taiwan's exports after controlling other country characteristics. In other words, the market expansion strategy is more prevailing for Taiwan's exports to both developed and developing countries. Moreover, the positive trade effect of IPRs is stronger for high-tech than non high-tech exports.

By employing various classification systems to differentiate the degree of threat-of-imitation across countries, the role of threat-of-imitation emphasized in theoretical arguments is examined in this study. We find that both market expansion and market power do exist in Taiwan's case and the market expansion strategy tend to be more prevailing, while the Taiwan evidence on the link between empirical evidence and theory on threat-of-imitation and trade seems to be contradictable with developed countries' experience.

Some key policy implications are inspired from the results. First, given the circumstance that high-tech exports have become one of major driving forces of Taiwan's economic growth and foreign IPRs protections indeed exhibit a positive

impact on Taiwan's exports, the Taiwan government should keep on encouraging firms to improve their technological capability through tax and non-tax measures in order to improve the international competitiveness of Taiwanese high-tech products in the global market.

IPRs protection is actually positively associated with trade and then the degree of law enforcement should play the key role in protecting patented imports. Therefore, the WTO-TRIPs agreement aiming to harmonize the mean of IPRs protection is beneficial to Taiwan from the dynamic point. For example, the trade between strait surged extremely rapid and now China has become Taiwan's major trade pattern. However, it is well known that the enhancement of patent protection is extremely weak in China and it can lead to the erosion of high profits for foreign innovating firms as local firms produce fake goods and set a lower price even though foreign firms have filed the patent in China. If China strengthens the enforcement of IPRs protection, it will stimulate further growth of Taiwan's exports to China.

Reference

Ahn, S.C. and P. Schmidt (1995), Efficient Estimation of Models for Dynamic Panel Data, *Journal of Econometrics*, 68, 5-27.

Al-Mawali, N. (2005), Bilateral Intra-industry Trade Flows and Intellectual Property Rights Protection: First Empirical Evidence, *Applied Economics Letters*, 12, 823-828.

Anderson, J.E. (1979), A Theoretical Foundation of the Gravity Equation, *American Economic Review*, 69, 106-116.

Anderson, T.W. and C. Hsiao (1982), Formulation and Estimation of Dynamic Models Using Panel Data, *Journal of Econometrics*, 18, 47-82.

Arellano, M. and O. Bover (1995), Another Look at the Instrumental Variable Estimation of Error-Components Models, *Journal of Econometrics*, 68, 29-51.

Bergstrand, J. (1985), The Gravity Equation in International Trade: Some Micro-economic Foundations and Empirical Evidence, *Review of Economics and Statistics*, 67, 474-481.

Brown, D. (1991), Tariffs and Capacity Utilization by Monopolistically Competitive Firms, *Journal of International Economics*, 30, 371-381.

Chu, W.W. (1988), Export-Led Growth and Import Dependence: The Case of Taiwan, 1969-1981, *Journal of Development Economics*, 28, 265-276.

Cohen, W.M., R.R. Nelson and P.J. Walsh (2000), Protecting Their Intellectual Assets: Appropriability Conditions and Why U.S. Manufacturing Firms Patent (or Not), NBER Working Paper Series, No. 7552.

Ferrantino, M.J. (1993), The Effect of Intellectual Property Rights on International Trade and Investment, *Weltwirtschaftliches Archiv*, 129, 300-331.

Ginarte, J.C. and W.G. Park (1997), Determinants of Patent Right: A Cross-National Study, *Research Policy*, 26, 283-301.

Gould, D.M. and W.C. Gruben (1996), The Role of Intellectual Property Rights in Economic Growth, *Journal of Development Economics*, 48, 323-350.

Hsiao, C. (1986), *Analysis of Panel Data*, Cambridge University Press.

Im, K., H. Pesaran and Y. Shin (2003), Testing for Unit Roots in Heterogeneous Panels, *Journal of Econometrics*, 115, 53-74.

Liu, W.H. and Y.C. Lin (2005), Foreign Patent Rights and High-tech Exports: Evidence from Taiwan, *Applied Economics*, 37, 1543-1555.

