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Factors Determining the Mode of Overseas R&D by Multinationals: Empirical Evidence

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Abstract

The large expansion of MNCs' overseas R&D is noteworthy. This paper investigates the factors affecting the expansion of support-oriented R&D and knowledge sourcing R&D by using qualitative data which indicate the modes of R&D conducted at a plant site and a laboratory. The empirical results suggest that (1) the export propensity of affiliate firms, relative abundance of human resources for R&D, and accumulated technological knowledge have a positive effect on both the modes of R&D at a plant site and a laboratory, and (2) the stronger enforcement of intellectual property positively affects the expansion of knowledge sourcing R&D. These results show that not only firm-specific but also country-specific factors positively affect the overseas expansion of R&D.

Keywords: Overseas R&D, MNCs, support-oriented R&D, knowledge sourcing R&D, IPRs

JEL classification: C35, F23, O31, O34

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1. Introduction

Recently, the R&D activities of multinational companies (MNCs) have rapidly increased, along with increasing foreign direct investment (FDI). In 2001, the share of foreign affiliates' R&D to the total R&D expenditures amounted to over 15% in OECD countries. Japanese MNCs have increased their overseas R&D expenditures from 2.1 billion dollars in 1995 to 3.3 billion dollars in 2000. The number of overseas research laboratories has also sharply increased from 367 in 1995 to 587 in 1998. Such an increase in R&D expenditures and the establishment of research laboratories implies that the function of overseas R&D activities is expanding to satisfy the various functions of R&D. The overseas expansion of R&D activities supplements the R&D capabilities, which are not solely realized by R&D activities in the home country.

A conventional type of overseas R&D involves adapting the technology generated in the home market to the local production, manufacturing conditions, regulations, and preferences of the users in the host countries as well as developing the product for the local market. This type of R&D is referred to as support-oriented R&D. Another type of overseas R&D, which is currently on the increase, aims to benefit from both local and worldwide R&D resources so as to generate technological knowledge by accessing expertise that exists in the local science base and hiring skilled engineers and scientists from the local market (Kuemmerle, 1997; Belderbos, 2001). This is associated with the knowledge-based view of MNCs, as originally argued by Hymer (1960).

Many studies have examined the factors determining the level of MNCs' R&D

activities to support production in the local market (Hakanson and Nobel, 1993; Odagiri and Yasuda, 1996). Other studies have investigated the reasons for and the factors causing the recent increase in MNCs' R&D for absorbing higher technological knowledge (Florida, 1997; Granstrand, 1999; Kuemmerle, 1999; Kumar, 2001; Iwasa and Odagiri, 2002; Iwasa, 2004). Although these researches have examined the factors causing the increase in overseas R&D, they have failed to provide an answer regarding what factors affect the choice of support-oriented R&D or knowledge sourcing R&D. This is because these studies have only discussed each type of R&D separately. In fact, often, both types coexist in an affiliate's R&D activities.

In order to investigate the reasons for the recent expansion in MNCs' R&D activities, we take into consideration the above studies and categorize the function of the overseas R&D of MNCs into two types: support-oriented R&D and knowledge sourcing R&D. Although some affiliates of MNCs in the manufacturing sectors do not conduct R&D activities, many others establish their R&D functions in order to support local production. Still other affiliates expand their R&D activities not only to support local production but also for technological knowledge sourcing.

The purpose of this paper is to examine the factors affecting the choice of R&D functions among affiliates of MNCs that conduct no R&D and affiliates that adopt the two types of R&D: support-oriented and knowledge sourcing. The problem faced in this case is the difficulty in identifying what function of R&D the affiliates of MNCs actually choose; this is because the type of R&D that is actually being engaged in cannot be observed. Despite the unobservable nature of the type of R&D activities, it is possible to observe the expenditure of the affiliates for R&D and what facilities they have for conducting R&D; this again depends on the availability of statistical data. R&D conducted by affiliates of MNCs is classified into four types: (1) no R&D, (2) conducting R&D at the plant site without the establishment of a research laboratory, (3) conducting R&D at both the plant site and research laboratory, and (4) conducting R&D solely at the research laboratory. The relationship between the function of R&D and the facility for R&D is useful when attempting to construct an analytical framework. Support-oriented R&D collocates with production activities. On the other hand, the representative organization that undertakes knowledge sourcing R&D is assumed to be a laboratory since the purpose of this facility is to absorb research sources and technological knowledge in the local market. Therefore, we assume that R&D conducted at the plant site, without the establishment of a research laboratory, corresponds to support-oriented R&D; R&D conducted solely at the research laboratory corresponds to knowledge sourcing R&D; and R&D conducted at both the plant site and research laboratory corresponds to both support-oriented R&D and knowledge sourcing R&D. The establishment of a research laboratory is a sign of R&D expansion for the purpose of knowledge sourcing. The association between the facilities for and the functions of R&D enables us to statistically test the factors affecting the expansion of the R&D functions of Japanese MNCs. This is the first aspect in which this paper can be distinguished from previous studies.

