18 The Effect of Harmonization of Intellectual Property Rights on the Activities of MNCs in Developing Countries (*)

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In trade negotiations such as WTO and TPP, the enhancement of IP rights is one of the high-priority issues that developed countries have been requesting developing countries to tackle. However, it has not been sufficiently clarified whether the strength of the IP rights in those countries would benefit the companies in developed countries. This paper estimates the production functions of overseas subsidiaries of Japanese companies and thereby empirically analyzes whether the strength of the IP rights in developing countries increase Japanese companies' productivity. The results show that the enhancement of the patent rights in developing countries excluding China has the effect of reducing the counterfeit damage that Japanese companies suffer in those countries and that, especially in the electric machinery industry in developing countries, the enhancement of patent rights and an increase in the number of patent applications applied by Japanese companies contribute to increasing the productivity of their overseas subsidiaries. These results suggest that the developed countries' policy of requesting developing countries to enhance their IP rights has been fully achieving its goal.

Ⅰ Introduction

Since the TRIPS Agreement, not only developed countries but also developing countries have been enhancing their IP systems. This might have reduced the counterfeit damage suffered by Japanese companies in other countries and thereby increased the profitability of Japanese companies. However, a detailed analysis has not been conducted in order to measure how much such move has contributed to their profitability. In trade negotiations at the WTO, TPP, etc., the establishment and enhancement of IP systems is one of the high-priority issues for which developed countries have been requesting special attention from developing countries. Under these circumstances, it is an important political objective to quantitatively analyze whether the establishment and enhancement of IP systems in developing countries actually improve the profitability of companies of developed countries.

In this paper, I estimate the production function of the subsidiaries of Japanese companies abroad. Since the seminal study of Griliches (1979), there have been many studies that estimate production functions and calculate the private rate of return of the knowledge stock acquired through investments in R&D activities. I newly introduce a "patent system" variable which measuring the strength of patent right in each country into the demand function in an attempt to distinguish the effect of the "stock of knowledge" variable (the conventional effect of R&D activities on profitability) from the effect of increasing profitability through the improvement in appropriability as a result of the enhancement of a patent system.

In this paper, I use the GP Index (the "GPI") as a variable to measure the strength of its patent system in each country. The GPI was created by Ginarte and Park (1997) and was used in many preceding studies. That index quantifies the strength of patent rights under the patent system of each country mainly by evaluating the text of relevant laws in a uniform manner. While this is a valuable indicator to measure the "formal" change for the system, due to the nature of the index, the index is limited for the inability to reflect unquantifiable factors of the "real" strengthen patent rights such as the enforcement of legal system firms face. Therefore, it is not certain whether the GPI is an ideal index for the patent enforceability experienced by companies.

For this reason, in this paper, I first analyze whether the GPI appropriately reflects the level of improvement in patent enforceability before

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estimating production functions. More specifically, I use the the *Survey on Counterfeit Damage* conducted by the JPO, which is now studying the counterfeit damage suffered by Japanese companies in other countries, calculated the counterfeit damage rates based on the damage suffered by Japanese companies in other countries, and determined the degree of correlation between said rate and the GPI. The estimation reveal that, in developing countries excluding China, there is a significantly negative correlation between the GPI and the counterfeit damage rate while in developed countries, there is no significant correlation between them. This result may indicate that the GPI reflects the actual patent enforceability to a certain extent at least in developing countries (excluding China).

Next, I estimate the production function of Japanese companies and obtain the following results. In the electric machinery industry, a rise in the GPI and an increase in the number of patent applications in developing countries appear to contribute to the improvement of subsidiaries' productivity. Also, in the chemistry and pharmaceutical industries, increasing of both variables are significantly positive associated with productivity in developed countries. On the other hand, in the case of the machinery industry, we find no significant relationship between the GPI, patent applications and firm's productivity.