Maskus, K.E. (1997), Implications of Regional and Multinational Agreement for Intellectual Property Rights, *World Economy*, 20, 681-694.

Maskus, K.E. (1998), The International Regulation of Intellectual Property, *Weltwirtschaftliches Archiv*, 134, 186-207.

Maskus, K.E. and M. Penubarti (1995), How Trade-Related Are Intellectual Property Rights? *Journal of International Economics*, 39, 227-248.

Palmberg, C. (2004), The Sources of Innovations – Looking beyond Technological Opportunities, *Economics of Innovation and New Technology*, 13, 183-197.

Rafiquzzaman, M. (2002), The Impact of Patent Rights on International Trade: Evidence from Canada, *Canadian Journal of Economics*, 35, 307-330.

Rapp, R.T. and R.P. Rozek (1990), Benefits and Costs of Intellectual Property Protection in Developing Countries, *Journal of World Trade*, 24, 75-102.

Schwartz, M. (1991), Patent Protection through Discriminatory Exclusion of Imports, *Review of Industrial Organization*, 6, 231-246.

Smith, P.J. (1999), Are Weak Patents a Barrier to U.S. Exports? *Journal of International Economics*, 48, 151-177.

Smith, P.J. (2001), How do Foreign Patent Rights Affect U.S. Exports, Affiliate Sales, and Licenses? *Journal of International Economics*, 55, 411-439.

Smith, P.J. (2002), Patent Rights and Trade: Analysis of Biological Products,

Medicinal and Botanicals, and Pharmaceuticals, *American Journal of Agricultural Economics*, 84, 495-512.

Taylor, M.S. (1993), TRIPS, Trade and Technology Transfer, *Canadian Journal of Economics*, 26, 625-637.

Yang, C.H. and R.J. Woo (2006), Do Stronger Intellectual Property Rights Induce More Agricultural Trade? A Dynamic Panel Data Model Applied to Planting Seed Trade, *Agricultural Economics*, 35(1), 91-102

Table 1 Empirical Studies of Intellectual Property Rights – Trade Relationship

Study	*Exporting Country, period(T), industry, and number of importing countries (N)*	*Model*	*IPRs protection index*	*IPRs Effect* (+, -, or no)
Cross-sectional Study				
Ferrantino (1993)	US, T=1982, Total exports, N=77	Gravity model	1. Number of conventions involved 2. Duration of patent protection	No
Maskus and Penubarti (1995)	US, T=1984, 28 ISIC 3-digit industries, N=77	Helpman-Krugman model	Rapp-Rozex index	+
Smith (1999)	US, T=1992, 19 SIC 2-digit industries N=95	Gravity model	Rapp-Rozex index	+, –
Smith (2001)	US, T=1989, Manufacturing sector, N=50	Gravity model	Rapp-Rozex index	+, –
Rafiquzzaman (2002)	Canada, T=1990, 22 SIC 2-digit industries, N=76	Gravity model	Rapp-Rozex index	+
Smith (2002)	US, T=1972, 1977, 1982, 1987, 1992, Biological products, Medical chemicals and botanical products, and Pharmaceutical preparations, N=105	Gravity model	Ginart-Park index	+, –
Liu and Lin (2005)	Taiwan, T=1989-2000, Semiconductor, Communication Equipment, and Information, N=54	Gravity model	Ginart-Park index	+, –
Panel Data Study				
Al-Mawali (2005)	South Africa, T=1995, 2000, Total intra-industry trade, N=50	Gravity model	Ginart-Park index	No
Yang and Woo (2006)	US, T=1990-2000, Planting seed, N=60	Gravity model	Adheres to IPRs agreements	No