In order to identify the function of R&D by a statistical test, it is necessary to have a large sample size of firm-level data of MNCs and their overseas affiliates. Insufficient availability of this data is one of the reasons for not being able to find rich analyses on the factors affecting the overseas expansion of R&D by MNCs' affiliates. This paper is successful in that it uses a large sample size of firm-level data of Japanese MNCs and their overseas affiliates, including statistical data pertaining to R&D facilities. The present paper also differs from previous research in that it uses a large sample size of firm-level data for the empirical estimation.

The examination requires not only firm-specific data of Japanese MNCs and their affiliates, including qualitative data pertaining to the facilities for overseas R&D, but also country-specific data, including data presenting the R&D factor abundance and enforcement of intellectual property rights (IPRs). Based on these data, in this research, we conduct a multinomial logit estimation to identify the factors determining the function of overseas R&D of MNCs.

On the basis of the results of the empirical examination, three major findings are put forth: (1) the export propensity of the affiliate firms has a positive effect on the overseas expansion of R&D, (2) the relative abundance of human resources and the high level of technological accumulation in the host country are the reasons to expand the MNCs' knowledge sourcing R&D, (3) the stronger enforcement of IPRs in the host country expands the MNCs' R&D for knowledge sourcing. MNCs' R&D is an essential source of technological evolution in the host countries. Firm- and country-specific factors are important for the expansion of MNCs' R&D; this suggests policy implications for increasing R&D in the host countries.

This paper is organized as follows: Section 2 introduces previous studies related to the determinants of overseas R&D. Section 3 presents the framework, hypotheses, and methodology for the empirical analysis. Section 4 describes the data used for the empirical analysis and the specifications for the estimation. Section 5 presents the results of the estimation, and Section 6 presents the discussions and conclusions including the issues for further study.

2. Literature

A number of literatures discuss the reasons for MNCs' overseas expansion of R&D. First, and fundamentally, it is necessary to make note of the knowledge-based view of MNCs. Hymer (1960) originally argued that MNCs' *raison d'être* lies in their ability to exploit knowledge more efficiently internally than would be possible through external market mechanisms. This perspective emphasizes that globally dispersed R&D operations provide MNCs with competitive advantages that are unavailable in single-country, centralized R&D operations (Brouthers et al., 2001; Penner-Hahn, 1998). The perspective also suggests that such a competitive advantage is based on how efficiently knowledge is shared across the parent firm and its subsidiaries (Gupta and Govindarajan, 2000; Doz et al., 2001).

There are also a number of empirical studies that present direct statistical evidence for why the affiliates of MNCs increase their overseas R&D expenditures. These studies share the stylized fact that there are two motivations for overseas R&D activities: support-oriented R&D and knowledge sourcing R&D. The expansion of support-oriented R&D is related to the size of the market in which MNCs supply their products. Hakanson and Nobel (1993) and Odagiri and Yasuda (1996) examined the factors determining the level of MNCs' R&D to support production in the local market. When MNCs enter a market, they require market-specific information in order to adapt or customize their products to the market-specific environment. The larger the size of the market in which they supply their products, the more likely they are to undertake R&D activities. Hence, a firm contributing to the local market with a higher share of sales is inclined to conduct R&D for that market.

By using the data aggregated for industry and region, Odagiri and Yasuda (1996) found that the share of local sales of Japanese affiliate firms is positively related to the R&D expenditures of affiliate firms. Kumar (2001) also showed that the market size of the host country has a positive effect on the volume of R&D expenditures by US and Japanese MNCs. However, other studies have revealed contradictory results. If the supply from the MNCs' affiliates is directed overseas due to the high profitability of export, their R&D expenditure will go toward innovation in exportables. Using data of Swedish MNCs, Zejan (1990) observed that the export ratio of foreign affiliate firms is positively related to the R&D in the foreign country. Similarly, Papanastassiou and Pearce (1992) found that the production share to the local market of affiliate firms has a negative effect on R&D. These results are consistent with those of Melitz (2003), which theoretically demonstrated that firms with higher productivity have a tendency to export their products. In some cases, the R&D intensity is positively correlated with a higher ratio of sales to the host country; however, in other cases, it is positively correlated with a higher propensity to export products. However, it remains ambiguous whether a higher ratio of sales to the host country or a higher propensity to export tends to accelerate the overseas R&D of MNCs.

With regard to knowledge sourcing R&D, previous studies have shown the positive effect of country-specific factors such as the abundance of human resources and the superiority of technological level on the expansion of R&D. The determinant of location choice of the R&D facility is similar to that of FDI with respect to the market-specific costs. Under a given condition of other factors, MNCs establish their R&D facilities in countries that have a relative abundance of R&D resources. A country that is relatively abundant in highly educated human resources engaged in R&D is supposed to be an attractive location for the establishment of R&D facilities. Kumar (2001) found that a higher ratio of scientists and engineers has a positive effect on the R&D expenditure of MNCs' affiliates; on the other hand, a higher wage of R&D personnel has a negative effect.

The expansion of knowledge sourcing R&D is affected by the externality of technological knowledge in the country in which the R&D facility is located. MNCs may be motivated to absorb new knowledge and benefit from spillover effects in the host country because the superior knowledge stock attributed by innovative activity in the host country is expected to have a positive externality for MNCs. Florida (1997), Granstrand (1999), Kuemmerle (1999), Kumar (2001), and Iwasa and Odagiri (2002) investigated the reasons for the recent increase in MNCs' R&D for the purpose of absorbing higher technological knowledge.