These results suggest that the strength of patent rights in developing countries in particular have decreased the counterfeit damage suffered by Japanese companies and clearly increased their profitability in some industries. The results indicate that the developed countries' policy of requesting developing countries to enhance their IP systems has fully achieved its goal. However, in the case of China where counterfeit damage is extremely serious, it is necessary to devise other measures.

Ⅱ Previous Literature

In this paper, an empirical analysis is conducted by estimating the production function of the overseas subsidiaries of Japanese companies in order to determine whether the strength of the local patent systems contribute to an increase in the productivity of those companies. Many studies have been conducted on the relationship between IP systems in developing countries and multinational companies' activities (hereafter MNCs), especially focusing on exporting goods and technology licenses to local companies and making direct investments in those countries (Maskus and Penubarti 1995, Maskus 1998, Smith 2001, Branstetter et al. 2006, Javorcik 2002, Ushijima 2013, Ito and Wakasughi 2009, Ushijima 2013, etc.). Many of these studies analyzed whether and how the enhancement of IP systems had promoted the transfer of knowledge through these activities of multinational companies. The focus was placed not on the profitability of MNCs, but on the benefits enjoyed by the countries that had enhanced their IP systems. While these studies support the validity of the efforts to enhance the IP systems in developing countries, those would fail to identify the benefits enjoyed by developed countries through MNCs. The studies may be interpreted to indirectly indicate the existence of the benefits enjoyed by developed countries in view of the fact that companies of developed countries export goods to and make direct investments in developing countries precisely because such activities are beneficial for them. It we take into consideration various factors such as the lack of incentive of governments of developing countries, which are hoping to enjoy the knowledge spillover effect caused by the export and direct investment from developed countries, to protect IP rights of developed countries, the many empirical studies that reveal that the increasing presence of MNCs in developing countries promotes the knowledge spillover effect, the fact that overseas corporate activities involve a high level of uncertainty, and the fact that overseas subsidiaries are more likely to withdraw from the market than local companies, it is necessary to analyze the IP systems of developing countries and the profitability of overseas subsidiaries of developed countries.

Ⅲ Estimation Method

In this paper, in order to determine whether the strength of the IP systems in other countries have a positive effect on the productivity of Japanese companies, I made the following evaluation by using the production function of each of their overseas subsidiaries located in those countries.

First, the production function is formulated as follows by use of the Cobb-Douglas Production Function.

$$Q_{ijt} = K_{ijt}^{\alpha_k} L_{ijt}^{\alpha_l} \exp(\varepsilon_{ijt}) \qquad (1)$$

In this formula, Q_{ijt} means the amount of production of Overseas Subsidiary i located in Country j during Period t. K_{ijt} means the capital input necessary for production activities. L_{ijt} means labor input. ε_{ijt} means the random shocks that affect the amount of production of the company during Period t.

However, the result obtained through such a simple estimation formula is known to be biased because, although this formula hypothesizes all of the factors that influence the amount of production to be random effects and indicates them as ε_{ijt}, the actual data would not satisfy such hypothesis.

To solve this problem, Olley and Pakes (1996) proposed to add the production-determining factor, ω_{ijt},, which is observable by the company, but not observable by econometricians. In this case, the production function may be formulated as follows.

$$Q_{ijt} = Q_{sjt}\left(\frac{Price_{ijt}}{P_{sjt}}\right)^{\eta_s} \exp(\mu_{ijt}) \qquad (2)$$

In this paper, I inset the Dixit-Stigliz type demand function (CES type) into the production function as a demand function. The adoption of such a clear hypothesis makes it possible to disregard the lack of the product price data of companies and to introduce explicit variables to indicate the demand-side effects. In this case, it may be formulated as follows.

$$Q_{ijt} = Q_{sjt}\left(\frac{Price_{ijt}}{P_{sjt}}\right)^{\eta_s} \exp(\mu_{ijt}) \qquad (3)$$