Table 2 Variable Definition, Basic Statistics, and Data Sources

Variable name	Definition	Mean	Standard Error	Data Source
EXP	The Value of exports from Taiwan to country *i* (US$ million)	2395.230	5825.410	Bureau of Foreign Trade, Ministry of Economic Affairs, Taiwan http://www.trade.gov.tw/index.asp
PGDP	Per capita gross domestic product of destination country (US$)	15494.862	10245.931	IMF World Economic Outlook Database
DIS	Geographic distance between Taiwan and country *i* (km)	14021.416	26615.953	GIS Research Center at Feng Chia University, Taiwan
POP	Population of destination country (thousand)	88745.233	220471.364	IMF World Economic Outlook Database
IPR	The degree of IPRs protection of destination Country. It ranges from 1-7 and a higher value denotes a stronger protection	4.667	1.177	The Global Competitiveness Report, World Economic Forum
OPEN	Openness Degree: the ratio of the sum of imports and exports to GDP. (%)	70.056	53.585	IMF World Economic Outlook Database
TB	Trade Barrier: average tariff rate of destination country	6.700	6.408	The Global Competitiveness Report, World Economic Forum
NTB	Non Tariff Barrier: hidden import barriers of destination country. It ranges from 1-7. 1= an important problem, 7=not an important problem.	5.017	0.992	The Global Competitiveness Report, World Economic Forum

Note: The means and standard errors are calculated by pooling data for the 1997-2003 period.

Table 3 IPRs and Trade (Pooling Data Estimates)

	Total	High-tech	Non High-tech
Constant	-11.662***	-14.674***	-9.969***
	(1.289)	(1.248)	(1.530)
lnPGDP	0.629***	0.806***	0.409***
	(0.092)	(0.089)	(0.109)
lnPOP	1.087***	1.137***	1.056***
	(0.040)	(0.039)	(0.048)
lnDIS	-0.597***	-0.593***	-0.629***
	(0.057)	(0.055)	(0.067)
lnOPEN	0.758***	0.810***	0.568**
	(0.088)	(0.085)	(0.105)
lnTB	-0.352***	-0.407***	-0.323***
	(0.104)	(0.100)	(0.123)
lnNTB	0.744**	0.897***	0.656
	(0.349)	(0.337)	(0.413)
lnIPR	1.870***	1.819***	1.701***
	(0.255)	(0.274)	(0.303)
R^2	0.799	0.829	0.716
Number of Obs.	357	357	357

Note: Figures in parentheses are standard deviations. *** and ** represent statistical significance at the 1% and 5% levels, respectively.

Table 4 IPRs and Taiwan's Exports (Within Estimates)

	Total Exports		High-tech		Non High-tech	
	Random Effects	Fixed Effects	Random Effects	Fixed Effects	Random Effects	Fixed Effects
Constant	1.888		-3.075*		-1.473	
	(1.761)		(1.498)		(2.037)	
lnPGDP	0.226***	0.166***	0.286***	0.202***	0.148***	0.114**
	(0.047)	(0.049)	(0.050)	(0.052)	(0.049)	(0.051)
lnPOP	0.804***	-0.351	0.814***	-0.713	0.782***	-0.535
	(0.080)	(0.678)	(0.077)	(0.720)	(0.094)	(0.702)
lnDIS	-0.593***	dropped	-0.587***	dropped	-0.632***	dropped
	(0.126)		(0.121)		(0.150)	
lnOPEN	0.435***	0.397***	0.423***	0.360***	0.337***	0.319***
	(0.102)	(0.116)	(0.106)	(0.123)	(0.109)	(0.119)
lnTB	-0.334***	-0.267***	-0.422***	-0.329***	-0.108	-0.060
	(0.068)	(0.072)	(0.072)	(0.076)	(0.071)	(0.074)
lnNTB	0.806***	0.661***	0.849***	0.650***	0.810***	0.709***
	(0.171)	(0.175)	(0.181)	(0.186)	(0.178)	(0.181)
lnIPR	0.521***	0.282**	0.576***	0.262*	0.405***	0.242*
	(0.134)	(0.140)	(0.142)	(0.148)	(0.140)	(0.144)
R^2	0.706	0.980	0.736	0.980	0.621	0.979
Hausman test		52.798***		74.978***		31.341***
D-W test	0.061***	0.860***	0.074***	0.979***	0.043***	0.739***

Note: Figures in parentheses are standard deviations. ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively. Dropped indicates that the variable is a time-invariant variable that is dropped out of the estimation because fixed effects estimation cannot estimate variables that do not change over time.

