G-SEC WORKING PAPER No.1

How Enforcement of Intellectual Property Rights Affects the International Technology Transfer: Evidence from Japanese MNCs

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June, 2005

Abstract

How stronger intellectual property rights affect technology transfer is one of important issues of international microeconomics. This paper examines empirically their effect on technology transfer in the world by using the panel data of Japanese multinational firms. The results of our estimation reveal that the technology transfer measured by royalty payments of affiliate to parent firms is substantial in the countries where the enforcement of IPRS is strict, and that it increases in the countries where IPRS are strengthened. Those results are consistent with the previous studies based on the US and European firm data. (96 words)

Keywords: Intellectual property rights; Technology transfer; Multinational firms; Firm-level data

JEL classification: C23, F23, O31, O34

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1. Introduction

It is remarkable that, according to the Balance of Payment Statistics, the transaction of technology takes a significant part of international trade. This is caused by an increase in the international transfer of technology evolved through foreign direct investment (FDI) and the international fragmentation of production process, in addition to a changing structure of trade in goods to trade in software. It is also notable that a number of developing countries have been strengthening the enforcement of intellectual property rights (IPRS) in their countries in these years. Such an enforcement of IPRS causes a question how it affects the international transfer of technology. Although this issue is one of important research subjects of law and international economics, few empirical analyses have been undertaken thus far. There are some reasons for this. The first is the limited availability of data. 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, almost all the literatures in this field have so far been dependent either on data from the U.S. or original surveys tailor-made by researchers. The second is that the reform of IPRS in developing countries has only been implemented since the late 1990s after the conclusion of TRIPs agreement under the WTO framework, and thus, the coverage of data appears to be insufficient. Consequently, empirical analyses have been hampered by the limited size of samples.

There are several avenues to technology transfer - the license fee accompaniment, the transfer pricing thorough trading of goods, and the distribution of dividends. This paper focuses on intra-firm technology transfer between a parent firm and its overseas affiliates since we can explicitly observe the transaction of technology between parent and affiliate firms from statistical data, in contrast to other channels of transfer.

In this paper, we at first present a simple analytical framework based on imperfect competition to explain how the strengthened IPRS might affect the technology diffusion from a foreign country to a domestic market. The central idea is that the enforcement of IPRS is to the cost of a local firm that imitated the foreign technology in a low cost and its disadvantage to lose the share of the production of the imperfectly competitive goods since the enforcement of IPRS will raise the approrpiability of the technology. On reflection, it is to the advantage of a foreign firm to capture a larger share of the production and raise the value of transferred technology. As a consequence, it is possible that the strengthened IPRS expands the technology flow of a foreign firm to the local market. It, however, is not obvious that this framework well explains the real technology diffusion.

In the part of empirical examination of the paper, we test how significantly the enforcement of IPRS affects the technology flow from Japan to the rest of the world along our theoretical framework. For this purpose, we construct original panel-data by matching firm-specific factors of Japanese multinationals with the market-specific factors including the enforcement index of IPRS. As long as the authors know, this is the first attempt to test the effects of IPRS by using Japanese firm-level data.

The findings of this paper are twofold. First, technology transfer will prevail in a country that has a high level of IPRS. Second, IPRS reform will stimulate technology transfers. These results are consistent with our theoretical hypothesis that strengthened IPRS would raise imitation costs, which as a result would increase the royalty fee, thus accelerating technology transfers. This paper relates to Maskus and Penubarti (1995), Lee and Mansfield (1996), Smith (1999, 2001), Branstetter, Fisman and Foley (2004), and Smarzynska (2004) which empirically examined the issue of the impact of strengthened IPRS on the transaction of technology.

This paper is organized as follows: Section 2 presents a theoretical background to examine the effect of the strengthened IPRS on technology transfer. Section 3 describes the framework for empirical examination. Section 4 describes the sample statistics and the data used for the estimation. Section 5 discusses the results of estimation. The last section concludes this paper.