In this formula, Q_{ijt} means the demand function indicating the demand available to each company. Q_{sjt} means the demand of the industry as a whole. $Price_{ijt}$ means the product price of the company. P_{sjt} means the average price of the industry as a whole. μ_{ijct} means the demand shock. R_{ijt}, which means the sales of the company, can be specified as $R_{ijt} = P_{ijt}Q_{ijt}$. If Equation (3) is substituted into this, it may be expressed as follows.

$$R_{ijt} = Q_{ijt}^{(\eta_s+1)/\eta_s} Q_{sjt}^{-1/\eta_s} P_{sjt}(\exp(\mu_{ijt}))^{-1/\eta_s} \qquad (4)$$

Furthermore, if Equation (2) is substituted into Equation (4), the following formula may be obtained after simplifying log expressions. Each of the lower-case characters indicates the logarithm of the variables.

$$\widetilde{r_{ijt}} = \beta_k k_{ijt} + \beta_l l_{ijt} + \beta_q q_{ijt} + \omega^*_{ijt} + \mu^*_{ijt} + \varepsilon_{ijt} \qquad (5)$$

Here, the sales are substantiated by using the industry-level deflator, $\widetilde{r_{ijt}} \equiv r_{ijt} - p_{sjt}$. The meaning of each parameter is as follows:

$$\beta_k = \left(\frac{\eta_s+1}{\eta_s}\right)\alpha_k, \beta_l = \left(\frac{\eta_s+1}{\eta_s}\right)\alpha_l, \beta_q = \left(\frac{1}{|\eta|}\right),$$

$$\omega^*_{ijt} \equiv \omega_{ijt}\left(\frac{\eta_s+1}{\eta_s}\right), \mu^*_{ijt} \equiv \mu_{ijt}\frac{1}{|\eta_s|}$$

This formula makes it possible to avoid the problem of being unable to obtain company-level price data. [1] In this paper, in principle, this formula will be used to make estimates. The main feature of this formula is the clear introduction of q_{ijt} into the estimation formula as a variable to indicate the demand available to the company.

The effect of the enhancement of the patent system in each country may be formulated as follows. I specify the demand function firms face affected by patent rights according to Helpman (1993), in which about IP systems in developed countries and developing countries assume that companies of developed countries are in competition with local companies in developing countries (imitators) for goods that are differentiated from other products and that the strength of patent right would force local companies to exit from the market. The exit of local companies means an increase in the residual demand which companies in developed countries face. Consequently, for the demand function used in this paper, this can be incorporated into the estimation equation as a demand shock through μ_{ijt} and may be expressed as follows.

$$\mu^*_{ijt} = \beta_{IP} IP_{jt} + \beta_{pIP} p_{ijt} \cdot IP_{jt} + \beta_p p_{ijt} + \tilde{\mu}_{it} \qquad (6)$$

This shows that the demand shock faced by companies may be broken down into the following factors: the part affected by the level of patent protection IP_{jt}, the number of patent applications, P_{ijt}, expressing product innovation and additional protection effect of patent acquisition, the interaction term between IP_{jt} and P_{ijt}, which expresses the synergistic effect of the level of patent protection and the effect of patent acquisition, and the independent and identically distributed, probabilistic demand shock $\tilde{\mu}_{it}$.[2]

The model where the enhanced patent system affects residual demand can separate the productivity enhancement effect by process innovation from the price rising effect caused by the exclusion of imitators. In other words, it is possible to clearly differentiate the productivity enhancement effect of inventions from the monopolization effect caused by patent rights.

In this paper, it assumes that the overall technical standard of a parent company affects productivity through the state variable ω_{ijt}. In other words, in this paper, the productivity of a company is assumed to go in line with the Markov process based on the results of R&D activities up to the preceding term and the shock τ_{ijt}, which is not expected by the company. This may be expressed as follows.

$$\begin{aligned}\omega_{ijt} &= E(\omega_{ijt}|IN_{ijt-1}) \\ &= E(\omega_{ijt}|\omega_{ijt-1}, RD_{ijt-1}) + \tau_{ijt} \\ &= g(\omega_{ijt-1}, RD_{ijt-1}) + \tau_{ijt} \qquad (7)\end{aligned}$$