Table 5 Panel Unit Root Tests

Method	Statistic	Probability
Im, Pesaran and Shin W-statistic	0.396	0.665
ADF-Fisher Chi-square	104.745	0.406

Note: the null hypotheses assume individual unit root process.

Table 6 IPRs and Trade (GMM for Dynamic Panel Data Model)

	Total	High-tech	Non High-tech
lnEXP(-1)	0.683***		
	(0.020)		
lnTEXP(-1)		0.688***	
		(0.020)	
lnNTEXP(-1)			0.727***
			(0.017)
lnPGDP	0.086***	0.079***	0.102***
	(0.011)	(0.014)	(0.011)
lnPOP	0.280***	0.302***	0.197***
	(0.019)	(0.020)	(0.011)
lnDIS	-0.456***	-0.488***	-0.383***
	(0.026)	(0.025)	(0.023)
OPEN	-0.007	-0.035	-0.033
	(0.035)	(0.038)	(0.030)
TB	-0.238***	-0.331***	-0.038**
	(0.026)	(0.041)	(0.016)
NTB	0.864***	1.003***	0.457***
	(0.073)	(0.117)	(0.081)
IPR	0.374***	0.373***	0.275***
	(0.034)	(0.029)	(0.024)
Sargan test (df)	25.522(34)	24.861(34)	25.310(34)

Note: Figures in parentheses are standard deviations. *** and ** represent statistical significance at the 1% and 5%, respectively.

Table 7 The Relationship between Threat of Imitation and Market Expansion and Market Power Effects

	Weak Patent Rights	Strong Patent Rights
Weak Imitative Abilities	2. Moderate Threat of Imitation; Ambiguous Effect (+/-)	1. Weak Threat of Imitation; Market Power Effect (-)
Strong Imitative Abilities	4. Strong Threat of Imitation; Market Expansion Effect (+)	3. Moderate Threat of Imitation; Ambiguous Effect (+/-)

Data Source: Smith (1999), p.156.

Table 8 Threat-of-Imitation and Taiwan's Exports (GMM for Dynamic Panel Data Model)

	Group 1 Weak Imitative Abilities, Strong IPRs	Group 2 Weak Imitative Abilities, Weak IPRs	Group 3 Strong Imitative Abilities, Strong IPRs	Group 4 Strong Imitative Abilities, Weak IPRs
Classification 1				
Total	0.278 (0.194)	0.288 (0.079)***	-0.320 (0.066)***	0.804 (0.241)***
High-tech	0.487 (0.196)**	0.179 (0.065)***	-0.336 (0.083)***	0.819 (0.186)***
Non High-tech	0.055 (0.124)	0.216 (0.042)***	-0.196 (0.035)***	0.672 (0.127)***
Classification 2				
Total	7.611 (6.177)	0.303 (0.042)***	-0.496 (0.099)***	0.053 (0.106)
High-tech	10.004 (8.042)	0.313 (0.056)***	-0.530 (0.093)***	-0.063 (0.064)
Non High-tech	6.460 (5.051)	0.177 (0.034)***	-0.464 (0.063)***	0.204 (0.088)**
Classification 3				
Total	0.387 (0.074)***	0.175 (0.055)***	-0.384 (0.069)***	no sample
High-tech	0.547 (0.102)***	0.135 (0.065)**	-0.439 (0.069)***	no sample
Non High-tech	0.277 (0.085)***	0.137 (0.045)***	-0.328 (0.057)***	no sample
Classification 4				
Total	0.330 (0.355)	0.220 (0.029)**	-0.255 (0.106)***	-0.457(0.182)**
High-tech	0.469 (0.396)	0.235 (0.038)***	-0.292 (0.105)***	-0.610 (0.177)***
Non High-tech	0.395 (0.319)	0.175 (0.027)***	-0.212 (0.076)***	-0.727 (0.222)***
Classification 5				
Total	0.460 (0.164)***	0.246 (0.067)***	-0.305 (0.068)***	-1.081 (0.384)***
High-tech	0.498 (0.196)**	0.209 (0.086)**	-0.306 (0.067)***	-0.809 (0.539)
Non High-tech	0.472 (0.146)***	0.188 (0.062)***	-0.327 (0.049)***	-0.930 (0.139)***

