What Factors Determine the Mode of Overseas R&D by Multinationals?

: Empirical Evidence

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Abstract

It is notable that overseas R&D expenditures and establishments of research laboratory by MNCs have increased rapidly. It is an interesting subject to investigate what factors cause the enlargement of their R&D activities from product development/process innovation to creation of innovative knowledge. Noting different stages of overseas R&D by MNCs' affiliates, this paper provides statistical evidences of the factors by using qualitative data of different R&D between in plant site and in laboratory. The empirical results present (1) the export propensity of affiliate firm, the abundance of human resources for R&D and the accumulated technological knowledge have a positive effect on both R&D in plant site and R&D in laboratory, and (2) the stronger enforcement of intellectual property rights pushes MNCs to enlarge their R&D for knowledge creation. These results show that not only firm-specific but also country-specific factors positively affect the enlargement of overseas R&D.

Keywords: overseas R&D, MNCs, Knowledge creation, Intellectual Property Rights, Export propensity, Human resources

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1. Introduction

In recent years, the R&D activity of multinational companies (MNCs) has rapidly grown along with the increasing foreign direct investment (FDI). The share of foreign affiliates' R&D to total R&D expenditures records more than 15% in OECD countries in 2001. Japanese MNCs have raised their overseas R&D expenditure from 2.1 billion dollars in 1995 to 3.3 billion dollars in 2000. The number of their overseas research laboratories sharply increased from 312 in 1995 to 520 in 1998 as well. Such an increase of R&D expenditures and research laboratories implies the enlargement of the stage of R&D activities from development of new products and improvement of process engineering to creation of new knowledge. Although it is an interesting subject to investigate why MNCs have enlarged globally the stage of their overseas R&D, previous literatures have not given a sufficient answer to this question. The purpose of our paper is to examine empirically what factors have caused the enlargement of the stage of MNCs' R&D in a global perspective.

R&D activities consist of different stages; one is for knowledge creation, another is for product and process development. It is not observable from the outside at which stage of knowledge creation or product/process improvement the firms are actually conducting R&D. However, from statistical data it is observable in what facilities they are conducting R&D. The modes for implementing R&D are classified into three; (1) no R&D at all, (2) conducting R&D in plant site without setting up research laboratory, (3) conducting R&D with setting up research laboratory. R&D in research laboratory corresponds to the function for knowledge creation,

while R&D without laboratory corresponds to the function for product and process development. The establishment of research laboratory indicates a sign of the firm to enlarge its R&D to the stage of knowledge creation. We use this conceptual framework for the analysis on what factors affect the enlargement of the stage of MNCs' overseas R&D.

Although we find that the previous studies explored what factors explain the intensity of overseas R&D expenditure, the R&D intensity is not sufficient to characterize the feature of R&D activities of MNCs' affiliates. It is an interesting subject to investigate what factors cause the enlargement of R&D activities from product and process development to creation of innovative knowledge. As long as the authors know, there is no analysis to investigate what factors affect the enlargement of overseas R&D function. This is a motivation to conduct our research in this paper. To do this research, a large size of firm-level data of MNCs and their overseas affiliates is needed. Insufficient availability of such firm-level data is a major reason why we do not find rich analyses of the factors to affect the enlargement of overseas R&D of MNCs' affiliates. This paper succeeds in using a large size firm-level data of Japanese MNCs and their overseas affiliates. The analysis of this paper is different from the previous researches in the characterization of R&D activities and the size of firm-level data used for the empirical estimation.

Based on the qualitative data of R&D modes, the firm-specific data of Japanese MNCs and their affiliates including of overseas R&D activities, and the country-specific data, we conduct the multinomial logit estimation to test statistically what factors affect the MNCs'

choice of overseas R&D modes between the function of product and process development and the function of knowledge creation.

The results of empirical examination in this paper present interesting findings: (1) the export propensity of affiliate firm has a positive effect on the enlargement of overseas R&D, (2) the abundance of human resources used for R&D and the high level of technology accumulation in host country accelerates the enlargement of MNCs' R&D function to knowledge creation, (3) the stronger enforcement of intellectual property rights (IPRs) in the host country pushes MNCs to enlarge their R&D to the stage for knowledge creation. The enlargement of R&D activities of MNCs' affiliates is an essential factor for the technological evolution in the host countries. These results therefore suggest that not only the firm-specific factors but also the country-specific factors are important for the stage up of MNCs' R&D which leads to an essential source for technological evolution in the host countries.

This paper is organized as follows: Section 2 introduces the previous studies related to the determinants of overseas R&D. Section 3 presents the hypotheses to be tested and the methodology for the empirical analysis. Section 4 describes the data used for the empirical analysis and the specification of model. Section 5 presents the results of estimation. The closing section discusses the conclusion and the remaining issues.

