Protection of Intellectual Property Right and International Technology Transfer: Empirical Evidence*

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Abstract

Whether intellectual property right (IPR) is actually protected is one of important issues for international economy. We conducted an original survey of firms' evaluation on IPR protection in forty-five countries, which presents that the actual enforcement differs from the enacted provisions. By matching the survey data with the firm-level data of Japanese MNCs, we examine statistically the effect of IPR protection on technology transfer. The results of our estimation reveal that the stronger enforcement of IPR accelerates the intra-firm technology transfer measured by royalty payments from affiliate to their parent firms and in particular that the elasticity of IPR protection to technology transfer estimated by the data of actual protection is larger than one by the data of legal provisions. The result of statistical examination based on our survey data suggests that not surface but actual enforcement of IPR protection is important for enhancing international technology transfer.

Keywords: Intellectual Property Right, Technology transfer, Multinational firms, WTO, TRIPS Agreement

JEL classification: C23, F23, O31, O34

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1. Introduction

The protection of intellectual property right (IPR) is a serious concern for international economy since it affects not only the trade of goods but also the decision of foreign direct investment and technology licensing of multinational firms. The government of the United States requested China for consultation at WTO concerning the practices of IPR protection in China. China committed the enactment of legal provisions for IPR protection when it became a member of WTO. After the ratification of TRIPS Agreement, many countries have enacted necessary legal provisions. WTO carefully has watched what system is introduced and sometimes has issued a recommendation to some countries including China to take an action to enforce more effectively its legislative provisions. Many firms including Japanese firms which are involved into international trade, FDI and technology licensing are becoming so sensitive to the implementation of IPR protection in growing countries like China and India

While the legal provisions are enacted according to international negotiations, the real implementation is determined by domestic reasons in each country including the capability to implement the legal and administrative system, the level of technology of domestic firms, human resources for R&D, and so on. The actual enforcement of IPR is more or less different from the enacted legal provisions in many countries. Multinational firms therefore are sensitive to how effectively the legislative system is implemented rather than what provisions exist. Therefore, it is important to observe the actual enforcement of IPR protection and investigate its effect on international trade, FDI and technology licensing.

There are several studies investigating of the effect of IPR on the international transactions such as export and FDI (Javorcik, 2004; Maskus and Penubarti, 1995; Lee and Mansfield 1996; Smith 1999, 2001). As for international technology transfer, Branstetter et al (2006) and Wakasugi and Ito (2005) examine the effect of IPR on intra-firm technology transfer of multinational firms., It is noted that these studies are based on the enacted legal provisions, not on the actual enforcement. In spite of a rising importance of the issue, as long as we know, there are few studies of the effect of actual implementation of IPR. There are some reasons for insufficient studies. One is due to the limited availability of data for the actual enforcement of IPR, which really affects the corporate decision of export, FDI and technology licensing. Another is the limited availability in using firm-level data of international trade, FDI and technology licensing. Few countries disclose firm-level data on the international transfer of technology. The United States exceptionally performs detailed surveys on the activity of multinational firms. Thus, most previous literatures on the analysis of IPR have so far depended on data of the U.S.

In order to supplement the previous studies, this paper contributes in two points. One is to provide new findings on the actual enforcement of IPR. With the cooperation of Research Institute of Economy, Trade and Industry of Japan, we conducted an original survey on how Japanese firms assess the actual protection of IPR is enforced in forty five countries. The survey supplies the useful data for clarifying the difference between the enacted provision and its actual implementation among courtiers. By using the data, we attempted to examine statistically the effects of enforcement of IPR on the intra-firm technology transfer. The technology transfer from the firms in the North to those in the

South is of course realized through arm's length licensing contract too. But we focused only the intra-firm technology flow between Japanese firms and their overseas affiliates due to the availability of the data.

Another contribution of this paper is en empirical analysis using firm-level data of Japanese foreign affiliates in these countries. We construct original panel-data by matching firm-specific factors of Japanese multinationals with the market-specific factors including the original survey data of their assessment of IPR protection.

For the purpose of empirical examination, we present a simple analytical framework based on imperfect competition that explains the mechanism on how the strengthened IPR affects the international technology transfer. The introduction of stronger protection of IPR, by preventing local firms in the host country from imitating freely foreign technology, raises their cost to produce the identical goods which the affiliates of foreign firms do. It in turn is beneficial to foreign affiliates using the technology transferred from their parent firms and provides parent firms with an incentive to supply more technology which lowers their marginal cost. Then the stronger enforcement of IPR in the host country eventually tends to accelerate the technology transfer from foreign firms to their affiliates, in comparison with the case of weaker enforcement of IPR. We assume that the stronger IPR provides the technology supplier with an incentive to transfer larger volume or higher value of technology. In the part of empirical examination of the paper, we test how significantly the actual enforcement of IPR affects the intra-firm technology flow from Japanese firms to their affiliates overseas.