Odagiri and Yasuda (1996) used the net technological exports from Japan to other countries as a proxy of the relative technological advantage of Japan. Taking into account the negative effect of Japanese net technology export on its overseas R&D, Odagiri and Yasuda asserted that more advanced technology in the host country is an attractive feature for MNCs. However, the extent of technological advancement in the host country must differ between industries. Kumar (2001) demonstrated that the host country's competency in a particular sector—measured by export competitiveness—has a significantly positive effect on the R&D expenditure of MNCs' affiliates. Fors (1996) explored the factors explaining the foreign R&D activity of Swedish MNCs and found that technological specialization in a particular industry in the host country has a significant and positive effect on the R&D expenditure of MNCs' affiliates.

The choice of facility for the R&D base is also influenced by the strength of protection for IPRs. While Kumar (2001) was unable to find a significant impact of the strength of IPRs on the overseas R&D expenditure of US and Japanese foreign affiliates, Branstetter, Fisman, and Foley (2006) found that the policy reforms of IPRs in host countries have a significantly positive impact 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. With regard to Japanese MNCs, a recent study by Wakasugi and Ito (2005) also confirmed the positive impact of IPRs on intra-firm technology transfer at the affiliate level. It should be noted that recently, many countries have been strengthening the enforcement of IPRs under the WTO framework. The enforcement of IPRs is an indispensable factor affecting the overseas R&D of MNCs.

3. Analytical Framework

3.1 Hypotheses

A number of previous studies have argued that there are two types of overseas R&D: support-oriented R&D and knowledge sourcing R&D. Although some affiliates do not conduct any R&D, many others establish their R&D functions for the purpose of supporting local production. Further, still other affiliates expand R&D activities not only for supporting local production but also for technological knowledge sourcing.

Regarding the modes of R&D, the affiliates of MNCs have four choices for R&D expenditures and facilities: (1) no R&D, (2) conducting R&D at the plant site without the establishment of a research laboratory, (3) conducting R&D at both the plant site and research laboratory, and (4) conducting R&D solely at the research laboratory when the MNC affiliates have no production capacity. For an analytical framework of this paper, we assume that the choices of R&D expenditure and facilities correspond to the function for R&D, as described in Table 1. This table presents the following cases: R&D is conducted at the plant site without the establishment of a research laboratory, which corresponds to support-oriented R&D; R&D is conducted at both the plant site and the research laboratory, which corresponds to both support-oriented and knowledge sourcing R&D; and R&D is conducted only at the research laboratory, which corresponds to knowledge sourcing R&D in the case of no production. The establishment of a research laboratory indicates a sign of expansion for the purpose of knowledge sourcing R&D. The concordance between the facilities for and the functions of R&D provides qualitative information that can be used to statistically test the factors affecting the expansion of R&D function of Japanese MNCs.

Table 1

Based on the abovementioned framework, this paper examines the factors affecting two types of R&D of Japanese overseas affiliates—support-oriented R&D and knowledge sourcing R&D. Although in a theoretical sense, there exists a case in which affiliates of MNCs conduct R&D only for knowledge sourcing, if the data were to indicate that none of the affiliates conduct R&D solely at the research laboratory, then the cell in Table 1—pertaining to R&D at research laboratories without production—will be empty. As the statistical data used in our study actually indicate that there were only few affiliates conducting R&D at research laboratories without production, we assume that this case is negligible, as mentioned later.

We assume that the choice of R&D type is determined both by market- and firm-specific factors.[1] When affiliates of MNCs begin supplying their products to the host country, the knowledge and technology necessary for production will be supplied by their parent firms in the home country or by their own R&D in the host country. However, when affiliates start exporting their products, they require more sophisticated knowledge and technology than the domestic supply oriented in order to customize their products to suit the world market. Therefore, the affiliates that export a large portion of their products are inclined to spend more money not only for support-oriented R&D but also for knowledge sourcing R&D. In other

[1] These alternatives of R&D functions are not specific to MNCs. They are observed even when a firm enters the domestic market. However, in the case of MNCs' affiliates, the factors affecting the expansion of R&D are more clearly observed in overseas R&D than domestic R&D.

words, a firm-specific factor, such as the high propensity to export, drives the affiliates of MNCs to expand their R&D functions. Hence, the hypotheses to identify the factors affecting the choice of R&D types are presented as follows:

Hypothesis 1: The high propensity of affiliate firms to export accelerates the expansion of both support-oriented and knowledge sourcing R&D.

The relative abundance of human resources for R&D and the accumulation of technological knowledge in a country are the factors that attract MNCs to establish R&D facilities in these countries. Therefore, the relative abundance of human resources for R&D and the accumulation of technological knowledge in the host country have a positive effect on MNCs' R&D activities. In addition, the magnitude of the effect varies depending on the choice of R&D function. Compared to support-oriented R&D, the relative abundance of highly educated researchers and the large opportunity to absorb a higher level of technological knowledge are crucial to knowledge sourcing R&D at research laboratories.

Hypothesis 2: The relative abundance of human resources engaged in R&D and the accumulation of technological knowledge provide affiliate firms with favorable conditions under which to expand their R&D, both for supporting local production and knowledge sourcing. The effect on the expansion of R&D is larger in knowledge sourcing R&D than in support-oriented R&D.