Table 8 Threat-of-Imitation and Taiwan's Exports (GMM for Dynamic Panel Data Model), Continuous

	Group 1 Weak Imitative Abilities, Strong IPRs	Group 2 Weak Imitative Abilities, Weak IPRs	Group 3 Strong Imitative Abilities, Strong IPRs	Group 4 Strong Imitative Abilities, Weak IPRs
Classification 6				
Total	0.593 (0.265)**	0.271 (0.048)***	-0.503 (0.105)***	-0.225 (0.075)***
High-tech	0.671 (0.271)**	0.208 (0.066)***	-0.520 (0.096)***	-0.142 (0.096)
Non High-tech	0.275 (0.140)**	0.212 (0.058)***	-0.276 (0.054)***	-0.328 (0.069)***
Classification 7				
Total	0.233 (0.043)***	0.188 (0.036)***	-0.592 (0.124)***	0.066 (0.019)***
High-tech	0.278 (0.052)***	0.145 (0.037)***	-0.597 (0.115)***	0.048 (0.020)**
Non High-tech	0.197 (0.048)***	0.162 (0.043)***	-0.512 (0.114)***	0.054 (0.025)**
Classification 8				
Total	-0.006 (0.077)	0.239 (0.026)***	-0.890 (0.194)***	-0.582 (0.183)***
High-tech	0.033 (0.072)	0.238 (0.033)***	-0.811 (0.180)***	-0.778 (0.207)***
Non High-tech	0.102 (0.056)*	0.152 (0.021)	-0.674 (0.150)***	-0.508 (0.135)***

Note: Figures in parentheses are standard deviations. ***, ** and * represent statistical significance at the 1%, 5% and 10% levels, respectively.

Classification 1: strong imitative abilities: per capita GDP > 8356; strong IPRs: IPRs index > 4

Classification 2: strong imitative abilities: per capita GDP > 8356; strong IPRs: IPRs index > mean (4.652)

Classification 3: strong imitative abilities: per capita GDP > Taiwan(13150); strong IPRs: IPRs index > 4

Classification 4: strong imitative abilities: per capita GDP > Taiwan(13150); strong IPRs: IPRs index > mean (4.652)

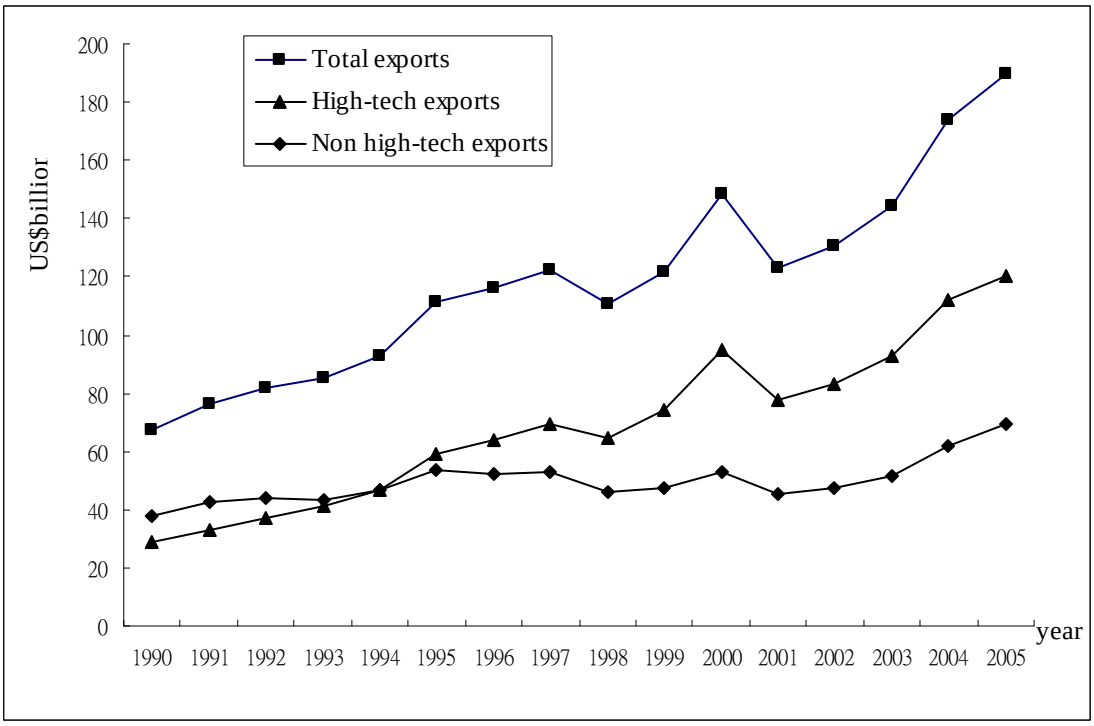
Classification 5: strong imitative abilities: RD/GDP > 0.5%; strong IPRs: IPRs index > 4