IN_{ijt-1} is the information set that determines the productivity of the following term. RD_{ijt-1} is the level of R&D investment of the company. This indicates that productivity depends on the R&D investments and the unexpected shock τ_{ijt}, which occurs at any time during t-1 and t. Unfortunately, in this paper, since the R&D investment data of overseas subsidiaries was not available, the R&D investment data of the parent company as a whole was used as a variable.[3] It may be reasonable to say that the productivity of overseas subsidiaries have not been achieved as a result of their R&D investments, but rather as a result of technology transfer from their parent companies. This hypothesis was adopted based on the presumption that productivity is not enhanced directly by the R&D investment of companies, but rather through uncertain routes represented as τ_{ijt}. This hypothesis may be compatible with the reality.[4]

In this paper, in order to examine the effect of patent acquisition and the effect of strength of the patent system, the following equation is established by substituting Equation (6) into Equation (5).

$$\widetilde{r_{ijt}} = \beta_k k_{ijt} + \beta_l l_{ijt} + \beta_p p_{ijt} + \beta_{pIP} p_{ijt} \cdot IP_{jt} + \beta_{IP} IP_{jt} + \beta_q q_{ijt} + \omega^*_{ijt} + \widetilde{\varepsilon_{ijt}} \qquad (8)$$

In this equation, $\widetilde{\varepsilon_{ijt}} = \tilde{\mu}_{it} + \varepsilon_{ijt}$, indicates that both of them are random shocks that are not correlated with any independent variable. If the number of patent applications itself has a positive effect on productivity, β_p would be positive. This effect contains the effect of product innovation as well as the effect of patent acquisition. On the other hand, β_{IP} is the measurement of the effect of a shift in the demand function, i.e., a reduction in the number of counterfeit companies as a result of the strength of the patent right. Eventually, the effect of increasing productivity through the enhancement of the level of patent protection will be measured by β_{pIPR}.

Furthermore, in the case of an overseas subsidiary of a Japanese company, more than a few employees are sent from Japan. These employees are different from local employees in terms of the job responsibilities and wage system (the Japanese parent company compensate wage for employees sent from Japan). For this reason, the labor input is divided into the local employees l^H_{ijt} and expatriate employees from Japan l^{JP}_{ijt}. In this case, Equation (8) may be formulated as follows.

$$\widetilde{r_{ijt}} = \beta_k k_{ijt} + \beta_{lH} l^H_{ijt} + \beta_{lJ} l^{JP}_{ijt} + \beta_p p_{ijt} + \beta_{pIPR} p_{ijt} \cdot IP_{jt} + \beta_{IPR} IP_{jt} + \beta_q q_{ijt} + \omega^*_{ijt} + \widetilde{\varepsilon_{ijt}} \quad (9)$$

In this paper, estimates are made by using this Formula (9).

The following section explains how to handle ω_{ijt}, i.e., the productivity shock observable by companies. This paper adopted the methods presented by Olley and Pakes (1996) and Levinson and Petrin (2003). The extremely important factor of this method is the timing of a company's decision of input. In this paper, it is hypothesized that companies' capital investment will increase their capital input during a time lag of one term. In other words, there is one-year lag between the decision of making capital investment and the actual use of the facilities. This may be expressed in the following equation.

$$k_{ijt} = (1-\delta)k_{ijt-1} + I_{ijt}$$

I_{ijt} is the amount of investment in the current term and δ means a obsolescence rate.

I assume that the company's labor input L_{ijt} is a completely variable input. This assumption means that it is possible to make a necessary increase or decrease in labor input, or input a necessary amount of labor in each term and that this has no effect on the future amount of production, etc. (meaning it is not a state variable). When a Japanese company determines the location of an overseas production site, one of the major determining factors is the flexibility in the amount of labor input. The company is also able to change the number of expatriate employees from Japan in accordance with the state of production activities. It is reasonable to say that each company determines the amount of labor input based on ω_{ijt} and other variables.