The protection of IPRs is also assumed to affect R&D activities. The regime of IPRs provides the owners of new knowledge and technology with the right to sue for infringement if another party attempts to use, sell, offer, import, or offer to import intellectual property into the country issuing the IPRs. The regime of IPRs is also associated with the trade policy in that it prohibits the unfair trade of commodities and services embodying IPRs. If the legal system to protect IPRs is completely harmonized around the world, the enforcement of IPRs itself will not affect the geographical distribution of MNCs' R&D activities. In other words, the enforcement of IPRs is not a country-specific factor that determines the R&D activities of MNCs. However, there is a large discrepancy in the regime for enforcement of IPRs among countries, particularly between the north and south. Needless to say, the function of MNCs' R&D is affected by various factors such as the size of the market and the cost for exporting. Given the same conditions for these factors, the difference in the enforcement of IPRs will affect the profitability of the owner. The weaker the protection of IPRs, the lower will be the profitability of new knowledge and technology. Therefore, weaker protection of IPRs results in an unfavorable condition for both support-oriented and knowledge sourcing R&D. Considering that R&D for the purpose of supporting local production tends to be conducted within a closed network between the headquarters and the affiliates of the MNCs, the weak enforcement of IPRs will more strongly undermine knowledge sourcing R&D than it will support-oriented R&D.

Hypothesis 3: The stronger enforcement of IPRs results in a favorable condition for the affiliates' knowledge sourcing R&D.

3.2 Specification for Estimation

In terms of the functions of R&D, we assume that the affiliates of MNCs have four choices: (1) no R&D, (2) support-oriented R&D, (3) R&D for supporting local production and technological knowledge sourcing, and (4) R&D solely for knowledge sourcing without the establishment of a production plant. The R&D functions carried out by the affiliates cannot be observed from the outside; however, based on statistical data on R&D expenditures and facilities, we can objectively observe an affiliate's expenditure on R&D and whether or not the affiliate has an R&D laboratory. On the basis of Table 1 and the conceptual framework mentioned in the previous section, we correspond the R&D functions of MNCs' affiliates with the information of R&D expenditure and facilities in four modes: (1) no R&D, (2) conducting R&D at the plant site without the establishment of an R&D laboratory, (3) conducting R&D both at the plant side and R&D laboratory, (4) conducting R&D solely at the R&D laboratory without the establishment of a production site. We assume that R&D carried out at the research laboratory is a sign indicating that the firm is expanding its R&D both for supporting production and for technological knowledge sourcing. An observation of the micro data used for our statistical test, however, reveals that few affiliates establish research laboratories without production sites. Therefore, we exclude choice (4) from our potential estimation choices.

In order to empirically test the factors affecting the overseas expansion of R&D by

MNCs' affiliates, we use the affiliates' choices from among the above three modes as a qualitative variable. The information pertaining to the choice of R&D mode enables us to identify the factors affecting the probability of choosing each type of R&D. In order to statistically estimate the factors, we use a multinomial logit model. The multinomial logit model, which provides probabilities for choice *m* taken by firm *i* in host country *h* is expressed as follows:

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

where Y_i denote the outcome of the different choices; let *m* denote the choice of firm *i*. In this case, considering that choice (4) has been excluded, *m* = 1, 2, and 3. We denote *m* = 1 for the choice of no R&D, *m* = 2 for the choice of conducting R&D at the plant site without the establishment of an R&D laboratory, and *m* = 3 for conducting R&D both at the plant side and R&D laboratory. The vector of explanatory variables $\mathbf{X}_{\mathbf{i,h}}$ consists of firm- and country-specific factors that affect the profit of the MNCs' affiliates. $\mathbf{i}$ denotes the index of the firm-specific variables, including the share of export to the total sales of the affiliate firms for testing Hypothesis 1; on the other hand, $\mathbf{h}$ denotes that of the host country-specific variables, such as the number of researchers and the level of technology with regard to Hypotheses 2 and 3. $\boldsymbol{\beta}'_{\mathbf{m}}$ is the vector of parameters on choice *m*.

The log-odds ratios of choosing *m* over the base choice are can be formulated as follows:

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

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. The estimated coefficients are obtained in order to maximize the log-likelihood under the assumption of independence of irrelevant alternatives.

In order to interpret the estimated coefficients, we compute the marginal effects of each variable on the predicted probabilities by differentiating equation (1) to identify the factors determining a firm's choice of 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 overseas Japanese affiliates with the statistics of the host countries. With regard to the firm-specific variables, we use the firm-level data from two statistical surveys conducted by the Ministry of Economy, Trade and Industry: "Basic Survey of Overseas Business Activities" as the source for Japanese overseas affiliate firms and "Basic Survey of Japanese Business Structure and Activities" as the source for Japanese parent firms.[2]

[2] The authors acknowledge the Ministry of Internal Affairs and Communications and the Ministry of

The Basic Survey of Overseas Business Activities comprehensively covers the statistical data of overseas affiliates of Japanese MNCs. According to this survey, we define “affiliates” in three ways: the subsidiaries whose Japanese share in stock is over ten percent, the sub-affiliates whose share of Japanese subsidiaries is over fifty percent, and the sub-affiliates whose total share of Japanese subsidiaries and Japanese firms is over fifty percent. Therefore, “branch,” “laboratory,” “joint venture,” and “consortium,” without the corporate entity, are excluded from “affiliates.” They are omitted from the observations for the statistical test. Data is available on both R&D expenditure and the number of R&D laboratories for each affiliate firm in 1995 and 1998. Using this data, we classify the affiliates into three types, based on their R&D modes: (1) affiliates that do not have any R&D expenditure, (2) affiliates with R&D expenditures without the establishment of a research laboratory, and (3) affiliates with R&D expenditures with the establishment of a research laboratory. Each mode corresponds to the number of choice variables from $m = 1$ to $m = 3$, respectively.