2. Theoretical Background

We use the simplest structure capable of presenting the effect of the enforcement of IPRS. Firm behavior is modeled as a simple Cournot-Nash duopoly, with one local firm and one foreign-affiliated firm, who produce identical products in the local market. We assume that both firms produce only for the local market. We let x and x^* denote the supply of the local firm and that of the foreign affiliate, respectively. The local firm imitates foreign technology with a cost per unit output, τ , which varies according to the degree of enforcement of IPRS. Along with the discussion by Helpman (1993) and Glass and Saggi (2002), we assume that the higher the degree of enforcement of IPRS the higher the imitation cost. The foreign affiliate uses the technology developed by its parent firm with royalty payment per unit output τ^* paid to its parent firm.

For analysis, we consider the following multi-stage one-shot game. In stage 0, the nature chooses the situation in which both the local firm with a low imitation cost of foreign technology and the foreign-affiliate with royalty payment to the genuine foreign technology supply their products for the local market. In stage 1, the government of the local market announces to strengthen the enforcement of IPRS. It raises the imitation cost of local firm. In stage 2, the parent firm of foreign country decides the level of royalty fee. In stage 3, given the degree of IPRS and the royalty fee, the local firm produces quantity x and the foreign affiliate produces x^* under their profit maximization. For the simplification, we assume the inverse market demand for the good in the local market is given by:

$$p(x+x^*) = a - (x+x^*)\,, \qquad (1)$$

where p is price in the local market. The local firm maximizes variable profit π :

$$\pi(x, x^*, c, \tau,) = xp(x+x^*) - cx - \tau x\,, \qquad (2)$$

where c is marginal cost for production except for the imitation cost of foreign technology. We assume that both the variable costs c and τ are constant regardless the quantity of production for the reason of simplification. While there may be some additional sunk costs which explain the existence of imperfect competition in this market, they are omitted because they play no role in this analysis.

The technology flow from parent firm in foreign country to its affiliate is expressed as the total amount of royalty payment defined by the function of quantity x^* and the royalty fee τ^*. We assume the total revenue of royalty payment TF is defined by:

$$TF = \tau^* x^*.$$

The parent firm determines the royalty fee to maximize its total revenue of royalty payment. The optimal royalty fee and the total revenue of technology flow are solved by backward induction.

The first-order condition for profit maximization of the local firm is:

$$\pi_x = a - 2x - x^* - (c + \tau) = 0\,, \qquad (3)$$

where derivative is denoted by subscript.

Similarly, the variable profit of the foreign affiliate, π^*, is given by:

$$\pi^*(x, x^*, c, \tau,) = x^* p(x + x^*) - c^* x - \tau^* x\,, \quad (2^*)$$

leading to first- order condition:

$$\pi^*_{x^*} = a - 2x^* - x - (c^* + \tau^*) = 0 \qquad (3^*)$$

First-order conditions (3) and (3*) show the best response of each firm to any particular output chosen by its rival. The solution to two equations is the non-cooperative solution that leads to the optimal supply of two firms:

$$x = \frac{1}{3}\left[a + c^* + \tau^* - 2(c + \tau)\right], \qquad (4)$$

$$x^* = \frac{1}{3}\left[a + c + \tau - 2(c^* + \tau^*)\right], \qquad (4^*)$$

For the simplification, we assume that the marginal cost is same between foreign affiliate and local firm, $c = c^* = w$. The total amount of royalty payment, TF, is expressed by:

$$TF = \frac{1}{3}\left[a - w + \tau - 2\tau^*\right]\tau^*, \qquad (5)$$

leading to first-order condition for maximization of royalty payment:

$$TF_{\tau^*} = \frac{1}{3}\left(a - w + \tau - 4\tau^*\right) = 0 , \qquad (6)$$

The solution to equation (6) with respect to τ^* is the optimal royalty fee under the given parameters: the enforcement of IPRS, market size and other variable costs. The optimal royalty fee and the total amount paid for the technology diffusion are denoted by:

$$\tau^* = \frac{1}{4}[a - w + \tau], \qquad (7)$$

$$TF = \frac{1}{24}[a - w + \tau]^2 , \qquad (7^*)$$

Equation (7) and (7*) state that the amount of royalty payment from affiliate to its parent firm is determined by the enforcement of IPRS τ and other market- and firm- specific conditions included in a and w.