2. Literature

There are a number of empirical studies to present statistical evidences for the reasons

why MNCs' affiliates raised their overseas R&D expenditures. As long as we know, the previous literatures have explored the answers about four factors.

First is related to the size of market in which MNCs supply. When MNCs enter a market, they need a market-specific information for adapting or customizing their products to the market specific environment. The larger the size of market to which they supply their products, the more they undertake R&D. Hence, a firm with higher share of sales to local market is inclined to conduct R&D for the market. Odagiri and Yasuda (1996) found that the share of local sales of Japanese affiliate firm is positively related with their R&D expenditures of affiliate firms by using industry aggregated data. Kumar (2001) also showed the market size of host country has positive effect on the volume of R&D expenditures by US and Japanese MNCs. However, there are opposite studies to them. If the supply from MNCs' affiliates is directed overseas because of high profitability of export, their R&D expenditure is spent for the innovation in exportable. Zejan (1990) found that the export ratio of foreign affiliate firm is positively related with R&D in the foreign country by using Swedish MNCs data. Similarly, Papanastassiou and Pearce (1992) also found that the production share to the local market of affiliate firms have negative effect on R&D. Those results would be consistent with Melitz (2003) who demonstrated theoretically that firms with higher productivity have a tendency to export their products. In some cases the R&D intensity is positively correlated with the higher ratio of sales to host country, but in other cases it is positively correlated with the higher propensity to export. It is ambiguous which a higher ratio of sales to host country or a higher

propensity to export inclines to accelerate overseas R&D of MNCs.

The second is related to R&D cost. The determinant of location choice of R&D facility is similar to that of FDI with respect to the market- specific costs. Holding other factors constant, MNCs will locate R&D facility in a country where it has an availability of abundant R&D resources at lower cost. Therefore the country abundant in highly educated human resource for R&D is supposed to attract the location of MNCs' R&D facilities. Kumar (2001) found that the higher ratio of scientist and engineers has a positive effect on R&D expenditure of MNCs' affiliates and the higher wage of R&D personnel has a negative effect on it.

The third is related to the externality of technological knowledge in a country where R&D facility is located. MNCs may be motivated to absorb new knowledge and benefit from spillover effects in host country because the superior knowledge stock attributed by innovative activity in the host country is expected to have a positive externality for MNCs. Odagiri and Yasuda (1996) used net technological export from Japan to other countries as a proxy of the relative technological advantage of Japan. Noting the negative effect of Japanese net technology export on its overseas R&D, they asserted that more advanced technology in the host country is attractive for MNCs. However the extent of technological advancement in host country must be different between industries. Kumar (2001) demonstrated that the competency in a particular sector in host country measured by export competitiveness has significantly positive effect on R&D expenditure of MNC's affiliates. Fors (1996), who explored the factors explaining foreign R&D activity of Swedish MNCs, also found that the technological

specialization in a particular industry in the host country has significant and positive effect.

The location choice of facility for R&D base may be influenced by the strength of protection for intellectual property rights (IPRs). While Kumar (2001) could not found significant impact of strength of IPRs on the overseas R&D expenditure of US and Japanese foreign affiliates, Branstetter, Fisman and Foley (2004) found that policy reform of IPRs in host countries has a significantly positive effect on both local R&D expenditure of US foreign affiliates and intra-firm technology transfer by US MNCs to their local affiliates at the affiliate level. As for Japanese MNCs, a recent study by Wakasugi and Ito (2005) also confirms the positive impact of IPRs on intra-firm technology transfer at the affiliate level. It is noteworthy that so many countries have been strengthening the enforcement of IPRs in these years under the WTO framework. The enforcement of IPRs is an indispensable factor to affect overseas R&D of MNCs.

MNCs are conducting a various types of overseas R&D for improving production process, developing new product and creating new knowledge. As well as domestic R&D; R&D activity of overseas affiliates is separated into two: “research” to create knowledge and “development” to develop new products or new process for existing products. By using these two types of R&D activities, the enlargement of overseas R&D by MNCs’ affiliates is classified into three stages: (1) MNCs do not conduct R&D at all in the host country, or (2) MNCs conduct only “development” and (3) MNCs conduct both stages of “research” and “development.” Although previous studies demonstrated that the volume of overseas R&D

expenditure is explained by such factors as market size, factor cost for R&D, and the accumulated knowledge, they have not examined how those factors have affected the enlargement of R&D stages from "development" to "research." It is an interesting issue to reveal what factors affect the enlargement of R&D.