The findings of this paper are twofold. Firstly, the paper presents the evidence that there exist

differences between the enacted provisions and firm's assessment of actual enforcement of IPR in many countries. We assume that firms determine the level of technology transfer based on the actual enforcement of IPR rather than its legal provisions. Secondly, our empirical examination, using the evaluation of firms on the IPR enforcement instead of the enactment of legal provisions, presents that stronger enforcement of IPR stimulates technology transfers. The result is consistent with and supportive to the previous studies.

This paper is organized as follows: Section 2 presents our original survey of Japanese firms' evaluation on actual enforcement of IPR in major trading countries. Section 3 describes the analytical framework and specification of model for empirical examination of the effect of the strengthened IPR on technology transfer. Section 4 describes statistical data used for estimation. Section 5 presents the estimated results. The last section concludes this paper.

2. Enacted Provisions vs. Actual Enforcement

Park and Wagh (2002) has surveyed the legal provisions of patent rights for 63 countries every five years. They allot scores based on the following five criteria: (1) Does the protection of patent right cover major industries such as pharmaceutical, chemical, foods, etc.? (2) How long is the protection of the patent right valid? (3) Is there provision for legal enforcement? (4) Is the country a member of international treaties? (5) Do restrictions exist on patent rights? The score ranges from 0 to 5; a high score implies a stronger IPR system. Their survey data constructed the index of IPR protection ("IPR I" hereafter) which was useful to express quantitatively the degree of

enforcement of IPR and conduct international comparison. Actually, many empirical studies were based on the index (e.g. Javorcik, 2004).

As we mentioned in Introduction, we note that the reasons why the US government requested consultations with China on April 2007 concerning the related measures to the protection and enforcement of IPR in China are possible inconsistencies with the TRIPS Agreement at four points: (1) the lack of criminal procedures and penalties for commercial scale counterfeiting and piracy in China as a result of the thresholds appears to be inconsistent with China's obligations under the TRIPS Agreement, (2) the requirement that infringing goods be released into the channels of commerce under the circumstances set force in the measures at issue appears to be inconsistent with China's obligation under the TRIPS Agreement, (3) authors of works whose publication or distribution has not been authorized appear not to enjoy the minimum standards of protection granted by the Berne Convention, to the extent that the Copyright Law denies protection of so-called related rights to performers and producers of sound recordings during the period of pre-publication or pre-distribution, the Copyright Law appears to be inconsistent with China's obligations under the TRIPS Agreement, to the extent that China's Copyright Law makes it impossible for rights holders to enforce their copyrights or related rights with respect to works, performances or sound recordings that have not been authorized for publication or distribution, China appears to act inconsistently with China's obligations under the TRIPS Agreement, (4) to the extent that willful copyright piracy on a commercial scale that consists of unauthorized reproduction of copyrighted works may not be subject to criminal procedures and penalties under the law of China, this would appear to be inconsistent with

China's obligation under the TRIPS Agreement. The foregone seems to be a problem for actual enforcement of IPR not for legal provisions and suggests that there exists a difference between the actual enforcement and the formal enactment of provisions. This is not a case only for China. The actual enforcement of IPR is more or less different from the formal provisions in many countries.

In the decision of transferring technology, firms are sensitive to how actually IPR is protected rather than what provisions are enacted. It is therefore essential to use the information of actual enforcement of IPR for examining its effect on technology transfer. In this sense, for the empirical test, the use of information of actual enforcement of IPR is more adequate than the index of Park and Wagh. Such data, however, have not been provided so far. In 2007, with the cooperation of Research Institute of Economy, Trade and Industry of Japan, we have conducted an original survey on 5500 Japanese firms, to collect their evaluation of the actual enforcement of IPR in 45 countries[1]. The survey asked what score from 1 to 5 they allot for their evaluation of IPR enforcement to each country. The score "5" is allotted to the country if the firm evaluates the protection of IPR complete, while the score "1" is allotted if they evaluate nothing to be protected at all. The firm is requested to choose the integer number from 5 to 1, corresponding to its evaluation for the strength of IPR protection among five stages: that is, 5 for completely protected, 4 for protected not completely but significantly, 3 for protected in some extent, 2 for protected only partly, 1 for not protected at all. We took the average of the scores given by Japanese firms for each country. In this paper we name them "IPR II" as index of actual IPR protection.