As mentioned earlier, we assume that the strengthened enforcement of IPRS causes an increase of imitation cost. By taking derivatives of τ^* and *TF* with respect to the imitation cost and other variable costs for production, we derive $x_\tau < 0$, $x_\tau^* > 0$, $\tau_\tau^* > 0$, $TF_\tau > 0$, $\tau_w^* < 0$, and $TF_w < 0$ [1]. They lead to the propositions as follows:

Proposition 1. A rise of the enforcement of IPRS

(1) reduces the supply of local firm;

(2) increase the supply of foreign affiliate;

(3) raises the optimal royalty fee of the transferred technology;

(4) increases the amount of royalty payment from foreign affiliate to its parent firm.

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[1] We assume that the supply quantity of goods of both firms is positive.

Proposition 2. A rise of variable costs for production decreases the optimal royalty fee and the amount of royalty payment.

3. Empirical Framework

Taking into account the difficulty to observe the royalty fee of each technology transaction, our empirical examination focuses on the amount of payment for transferred technology. In order to test empirically how the enforcement of IPRS and other market- and firm- specific conditions affect the international technology diffusion, we use the following equation:

$$\ln TF_{ilt} = \beta_0 + \beta_1 \ln \tau_{jt} + \beta_2 \ln P_{it} + \beta_3 \ln A_{ilt} + \beta_4 \ln H_{jt} + \varepsilon_{ilt} + u_{il}, \qquad (8)$$

where *l* is the index for affiliates, *i* is the index for the affiliate's parent firm, *t* is an index indicating the year, and *j* denotes the affiliate's host country. The dependent variable TF_{ilt} is the proxy for the volume of transferred technology from parent firm *i* to affiliate firm *l* at the year *t*. τ_{jt} denotes the imitation cost in country *j*. P_{it} represents a vector of characteristics of the parent firm, such as R&D expenditure. A_{ilt} represents a vector of characteristics of the affiliates, including the type of transaction with the parent firm. H_{jt} represents a vector of characteristics of the host country. β_0 is a constant, u_{il} denotes the time-invariant fixed effects for the affiliates, representing their individual characteristics, and ε_{ilt} is the error term.

As explained in the above framework, the imitation cost of local firm would depend on the level of IPRS. Thus, we introduce the level of IPRS in the host country (*IPR*) as the proxy for τ_{jt}. With regard to the characteristics of the parent firm P_{it}, R&D expenditure (*P_R&D*) is employed, considering the parent's R&D size. Although this parameter should be measured in terms of the R&D stock in order to take into account the accumulated knowledge over a long time, we use R&D flow because of the unavailability of stock data. Regarding the characteristics of the affiliates, in addition to the number of employees (*EMP*) as a proxy for firm size, capital goods (*INVIMJP*) and intermediate products (*BUYJP*) which affiliates imported from Japan are considered in order to control the firm specific relationship with their parent firm in the transactions. Most affiliates manufacture products by importing capital goods such as machinery and its parts from Japan. In this case, these imported goods from Japan may be accompanied by the technology involved in their usage. Thus, it is expected that the technology that complements such imported goods is simultaneously transferred in the transaction of capital and intermediate goods.

Concerning the characteristics of the host country, we note that previous studies have empirically demonstrated the importance of the openness of the host country's market. We introduce the parameters of market openness, FDI openness, and corporate tax rate along the lines of precedent research. The effect of market size is not directly estimated since the market size of each production is not observable and is thought to be subsumed in the time-invariant term u_{il} in equation (8).