3. Analytical Framework

3.1 Hypotheses

When the affiliates of MNCs enter the overseas market, they have three options for R&D activities; (i) to produce without any R&D activity, (ii) to produce with only development activity of new process and product, (iii) to produce with not only development activity but also research activity for creating new knowledge and technology. We assume that the choice of R&D types is determined both by market-specific and firm-specific factors[1]. Here, the hypotheses to identify the factors to affect the choice of R&D stages are described as follows:

Hypothesis 1: *A firm-specific factor such as high propensity of affiliate firms to export accelerates the enlargement of their R&D activities from "development" for new process/product to "research" for knowledge creation.*

When MNCs' affiliates start to supply their goods for the host country, the knowledge

[1] Those alternatives of R&D stages are not particular to MNCs. They are observed even when a firm enters a domestic market. However, in the case of MNCs' affiliates, what factors affect the enlargement of R&D is more clearly observable in overseas R&D than in domestic R&D.

and technology necessary for production will be supplied by their parent firms in home country or by their own R&D in the host country. However, when they export, they need more sophisticated knowledge and technology than the domestic supply oriented because they need technology and knowledge to customize their products to fit the foreign market. Therefore, the affiliates which export a large portion of their products are inclined to spend more money for not only development but also research of new knowledge. In other words, such a firm-specific factor as a high propensity to export pushes MNCs' affiliates to enlarge their stage of R&D.

Hypothesis 2: Market specific factors of a country in which the human resources engaged in R&D are abundant and technological knowledge is abundantly accumulated provide affiliate firms with favorable conditions to enlarge their R&D activities from development to both research and development.

The abundant human resources for R&D and accumulation of technological knowledge in a country attract MNCs to locate R&D facility because it lowers the cost of R&D in the country. Therefore, the abundant human resources for R&D and the abundant accumulation of technological knowledge in the host country have a positive effect on R&D activities of MNCs. However, the magnitude of the effect is different according to the stage of R&D. In comparison with the development of product and manufacturing process, the abundance of highly educated researchers and the large opportunity to absorb high level of

technological knowledge are crucial for the creation of new knowledge which is generated in research laboratory. Favorable market specific factors such as abundant R&D human resource and accumulation of superior technology raise the probability of conducting both research and development.

Hypothesis 3: *The stronger enforcement of intellectual property rights increases the probability of affiliate firms to enlarge the research function for knowledge creation.*

The technological knowledge for developing new process/product usually will be embodied in their products. Those embodied knowledge and technology will be protected by the ownership of product in some extent even if they are not sufficiently protected by IPRs. However, the new knowledge and technology created by research activity will be imitated in the host country unless it is protected by IPRs. The affiliates hesitate to conduct research activity for creating new knowledge and technology in the country which is characterized by weak IPRs. Institutional factors such as the strong IPRs encourage affiliates' function on research activity.

3.2 Specification for Estimation

We assume that affiliates of MNCs have three choices on R&D; the first choice is only to produce without R&D activity, the second choice is to conduct only development, and the third choice is to conduct both research and development. While it is not observable from the

outside at which stage of knowledge creation or product/process improvement the firms are actually conducting R&D, from statistical data we can observe whether a foreign affiliate spend R&D expenditure or not and whether it hold R&D laboratory or not. That is, it is observable in what fashion they implement R&D. The implementation of R&D are classified into three modes; (1) no R&D at all, (2) conducting R&D in plant site without setting up R&D laboratory, (3) conducting R&D with setting up R&D laboratory. We assume that the establishment of research laboratory indicates a sign of the firm to enlarge its R&D to the stage of knowledge creation.

In order to test empirically what factors affect the enlargement of overseas R&D stages by MNCs affiliates, we use this conceptual framework for the analysis on what factors affect the enlargement of the stage of MNCs' overseas R&D. We define the enlargement of R&D by three modes of R&D fashion, respectively corresponding to choice 1, choice 2 or choice 3. Therefore, the information on the modes of R&D will enable us to identify a factor affecting on each choice. In order to estimate the factors statistically, we use a multinomial-logit model.