In this case, the demand function indicating the demand for local employees may be expressed as follows.

$$l_{ijt}^{H} = l_{jt}^{H}(\omega_{ijt}, k_{ijt}, l_{ijt}^{JP}, p_{ijt}, IP_{jt}, q_{ijt})$$

In this paper, according to Levinsohn and Petrin (2003), I compute non-parametrically ω_{ijt} using of the factor demand function of labor input.[5] It should be noted that many preceding studies that used the factor demand function permit time fluctuations, while assuming that each company will face various factors such as the same prices (labor costs).[6] However, in some cases, such as this paper, companies having overseas subsidiaries in multiple countries are studied. In such cases, this assumption is unrealistic because the level of wage differs greatly from one country to another. On the other hand, if a country-specific estimation is made in order to avoid this problem, it would make it impossible to determine the effect of the enhancement of the patent system in each country. For this reason, this paper assumes that the labor demand available to companies will depend on the level of wage w_{jt} during Term t in each country. This may be expressed as follows:

$$l_{ijt}^{H} = l_{jt}^{H}(\omega_{ijt}, k_{ijt}, p_{ijt}, IP_{jt}, q_{ijt}, w_{jt})$$

By making an inverse function of ω_{ijt}, this equation may be expressed as follows.[7]

$$\omega_{ijt} = h_{tj}(k_{ijt}, p_{ijt}, IP_{jt}, q_{ijt}, w_{jt}, l_{ijt}^{H})$$

Since the function form of h_{tj} is not known, a cubic polynomial function is used as a substitute. If this equation is substituted into Equation (9), the following equation may be established.

$$\widetilde{r_{ijt}} = \beta_k k_{ijt} + \beta_{lH} l_{ijt}^{H} + \beta_{lJ} l_{ijt}^{JP} + \beta_p p_{ijt} + \beta_{pIP} p_{ijt} \cdot IP_{jt} + \beta_{IP} IP_{jt} + \beta_q q_{ijt} + h_{tj}(k_{ijt}, p_{ijt}, IP_{jt}, q_{ijt}, w_{jt}, l_{ijt}^{H}) + \widetilde{\varepsilon_{ijt}} \quad (10)$$

When making an estimate, first, Equation (1) will be regressed by OLS. Since any variables other than l_{ijt}^{JP} are included in the inverse function, they are unidentifiable. Therefore, the purpose of the OLS regression is to calculate l_{ijt}^{H} parameter and the following equation.

$$\widehat{\varphi}_{ijt} \equiv \beta_k k_{ijt} + \beta_p p_{ijt} + \beta_{pIP} p_{ijt} \cdot IP_{jt} + \beta_{IP} IP_{jt} + \beta_q q_{ijt} + h_{tj}(\omega_{ijt}, k_{ijt}, p_{ijt}, IP_{jt}, q_{ijt}, w_{jt}, l_{ijt}^{H})$$

In this equation, if $\widehat{\varphi}_{ijt}$ is known, the following equation concerning $\widehat{\omega}_{ijt}$ may be established (however, $\hat{\omega}_{ijt}$ cannot be calculated at this stage).

$$\hat{\omega}_{ijt} = \hat{\varphi}_{ijt} - (\beta_k k_{ijt} + \beta_p p_{ijt} + \beta_{pIP} p_{ijt} \cdot IP_{jt} + \beta_{IP} IP_{jt} + \beta_q q_{ijt})$$

Equation (7) makes it possible to calculate the rest of parameters by regressing $\hat{\omega}_{ijt}$ to the previous $\hat{\omega}_{ijt-1}$ and R_{ijt-1}. In this case, those remaining variables and τ_{ijt} need to be uncorrelated.

$$E\{\tau_{ijt}(\beta_k, \beta_p, \beta_{pIP,}\beta_{IP,}\beta_{q,}\beta_{lH})(k_{ijt-1}, p_{ijt}, p_{ijt} \cdot IP_{jt}, IP_{jt}, q_{ijt}, l^H_{ijt-1})'\} = 0$$

The above equation makes it possible to use GMM estimation of parameters by using these variables.[8] Meanwhile, since the function form of $E(\omega_{ijt}|\omega_{ijt-1}, R_{ijt-1})$ is not known, a cubic polynomial function is used as a substitute in this formula as well.