Table 2 presents the distribution of Japanese affiliate firms in the manufacturing sector, tabulated according to R&D mode. The total number of affiliates that did not have any R&D expenditure was 958 and 1,082 in 1995 and 1998, respectively. The number of affiliates with R&D expenditures and without a research laboratory decreased from 272 in 1995 to 254 in 1998, while the number of affiliates with R&D expenditures and a laboratory increased from 169 in 1995 to 215 in 1998. This table also presents the uneven distribution of affiliates according to the mode of R&D. The affiliates conducting R&D and holding research laboratories is more

Economy, Trade and Industry who provided official permission to use the firm-level data of these statistics.

concentrated in the machinery and chemical industries. The rate of increase in R&D expenditures was also high in these industries from 1995 to 1998.

Table 2

Table 3 shows that the overseas R&D of Japanese MNCs is also unevenly distributed across the world, with a strong concentration in industrialized countries and East Asian countries. In 1995, almost half of the research laboratories were located in the US. Collectively, the East Asian countries host almost a quarter of the MNCs' research laboratories. The number of affiliates conducting R&D both with and without laboratories is on the increase.

Table 3

The dependent variable in equation (2) represents the odds ratio of choosing either mode $m = 2$ or 3, corresponding to R&D without and with a laboratory, respectively, over the base choice of $m = 1$, corresponding to no R&D.

4.2 Firm-specific Variables

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

In order to control other firm-specific factors, we take into account several other factors. Larger firms will dominate over smaller firms to finance R&D, and it will be easier for these larger firms to set up R&D bases in foreign countries. MNCs' affiliate firms with a high R&D intensity will also be apt to conduct R&D activities in the host country. Zejan (1990) presented a positive relationship between R&D intensity of the affiliate firms of Swedish MNCs and those of the parent firms. Since some empirical studies also confirmed these effects, it is suggested that the firm size of the affiliate and parent firms and the R&D intensity of the parent firm will have a positive effect on overseas R&D. Therefore, it is necessary to control them. As a proxy of the firm size, the total sales of the affiliate firm (*Sales*) and that of its parent firm (*P_Sales*) are included in the equation. We define the R&D intensity of the parent firm as the ratio of R&D expenditure to the total sales of the parent firm (*P_R&D*).

The operation of MNCs' affiliates accompanies the process of learning by doing, which will positively affect the overseas expansion of R&D. We assume that the affiliate firm's accumulated operational experience in the host country has a positive effect on the probability of decisions regarding the further overseas expansion of R&D. In order to test this theoretical conjecture, we include the firm age (*Age*) in the equation for estimation; the age is defined by the number of years since the affiliate firm was established. These firm-specific variables of affiliates are collected from the Basic Survey of Overseas Business Activities and the Basic Survey of Japanese Business Structure and Activities.

4.3 Country-specific Variables

In order to test Hypothesis 2, we examine the effects of the abundance of human resources engaged in R&D and the accumulation of technological knowledge on the expansion of R&D of the MNCs' affiliates. First, we assume that the relative abundance of human resources for R&D in a country is one of the reasons for MNCs to expand R&D activities in that country. In order to examine the effects of this, the ratio of the number of researchers to the total population in the host country (*Researchers*) is included in the equation as a proxy of the relative abundance of human resources. The effect of relatively abundant R&D human resources on the decision to expand R&D activities will be positive. In this case, the data are taken from the World Development Indicator (WDI).

Second, we note the spillover effect of technological knowledge in the host country. We assume that the country having highly accumulated technological knowledge is inclined to provide a favorable environment for R&D activities. This is because this country supplies a positive externality of technological diffusion. Compared to the affiliates conducting R&D only at the plant site, we assume that the affiliates conducting R&D at both the plant site and the research laboratory receive a greater benefit from the externality of the spillover effect of technological accumulation and also assume that the larger the amount of a country's net royalty receipts, the higher is the level of technological accumulation in that country, and consequently, the larger is the spillover effect. As a variable presenting the source of technological externality in the host country, we use the net royalty receipts of the host country from foreign countries, namely, the royalty receipts minus the royalty payments over the GDP (*Tech*). This data is also collected from the WDI.