[1] The total number of firms covered by the survey is 5528. They assessed IPR protection in at least one country, but did not necessarily assess IPR in all 45 countries.

Figure 1 presents IPR II of each country. The horizontal axis shows the per capita GDP and the vertical axis the average score of firm's evaluation by country. The scores of 45 countries are plotted along the order of per capita GDP. The figure presents a finding that the country of higher per capita GDP tends to enforce the stronger protection of IPR. Nine countries, the United Sates, Germany, United Kingdom, France, Canada, Switzerland, Sweden, Australia and Italy record the score of more than "4" while eighteen countries including China, Bangladesh Colombia, Sri Lanka, Indonesia, Brazil and Thailand record the score less than "3".

Figure 1

In order to clarify the difference between the firm's evaluations on the actual enforcement of IPR and the level of enacted legal provisions, we plot both IPR I and IPR II in the same figure. Table 1 also presents the indices of IPR I and IPR II by country.

Table 1

As well as IPR II, IPR I shows the trend that the country with higher per capita GDP presents the higher score of protection. The rank correlation coefficient between IPR Ⅰ and IPR Ⅱ in 45 countries is 0.703, which means both indices are correlated in some extent. However, in 27 the value of IPR II is lower than one of IPR I. In particular, in 17 countries record the wide difference between IPR I and IPR II at the margin of more than 10 percent. The comparison of two indices provides the evidence that the actual enforcement based on the firm's evaluation is not necessarily similar to the level of enacted legal provisions. For examining how significantly IPR affects the corporate decision of trade, FDI and technology licensing, the data for actual enforcement is more

adequate than the legal provisions.

3. Empirical Examination

3.1 Analytical Framework

In this section we examine statistically the effect of IPR protection on the corporate decision for intra-firm technology licensing. We assume a simple framework consisting of two types of firms: local firms and affiliates of foreign firms in the host country as follows. Firms of both types supply the sama goods with different marginal costs due to the different level of production technology.

The foreign affiliates use the technology provided from their parent firms through licensing and local firms use foreign technology by imitating from the foreign affiliates. We assume that the higher the intra-firm technology transfer, the lower the marginal cost of their production, but for absorbing the advanced technology they have to pay higher cost than the proportional increase of the technology level. We also assume that the higher the level of imitated technology, the lower the marginal cost of local firms for production, but they have to pay additional cost if the government in the host country strengthens the enforcement of IPR protection for foreign technology. This indicates that the stronger enforcement of IPR causes a rise of marginal cost to product. As both firms supply the same goods in the host country, the foreign affiliates increase their production volume, and on the other hand the local firms reduce the volume of production when the government in the host country raises the level of IPR enforcement since it causes an increase in imitation cost for local firms.

As for the intra-firm technology flow and the level of enforcement of IPR protection, we

assume that the parent firms of their affiliates choose the optimal level of technology transfer so as to maximize the profitability of the affiliates under the given market condition endogenously, but the government in the host country is obliged to reduce a given level of IPR protection due to international arrangements. Then the decision of the government will in turn affect the optimal level of technology transfer.

Of course, the larger production of foreign firms may positively affect the consumer welfare in the host country even if it replaces a part of supply of local firms, and in a long run, the stronger enforcement of IPR may stimulate the technological innovation in the host country. It is needed to the long-run effect. However, we do not take into account the indirect effects, but only focus on the profits of parents firms and their affiliates so as to extract the direct effects of IPR protection on the determinants of the level of intra-firm technology flow. As the optimal level of technology transfer under the profit maximization of foreign firms is determined by exogenous factors, we set forth the hypotheses on the determinants of intra-firm technology flow as follows:

(1) A rise of imitation cost caused by the strengthened enforcement of IPR increases the intra-firm technology flows.

Secondly, we also note other market specific factors including the size of the market in the host country, the difference of corporate tax between two countries: foreign and host countries, the market openness of the host country.

(2) The size of market will provide incentives to increase technology flow, and then promotes the technology transfer.

(3) If the corporate tax varies between two countries, the technology transfer may be used as a channel of remittance of profit from the affiliates to parent firms. Suppose the affiliates face a rise of corporate tax rate in the host country. They tend to remit their profits as a pose of royalty payments in order to save the tax payment. In this case, the royalty payment for technology transfer is counted over the actual amount of technology transfer. The difference in tax rate between two countries will distort the royalty payment for technology transfer if the affiliate firms execute it as a toll of transfer pricing.