Let Y_i denote the outcome of the different choices, m of firm i. In this case, m = 1, 2 and 3. The vector of explanatory variables, $\mathbf{X_{i,h}}$ consists of firm- and country- specific factors which affect the profit of MNCs affiliates. $\mathbf{i}$ denotes the index of firm-specific variables including the share of export to total sales of affiliate firm for testing the hypothesis 1 while $\mathbf{h}$ denotes that of host country-specific variables such as the number of researchers and the level of

technology with regard to the hypothesis 2 and 3. The multinomial logit model which provide probabilities for the choice *m* taken by firm *i* in host county *h* is expressed as below.

$$P_{ih}\left(Y_i = m\right) = \frac{\exp\left[\boldsymbol{\beta}'_{\mathbf{m}}\mathbf{X}_{\mathbf{i,h}}\right]}{\sum_{m=1}^{3}\exp\left[\boldsymbol{\beta}'_{\mathbf{n}}\mathbf{X}_{\mathbf{i,h}}\right]}, \quad \text{for } m = 1, 2, 3 \qquad (1)$$

where $\boldsymbol{\beta}'_{\mathbf{m}}$ is vector of parameters on choice *m*. In this analysis, the estimated coefficients present the marginal effects on the odds ratio of choosing *m* over the base choice, *m* = 1 (No R&D), of changes in the explanatory variables. Therefore the log-odds ratios of choosing *m* over the base choice are can be formulated as;

$$\ln\left[\frac{P_{ih}\left(Y_i = m\middle|\mathbf{X}_{\mathbf{i,h}}\right)}{P_{ih}\left(Y_i = 1\middle|\mathbf{X}_{\mathbf{i,h}}\right)}\right] = \boldsymbol{\beta}'_{\mathbf{m}}\mathbf{X}_{\mathbf{i,h}}, \qquad \text{for } m = 2, 3. \qquad (2)$$

The estimated parameters are obtained to maximize log-likelihood under the assumption of independence of irrelevant alternatives. For the interpretation of the estimated coefficients, we compute the marginal effects of each variable on the predicted probabilities by differentiating equation (1) to identify factors which determine firm's choice with respect to R&D mode.

4. Data and Estimation

4.1 Sample and Dependent Variable

The empirical test uses the data set constructed by matching the firm-level data of Japanese affiliates overseas with the statistics of host countries. As for the firm-specific variables, we use the firm-level data from two statistics conducted by the Ministry of Economy, Trade and Industry: "Basic Survey of Overseas Business Activities" as the source for Japanese local affiliate firms located in various foreign countries and "Basic Survey of Japanese Business Structure and Activities" as the source for Japanese parent firms.[2]

"Basic Survey of Overseas Business Activities" includes the data on both R&D expenditure and the number of R&D laboratories for each affiliate firm in 1995 and 1998. We classify affiliate firms into three types according to their R&D modes; affiliates spending no R&D expenditure at all, affiliates spending R&D expenditures without research laboratory, and affiliates spending R&D with research laboratory. The dependent variable is odds ratio of choosing mode *m=2, or 3, corresponding to* R&D without lab or R&D with lab, respectively, over the base choice of *m*=1 corresponding to no R&D. With regard to the distribution of affiliate firms tabulated by mode in the sample, the number of affiliates spending no R&D expenditure is 958 and 1,082 in 1995 and 1998, respectively. The number of affiliates spending R&D expenditures without research laboratory decreased from 272 in 1995 to 254 in 1998 while that of affiliates holding R&D laboratory increased from 169 to 215.

[2] The authors acknowledge Ministry of General Affairs and Ministry of Economy, Trade and Industry who have given them an official permission to use the firm-level data of these statistics.

4.2 Firm-specific Variables

In order to test Hypothesis 1 discussed in the previous section, as explanatory variables we include the share of export to total sales of affiliate firm (*SalesEx*). When firms enter export market, they need more sophisticated knowledge and technology to customize their products to fit the foreign market. Therefore, we expect that a higher propensity to export is positively related with the enlargement of R&D activity.

We take into account several factors to control other firm-specific factors. Larger firms will be in the ascendancy over smaller firms to finance R&D and they will be easier to set up R&D base in foreign countries. The affiliate firm of its parent firm with a high R&D intensity will also be apt to operate R&D in host country. Zejan (1990) found that there is a positive relation between R&D intensity of affiliate firm of Swedish MNCs and that of its parent firm. Since some empirical studies also confirmed those effects, it is expected that the firm size of affiliate and parent firm and the R&D intensity of parent firm have positive effects on overseas R&D. Therefore, it is necessary to control them. As a proxy for the size of firm, both the total sales of affiliate firm (*Sales*) and that of its parent firm (*P_Sales*) are included in the equation. We define the R&D intensity of parent firm as the ratio of R&D expenditure to total sales of parent firm (*P_R&D*).

The operation of MNCs' affiliates accompanies the learning by doing, which will positively affect the enlargement of overseas R&D. We assume that the accumulated experience

in operation of affiliate firm in the host country has a positive effect on the probability of decision on a higher enlargement of overseas R&D. In order to test it, we include in the equation for estimation the firm age (*Age*) defined by the number of years passed after the establishment year of affiliate firm. Those firm-specific variables of affiliates are collected from "Basic Survey of Overseas Business Activities" and "Basic Survey of Japanese Business Structure and Activities."