Ⅳ Data

My primary data used in my estimation i.e., the data on overseas subsidiaries such as the sales, the number of employees, the number of expatriate employees from Japan, the capital, and the type of industry, was obtained from *Kaigai shinshutsu kigyou souran* (Overseas Japanese companies) published by Toyo Keizai Inc. The Input Output Table provided by The World Input-Output Database (WIOD) was used as the data on the industry-specific deflator and the industry-specific demand in each industry. *PATSTAT* published by the EPO was used to obtain data on the overseas patent applications filed by Japanese companies. Also, the following databases were used to obtain various data such as the data on the countries in which overseas subsidiaries are located. In addition, the GPI was used in order to obtain data on the level of patent protection in each country. The following analysis was conducted to determine to what extent such data reflects the actual patent enforceability.

Before estimating production function, I first examine the relation between the GPI and the counterfeit damage suffered by Japanese companies in other countries and thereby determined to what extent the GPI can explain the patent enforceability actually experienced by Japanese companies.

I assume that the determinant factor of counterfeit damage is expressed by the following simple formula.

$$\text{Imitation rate} = \beta_0 + \beta_1 GPI_{jt} + \beta_2 \ln GDPcapita_{jt} + \beta_3 \ln Rpatent_{jt} + \beta_4 \ln Fpatent_{jt} + +\beta_5 FDI_{jt} + +\beta_6 EX_{jt} + \varepsilon_{jt}$$

where *Imitation rate* shows as dependent variable, the rate of the companies damaged by counterfeit country j in year t by the total number of respondent companies. Based on the *Survey on Counterfeit Damage*, compiled by the JPO. This variable is in between 0 and 1.

As an independent variable, the GPI was used as the index to measure the strength of the patent right. The main purpose of this analysis is to determine whether this variable decreases the damage rate with significance. The *lnGDPcapita* is the logarithmic of GDP per capita in each country. Although GDP per capita might not have a direct effect on counterfeit damage, it is known that the enhancement of the patent system itself goes in tandem with the establishment of other systems in an economic growth (Chen and Puttitanun 2005, Park and Lippoldt (2008)). This variable is used as a variable to capture the overall level of economic development and the changes made in other systems.

The *lnRpatent* variable is a logarithmic of the number of domestic patent applications filed by domestic residents. This variable is used to express the imitation capability of each country. Many of the previous studies concluded that the difference among countries in terms of imitation capability affects companies' choice of import destinations and production locations (for example Qi 2001, Ushijima 2010). In this paper, this variable is used to determine whether such difference in imitation capability significantly affects the counterfeit rate.

The *lnFpatent* is a logarithmic of the number of patent applications applied by foreign residents e.g. MNCs. for the local patent office. This is a variable to reflect foreign companies' use of the patent system.

FDI is a variable to express whether each of the respondent companies has subsidiaries in a certain country. As described above, the possibility of recognizing counterfeit damage in a certain country depends on each company's capability to recognize counterfeit damage in a certain country. The rate of recognition is considered to be higher if the company has an office in that country. A company that has an overseas office is more likely to be engaged in large-scale production and sale in that country, which could consequently increase the risk of counterfeit damage. Therefore, FDI is expected to have a positive correlation with the rate of counterfeit damage.

EX is a variable that expresses whether a company exports goods to a certain country. The goods exported to and commercialized in a certain country could increase counterfeit damage in that country.

The estimation is made for the period from 1999 to 2009 based on the unbalanced panel data. The year 2000 was excluded from the estimation due to the missing of the total number of responses. First, I conducted an OLS estimation that largely concerns a comparison between countries, and a tobit estimation that takes data cutoff into consideration. Then, I estimate the equation using a fixed effect model in order to control for unobserved time invariant differences among countries such as culture, business custom which poetically affect the damage rate.