The equation for estimation takes the following form:

$$\begin{aligned} \ln TF_{ilt} = \beta_0 &+ \gamma_1 \ln(IPR_{jt}) + \gamma_2 \ln(P\_R\&D_{it}) + \gamma_3 \ln(EMP_{ilt}) \\ &+ \gamma_4 \ln(INVIMJP_{ilt}) + \gamma_5 \ln(BUYJP_{ilt}) + \gamma_6 \ln(OPEN_{jt}) \\ &+ \gamma_7 \ln(FDI_{jt}) + \gamma_8 \ln(TAX_{jt}) + \varepsilon_{ilt} + u_{il} \end{aligned} \tag{9}$$

where the coefficients $\gamma_k \ (k = 1, 2, \cdots 8)$ indicate the elasticity of technology transfer to the change of each variable.

In addition to equation (9), we examine the difference in the growth of technology transfer between 1995 and 2001 using the following equation to determine whether IPR reforms impact the growth of technology transfers. The constant term and fixed effects for the affiliates are eliminated in the difference approach of equation (10),

$$\ln\left(\frac{TF_{ilt}}{TF_{ilt-1}}\right) = \delta_1 \ln\left(\frac{\tau_{jt}}{\tau_{jt-1}}\right) + \delta_2 \ln\left(\frac{P_{it}}{P_{it-1}}\right) + \delta_3 \ln\left(\frac{A_{ilt}}{A_{ilt-1}}\right) + \delta_4 \ln\left(\frac{H_{jt}}{H_{jt-1}}\right) + \varepsilon_{ilt}. \qquad (10)$$

Equation (9) is estimated using the fixed effects and random effects models. Various specification tests, such as F test, Breusch-Pagan Lagrangian multiplier test, and Hausman test, were used to select the appropriate model for the estimation. Equation (10) is estimated by ordinary least square regression method (OLS).

4. Sample Statistics and Data Description

4.1 Sample Statistics

This paper uses firm-level data collected from referred to as "Kaigai Jigyo Katsudo Kihon Cyousa" issued by Japanese Ministry of Economy, Trade and Industry, which is a survey of activities of Japanese multinational companies. The data are obtained from a survey of each year; a full survey is carried out every three years, while complementary surveys are carried out between the full surveys. The survey examines those 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. The data of royalty payments is available for the year of 1995, 1998, and 2001, in which a full survey was carried out. The number of affiliates was 10,420, 13017, and 13,693 in 1995, 1998, and 2001, respectively. We constructed the complete panel data comprising 5,764 affiliates in order to avoid fluctuation in the number of affiliates over time. The sample size is restricted due to the limited availability of Index of Patent Right (IPR) data provided by Park and Wagh (2002). The IPR is surveyed every five years; thus, the points of time considered in our analysis are 1995 and 2001, and samples that are not merged with the IPR are omitted from the data set. As a result, 4,872 and 4,866 affiliates remained in the data sets of 1995 and 2001, respectively. Consequently, the maximum sample size was 9,738. Table 1 tabulates this data under the headings of host country name and number of affiliates in 1995 and 2001.

The dependent variable denotes the royalty payments made to parent firms in Japan. The total payment directed to the Japanese investors comprises the dividend and royalty payments. We checked for consistency in these payments and proceeded to refine the data. However, 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.

4.2 Data Description

As for explanatory variables, R&D expenditures are considered to be characteristic of the parent firm because technology transfers are expected to increase with the R&D capability of affiliate's parent firms. Data regarding the R&D expenditures of the parent firm are also collected in the survey, and it is possible to merge this data with that of the corresponding affiliates by using a parent code and an affiliate code. In case of the affiliates, the total number of employees and the import of capital and intermediate goods from Japan are considered. These data also are obtained from the survey data.

Every five years, the key variable - the IPR - was surveyed for 63 countries by Park and Wagh (2002). 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 to international treaties? (5) Do restrictions exist on patent rights? The score ranges from 0 to 5; a high score implies a stronger IPR system. We combined the IPR data with the affiliate data using the host country code. As a result, the panel data comprising the IPR data of 49 countries is obtained for estimation as seen in Table 1.