4.3 Country-specific Variables

In order to test Hypothsis 2, we examine the effects of the abundance of human resources engaged in R&D and the accumulation of technological knowledge on the enlargement of R&D of MNCs' affiliates. At first, we assume that the abundance of human resources for R&D at a low cost in a country is a reason of MNC's to enlarge R&D in the country. To examine its effect, the number of researchers per million people in host country (*Researchers*) is included as a proxy of the abundance of human resources in the equation. The effect of abundant R&D human resources on the decision of the enlargement of R&D will be positive. The data are from the World Development Indicator (WDI).

Secondly, we note the spillover effect of technological knowledge in the host country. We assume that the country that has a highly accumulated technological knowledge is inclined to provide a favorable environment for R&D activities since it supplies a positive externality of technological diffusion. We assume that the affiliates conducting R&D in both plant site and

research laboratory receive more benefit from the externality of spillover effect of technological accumulation than the affiliates conducting R&D only in plant site. As a variable presenting the source of technological externality in the host country, we use the net royalty receipts of host country from foreign countries, namely, the royalty receipts minus the royalty payments over GDP (*Tech*). The data is also collected from the WDI. It is assumed that the larger the amount of net royalty receipts of a country, the higher the level of technological accumulation in the county, and in turn the larger the spillover effect.

In order to test Hypothesis 3 that the enlargement of R&D activities is influenced by the strength of IPRs, we employ "Index of Patent Right" by Park and Wagh (2002) as a proxy of the level of protection for IPRs in the countries in which Japanese firms locate their affiliates. This index is constructed by the numerical average of the figures for 5 categories concerning the protection of patent right: (1) the coverage of patentability for major industries including pharmaceuticals, chemicals, and food, (2) the duration of patent rights, (3) the strictness of legal enforcement, (4) the ratification of international agreements related to the patent protection, and (5) the existence of policies that undermine the implementation of patent rights. Higher score of the index represents a country with a higher level of patent protection. Since the index is updated every 5 years, we employ the index for 1995 data and the mean of 1995 index and 2000 index as an approximation for 1998 index.

It is possible that there is a multi-colinearity between Index of Patent Right and country-specific variables such as a market size. So as to avoid this problem, we employ the

income adjusted Index of Patent Right (*R_IPR*) which is defined as the residual after a regression of the "Index of Patent Right" on the per capita GDP and the constant term, instead of the direct use of the index.

4.4 Estimation

The following reduced form is used in order to estimate the effects of the factors mentioned above.

$$\ln\left[\frac{\mathrm{Pr}_m}{\mathrm{Pr}_1}\right] = \beta_0 + \beta_1\left(SalesEx\right)_{ilm} + \beta_2\left(Age\right)_{ilm} + \beta_3\left(Sales\right)_{ilm} + \beta_4\left(P\_R\&D\right)_{im} + \beta_5\left(P\_Sales\right) + \beta_6\left(Researchers\right)_{jm} + \beta_7\left(Tech\right)_{jm} + \beta_8\left(R\_IPR\right)_{jm} + \varepsilon_{ijm} \quad (5)$$

where subscript *i* denote the index of MNC and *l* is the index of its affiliate firm. The subscript *j* expresses the index of host country.

Considering the fact that most R&D is conducted by the manufacturing firms, we focus on the manufacturing industry. Table 1 shows the distribution of sample affiliate firms over manufacturing industries according to the R&D mode. As it shows, the number of affiliates conducting R&D and holding research laboratory are concentrated in machinery industries and chemical industry. The rate of increase from 1995 to 1998 is also high in these industries. Taking into account such a large difference in intensity of R&D activity among industries, we added industry dummy variables in the equation to control the difference between industries

attributed by unobservable industry-specific factors.

Table 1 around here

Table 2 shows the distribution of sample affiliate firms over host countries according to the R&D mode. Although there is a large difference in the number of affiliate conducting R&D across countries, it will be controlled by country-specific variables. Table 3 and Table 4 describe the data descriptions and the summary of statistics for each variable over the R&D mode for 1995 and 1998, respectively.

Table 2, Table 3 and Table 4 around here

5. Results of Estimation

We conduct the estimations based on multinomial logit model by using two datasets for 1995 and 1998, separately. The estimated results are presented in Table 5 and 6, respectively. Both tables include the estimated coefficients $\boldsymbol{\beta}'_{\mathbf{m}}$ for each mode, standard errors and the marginal effects. The estimated coefficients present the effect of explanatory variables on the choice of mode 2 (development) and mode 3 (research and development) in comparison with the choice of mode 1 (No R&D). After the estimations, predicted probabilities can be calculated for each observation by using estimated coefficients. Thus, it is possible to examine that

affiliates actually choose the mode with the highest predicted probability or not. For the both two datasets, the approximately 70 percent of observations is correctly predicted.