In order to test Hypothesis 3—according to which the expansion of R&D activities is influenced by the strength of the IPRs—we employ the Index of Patent Rights by Park and Wagh (2002) as a proxy of the level of protection for IPRs in countries wherein the affiliates of Japanese firms are situated. This index is constructed by the numerical average of the figures for five categories pertaining to the protection of patent rights: (1) the coverage of patentability for major industries, including pharmaceuticals, chemicals, and food; (2) the duration of patent rights; (3) the strictness of the legal enforcement; (4) the ratifications of international agreements associated with patent protection; and (5) the existence of policies that undermine the implementation of patent rights. An index having a higher score represents a country that has a higher level of patent protection. Since the index is updated every five years, we employ the index for the data pertaining to 1995, and the mean of the 1995 and 2000 indices function as an approximation for the 1998 index. It should be noted that the Index of Patent Rights by Park and Wagh covers only the enforcement of patent rights and does not cover the degree of protection for know-how, trade secrets, other non-patented IPRs, or research exemptions. Taking this fact into consideration, the coverage of the index by Park and Wagh is very limited in scope and does not reflect the international comparison of the protection of IPRs over a broad range.

It is possible that there exists multicollinearity between the Index of Patent Right and country-specific variables like market size. Therefore, in order to avoid this problem, instead of directly using the index, we employ the income adjusted Index of Patent Rights (*R_IPR*), which is estimated as the residual after a regression of the Index of Patent Rights on the per capita GDP and the constant term.

4.4 Estimation

The following equation is used to estimate the effect of the explanatory variables on the function of the affiliates' R&D activities.

$$\ln\left[\frac{\Pr_m}{\Pr_1}\right] = \beta_0 + \beta_1 (SalesEx)_{ilm} + \beta_2 (Age)_{ilm} + \beta_3 (Sales)_{ilm} + \beta_4 (P\_R\&D)_{im} + \beta_5 (P\_Sales) + \beta_6 (Researchers)_{jm} + \beta_7 (Tech)_{jm} + \beta_8 (R\_IPR)_{jm} + \varepsilon_{ijm}, \quad (3)$$

where subscript *i* denotes the index of the parent firm, and *l* is the index of its affiliate firm. The subscript *j* expresses the index of the host country.

Considering the fact that most R&D activities are conducted by manufacturing firms, we limit our estimation to the manufacturing sector. Table 2 shows the distribution of the sample affiliate firms over manufacturing industries, according to R&D mode. Taking into account such an uneven intensity of R&D activity among industries, we included industry dummy variables in the equation in order to control the differences between industries, which can be attributed to unobservable industry-specific factors.

Table 3 shows the distribution of the sample affiliate firms across the host countries, according to the R&D mode. Although there is a large difference in the number of affiliates conducting R&D across countries, this difference will be controlled by the country-specific variables. Tables 4 and 5 describe the data descriptions and the summary of the statistics for each variable based on the R&D mode for the years 1995 and 1998, respectively.

Tables 4 and 5

5. Results of the Estimations

We conduct separate estimations using two datasets for 1995 and 1998 based on the multinomial logit model. The estimated results for 1995 and 1998 are presented in Tables 6 and 7, respectively. These tables present the estimated coefficients $\boldsymbol{\beta}'_{\mathbf{m}}$ for each R&D mode, standard errors, and marginal effects. The estimated coefficients present the effect of the explanatory variables on the choice of mode 2 (R&D conducted at the plant site without a research laboratory) and mode 3 (R&D conducted at both the plant site and research laboratory) in comparison with the choice of mode 1 (no R&D).

Tables 6 and 7

With regard to firm-specific variables, the export propensity of the affiliate firm (*SalesEx*) is positively related to R&D conducted both with and without a laboratory. The results provide evidence that is consistent with our theoretical conjecture. The marginal effect of the export propensity on the probability of choosing mode 1 (no R&D) is negative, while those for the other choices on R&D are positive; further, the marginal effect for choosing mode 3 shows a large magnitude, as predicted by Hypothesis 1. These results indicate that the expansion of the R&D activities of MNCs' affiliates can be observed in export-oriented affiliate firms. This is consistent with the theoretical argument put forth by Melitz (2003). The result implies that the firm having a higher productivity that is attributed to R&D activity is inclined to export a higher portion of its products.

The estimated results show that the firm age of the affiliates (*Age*) has a positive effect on and is statistically significant to choosing R&D mode 3 in both 1995 and 1998. This result is consistent with the results of previous studies, which suggested that the operation experience of firms has a positive effect on the overseas R&D of Japanese firms.[3]

The marginal effect of the parent firm's R&D intensity (*P_R&D*) is found to be positive for the expansion of R&D activities, while it is found to have a negative effect on the choice of mode 1. These results suggest that a parent firm with a higher R&D intensity has a tendency to conduct more overseas R&D, particularly for the purpose of knowledge sourcing.

With regard to the size of affiliates, the marginal effects of the total sales of the affiliate firm (*Sales*) are positive for both the choice of modes 2 and 3, while the effect of the total sales of the parent firm (*P_Sales*) is insignificant. The size of the affiliate firm is positively related to R&D activity, while that of the parent firm has no significant effect on R&D decisions.

Tables 6 and 7 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

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

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 probability of choosing both R&D modes. The larger magnitude of marginal effects expressed in the choice of mode 3 in 1998 provides evidence in support of Hypothesis 2, while it appears that there is no significant difference in the effect of the abundance of human resources engaging in R&D between the choice of modes 2 and 3 for 1995.

