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What Determines Overseas R&D Activities? The Case of Japanese Multinational Firms*

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Abstract

This paper explores what factors determine the nature, extent, and location of Japanese multinationals' R&D activities abroad. Taking advantage of a rich micro-level dataset from the survey on Japanese overseas subsidiaries, the study distinguishes between two types of overseas R&D: innovative and adaptive. We find several differences between the determinants of overseas innovative and adaptive R&D. These differences confirm the view that overseas innovative R&D aims at the exploitation of foreign advanced knowledge, whereas overseas adaptive R&D is mostly influenced by the market size of the host country. Our results provide a convincing and comprehensive explanation of the geographical distribution of overseas R&D by Japanese MNEs.

Keywords: overseas R&D activities, multinational enterprises, locational choice, multinomial logit estimation.

JEL classifications: F23, O30.

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1. Introduction

There has been a remarkable expansion of overseas R&D activities by multinational enterprises (MNEs) in recent years (Kuemmerle, 1999; Granstrand, 1999; Patel and Vega, 1999; Pearce, 1999; Pearce and Papanastassiou, 1999; Le Bas and Sierra, 2002). Japanese MNEs are no exception: a drastic increase in their overseas R&D activities can be observed from the beginning of the 1990s onward. In 1989, overseas R&D expenditure by Japanese MNEs amounted to only 0.7% of the total R&D investment spent domestically,[1] although Japan's foreign direct investment increased significantly during the 1980s in response to rapid yen appreciation. However, the ratio of overseas to domestic R&D expenditure in 2002 was 4.1%, indicating that there has been a significant expansion of overseas R&D activities by Japanese MNEs in the 1990s.

In addition to the marked expansion, noteworthy changes in locational distribution of overseas R&D can be observed. Until the early 1990s, overseas R&D activities were concentrated in the advanced economies of North America and Europe, but this is no longer the case today. Instead, over the past decade and a half or so, Japanese MNEs have also invested in R&D in newly industrialized economies and less developed countries, especially those in East Asia, as we will see in detail later.

The purpose of this study is to explore the determinants of the locational choice of overseas R&D activities by Japanese MNEs, highlighting differences in the two types of overseas R&D. The first of these is for the utilization and acquisition of foreign advanced knowledge that would otherwise be unavailable in the home country, while the second is for the adaptation of existing technologies and products to the local conditions of the host country.[2] We will hereafter denote the former type of overseas R&D as innovative R&D and the latter as adaptive R&D. Differences between the two types of overseas R&D have been pointed out by existing studies such as

[1] This figure is obtained by dividing the amount of R&D investment by foreign subsidiaries (Ministry of Economy, Trade and Industry, *Wagakuni Kigyo no Kaigai Jigyo Katsudo (Overseas activities of Japanese Firms)* by the total R&D investment available from *Kagaku Gijutsu Kenkyu Chosa Hokoku (Report on the Survey of Research and Development)* compiled by the Statistics Bureau, Ministry of Internal Affairs and Communications.

[2] Examining U.S. MNEs, Teece (1977) found that the costs of such adaptations are significant and account for 19 percent of total investment costs.

Kuemmerle (1999), Granstrand (1999), Pearce (1999), Le Bas and Sierra (2002), and Iwasa and Odagiri (2004).[3] Although several studies have already examined the determinants of overseas R&D using Japanese firm-level data (Odagiri and Yasuda, 1996; Belderbos, 2001) and industry-level data for the U.S. and Japan (Kumar, 2001), these studies do not distinguish between overseas innovative and adaptive R&D. However, it is quite plausible to assume that the determinants of the two types of overseas R&D are different. This is because the major motive underlying overseas innovative R&D is to acquire advanced knowledge available in the host country that is often tacit and accessible only in that country; in contrast, the motive for adaptive R&D is to enhance local sales by satisfying local needs. Therefore, innovative R&D is likely to be performed in technologically advanced countries, whereas adaptive R&D is probably performed in countries with a large market size.

This paper investigates such differences between the determinants of innovative and adaptive R&D abroad, using a rich firm-level panel dataset for Japanese MNEs that enables us to distinguish between the two types. Our dataset consists of data for Japanese parent firms and their overseas subsidiaries both in developed and less developed countries in R&D-intensive manufacturing industries, covering the period 1996-2001. As far as we are aware, ours is the most comprehensive dataset available on the overseas R&D activities of Japanese MNEs.