(4) The characteristics of the host country include the openness of the market defined by the total trade volume (export + import) per GDP. We note that previous studies have empirically demonstrated the importance of the openness of the host country's market. If the economy highly depends on the international trade, it tends to realize the larger international technology transfer.

Thirdly we note the specific factors of parent and affiliate firms such as the capability to absorb the technology. The theory of "learning by doing" indicates that the larger the R&D expenditure of the firm, the higher the capability to absorb the technology.

(5) Then, we assume that the larger R&D expenditure of the parent firm induces the lower cost of its affiliate to absorb the technology and then the absorption cost of the subsidiary is lower if R&D expenditure of parent firm is larger.

(6) Both sizes of parent and affiliate firms positively affect the volume of technology transfer. The term of affiliate to operate in the host country may affect the technology transfer. It is conceivable that the longer the period to operate, the larger the volume of technology transferred to the affiliate. On the other hand, at the beginning stage of operation, affiliate firms tend to depend largely on the parent

firm's technology. There may be a case that the shorter the operation period, the higher the dependency of affiliate firms on the technology from the parent firms. It is ambiguous whether the length of operation raises the volume of technology transfer. The parent firm's share holding of affiliate firms may also affect the technology transfer to its affiliate.

Fourthly, we take into account the industry specific factor and the year specific factor for technology transfer. Some industries in some period tend to transfer the technology so largely while others may not. They must be controlled for identifying only the effect of IPR protection.

3. 2 Model for Estimation

Based on the theoretical conjecture foregone, we test empirically how the enforcement of IPR and other market- specific and firm- specific conditions affect the international technology transfer. Due to the limited availability of firm-level data, our empirical examination focuses on the volume of transferred technology from Japanese multinationals to their affiliates in foreign countries. The equation for estimation is specified as follows:

$$\begin{aligned} \ln TF_{ilt} = {} & \alpha_0 + \beta_1 \ln(IPR_{jt}) + \beta_2 \ln(Size_{jt}) + \beta_3 (TAX_{jt} - TAX_{Japant}) \\ & + \beta_4 Openness_{jt} + \gamma_1 \ln(P\_R\&D_{it}) + \gamma_2 \ln(P\_size_{it}) \\ & + \gamma_3 \ln(A\_size_{lt}) + \gamma_4 \ln(A\_age_{lt}) + \gamma_5 (A\_share_{lt}) \\ & + \delta_t^1 D_t(year) + \sum_{m=1}^{N} \delta_m^2 D_m + u_l + \varepsilon_{ilt} \end{aligned} \qquad (1)$$

where l denotes the affiliates of Japanese firm i, i is the index for the affiliate's parent firm, j denotes

the affiliate's host country, and *t* is the year. α_0 is a constant, u_l represents the individual effect of the affiliate *l*, and ε_{ilt} is the idiosyncratic error term distributed as iid.

The dependent variable TF_{il} is the royalty payment from foreign affiliate *l* to the parent firm *i* , a proxy of the volume of transferred technology from parent firm *i* to affiliate firm *l*. As discussed in the previous section, the imitation cost of local firm is affected by the level of IPR protection in the host country[2]. In equation (1) we use the level of IPR enforcement in country *j* for IPR_j, the predicted sign of the coefficient of IPR_j is positive.

$Size_{jt}$, $TAX_{jt} - TAX_{Japan,t}$, $Openness_{jt}$ present the market size in the host country, the difference of corporate tax defined by the corporate tax rate in the host country minus the corporate tax in Japan, and the openness of the host country to the international market defined by the ratio of total trade volume, export and import, per GDP, respectively. The predicted signs of these variables all are positive.

With regard to the capability of affiliate firms to absorb the technology, R&D expenditure of parent firm $P\_R\&D_i$ is employed. The predicted sign of the coefficient of $P\_R\&D_i$ is positive. P_size_i, A_size_l and A_age_l indicate the size of parent firms, the size of affiliate firm and the period of the affiliate to have operated in the host country, respectively. A_share_l presents the parent firm's share holding of its affiliate. The predicted sign is positive for P_size_i and A_size_l, but ambiguous for A_age_l and A_share_l.

Estimation is conducted under Ordinary Least Square and Random Effects Model. Due to the

[2] In addition to the level of IPR, the imitation cost also is affected by the capability to absorb the technology, which is different among firms and countries.

unbalanced panel data of two periods, we did not estimate under the fixed effects model.