Classification 6: strong imitative abilities: RD/GDP > 0.5%; strong IPRs: IPRs index > mean (4.652)

Classification 7: strong imitative abilities: RD/ GDP > Taiwan(1.92); strong IPRs: IPRs index > 4

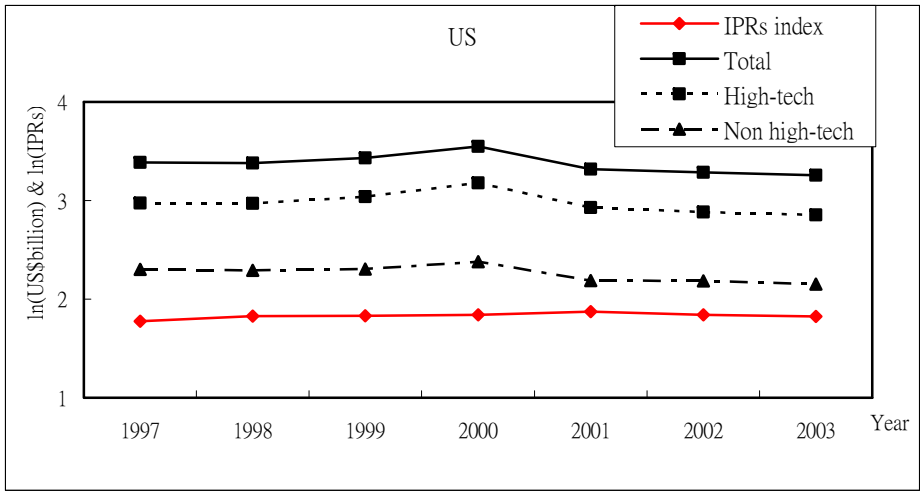
Classification 8: strong imitative abilities: RD/ GDP > Taiwan(1.92); strong IPRs: IPRs index > mean (4.652)

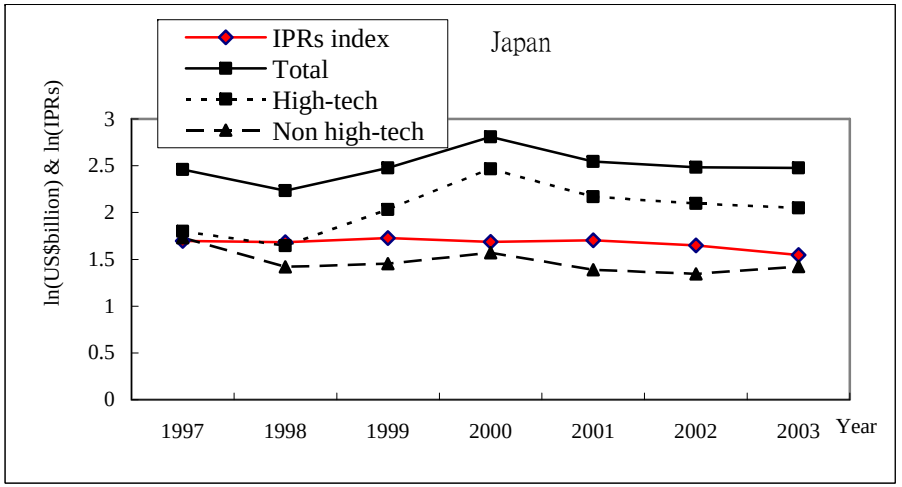
Figure 1 Taiwan's Exports and Its Composition, 1990-2005