Our estimates are based on a multinomial logit model, in which Japanese overseas subsidiaries are faced with three options: to perform innovative R&D, to perform adaptive R&D, or to perform no R&D. We indeed find differences between overseas innovative and adaptive R&D. Most notably, Japanese MNEs are more likely to perform overseas innovative R&D when the national R&D expenditure-to-GDP ratio of the host country, which represents the host country's knowledge level, is high. In contrast, the R&D expenditure-GDP ratio of the host country has no impact on whether Japanese MNEs engage in adaptive R&D in that country. In addition, a large host country GDP, a proxy for local market size, is associated with a large probability of Japanese

[3] In the previous studies, the former type is also often referred to as demand-led, home-base-exploiting, or research-oriented R&D, and the latter is referred to as supply-led, home-base-augmenting, or local-support-oriented R&D.

MNEs' performing both innovative and adaptive R&D in that country. These findings are consistent with the view that innovative R&D aims at the exploitation of foreign advanced knowledge, whereas adaptive R&D is mostly determined by the size of the local market. Other factors that influence overseas R&D include the parent firm's R&D expenditure-to-sales ratio, the overseas subsidiary's sales and years of operation, the distance from Tokyo, and the wage level of local engineers.

These estimation results explain what drives the actual patterns of overseas R&D by Japanese MNEs. For example, during the period 1996-2001, innovative R&D by Japanese MNEs was largely concentrated in technological-frontier countries and some newly industrialized economies such as South Korea and Taiwan. This pattern suggests that, indeed, innovative R&D is promoted by the high knowledge levels of those countries, and in the case of South Korea and Taiwan, this factor is further enhanced by their geographical proximity to Japan. Another major trend in recent years has been the rapid increase of overseas R&D by Japanese MNEs in China. Our estimation results suggest that the underlying factor is the expansion of the country's local market based on brisk economic growth.

The remainder of the paper is organized as follows. Section 2 describes the dataset used in this study. Section 3 provides an overview of recent trends and patterns in the overseas R&D activities of Japanese MNEs and highlights some notable characteristics. Section 4 presents the specification of our model to empirically examine the locational determinants of overseas R&D activities, and Section 5 provides the estimation results. Section 6 concludes.

2. Description of the dataset

In this study, we use two firm-level datasets for the period 1996-2001: one for Japanese firms, the *Kigyo Katsudo Kihon Chosa* (Basic Survey of Enterprise Activities), and the other for overseas subsidiaries of Japanese firms, the *Kaigai Jigyo Katsudo Kihon Chosa* (Basic Survey of Multinational Enterprises). Both datasets are collected annually by the Ministry of Economy, Trade and Industry.

Since the survey for subsidiaries includes questions on the role of overseas R&D activities, we can classify the R&D activities of each subsidiary according to the subsidiary's survey response: those engaged in basic or applied research are defined as subsidiaries performing innovative R&D, while subsidiaries not performing these activities but instead engaged in development or design are defined as subsidiaries performing adaptive R&D.[4,5] Overseas subsidiaries that reported positive R&D expenditures but did not specify the functions of their R&D are categorized as subsidiaries performing unclassified R&D. These classification procedures imply that both of subsidiaries that engaged in basic/applied research *but not* in development/design and subsidiaries that engaged in basic/applied research *and* development/design are classified as innovative-R&D-performing subsidiaries. We do not distinguish between the potentially two types of subsidiary, since the former type constitutes only 0.3 percent of all subsidiaries in our dataset.[6]

We match the data of the two surveys for the period 1996-2001, since it is possible to distinguish between overseas innovative and adaptive R&D in a consistent manner only for this period. The combined dataset covers 24 manufacturing industries at the two-digit level.[7] We exclude all observations for which R&D expenditure or sales are not reported.