4. **Statistical Data**

For all firm specific data of affiliate firms, TF_{il}, A_size_l and A_age_l .this paper uses the firm-level data of the *Basic Survey of Overseas Business Activities* issued by Japanese Ministry of Economy, Trade and Industry, which is a survey of activities of Japanese multinational companies. Full survey is carried out every three years, while complementary surveys are carried out between the full surveys. The survey cover the affiliates that are capitalized over 10% by Japanese investors, sub-affiliates capitalized over 50% by their affiliates, which are in turn capitalized over 50% by Japanese investors, and the parent firms that own these affiliates.

Data of Japanese affiliates in foreign countries are available for the year of 1995 and 2001, in which a full survey was carried out. The survey covers 10,420 affiliates and 13,693 affiliates in 1995 and 2001, respectively. The sample size is restricted due to the limited availability of data for IPR I, Index of Patent Right (IPR) data provided by Park and Wagh (2002), IPR II, Index of Japanese firms' evaluation of IPR enforcement and the other explanatory variables in equation (1). We constructed the unbalanced panel data comprising 2,227 observations on 1,563 affiliates. We used the data of royalty payments made from affiliate to parent firms in Japan as a proxy of TF_{il} [3].

As for IPR, we used IPR II which covers 45 countries as presented in Table 1 as well as .

[3] With regard to the distinction between the "zero" and "missing" values, a missing value is set to zero only if zero is entered as the total payment for the Japanese investors. After the data cleaning, one value is added for all variables representing the characteristics of parent firms and their affiliates and logarithm is taken for them.

IPR Ⅰ which is is the data surveyed every five years.

The difference between the corporate tax rate in the host country and Japanese corporate tax rate, $TAX_{jt} - TAX_{Japant}$, is obtained from the *Corporate Tax Rate Survey* carried out by KPMG. Data for the total value added of the manufacturing industries in the host country, $Size_{jt}$, and the ratio of total trade volume to GDP as a proxy of the market openness, $Openness_{jt}$, are obtained from the *World Development Indicator* by the World Bank.

Although it is preferable to use R&D stock data for the measurement of the accumulated knowledge of parent firm, we use R&D flow data because of the unavailability of R&D stock data. Data regarding the R&D expenditures of parent firms, $P\_R\&D_i$, and the total sales of parent firms P_size_i as a proxy of the size of parent firm, are collected from the *Basic Survey of Corporate Activities* of Ministry of Economy, Industry and Trade. We matched these data with those of the corresponding affiliates by using a parent code and an affiliate code. Data for the number of affiliate's employees as a proxy of the size of the affiliate firm, A_size_l and the operation period of affiliate firm, A_age_l, and Japanese investor's share holding of affiliate firm, A_share_l, are obtained from the *Basic Survey of Overseas Business Activities*. Table 2 presents the descriptive statistics of variables used for estimating equation (1).[4]

Table 2

[4] The royalty payment, the R&D expenditure and the total industrial value added are deflated by the GDP deflator and expressed in the price of 1995, respectively.

5. Estimated Results

Table 3 presents the results of estimation for equation (1) using the panel data. We estimated equation (1) on OLS and the random effects model, based on the data of IPR II as well as IPR I. We omitted the fixed effects model because of the limited availability of data which cover only one period for many firms. By conducting Breusch-Pagan test, we examine which OLS on the pooling data or random effects model is efficient. Rejecting that the variance is zero implies that the random effects model should be used. The result of the Breusch-Pagan test rejects the pooling estimation model and supports the random-effects model as shown in the last row of the Table 3.

The estimated results based on the data of IPR II are presented at the second column in Table 3. As predicted, the sign of the coefficient of ln(*IPR*) is positive. The value of the estimated elasticity of technology transfers with regard to IPR II is 0.96 with a statistical significance at the 1% level. The wald test of the equality with unit is not rejected, implying that the rate of increase of technology transfers is same as that of the strengthening of IPR.

It is notable that the coefficients of $TAX_{jt} - TAX_{Japan,t}$, which represents the difference in the corporate tax rate between the host country and Japan, is positive. This result is consistent with the theoretical conjecture that a rise of corporate tax rate in the host country accelerates the technology transfer, suggesting the existence of transfer pricing. The market openness also positively affects the technology transfer as expected, and the elasticity of market openness calculated by mean value is 0.17. On the other hand, the market size measured by the total industrial value added in the host country affects negatively.

The estimated coefficient of ln(*P_R&D*), which is a proxy for the R&D capability of the parent firm, presents a positive effect on the technology transfer with a statistical significance at the 1% level. Sizes of both parent and affiliate firms also positively affect the technology transfer with a statistical significance. The magnitude of the size effect is large for affiliate firms. The effect of 1% increase in size of affiliate firms is associated with 0.63% increase in technology transfer from their parent firms. However, the period of affiliate's operation in the host country, A_age_l and Japanese investor's share holding of affiliate firm, A_share_l have no significant effects on the technology transfer.