The characteristics of the host country include the openness of the market determined by the formula "(export + import)/GDP" (*OPEN*), the FDI openness determined by the formula "(inflow of FDI)/GDP" (*FDI*), and the difference between the corporate tax rate in the host country and that in Japan (*TAX*). It is indicated that firms sometimes incorrectly report the amount of royalty payments in order to avoid taxation. To cope with this problem, Hines (1995) and Grubert (1998), who examined the impact of taxation on declarations by firms, demonstrated that the impact is controlled by the corporate and withholding tax rates in the host country. With regard to the source of these data pertaining to different countries, the tax data is obtained from the "Corporate Tax Rate Survey" carried out by KPMG and other data is obtained from the "World Development Indicator" by the World Bank.

Table 2 presents the descriptive statistics of variables used in estimating equation (2). The descriptive statistics of variables used in estimating equation (3), which adopts a difference approach, are presented in Table 3.

5. Estimation Result

The results of estimation using the panel data for equation (2) are presented in Table 4, while those of the difference approach are presented in Table 5. The three combinations of explanatory variables deserve particular attention and are selected and numbered in the tables as [1]-[3].

5.1 Estimation for Fixed Effects

The natural logarithms for the parent firm's R&D expenditures (*P_R&D*), total number of employees (*EMP*), and IPRS of the host country (*IPR*) are used for all estimations, while the remaining explanatory variables, such as the characteristics of the host country and the measures of relationships between affiliates and their parent firms, are considered over time in order to examine their effect on technology transfers.

The procedure for the specification of the model is as follows. First, by using F test, it is examined whether all the estimated individual effects u_{il} are equal to zero. If all values are zero, the pooling estimation model is more appropriate for the data set than the fixed effects model. Breusch-Pagan test, which examines whether the variance of the individual effects is zero, is used to compare the pooling and random effects models. Rejecting that the variance is zero implies that the random effects model should be used. Next, we proceed to examine the Hausman test, which tests the validity of the random effects model against the fixed effects model.

With regard to model [1], the result of the F test leads to the rejection of the null hypothesis that individual effects equal zero; thus, the fixed effects model is adopted. Moreover, the result of the Breusch-Pagan test rejects the pooling estimation model and supports the random-effects model. In the Hausman test, the random effect model is rejected at 5 percent of statistical significance. Thus, the fixed effects model is judged to be the most appropriate method for our estimation. In models [2] and [3], specification test are carried out in the same manner, supporting the fixed effects model.

The impact of IPRS is a major concern of this study. As expected, the signs of all coefficients of ln(*IPR*) are positive, and all the estimates are significantly greater than zero, except for the case of Random[2] and Fixed[3]. The value of the estimated elasticity of technology transfers with regard to IPR determined by Fixed[1] is 1.06, implying that the rate of increase of technology transfers exceeds that of the strengthening of IPRS. Estimates of the coefficient of ln(*P_R&D*), which is a proxy for the R&D capability of the parent firm, are statistically insignificant for all fixed effects models. Although the R&D expenditures of the parent firm are larger, its technology may not always be transferred to its affiliates. In contrast, estimates of the coefficient of the number of affiliate employees (*EMP*) are always significantly positive, irrespective of the combination of the explanatory variables. In addition, as seen from the value of the standard error, the coefficients are highly significant. With regard to the characteristics of the host country, while trade openness and FDI openness is entirely insignificant, with the exception of Random[2], the coefficients of ln(*TAX*), which represents the difference in the corporate tax rate between Japan and the host country, are always significantly negative.

Even after certain characteristics of a country, such as trade openness, FDI openness, and differential corporate tax rate are controlled, the coefficient of ln(*IPR*) remains significantly positive and its magnitude appears to be almost unchanged (see Fixed[1], Fixed[2] in Table 4). However, the coefficient of log of (*IPR*) becomes insignificant with the introduction of both imported capital goods and intermediate goods from Japan which are proxies for the linkage of transactions between affiliates and their parent firm and are considered as explanatory variables.