First, I estimate with developing countries and find that the GPI is positive and that some of the coefficients are significant. However, if China is excluded from the estimation, all estimation methods, i.e., OLS, tobit, and fixed effect, show that the coefficient of the GPI turn to be negative with highly significance. This result indicates that the counterfeit damage rate of China, which is extremely high irrespective of the level of the GPI, would be an outlier in the estimation concerning developing countries. At least, as far as developing countries excluding China is concerned, the higher the GPI is in a country, the less likely companies suffer counterfeit damage in that country. The fact that the coefficient is -0.002 suggests that one-unit increase in GPI would decrease counterfeit damage by 0.2%. This indicates the possibility that, in developing countries other than China, the GPI reflects patent enforceability to a certain extent. In contrast, it is indicated that, in China, actual enforceability is extremely low despite the formal legal provisions to protect patent rights. This result is consistent with a case study that has revealed that many overseas subsidiaries especially suffer from counterfeiting activities in China.

On the other hand, I was unable to obtain any statistically significant result concerning developed countries except for some exceptions. This may be attributable to the fact that developed countries have already established their respective patent systems and have been enforcing them with a certain level of effectiveness and that any additional formal enhancement of their patent systems would not make a significant contribution to decreasing counterfeit damage.

V Results

Next, I estimate the production function concerning some industries of developing countries, namely, the electric machinery, machinery, chemistry, and pharmaceutical industries, by using various methods, i.e., OLS, fixed effect, and the LP model. In the chemistry and pharmaceutical industries, I use not only the GPI but also the PIPP which are another patent indexes for pharmaceutical products established by Liu and La Croix (2015). First, I find that, for the electric machinery industry, the number of patent applications and the GPI have a statistically-significant positive for the productivity. However, the interaction term of these two variables is significantly negative. These suggest that, in the electric machinery industry, the patent applications filed in a developing country effectively contribute to increasing productivity. These also show that the enhancement of the patent system in a country increases the companies' patent appropriability in that country. However, the interaction term shows that such effect is limited and therefore the stronger the patent system is, the weaker effect the filing of a patent application would have in terms of the effect of increasing productivity.

Also, the results reveal that the number of patent applications are statistically insignificant in the machinery industry and the pharmaceutical industry in developing countries. This suggests that patent applications in a country would not increase the productivity of the overseas subsidiary in that country. In some estimations, GPI and PIPP are significantly positive in the machinery industry and the pharmaceutical industry. In consideration of the facts that the number of samples is small and that variation in both indexes is also small, the enhancement of the patent system could be contributing to increasing productivity to a certain extent. Regarding other variables, coefficient of demand is significantly negative. This variable is an inverse number of the price elasticity of demand and my result is inconsistent with the theory. This is probably due to the fact that market demand measured in the two-digit category fail to accurately match to the demand the Japanese subsidiaries face.

In the electric machinery industry and the machinery industry in developed countries, the GPI variable are insignificant in all estimations. In consideration of the fact that patent enforceability is already high in developed countries, this indicates that additional enhancement of the patent system does not increase the productivity of companies. This result is compatible with the aforementioned analysis results produced by use of the counterfeit damage rate and also with the results of the preceding studies that concluded that the companies' patent appropriability in the electric machinery industry and the machinery industry is not high.

In the chemistry industry and pharmaceutical industry, I obtain the result that, although PIPP is insignificant, GPI is statistically significant and the number of patent applications is generally significantly positive. These results indicate that, in the chemistry industry and the pharmaceutical industry, the enhancement of the patent system in developed countries could increase productivity. This shows that patent appropriability in those industries is high in developed countries.

It should be noted that the interaction term between the enhancement of the patent system and the number of patent applications is significantly negative. This indicates that, the stronger the patent system is, the weaker the additional effect of increasing profitability would be even if a patent application is filed.