Table 5 and Table 6 around here

With regard to firm-specific variables, the export propensity of affiliate firm (*SalesEx*) is positively related with both R&D without laboratory and R&D with laboratory. The results show evidences consistent with our theoretical conjecture. The marginal effect of export share on the probability for the choice of mode 1 (No R&D) is negative while those for other choices on R&D are positive and that for the choice of mode 3 shows a large magnitude as predicted in Hypothesis 1. These results indicate that the enlargement of R&D activities of MNCs' affiliates is found in the export-oriented affiliate firms. This is consistent with the theoretical prediction by Melitz (2003). The result implies that the firm with higher productivity attributed to R&D activity is inclined to export a higher portion of its products.

The estimated results show that the operation age of affiliates (*Age*) has a positive effect on the enlargement of R&D for both 1995 and 1998 for the choice of mode 3 with a statistical significance. It supports the previous studies which found that the experience of firms have positive effect on overseas R&D among Japanese firms.[3]

As predicted, it is found that the marginal effect of parent firm's R&D intensity (*P_R&D*) is positive for the enlargement of R&D activities while it has a negative effect on the

[3] Refer to Odagiri and Yasuda (1996) and Belderbos (2001).

choice of mode 1. These results suggest that more R&D intensive firms have a tendency to conduct the enlargement of overseas R&D, especially for knowledge creation.

As for the firm size, the marginal effects of total sales of affiliate firm (*Sales*) are positive for both choices of mode 2 and mode 3, while the total sales of parent firm (*P_Sales*) is insignificant. The size of affiliate is positively related with R&D activity while that of parent firm has no significant effect on the decision of R&D.

The tables also show the results of country-specific factors such as the number of researchers per million people (*Researchers*), the net royalty receipts over GDP (*Tech*), and the income adjusted IPR (*R_IPR*). The abundance of human resources for R&D expressed by the number of researchers per million people has a significantly positive effect on the probabilities choosing both R&D modes. The larger magnitude of marginal effects expressed in the choice of mode 3 in 1998 supplies evidence that supports Hypothesis 2 while it appears that there is no significant difference in the effect of the abundance of human resources between the choices of mode 2 and mode 3 for 1995.

The externality effect of the accumulated technological knowledge, measured by net royalty receipts of host country, shows a similar result to the abundance of human resources. The magnitude of marginal effects is different between 1995 and 1998. The marginal effect for the choice of mode 3 presents a large and positive effect in 1998 as well as for the choice of mode 2 in 1995. It is consistent with the prediction based on Hypothesis 2.

As for a test of Hypothesis 3, the estimated results present that the marginal effects of

R_IPR are positive for the probability of both choices of R&D mode in two periods. They imply that the stronger protection of IPRs in host country increase the enlargement of overseas R&D of affiliates and the effect is stronger for the choice of mode 3 than the choice of mode 2. The coefficients in 1998 denote that a unit increase in income adjusted IPR increases the odds of choosing mode 2 (development) over the choice of mode 1 (No R&D) by 2 times and increases the odds of choosing mode 3 (research and development) over mode 1 by 3 times. The marginal effects of *R_IPR* which come up with a large magnitude for choice of mode 3 in both years are consistent with Hypothesis 3. It is notable that the stronger enforcement of IPRs in the host country pushes MNCs to enlarge their R&D to the stage for knowledge creation.

6. Concluding Remarks

This paper examine what firm-specific and country-specific factors affect the enlargement of overseas R&D activities from the stage of production/process development in plant site to the stage of knowledge creation in research laboratory, by using firm-level data. Our examination is different from previous studies which have explored what factors explain only the intensity of overseas R&D activity in several points. We classify affiliate firms of Japanese MNCs into three types according to their choice of R&D mode: (1) affiliates spending no R&D expenditure at all, (2) affiliates spending R&D expenditures without research laboratory, and (3) affiliates spending R&D with research laboratory. Using the qualitative data of three choices as dependent variables, we attempt to test statistically three hypotheses: (1)

firm-specific factors such as high propensity of affiliate firms to export accelerate the enlargement of their R&D activities from “development” for new process/product to “research” for knowledge creation, (2) market-specific factor of a country in which the human resources engaged in R&D are abundant and technological knowledge is abundantly accumulated provides affiliate firms with favorable conditions to enlarge their R&D activities from development to both research and development, and (3) the stronger enforcement of IPRs the probability of affiliate firms to enlarge the research function for knowledge creation.