To summarize, we observed a positive effect of IPR on technology transfers, after controlling the country-specific factors such as market size, trade openness and the difference in corporate tax rate and the firm-specific factors including firm size, R&D intensity, operation period and share holding. This result is consistent with Branstetter et al (2006) which also found the positive correlation between IPR reform and intra-firm technology transfer using U.S firm-level data.

Lastly, we compare the estimated result of the effect of IPR protection based on IPR Ⅱ with those based on IPR Ⅰ. The third column of the Table 3 presents the estimated result based on the data of IPR I. Although the signs of the coefficients and the statistical significances of explanatory variables for the case of IPR I are almost same as those for the case of IPR II, it is noteworthy that the elasticity of IPR II that is 0.96 is far larger than one of IPR I that is 0.36. As for the coefficient of IPR I, the Wald test of the equality with unit is rejected in turn. This is evidence that the corporate decision of technology transfer is so sensitive to the actual enforcement of IPR protection, compared with the

legal provisions of IPR protection.

6. Conclusions

Whether stronger IPR accelerate the international transaction of technology is an issue of particular interest. The recent request of the United States for the consultation with China at WTO concerning the enforcement of IPR protection highlights the difference between the actual protection of IPR and the legal provisions for protection. Until date, although some empirical analyses have found the positive impact of IPR on technology transfer, they tested the effect of IPR protection on international technology transfer based on the legal provisions, not based on the actual enforcement of IPR protection. To overcome this shortcoming, we conducted the original survey for Japanese firm's evaluation of IPR protection in foreign markets. It provides interesting information of the magnitudes of IPR protection which is useful for the empirical examination of the effect of IPR protection on international technology transfer.

Based on this survey data, the estimated results present that the stronger enforcement of IPR protection accelerates the intra-firm technology transfer. They are consistent with the theoretical conjecture that the strengthened IPR would raise imitation costs, bring a higher incentive to transfer the technology, and increase the royalty payments of transferred technology. The results obtained in this paper support the results of previous studies that the technology transfer by multinational companies could play an important role. It presents a finding that the decision of technology transfer by Japanese firms was so sensitive to the actual enforcement of IPR and the magnitude of the

sensitivity to the actual protection was far larger than one to the legal provisions.

Before closing the paper, we briefly discuss remaining subjects for further study on this issue. The enforcement of IPR often is discussed from the aspect of income distribution between the donor and recipient countries of technology. While this paper did not address the issue of how technology transfer affects economic welfare in both sides because of the difficulty to abstract statistically the effect of technology transfer on economic welfare, it is an important issue. The difference between the actual enforcement of IPR evaluated by firms and the enforcement described in the legal provisions in this paper suggests that the actual enforcement of IPR is determined by the host country endogenously, after judging whether the introduction of IPR enforcement improves the welfare of the country.

It is also noted that technology transfer between affiliates and their parent firms is not a unique channel. While we focused on only the case of intra-firm technology transfer because of the limited availability of data, it is certain that the licensing at arm's length transaction is also a significant channel of technology transfer. A variety of technology transfer channels should be examined. It should also be taken into account that there may be a variation in the effects of IPR on technology transfer for different firms. Such a knowledge-intensive firm as holding a large number of patents will benefit from IPR enforcement. The combination of firm-specific data with patent data will lead us to further analysis.

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Figure 1 Difference between Legal Provisions and Evaluation of IPR