To summarize, we observed a positive effect of IPRS on technology transfers after controlling the firm and market specific factors such as trade and FDI openness and taxation in the host country. The impact is attenuated by controlling the business relationships between affiliates and their parent firm.

5.2 Estimation Result of Difference Approach

Another fundamental concern of this analysis is to examine whether the reinforcement of IPRS induces technology transfers. The strengthened IPRS are expected to be positively correlated to the increase in technology transfers as well as a positive correlation between the level of the IPRS and the volume of transferred technology. The results of the estimation of the difference approach are presented in Table 5. The combination of explanatory variables displayed is identical to that of the panel data. The constant term and fixed effects for affiliates on account of adopting the difference approach are eliminated.

The coefficients of ln(IPR_t / IPR_{t-1}) are positive with a statistical significance and range from 0.22 to 0.29. The coefficients of the growth rate of R&D expenditures by the parent firm become significantly positive, while these were insignificant when the level of the variables was considered. The growth rate of affiliate's employees is also significantly positive. Even when the characteristics of the host country and the proxies for the linkage of transactions between affiliates and their parent firms are considered as explanatory variables, the change in IPR remains positive in high statistical significance. These results clearly indicate that the IPR reforms from 1995 to 2000 contributed toward increasing technology transfers of Japanese multinational firms to their affiliates in foreign countries.

6. Conclusions

Whether stronger IPRS accelerate the international transaction of technology is an issue of particular interest. The recent reinforcement of IPRS provides a basis to investigate this issue. Until date, although various empirical analyses have observed the positive impact of IPRS on technology transfer, only few studies use firm-level data. In particular, while the transaction of technology by multinational companies has been considered as a crucial channel for technology transfer, few empirical investigations have been conducted on this channel. This paper examines whether the strengthening of IPRS increases technology transfers by using firm-level data of Japanese multinational companies. Results of the estimation indicate that technology transfer would prevail in those countries that have a high IPR level. It is remarkable that IPRS have positive effects on technology transfers even at the firm level. Further, the difference approach revealed that IPR reforms stimulate technology transfers. These results are consistent with the theoretical hypothesis that strengthened IPRS would raise imitation costs, bring a higher incentive to transfer the technology, and increase the royalty fee and the total 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.

In closing the paper, we briefly note remaining subjects for further study on this issue. The enforcement of IPRS often is evaluated 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 because of the difficulty to abstract statistically the effect of technology transfer by Japanese MNCs on economic welfare, it is an interested issue. It is also noted that technology transfer between affiliates and their parent firms is not a unique channel. While we did not discuss it because of the limited availability of data, it is certain that the licensing to arm's length parties is also a major channel of technology transfer. A variety of technology transfer channels including this type could be examined. As for data set, we utilized the IPR data provided by Park and Wagh (2002) as a proxy for the strength of intellectual property rights. It is possible that the indices do not present the timing when IPRS in the host country really were strengthened. This problem can be mitigated by using data that identify IPRS reforms for every country. It should also be taken into account that there may be a large variation in the effects of IPRS on technology transfer for different firms. For example, knowledge-intensive firms, such as a firm holding a large number of patents, may benefit from the effects of IPRS. Combining the micro data and patent data could make the analysis possible.

Acknowledgement

The authors acknowledge the Statistics Department of Japanese Ministry of Economy, Trade and Industry, which permitted them to use the firm level data of "Kaigai Jigyo Katsudo Kihon Cyousa"

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Table 1: The Distribution of Affiliates