3. Recent patterns and trends in the overseas R&D activities of Japanese MNEs

This section looks at the characteristics of the overseas R&D activities of Japanese MNEs in recent years. Table 1 shows the trend between 1996 and 2001 in the number and proportion of

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[4] The *Kaigai Jigyo Katsudo* survey included questions on the extent of each of 6 types of R&D activity: basic research, applied research, development for the world market, development for the domestic market, design for the world market, and design for the domestic market. To each of these questions, overseas subsidiaries are provided with a choice of four answers: (1) expanding, (2) stable, (3) shrinking, and (4) absent. If subsidiaries' choice on the extent of a certain type of R&D activity was (1), (2), or (3), we regard that those subsidiaries performed that type of R&D activity. Among subsidiaries that chose (1), (2), or (3), roughly 30-40 percent chose (1), 60-70 percent chose (2), and only 2-3 percent chose (3), although these percentages vary to some extent across types of R&D activity.

[5] Alternatively, we could classify subsidiaries that engaged in *development for the world market* as those performing innovative R&D, rather than adaptive R&D, since R&D activities of such subsidiaries may not aim at adaptation of existing products to local conditions. However, using this modification did not virtually change the conclusions of the present analysis.

[6] Moreover, distinguishing between these two did not virtually change the conclusions of the present analysis.

[7] We classify overseas subsidiaries into 2-digit industries according to the industry code of their parent firms.

overseas subsidiaries performing R&D.[8] The figures indicate that the share of R&D-performing subsidiaries increased slightly from 25.5% to 27.8%. If we divide subsidiaries into those conducting innovative, adaptive, and unclassified R&D, we can notice a jump in 2001 in the share of subsidiaries performing unclassified R&D. This jump is probably the result of a minor modification in the survey question on the nature of overseas subsidiary's R&D activities.[9] Therefore, to investigate the time trend in the share of each type of overseas R&D, we focus on the figures until 2000. Doing so, we find that the share of innovative R&D-performing subsidiaries decreased slightly while that of adaptive R&D-performing subsidiaries expanded.

Table 2 presents the industry distribution of overseas R&D by Japanese MNEs. For simplicity, we only show figures for six industries in which the extent of overseas R&D is particularly large as well as the total for all industries.[10] Looking at Panel (A), which is based on the pooling of observations for the period 1996-2001, the average share of R&D-performing subsidiaries in the total number of overseas subsidiaries is 27.1%. The share is highest in the chemical industry (37.9%), followed by the food industry (37.6%). The high level of overseas R&D, and particularly of innovative R&D, in the food industry can probably be attributed to R&D in biotechnology by firms in this industry. For example, Kirin, the largest beer company in Japan, has two subsidiaries in the U.S. that conduct R&D in biotechnology and medicine.[11] In the electrical equipment, transportation equipment, and precision machinery industries, more than a quarter of all overseas subsidiaries perform R&D. Further, when we look at the type of R&D involved, we find

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[8] Our empirical analysis is based on the *number* of innovative-, adaptive-, and non-R&D-performing overseas subsidiaries, although we do have data on R&D *expenditure* for each subsidiary. We use such count data on firm-level R&D activities, since by doing so, determinants of innovative and adaptive R&D can be examined simultaneously by a multinomial logit model. Another advantage of the use of the count data is that we can avoid possible differences in what is defined as R&D expenditure across firms, while its obvious disadvantage is that we neglect the variation in the size of R&D activities across R&D-performing firms. Todo and Shimizutani (2005) investigate determinants of innovative and adaptive overseas R&D, using firm-level data on R&D expenditure, and lead to the same conclusions as in this paper.

[9] To the question on the extent of each type of R&D activity explained in footnote 4, the *Kaigai Jigyo Katsudo* survey in 2001 did not offer the fourth choice, "absent." Therefore, if a subsidiary did not perform basic research, for example, the subsidiary was supposed to leave the answer blank. This modification is likely to have affected firms' response.

[10] The R&D-performing subsidiaries in the six industries account for 76% of the total number of R&D-performing subsidiaries.

[11] We are grateful to René Belderbos for providing this information.

that the variation in total overseas R&D activity primarily derives from large differences in the share of subsidiaries that engage in innovative R&D. The high overall share of overseas R&D in the chemical and food industries is due primarily to the high share of innovative R&D. In contrast, the share of subsidiaries engaged in adaptive R&D varies less widely across industries.