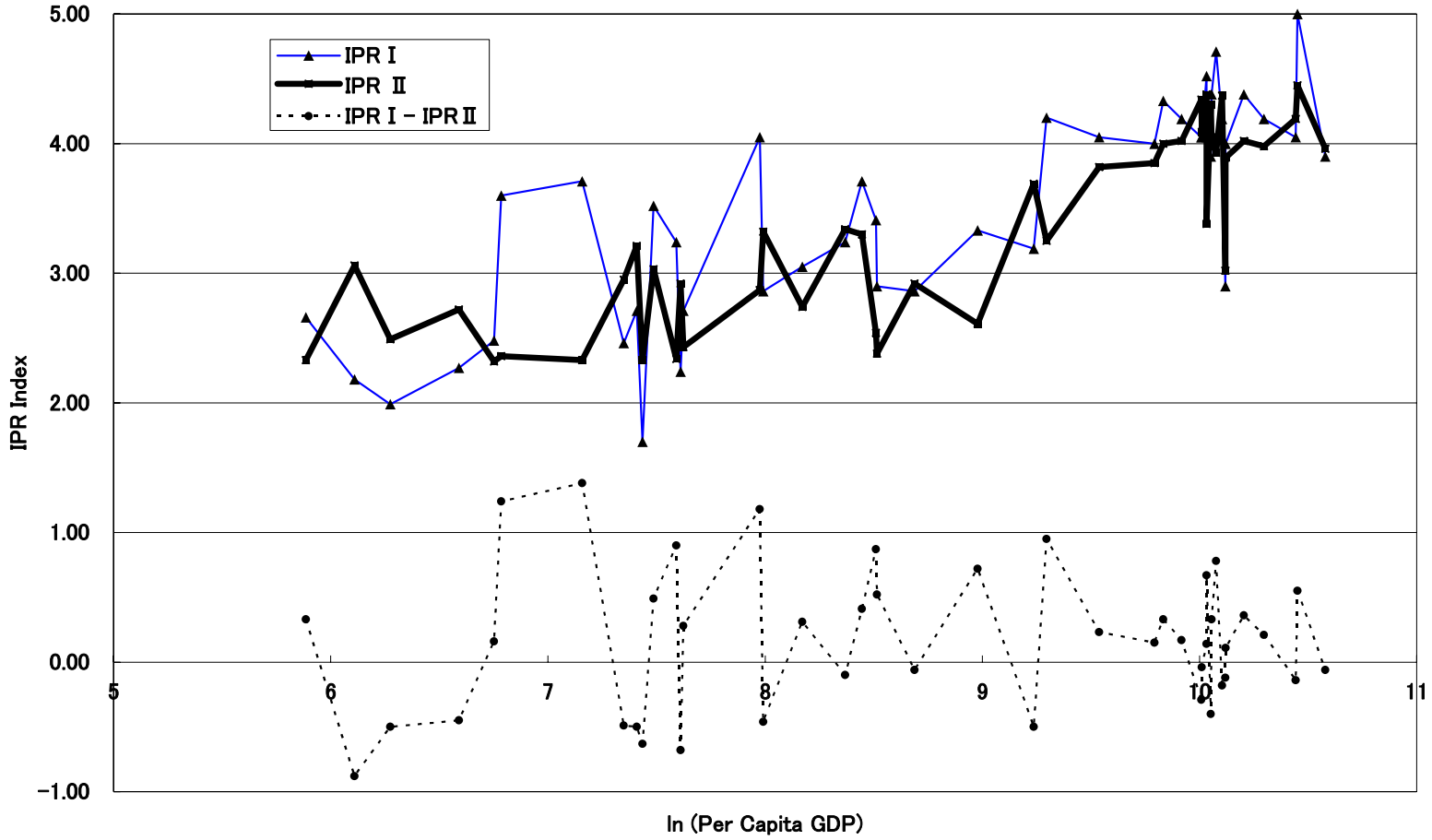

Table 1 IPR I and IPR II by Country

Country	IPR I	IPR II	IPR I - IPR II
Ecuador	3.71	2.33	1.38
Sri Lanka	3.60	2.36	1.24
Israel	4.05	2.79	1.26
South Africa	4.05	2.87	1.18
Colombia	3.24	2.34	0.90
Chile	3.41	2.54	0.87
Korea, Republic of	4.20	3.25	0.95
Argentina	3.33	2.61	0.72
Venezuela	2.90	2.38	0.52
Austria	4.71	3.93	0.78
Singapore	4.05	3.38	0.67
Russian Federation	3.52	3.03	0.49
Bangladesh	2.66	2.33	0.33
Hungary	3.71	3.30	0.41
United States	5.00	4.45	0.55
Peru	2.71	2.43	0.28
Brazil	3.05	2.74	0.31
Sweden	4.38	4.02	0.36
Italy	4.33	4.00	0.33
Netherlands	4.38	4.05	0.33
China	2.48	2.32	0.16
Spain	4.05	3.82	0.23
Denmark	4.19	3.98	0.21
Australia	4.19	4.02	0.17
New Zealand	4.00	3.85	0.15
Germany	4.52	4.38	0.14
Ireland	4.00	3.89	0.11
Belgium	4.05	4.09	-0.04
Norway	3.90	3.96	-0.06
Mexico	2.86	2.92	-0.06
Poland	3.24	3.34	-0.10
Switzerland	4.05	4.19	-0.14
Hong Kong	2.90	3.02	-0.12
United Kingdom	4.19	4.37	-0.18
France	4.05	4.34	-0.29
Canada	3.90	4.30	-0.40
Greece	3.19	3.69	-0.50
Turkey	2.86	3.32	-0.46
Romania	2.71	3.21	-0.50
Indonesia	2.27	2.72	-0.45
Egypt	2.46	2.95	-0.49
Pakistan	1.99	2.49	-0.50
Thailand	2.24	2.92	-0.68
Guatemala	1.70	2.33	-0.63
India	2.18	3.06	-0.88
Mean	*3.49*	*3.30*	*0.19*