Country	1995	2001	Total
Argentina	20	20	40
Australia	199	199	398
Austria	16	16	32
Bangladesh	3	3	6
Belgium	61	61	122
Brazil	101	101	202
Canada	120	122	242
Chili	26	25	51
China	532	534	1,066
Colombia	12	12	24
Czech Republic	8	8	16
Denmark	10	10	20
Ecuador	4	4	8
Egypt	3	3	6
Ethiopia	1	1	2
France	115	114	229
Germany	224	224	448
Greece	3	3	6
Guatemala	2	2	4
Hong Kong	341	341	682
Hungary	7	7	14
India	28	29	57
Indonesia	226	224	450
Ireland	9	10	19
Islael	2	2	4
Italy	64	64	128
Kenya	1	1	2
Korea	136	134	270
Madagascar	1	1	2
Mexico	60	61	121
Netherlands	135	136	271
New Zealand	42	42	84
Norway	10	10	20
Pakistan	9	9	18
Peru	9	9	18
Poland	8	8	16
Romania	2	2	4
Russia	12	12	24
Singapore	338	336	674
South Africa	3	3	6
Spain	56	56	112
Sri Lanka	3	3	6
Sweden	24	24	48
Swizerland	20	20	40
Thailand	364	367	731
Turkey	10	10	20
United Kingdom	291	286	577
United States	1,188	1,184	2,372
Venezuela	13	13	26
Total	4,872	4,866	9,738

Table 2: Descriptive Statistics for Panel Data

	1995				2001			
Variable	Mean	Std. Dev	Min	Max	Mean	Std. Dev	Min	Max
Royalty	64.06	750.52	1	39241	168.37	3413.97	1	161939
IPR	3.46	1.19	0	4.86	3.79	1.01	1	5
P_R&D	34401.04	79516.54	1	477430	52368.73	97420.45	1	527360
EMP	287.37	1064.30	1	44339	324.89	1323.78	1	48189
INVIMJP	96.31	601.40	-254	18740	81.64	506.27	1	12204
BUYJP	4065.34	17671.36	1	409855	5883.65	60376.11	1	2893831
OPEN	86.91	97.26	17	345	93.48	93.45	22	341
FDI	2.64	3.42	0	13.7	4.65	5.51	-2.32	32.36
TAX	17.69	7.46	-1.56	36.64	8.85	6.84	-0.1	27

	1995				2001			
Variable (log)	Mean	Std. Dev	Min	Max	Mean	Std. Dev	Min	Max
$\ln(Royalty)$	1.01	1.90	0	10.58	1.28	2.10	0	11.99
$\ln(IPR)$	1.16	0.42	0	1.58	1.29	0.29	0	1.61
$\ln(P\_R\&D)$	6.88	4.25	0	13.08	9.01	2.43	0	13.18
$\ln(EMP)$	4.03	1.82	0	10.70	3.90	2.10	0	10.78
$\ln(INVIMJP)$	1.05	2.10	0	9.84	0.97	2.00	0	9.41
$\ln(BUYJP)$	5.60	2.82	0	12.92	5.49	3.11	0	14.88
$\ln(OPEN)$	4.04	0.84	2.83	5.84	4.16	0.83	3.09	5.83
$\ln(FDI)$	0.52	0.98	-4.61	2.62	1.17	0.90	-1.77	3.48
$\ln(TAX)$	2.81	0.40	1.95	3.60	1.88	0.87	0.56	3.30

Table 3: Descriptive Statistics for Difference Data

Variable	Mean	Std. Dev	Min	Max
$\ln\left(Royalty_{ilt}/Royalty_{ilt-1}\right)$	0.06	0.57	-6.21	6.46
$\ln\left(IPR_{jt}/IPR_{jt-1}\right)$	-0.02	0.50	-5.10	8.87
$\ln\left(P\_R\&D_{it}/P\_R\&D_{it-1}\right)$	0.12	0.56	-3.17	3.78
$\ln\left(EMP_{ilt}/EMP_{ilt-1}\right)$	0.05	0.93	-6.57	7.94
$\ln\left(INVIMJP_{ilt}/INVIMJP_{ilt-1}\right)$	0.45	0.64	-2.38	3.76
$\ln\left(BUYJP_{ilt}/BUYJP_{ilt-1}\right)$	-0.78	0.61	-2.38	0.48
$\ln\left(OPEN_{jt}/OPEN_{jt-1}\right)$	0.12	0.95	-8.56	8.48
$\ln\left(FDI_{jt}/FDI_{jt-1}\right)$	0.10	0.16	-2.08	1.80
$\ln\left(TAX_{jt}/TAX_{jt-1}\right)$	0.11	0.17	-0.80	1.39