Panel (B) reports the share of R&D-performing subsidiaries in 1996 and 2000.[12] A particularly large increase of 12 percentage points in the share of R&D-performing subsidiaries can be observed in the food industry. This large increase is mostly caused by the 12-percentage-point increase in the share of innovative R&D-performing subsidiaries. Another notable change is the 3.5-percentage-point increase in the share of subsidiaries performing R&D in the transportation equipment industry. This increase may be due to the fact that Japanese automobile firms like Toyota and Honda expanded R&D centers in the United States and Europe to conduct innovative R&D and established new R&D centers in Asia, in particular China and Thailand, to develop automobiles specific to each country or region, as they expand sales abroad.

Tables 3 and 4 examine the geographical distribution of overseas R&D activities by Japanese MNEs using the pooled data. Table 3 reports the number and the share of R&D-performing overseas subsidiaries by location and detailed R&D classification. We concentrate our analysis on 14 countries which together host 76% of all Japanese overseas subsidiaries and consist of six countries on the technological frontier and eight East Asian countries.[13] This table indicates that Japanese MNEs tend to conduct more R&D in the frontier countries than in the East Asian countries. In the frontier countries, 33.0% of all subsidiaries are engaged in R&D, but the corresponding figure for the East Asian countries is 22.5%. In addition, the ratio of R&D-performing subsidiaries in the frontier countries is higher than the corresponding ratio in the East Asian countries for any detailed category of R&D. However, it should also be noted that the number of Japanese subsidiaries performing innovative R&D, including basic and applied research, in East

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[12] We use data for 2000, rather than 2001, the final year in our data, since, as mentioned above, the share of unclassified R&D in 2001 is substantially higher than in other years.

[13] The frontier countries include Australia, Britain, France, Germany, the Netherlands, and the United States. The East Asian countries include China, Hong Kong, Indonesia, Malaysia, the Philippines, the Republic of Korea, Singapore, and Taiwan.

Asia is not negligible. Surprisingly, 7.5 percent of all Japanese subsidiaries in East Asia perform basic research. This figure is smaller than but close to the 8.1 percent share of subsidiaries performing basic research in the frontier countries.

Table 4 provides detailed information on the distribution of R&D activities by host country. In Panel (A), we can see notable differences in the share of R&D-performing subsidiaries and the relative importance of innovative and adaptive activities across host countries. A priori, we would expect the share of R&D-performing subsidiaries of Japanese firms to be highest in the frontier countries. And indeed, that share in the frontier countries is substantial and, at 45.9%, highest in arguably the most advanced country, the United States. However, the figure for South Korea (45.6%) is almost on par with that for the U.S., and the figure for Taiwan (40.6%) is also higher than that for any of the other frontier countries such as Britain (33.9%) and France (34.0%). China and Malaysia also show a high share of R&D-performing subsidiaries, 26.3% and 22.4%, respectively. These figures are comparable to those for Germany (24.1%) and the Netherlands (27.1%). In Australia and the remaining East Asian countries (Hong Kong, Indonesia, the Philippines, Singapore, and Thailand) the share of R&D-performing subsidiaries is relatively small and less than 20%.

Another pattern that emerges from Table 4(A) is that in host countries where a high share of Japanese subsidiaries engage in R&D much of that R&D is accounted for by innovative R&D. For example, about half of R&D-performing subsidiaries in Britain, the U.S., and South Korea are engaged in innovative R&D, while in France, China, Malaysia, Singapore, and Taiwan, about 40% of all R&D-performing subsidiaries engage in innovative R&D. In the remaining countries, where the share of subsidiaries conducting R&D is low, the share of innovative R&D-performing subsidiaries is less than 40% of the share of all R&D-performing subsidiaries.

Panel (B) of Table 4 shows the change in the share of R&D-performing subsidiaries from 1996 to 2000. We observe an increase in the share of R&D-performing subsidiaries in all of the frontier countries, while in East Asia, with the exception of China, Hong Kong, and Singapore, the share either stagnates or decreases. China shows a remarkable increase in the overall share of R&D-

performing subsidiaries from 22.1% to 27.9% and in the share of innovative R&D-performing subsidiaries from 8.7% to 13.2%.