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

With regard to testing Hypothesis 3, the estimated results suggest that the marginal effects of *R_IPR* are positive for the probability of both choices of R&D mode in both the periods. The results present that the stronger protection of IPRs in the host country increases the affiliates' overseas expansion of R&D, and the effect is stronger for the choice of mode 3 than it is for mode 2. The coefficients in 1998 denote that a unit increase in income adjusted IPR increases the odds of choosing mode 2 (development) over mode 1 (no R&D) by two-fold and increases the odds of choosing mode 3 (research and development) over mode 1 by three-fold. The marginal effects of *R_IPR*, which result from 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 drives MNCs to expand their R&D to the function for knowledge creation.

6. Discussion and Conclusion

This paper has identified the firm- and country-specific factors that affect the overseas expansion of R&D activities for both the conventional type of support-oriented R&D and knowledge sourcing R&D by simultaneously using firm- and country-specific data. Previous studies have examined either the factors determining the expansion of R&D for supporting local production or those determining the expansion of knowledge sourcing R&D conducted in a research laboratory, separately. However, our examination differs from past ones in that it examines the factors causing the expansion of both types of R&D: support-oriented R&D and knowledge sourcing R&D. For the statistical examination, we constructed the concordance of R&D modes—no R&D, R&D conducted at the production site without a research laboratory, and R&D conducted at the production site and research laboratory—based on the type of R&D: support-oriented and knowledge sourcing R&D. This method enables us to use the qualitative data for the three R&D modes and simultaneously identify the factors resulting in the expansion of the two functions of R&D, and then compare the difference in the effects of explanatory variables between the functions of R&D. This methodology differentiates our paper from previous studies.

Using qualitative data on the three choices of the R&D mode as dependent variables, we attempted to statistically test three hypotheses: (1) whether the high propensity of affiliate firms to export accelerates the expansion of their R&D activities for supporting local production or knowledge sourcing; (2) whether market-specific factors of a country—in which the human resources engaged in R&D are relatively abundant and technological knowledge is abundantly accumulated—provide affiliate firms with favorable conditions under which they can expand their R&D activities; and (3) whether the stronger enforcement of IPRs provides a favorable condition for, and subsequently expands R&D for knowledge sourcing.

The estimated results reveal that Japanese affiliate firms with a high propensity to export have a tendency to expand R&D activities in the host country. The results also reveal that the relative abundance of human resources for R&D and the spillover effect from the large accumulation of technological knowledge in the host country drive the affiliates to expand their R&D activities. The empirical examination also shows that the high R&D propensity of the parent firm correlates with the expansion of R&D, particularly the expansion of knowledge sourcing R&D. Regarding IPRs, this paper presents evidence suggesting that the expansion of R&D to knowledge sourcing is observed in the host country that has a stronger enforcement of IPRs.

The estimated results present several findings that differ from previous studies. Odagiri and Yasuda (1996) estimated the effects of the export propensity of Japanese MNCs on R&D and asserted that the expansion of R&D was negatively correlated to export propensity. However, our examination uses data in a manner that differs from previous examinations. Odagiri and Yasuda's estimation was based on industry- and region-specific data, while our estimation is based on firm- and country-specific data, controlling for industry-specific features. Melitz (2003) theoretically argued that the firm with the higher productivity has a tendency to export its products. Our results supplement the recent development of the theoretical discussion on international operation of MNCs.

With regard to the R&D intensity of parent firms, Cohen and Levinthal (1989), originally, and Iwasa (2003), recently, argued that the absorptive capability to appropriate external technological knowledge is crucial for knowledge sourcing R&D. These studies suggested that the high R&D intensity of the parent firm expands the R&D activities of its affiliates. Antras (2005) asserted the importance of incorporating organizational economics into the study of the international organization of production. Since an affiliate is an organization that exists within the boundary of the firm, it is expected that the higher the R&D propensity of the parent firm, the higher will be the R&D propensity of its affiliates. Our results, which were consistent with those of the previous studies, support the organization theory of international firms.

Through a statistical test based on Japanese firm data, Belderbos (2003) revealed that the larger the size of the firm, the more are their R&D activities to develop state-of-the-art technology. If the affiliate is considered as part of the corporate organization, the effect of the firm size on R&D may be shared by both the parent firm and its affiliates. However, our estimation results showed that this is true only in the case of the size of the affiliates and not for the total sales of the parent firm. Our interpretation of this result is that the direct effect of the size of the affiliates overrides the indirect effect of the size of their parent firms.

The introduction of the variable of IPRs protection in the estimation is yet another unique feature of our estimation. We found that the establishment of research laboratories rapidly increased in the late 1990s. During this period, the enforcement of IPRs was significantly strengthened by the introduction of the WTO's TRIPS agreement. The estimated result provides evidence that the IPRs protection strongly influences the expansion of the support-oriented and knowledge sourcing R&D functions of MNCs.

Before concluding, we describe the subjects left for further study. Since the estimation provided in this paper is based only on Japanese firm-level data over two specific periods, the results do not necessarily reflect the causality between the overseas expansion of R&D and the explanatory factors. In order to overcome this shortcoming, it is necessary to conduct further analyses using richer data with time sequences. Our estimation depends only on the data of Japanese MNCs. The purpose of the estimation is to investigate the true reason for the MNCs' overseas expansion of R&D. Further, the information in this paper will be useful in identifying whether Japanese firms are unique or similar to MNCs in other countries, and if so, why. To achieve this goal, it will be necessary to conduct an international comparison.