Table 4: Estimation for Panel Data

	Fixed[1]	Random[1]	Fixed[2]	Random[2]	Fixed[3]	Random[3]
ln(*IPR* : IPR level of host country)	1.065** (0.265)	0.326** (0.088)	0.942* (0.415)	0.187 (0.116)	0.584 (0.814)	0.445** (0.144)
ln(*P_R&D* : R&D expenditures of parent firm)	0.035 (0.034)	0.065** (0.009)	-0.017 (0.038)	0.059** (0.010)	-0.020 (0.085)	0.050** (0.014)
ln(*EMP* : the number of affiliate's employee)	0.521** (0.057)	0.551** (0.018)	0.513** (0.062)	0.552** (0.019)	0.779** (0.135)	0.508** (0.032)
ln(*INVIMJP* : Import investment goods from Japan)					0.039 (0.050)	0.217** (0.020)
ln(*BUYJP* : Procurement from Japan)					0.081 (0.053)	0.048** (0.016)
ln(*OPEN* : Trade openness)			-0.069 (0.437)	0.206** (0.064)	0.201 (0.794)	0.084 (0.084)
ln(*FDI* : FDI openness)			-0.072 (0.136)	-0.084 (0.047)	-0.244 (0.274)	0.013 (0.062)
ln(*TAX* : The difference of host corporate tax rate and Japan corporate tax rate)			-0.278** (0.085)	-0.160** (0.044)	-0.394* (0.157)	-0.196** (0.062)
Constant	-2.565** (0.423)	-2.065** (0.155)	-0.974 (1.665)	-2.222** (0.289)	-2.896 (2.869)	-2.315** (0.395)
The number of observations	3692	3692	3410	3410	1749	1749
The number of groups	2664	2664	2517	2517	1433	1433
F test that all u_{il} = 0 (pooling vs fixed effects)	F = 2.46 Pr>F = 0.000		F = 2.37 Pr>F = 0.000		F = 1.88 Pr>F = 0.001	
Breusch-Pagan Lagrangian multiplier test (pooling vs random effects)	chi-sq = 412.28 Pr>chi-sq = 0.000		chi-sq = 347.23 Pr>chi-sq = 0.000		chi-sq = 90.74 Pr>chi-sq = 0.000	
Hausman test (random effect vs fixed effect)	chi-sq = 9.04 Pr>chi-sq = 0.028		chi-sq = 19.01 Pr>chi-sq = 0.004		chi-sq = 29.08 Pr>chi-sq = 0.000	

Note: The numbers of parentheses present standard errors.

* and ** indicate the statistical significance with 5 percent and 1 percent, respectively.

Table 5: Estimation for Difference

	OLS[1]	OLS[2]	OLS[3]
$\ln(IPR_t / IPR_{t-1})$	0.244** (0.072)	0.217* (0.108)	0.294* (0.145)
$\ln(P\_R\&D_t / P\_R\&D_{t-1})$	0.168** (0.023)	0.141** (0.025)	0.094** (0.034)
$\ln(EMP_t / EMP_{t-1})$	0.101** (0.016)	0.097** (0.017)	0.086** (0.022)
$\ln(INVIMJP_t / INVIMJP_{t-1})$			0.044 (0.030)
$\ln(BUYJP_t / BUYJP_{t-1})$			0.074** (0.020)
$\ln(OPEN_t / OPEN_{t-1})$		-0.000 (0.107)	-0.094 (0.139)
$\ln(FDI_t / FDI_{t-1})$		-0.004 (0.029)	-0.015 (0.036)
$\ln(TAX_t / TAX_{t-1})$		-0.087** (0.020)	-0.083** (0.024)
The number of observations	1897	1649	780

Note: The numbers of parentheses present standard errors.

* and ** indicate the statistical significance with 5 percent and 1 percent, respectively.