Finally, Table 5 focuses on 1,527 Japanese MNEs that have subsidiaries in both the frontier countries and East Asia. Reporting the locational distribution of overseas R&D by these Japanese MNEs, this table allows us to observe MNEs' total strategy for overseas R&D activities in different types of country. Like Tables 3 and 4 have shown, Table 5 shows that Japanese MNEs are more likely to perform R&D in the frontier countries than in East Asia. For example, 14.2% of Japanese MNEs perform innovative R&D in the frontier countries (the top right corner), while 6.1% perform it in East Asia (bottom left). 7.6%, 4.9%, and 2.6% of the Japanese MNEs perform innovative, adaptive, and unclassified R&D, respectively, in the frontier countries without engaging in any type of R&D in East Asia. These figures suggest that Japanese MNEs heavily rely on the frontier countries as hosts to overseas R&D. However, we also observe that a substantial number of Japanese MNEs, 5.7% of the total, engage in R&D in East Asia but not in the frontier countries, even though they have subsidiaries in both regions.[14]

So far, we have looked at the number of R&D-performing Japanese overseas subsidiaries, since we will use this information to examine how the decision of Japanese MNEs on whether to perform overseas R&D is made, using a multinomial logit model. However, results from such count data may be misleading, since the size of R&D activities, or more precisely R&D expenditure, of each overseas subsidiary varies across host countries and may be larger in the frontier countries than in East Asia. Therefore, we further present in Table 6 the aggregate R&D intensity by host country, defined as the ratio of the total R&D expenditure of Japanese overseas subsidiaries to their total sales in each host country. Table 6 indicates that the difference between the frontier countries and East Asia in the R&D intensity is more substantial than the difference in the share of R&D-performing subsidiaries in the total number of subsidiaries shown in Table 4: The R&D intensity for frontier countries is 0.79 percent, while that for East Asia is 0.10 percent. However, the R&D intensity of some East Asian countries is as high as that of the frontier countries. Most notably, the

[14] 5.7% is the sum of 1.9%, 2.2%, and 1.6%, the share of Japanese MNEs performing innovative, only adaptive, and unclassified R&D, respectively, in East Asia but no R&D in the frontier countries.

R&D intensity of Taiwan, 0.74 percent, is very close to the R&D intensity of the United States, 0.75 percent, and the innovative R&D intensity, the ratio of expenditure on innovative R&D to sales, is 0.20 percent for Taiwan and 0.29 percent for the United States. South Korea follows Taiwan, having R&D intensity of 0.37 percent that is comparable to the R&D intensity of Germany (0.48 percent). Therefore, the data on R&D intensity support the main conclusion from the analysis of the count data that the extent of R&D activities by Japanese subsidiaries in East Asia, most notably South Korea and Taiwan, is not negligible. This evidence suggests that the role of East Asia not only as a production base, but increasingly also as an R&D base for Japanese MNEs cannot be ignored.

4. Empirical specification

To explore which factors determine whether an overseas subsidiary conducts R&D, and if so, what type of R&D, we employ a multinomial logit model. We assume that Japanese overseas subsidiaries determine whether to perform innovative R&D, to perform adaptive R&D, or to perform no R&D at the beginning of each year based on information obtained in the previous year. More specifically, the probability that subsidiary *i* engages in R&D type *j* in year *t* is assumed to be given by:

$$\text{Prob}(Y_{it} = j) = \frac{\exp(\beta_j' \mathbf{x}_{it-1} + \gamma_j' \mathbf{z}_{it-1})}{1 + \sum_{k=1}^{2} \exp(\beta_k' \mathbf{x}_{it-1} + \gamma_k' \mathbf{z}_{it-1})} \qquad \text{for} \quad j = 1, 2$$

where Y_{it} represents the R&D activity that subsidiary *i* in year *t* is engaged in: innovative R&D (j = 1), adaptive R&D (j = 2), or no R&D (j = 0). We assume $\beta_0' = 0$ and $\gamma_0' = 0$ for normalization.