(Note) IPR Ⅰ is from Park and Wagh (2002)

Table 2 Descriptive Statistics of Panel Data

Variable	obs.	Mean	Std. Dev	Min	Max
ln*TF* : Royalty payments from affiliates to parent	2227	1.96	2.37	0	10.58
ln*IPR I* : Index of Patent Rights by Park and Wagh	2227	1.17	0.40	0.08	1.61
ln*IPR II* : Index of Patent Rights by RIETI survey	2227	1.22	0.24	0.84	1.49
ln*EMP* : Total host country industrial value added (million $)	2227	26.00	1.62	21.32	28.28
TAX_j-TAX_Japan : The difference in corporate tax rate (%)	2227	-13.05	7.57	-35.10	1.60
Openness : (Export + Import) / GDP in host country (%)	2227	83.83	88.74	17	345
ln*P_R&D* : Parent R&D expenditures (million Yen)	2227	8.20	3.13	0	12.85
ln*P_size* : Parent total sales (million Yen)	2227	12.20	1.99	2.48	16.50
ln*A_size* : The number of affiliate's employee	2227	5.00	1.69	0	10.70
ln*A_age* : Affiliate's age	2227	2.33	0.80	0	4.42
A_share : Affiliate's share by Japanese investors (%)	2227	80.14	26.14	0	100

Table 3 Estimation Results

Dependent variable: ln(Royalty payments from affiliate to parent firm)	*OLS (1)*	*OLS (2)*	*Random effects model (1)*	*Random effects model (2)*
ln*IPR Ⅱ* : Evaluation index of IPR protection in the host country	1.009		0.960	
	[0.266]***		[0.282]***	
ln*IPR Ⅰ* : Index of IPR protection in the host country		0.335		0.359
		[0.156]**		[0.159]**
ln*Size* : Total industrial value added in the host country	-0.097	-0.102	-0.097	-0.107
	[0.040]**	[0.044]**	[0.044]**	[0.048]**
TAX_j-TAX_Japan : The difference defined as host corporate tax rate minus Japan corporate tax rate	0.027	0.041	0.024	0.036
	[0.013]**	[0.012]***	[0.013]*	[0.012]***
Openness: Trade openness defined as (export+import) / GDP	0.002	0.002	0.002	0.002
	[0.001]**	[0.001]***	[0.001]**	[0.001]**
ln*P_R&D* : R&D expenditures of Japanese parent firms	0.054	0.056	0.056	0.058
	[0.017]***	[0.017]***	[0.018]***	[0.018]***
ln*P_size* : Total sales of Japanese parent firms	0.053	0.054	0.053	0.055
	[0.024]**	[0.024]**	[0.026]**	[0.026]**
ln*A_size* : The number of affiliate's employee	0.663	0.653	0.634	0.625
	[0.031]***	[0.030]***	[0.033]***	[0.033]***
ln*A_age* : Affiliate's age	0.021	0.052	0.044	0.066
	[0.061]	[0.060]	[0.064]	[0.064]
A_share : Affiliate's share by Japanese investors	-0.001	0.000	-0.002	-0.001
	[0.002]	[0.002]	[0.002]	[0.002]
Year dummy variable	-0.023	-0.247	0.064	-0.125
	[0.156]	[0.135]	[0.149]	[0.129]
2-digit industry dummy variables	Yes	Yes	Yes	Yes
Constant	-0.574	0.529	-0.494	0.639
	[1.247]	[1.258]	[1.342]	[1.379]
the number of observations	2227	2227	2227	2227
the number of groups			1563	1563
R-sq: within			0.121	0.122
between			0.337	0.334
overall	0.330	0.330	0.327	0.324
Breusch-Pagan Lagrangian multiplier test (pooling vs random effects)			chi-sq = 164.0 Pr>chi-sq = 0.000	chi-sq = 167.1 Pr>chi-sq = 0.000

Robust standard errors in brackets
* significant at 10%; ** significant at 5%; *** significant at 1%