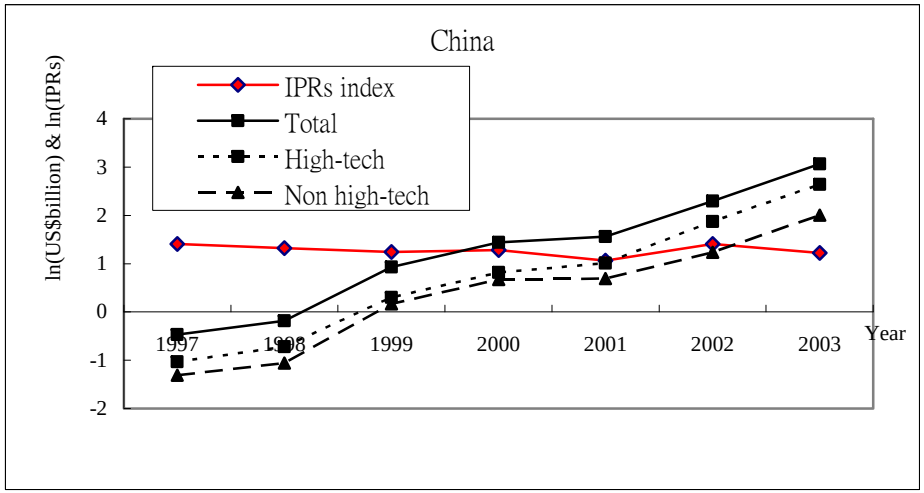


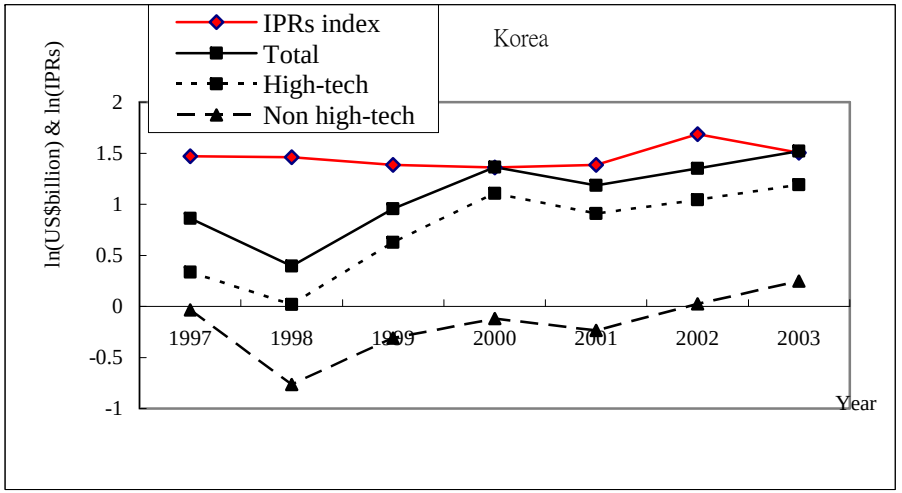
Data Source: The data for total exports are obtained from Ministry of Economic Affairs, Taiwan. The values of high-tech and non high-tech exports are calculated by the authors.