The estimated results present that Japanese affiliate firms with a high propensity to export have a tendency to enlarge R&D activities in the host country, the abundance in human resource for R&D and the spillover effect from the large accumulation of technological knowledge in host country accelerate the affiliates to enlarge their R&D activities. The empirical examination shows that the superiority of technological knowledge is a crucial factor for the enlargement of R&D activities, in particular for the knowledge creation. The paper presents clear evidences to state that the stronger enforcement of IPRs in the host country pushes MNCs to enlarge their R&D to the stage for knowledge creation.

As the estimation of this paper is only based on Japanese firm-level data in two specific periods, we must be careful in generalizing the results in this paper. Further analysis using the data of affiliates in other countries in different periods is needed. Although there still remain these problems to be examined further, it is notable that the estimated results are consistent with the theoretical predictions of previous studies and that not only firm-specific but

also country-specific factors are important for the stage up of MNCs' R&D that is an essential source for technological evolution in the host countries.

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Table 1: Number of affiliates by R&D mode and industry

	1995				1998			
Industry	No, R&D	No, Lab	Yes, Lab	Total	No, R&D	No, Lab	Yes, Lab	Total
Food	44	15	13	72	46	12	9	67
Texitile	63	13	6	82	97	11	2	110
Wood pulp	11	1	2	14	15	1	2	18
Chemistry	91	44	40	175	119	38	56	213
Petroleum	7	1	4	12	8	0	2	10
Soil and stone	40	11	2	53	34	8	3	45
Steel	28	3	0	31	49	2	2	53
Nonferrous metal	30	9	4	43	25	4	2	31
Metal	17	2	2	21	26	7	4	37
General machinery	114	28	18	160	123	26	23	172
Electrical machinery	258	60	43	361	278	82	50	410
Transportation machinery	131	44	17	192	164	29	34	227
Precision machinery	38	13	8	59	26	13	13	52
Other manufacture	86	28	10	124	72	21	13	106
Total	958	272	169	1399	1082	254	215	1551

Table 2: Number of affiliates by R&D mode and country

Host Country	1995				1998			
	No R&D	No Lab	Yes Lab	Total	No R&D	No Lab	Yes Lab	Total
Argentina	-	-	-	-	4	0	0	4
Australia	24	2	1	27	33	4	2	39
Belgium	2	4	4	10	13	3	2	18
Canada	22	2	1	25	22	3	1	26
Chili	2	0	0	2	1	0	0	1
China	171	30	11	212	283	48	25	356
Colombia	1	1	0	2	3	0	0	3
Finland	-	-	-	-	0	0	1	1
France	16	8	5	29	19	7	12	38
Germany	52	13	11	76	43	10	14	67
Greece	0	0	1	1	-	-	-	-
Hong Kong	-	-	-	-	68	7	2	77
Hungary	2	2	1	5	0	1	0	1
Ireland	3	1	0	4	2	1	0	3
Italy	8	3	1	12	12	3	4	19
Korea	52	29	18	99	40	24	19	83
Mexico	21	1	0	22	30	3	2	35
Netherlands	20	2	5	27	10	7	3	20
New Zealand	7	1	0	8	5	2	1	8
Pakistan	-	-	-	-	1	0	0	1
Singapore	98	9	8	115	79	12	5	96
Sweden	5	0	0	5	1	2	1	4
Thailand	116	15	9	140	144	13	11	168
Turkey	0	1	0	1	2	1	0	3
United Kingdom	62	32	8	102	43	22	12	77
United States	274	116	85	475	224	81	98	403
Total	958	272	169	1399	1082	254	215	1551

Table 3: Descriptive statistics for 1995

Variable		Mean [Std. Dev.] No, R&D	No, Lab	Yes, Lab	Total
Affiliate Export Sales / Total Sales	SalesEx	0.364 [0.408]	0.354 [0.390]	0.401 [0.393]	0.367 [0.402]
Affiliate's Age	Age	10.593 [7.581]	11.004 [6.983]	12.036 [9.032]	10.847 [7.669]
Affiliate Sales (billion Yen)	Sales	5.978 [21.488]	11.590 [35.079]	19.917 [70.073]	8.753 [34.155]
Parent R&D Expenditures / Sales	P_R&D	0.029 [0.027]	0.034 [0.029]	0.044 [0.036]	0.032 [0.029]
Parent Sales (billion Yen)	P_Sales	953.3 [2762.7]	898.4 [2176.4]	613.2 [1440.6]	901.5 [2530.6]
Host Country Researchers (per million)	Researchers	2104.5 [1412.6]	2585.0 [1259.4]	2802.3 [1159.5]	2282.2 [1381.0]
Host Country Net Royalty Receipt / GDP	Tech	-0.00231 [0.00794]	-0.00016 [0.00557]	-0.00024 [0.00585]	-0.00164 [0.00737]
IPR Adjusted by GDP	R_IPR	0.115 [0.333]	0.204 [0.365]	0.259 [0.340]	0.150 [0.344]
Observations		958	272	169	1399