Although these issues remain unsolved and have to be examined further, it should be noted that the estimated results based on the large size firm-level data of Japanese overseas affiliates suggest that both firm- as well as country-specific factors are important for the functions of MNCs' R&D activities. The new findings put forth in this paper supplement the theoretical and empirical examinations of previous studies on the international organization of R&D.

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Table 1. Correspondence between R&D facilities and R&D functions in both production and no-production cases

Production	R&D expenditure	Research laboratory	
		No	Yes
Yes	No	(1) No R&D	
	Yes	(2) Support-oriented R&D	(3) Support-oriented R&D and knowledge sourcing R&D
No	No	(1) No R&D	
	Yes		(4) Knowledge sourcing R&D

Table 2. 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*

Source: Computed from METI "Basic Survey of Overseas Business Activities"

Table 3. 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*

Source: Computed from METI "Basic Survey of Overseas Business Activities"

Table 4. Descriptive statistics for 1995

Variable		Mean [Std. Dev.] No, R&D	No, Lab	Yes, Lab	Total
Affiliate Export Sales / Total Sales (%)	SalesEx	36.4 [40.8]	35.4 [39.0]	40.1 [39.3]	36.7 [40.3]
Affiliate's Age	Age	10.6 [7.6]	11.0 [7.0]	12.0 [9.0]	10.8 [7.7]
Affiliate Sales (billion Yen)	Sales	6.0 [21.5]	11.6 [35.1]	19.9 [70.1]	8.8 [34.2]
Parent R&D Expenditures / Sales (%)	P_R&D	2.9 [2.7]	3.4 [2.9]	4.4 [3.6]	3.2 [2.9]
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 (%)	Researchers	0.21 [0.14]	0.26 [0.13]	0.28 [0.12]	0.23 [0.14]
Host Country Net Royalty Receipt / GDP (%)	Tech	-0.23 [0.79]	-0.02 [0.56]	-0.02 [0.58]	-0.16 [0.74]
IPR Adjusted by GDP	R_IPR	0.11 [0.33]	0.20 [0.37]	0.26 [0.34]	0.15 [0.34]
	Obs.	958	272	169	1399

Table 5. Descriptive statistics for 1998

Variable		Mean [Std. Dev.]			
		No, R&D	No, Lab	Yes, Lab	Total
Affiliate Export Sales / Total Sales (%)	SalesEx	33.2 [39.1]	31.2 [35.8]	30.7 [33.8]	32.5 [37.9]
Affiliate's Age	Age	10.7 [8.5]	11.4 [8.5]	12.6 [9.1]	11.1 [8.6]
Affiliate Sales (billion Yen)	Sales	6.6 [25.2]	16.1 [64.8]	16.3 [34.4]	9.5 [36.2]
Parent R&D Expenditures / Sales (%)	P_R&D	3.4 [3.2]	4.3 [3.4]	4.9 [4.1]	3.7 [3.4]
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 (%)	Researchers	0.19 [0.17]	0.25 [0.16]	0.30 [0.16]	0.22 [0.17]
Host Country Net Royalty Receipt / GDP (%)	Tech	-0.20 [0.74]	-0.12 [0.79]	0.02 [0.43]	-0.16 [0.72]
IPR Adjusted by GDP	R_IPR	-0.03 [0.44]	0.12 [0.38]	0.19 [0.32]	0.03 [0.42]
	Obs.	1082	254	215	1551

Table 6. 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	**0.003** **[0.002]**	**0.005** **[0.002]***	**-0.0008**	**0.0002**	**0.0005**
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	0.044 [0.027]	0.132 [0.031]**	-0.017	0.005	0.012
P_Sales	0.00001 [0.00003]	-0.00007 [0.00006]	0.000005	0.000001	-0.000006
Researchers	**1.813** **[0.633]****	**2.757** **[0.860]****	**-0.458**	**0.225**	**0.232**
Tech	**0.358** **[0.131]****	**0.262** **[0.153]**	**-0.069**	**0.053**	**0.015**
R_IPR	**0.377** **[0.237]**	**0.894** **[0.309]****	**-0.105**	**0.034**	**0.070**
Industry dummy	Yes	Yes			
Constant	-2.225 [0.271]**	-3.554 [0.362]**			
Pseudo R2	0.079				
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 7: 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	**0.002** **[0.002]**	**0.007** **[0.002]****	**-0.0006**	**0.0002**	**0.0005**
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	0.058 [0.023]*	0.091 [0.024]**	-0.018	0.008	0.010
P_Sales	0.00005 [0.00003]	0.00006 [0.00004]	-0.000004	0.000002	0.000002
Researchers	**1.118** **[0.521]***	**2.091** **[0.597]****	**-0.360**	**0.134**	**0.226**
Tech	**0.092** **[0.108]**	**0.498** **[0.178]****	**-0.047**	**0.002**	**0.045**
R_IPR	**0.722** **[0.230]****	**1.081** **[0.286]****	**-0.159**	**0.073**	**0.086**
Industry dummy	Yes	Yes			
Constant	-2.016 [0.250]**	-3.391 [0.309]**			
Pseudo R2	0.096				
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.