Figure 2 IPRs Strength and Imports Trend









Appendix Countries and Threat-of-Imitation Data

Case	Country	System 1	System 2	System3	System 4	System 5	System6	System 7	System 8
1	Argentina	G4	G4	G2	G2	G2	G2	G2	G2
2	Australia	G3	G3	G3	G3	G3	G3	G1	G1
3	Austria	G3	G3	G3	G3	G3	G3	G1	G1
4	Belgium	G3	G3	G3	G3	G3	G3	G1	G1
5	Brazil	G1	G2	G1	G2	G3	G4	G2	G2
6	Canada	G3	G3	G3	G3	G3	G3	G1	G1
7	Chile	G3	G4	G1	G2	G3	G4	G2	G2
8	China, PR	G2	G2	G2	G2	G4	G4	G2	G2
9	Colombia	G2	G2	G2	G2	G2	G2	G2	G2
10	Czech	G3	G4	G1	G2	G3	G4	G2	G2
11	Denmark	G3	G3	G3	G3	G3	G3	G3	G3
12	Egypt	G2	G2	G2	G2	G2	G2	G2	G2
13	Finland	G3	G3	G3	G3	G3	G3	G3	G3
14	France	G3	G3	G3	G3	G3	G3	G3	G3
15	Germany	G3	G3	G3	G3	G3	G3	G3	G3
16	Greece	G3	G4	G1	G2	G3	G4	G2	G2
17	Hong Kong	G3	G3	G3	G3	G1	G1	G1	G1
18	Hungary	G1	G2	G1	G2	G3	G4	G2	G2
19	Iceland	G3	G4	G3	G4	G3	G4	G4	G4
20	India	G2	G2	G2	G2	G2	G2	G2	G2
21	Indonesia	G2	G2	G2	G2	G2	G2	G2	G2
22	Ireland	G3	G3	G3	G3	G3	G3	G1	G1
23	Israel	G3	G3	G3	G3	G3	G3	G3	G3
24	Italy	G3	G3	G3	G3	G3	G3	G1	G1
25	Japan	G3	G3	G3	G3	G3	G3	G3	G3

26	Jordan	G2	G2	G2	G2	G2	G2	G2	G2
27	Korea, RP	G3	G4	G3	G4	G3	G4	G4	G4
28	Malaysia	G3	G3	G1	G1	G1	G1	G1	G1
29	Mexico	G3	G4	G1	G2	G1	G2	G2	G2
30	Netherlands	G3	G3	G3	G3	G3	G3	G3	G3
31	New Zealand	G3	G3	G3	G3	G3	G3	G1	G1
32	Norway	G3	G3	G3	G3	G3	G3	G1	G1
33	Peru	G2	G2	G2	G2	G2	G2	G2	G2
34	Philippines	G2	G2	G2	G2	G2	G2	G2	G2
35	Porland	G1	G2	G1	G2	G3	G4	G2	G2
36	Portugal	G3	G4	G3	G4	G3	G4	G2	G2
37	Russia	G2	G2	G2	G2	G2	G2	G2	G2
38	Singapore	G3	G3	G3	G3	G3	G3	G1	G1
39	Slovak	G4	G4	G2	G2	G4	G4	G2	G2
40	South Africa	G1	G1	G1	G1	G1	G1	G1	G1
41	Spain	G3	G3	G3	G3	G3	G3	G1	G1
42	Sweden	G3	G3	G3	G3	G3	G3	G3	G3
43	Switzerland	G3	G3	G3	G3	G3	G3	G3	G3
44	Thailand	G1	G2	G1	G2	G1	G2	G2	G2
45	Turkey	G1	G2	G1	G2	G1	G2	G2	G2
46	Ukraine	G2	G2	G2	G2	G2	G2	G2	G2
47	U.K.	G3	G3	G3	G3	G3	G3	G3	G3
48	U.S.	G3	G3	G3	G3	G3	G3	G3	G3
49	Venezuela	G4	G4	G2	G2	G2	G2	G2	G2
50	Vietnam	G2	G2	G2	G2	G2	G2	G2	G2
51	Zimbabwe	G2	G2	G2	G2	G2	G2	G2	G2