Table 4: Descriptive statistics for 1998

Variable		Mean [Std. Dev.] No, R&D	No, Lab	Yes, Lab	Total
Affiliate Export Sales / Total Sales	SalesEx	0.332 [0.391]	0.312 [0.359]	0.307 [0.338]	0.325 [0.379]
Affiliate's Age	Age	10.744 [8.495]	11.445 [8.468]	12.595 [9.084]	11.115 [8.593]
Affiliate Sales (billion Yen)	Sales	6.637 [25.246]	16.099 [64.799]	16.301 [34.350]	9.526 [36.222]
Parent R&D Expenditures / Sales	P_R&D	0.034 [0.032]	0.043 [0.034]	0.049 [0.041]	0.037 [0.034]
Parent Sales (billion Yen)	P_Sales	1147.1 [2666.4]	1140.9 [2259.8]	1043.1 [2208.6]	1131.7 [2542.9]
Host Country Researchers (per million)	Researchers	1913.5 [1651.5]	2531.3 [1594.2]	2985.6 [1563.6]	2163.3 [1677.5]
Host Country Net Royalty Receipt / GDP	Tech	-0.0020 [0.0074]	-0.0012 [0.0079]	0.0002 [0.0043]	-0.0016 [0.0072]
IPR Adjusted by GDP	R_IPR	-0.028 [0.440]	0.118 [0.377]	0.192 [0.324]	0.026 [0.424]
Observations		1082	254	215	1551

Table 5: Estimation results for 1995 (Base choice: No R&D)

	1995 Coefficients		1995 Marginal Effects		
Variable	No, Lab	Yes, Lab	No, R&D	No, Lab	Yes, Lab
SalesEx	**0.252 [0.194]**	**0.511 [0.238]***	**-0.078**	**0.025**	**0.053**
Age	0.003 [0.010]	0.013 [0.012]	-0.0016	0.0003	0.0014
Sales	0.006 [0.003]*	0.009 [0.003]**	-0.0014	0.0008	0.0006
P_R&D	4.434 [2.733]	13.198 [3.095]**	-1.726	0.539	1.186
P_Sales	0.00001 [0.00003]	-0.00007 [0.00006]	0.000005	0.000001	-0.000006
Researchers	**0.00018 [0.00006]****	**0.00028 [0.00009]****	**-0.00005**	**0.00002**	**0.00002**
Tech	**35.816 [13.131]****	**26.215 [15.372]**	**-6.862**	**5.335**	**1.527**
R_IPR	**0.377 [0.237]**	**0.894 [0.309]****	**-0.105**	**0.034**	**0.070**
Industry fixed effects	Yes	Yes			
Constant	-2.225 [0.271]**	-3.554 [0.362]**			
Predicted Probabilities			0.703	0.195	0.102
Pseudo R2	0.079				
Percent correctry predicted	68.7				
Number of obs	1399				

Note: The numbers of parentheses present robust standard errors.

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

Table 6: Estimation results for 1998 (Base choice: No R&D)

	1998 Coefficients		1998 Marginal Effects		
Variable	No, Lab	Yes, Lab	No, R&D	No, Lab	Yes, Lab
SalesEx	**0.167 [0.211]**	**0.683 [0.237]****	**-0.068**	**0.017**	**0.051**
Age	0.002 [0.009]	0.021 [0.009]*	-0.0021	0.0002	0.0019
Sales	0.006 [0.002]**	0.005 [0.003]*	-0.0010	0.0007	0.0004
P_R&D	5.771 [2.293]*	9.08 [2.383]**	-1.815	0.801	1.014
P_Sales	0.00005 [0.00003]	0.00006 [0.00004]	-0.000004	0.000002	0.000002
Researchers	**0.00011 [0.00005]***	**0.00021 [0.00006]****	**-0.00004**	**0.00001**	**0.00002**
Tech	**9.209 [10.787]**	**49.777 [17.890]****	**-4.702**	**0.161**	**4.541**
R_IPR	**0.722 [0.230]****	**1.081 [0.286]****	**-0.159**	**0.073**	**0.086**
Industry fixed effects	Yes	Yes			
Constant	-2.016 [0.250]**	-3.391 [0.309]**			
Predicted Probabilities			0.720	0.164	0.116
Pseudo R2	0.096				
Percent correctry predicted	70.9				
Number of obs	1551				

Note: The numbers of parentheses present robust standard errors.

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