Ⅵ Conclusion

This paper first examine the extent to which the patent index designed to quantify the level of the strength of the IP system of each country is related to the improvement in the actual enforceability of IP rights by analyzing the correlation with the counterfeit damage suffered by Japanese companies in that country. Then, this paper investigate, by using the production function and the patent index, whether the enhancement of the patent system in that country increases the productivity of Japanese companies' overseas subsidiaries in that country.

The results show that a rise in the patent index has a negative correlation with the counterfeit damage suffered by Japanese companies in developing countries excluding China, whereas no statistically significant correlation between patent index and counterfeit damage in China and developed countries. This shows that, in many developing countries where the patent system has not been sufficiently established, the quantifiable formal enhancement of the patent system would adequately contribute to improving patent enforceability. The resultd also suggests that China, in which counterfeit damage is extremely serious, is an exception and that, in the case of developed countries: in which the patent system has already been fully established, the formal establishment and enhancement of the patent system would not result in additional improvement of patent enforceability.

Based on the above-described analysis, I estimate productivity by using the production function as follows. First, in the electric machinery industry in developing countries, it reveals that both a rise in the patent index and an increase in the number of patent applications filed by companies increase their productivity. However, the interaction term between these two variables is significantly negative, which indicates that a high patent index would weaken an additional effect of patent application. This may indicate that the marginal effect of patent acquisition would decrease as the patent right itself gets stronger.

In the chemistry industry and the pharmaceutical industry, the results show that, in developed countries, both the patent index and the number of patent applications significantly increase the productivity. As previous studies show that the patent appropriability is high in the pharmaceutical industry, this result is consistent with the same result from using of the production function. It should be noted that the interaction term is significantly negative and that a strong patent system would decrease the additional effect of patent acquisition.

These results described above show that the strength of the patent system in each country would decrease the counterfeit damage suffered by Japanese companies and contribute to increasing their productivity. However, such effect would be different from one industry to another. Such effect is clearly observable especially in the electric machinery industry in the case of developing countries and in the chemistry industry and the pharmaceutical industry in the case of developed countries.

Summing up, it may be said that the request made from developed countries including Japan to developing countries for enhancing their patent system and the developed countries' cooperation to achieve this goal are likely to have contributed to reducing the counterfeit damage suffered by companies from developed countries and then increase their profitability.

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[1] It should be interpreted that technology protection by patent rights would increase companies' markups through market monopolization rather than improving their productivity. In this case, like Hall (1986) and Cassiman and Vanormelingen (2013), it would be necessary to analyze the relation between parent rights and markups. However, this analysis would require data on labor cost share (labor costs/total production costs). Unfortunately, such data is not used in this paper. A further study should be conducted to make a markup estimation.

[2] Hall et al. (2005) stated that the number of patents obtained by a company indicates the successful cases where the company acquired new proprietary knowledge on the presumption that the company made R&D investments.

[3] Only a small number of companies have their overseas subsidiaries conduct R&D activities. The scale of such activities is just around 4.4% of the R&D costs of those companies as a whole (*The 43rd Survey of Overseas Business Activities*, Ministry of Economy, Trade and Industry (2014))

[4] Doraszelski and Aumandreu (2013) pointed out that this model is more realistic than the production function-based estimation method that has been adopted since the study of Griliches (1979).

[5] Levinsohn and Petrin (2003) used the raw material costs such as the electricity usage determined in the current term. However, due to the lack of such data, the demand for labor input was used to express ω_{ijt}.

[6] Doraszalski and Jaumandreu (2013) conducted an exceptional study where they used the labor cost data of each company and explicitly estimated the parametric labor demand function.

[7] Please refer to De Loeker (2011), who proved that an inverse function is possible under monopolistic competition.

[8] τ_{ijt} has a correlation with the number of overseas expatriates from Japan in the current term. However, since it is hypothesized that the number of overseas expatriates from Japan is a completely variable input, τ_{ijt} has no correlation with the number of overseas expatriates from Japan in Term t-1.