Vector $\mathbf{x}_{it-1}$ stands for several firm-level variables for subsidiary *i* in year $t-1$ which affect its decision regarding overseas R&D. Included are, for example, the R&D expenditure-to-sales ratio of the parent firm, the subsidiary’s sales, and the years of operation in the host country. We assume that the R&D expenditure-sales ratio of the parent firm represents its knowledge level. The knowledge level of the parent firm positively affects the probability of performing innovative (adaptive) R&D, if the parent firm's firm-specific knowledge is used in overseas innovative (adaptive) R&D. In contrast, if overseas innovative (adaptive) R&D activities mostly rely on the knowledge of the host country, the knowledge level of the parent firm is less likely to be related to its overseas subsidiary's decision of performing innovative (adaptive) R&D. The subsidiary's sales[15] are expected to capture its size, which may positively affect the probability of performing innovative and adaptive R&D since subsidiaries of a larger size may be more easily able to finance initial fixed costs of R&D activities under the presence of credit constraints. In addition, the longer the years of operation, the more the subsidiary knows the local conditions in the host country, including consumers' preferences and engineers' knowledge levels. Since such information is helpful to starting up R&D activities, years of overseas operation is positively associated with the probability of performing innovative and adaptive R&D.

Vector $\mathbf{z}_{it-1}$ represents variables relating to the host country, including the logarithm of the host country's GDP, the ratio of national R&D expenditures to GDP, the distance from Tokyo, and the average gross annual income of engineers. We expect that the probability of performing R&D is positively correlated with the host country's GDP, which represents the market size. Market size is likely to be more important in the case of adaptive R&D, since a large market provides more incentives to adapt products to local preferences. However, since the key motive for innovative R&D is to obtain foreign advanced knowledge, the market size of the host country may not largely influence the extent of innovative R&D.[16] The R&D expenditure-GDP ratio of the host country represents the host country's knowledge level. Since the major motive of overseas innovative R&D is to acquire foreign advanced technology, the size of national R&D in the host country should be positively correlated with the probability of subsidiaries' performing innovative R&D. However, since overseas adaptive R&D follows no such motive, the size of national R&D is not related to the probability of performing adaptive R&D.

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[15] We deflate nominal sales by the output price deflator for each 3-digit industry, taken from the JIP database that was constructed at the Research Institute of Economy, Trade and Industry and is available at www.rieti.go.jp.

[16] If overseas subsidiaries are an export platform, the size of the export market, rather than the domestic market, should influence the probability of performing adaptive R&D. However, due to data constraints, we do not incorporate the size of the export market.

Since the country-level GDP is a proxy for the host country's market size that Japanese MNEs observe, the GDP should be represented by yen. We construct the real, yen-based host country GDP from nominal GDP, the nominal exchange rate, and the GDP deflator of Japan taken from World Bank (2005). Data for the ratio of national R&D expenditures to GDP are taken from UNESCO (2005), while the distance from Tokyo is obtained using the "City Distance Tool" provided by Geobytes, Inc. (available at geobytes.com). The annual income of engineers is the gross income per capita of engineers taken from UBS (1997, 2000) converted into yen and deflated by the Japanese price level.[17]

Assuming that Japanese MNEs determine whether or not to engage in overseas R&D based on information for the previous year, explanatory variables are lagged by one year. The use of lagged regressors may also alleviate simultaneity biases due to shocks that affect both Japanese MNEs' decision on overseas R&D and contemporaneous firm- and country-level variables. Moreover, we add industry dummies and year dummies.

We pool all observations for the period 1996-2001 but limit our sample for the specification including engineers' income as an explanatory variable to the years 1998 and 2001, since data for engineers' income are available only for 1997 and 2000. Because the role of R&D varies substantially across industries, we focus on the six industries with the largest share of overseas R&D-performing subsidiaries, namely the food, chemical, general machinery, electrical equipment, transportation equipment, and precision machinery industries (see Table 2). Table 7 reports summary statistics for the variables used in the regression. Among the 4,561 observations in the sample covering the period 1996-2001, 627, or 14%, perform innovative R&D, whereas 540, or 12%, perform adaptive R&D.

A crucial assumption of multinomial logit estimation is the independence from irrelevant alternatives (IIA), or that Prob($Y_{it} = j$)/Prob($Y_{it} = k$) is independent of the remaining probabilities (Greene, 2003, p. 724). In the case of the present analysis, this implies, for example, that the

[17] Since UBS (1997, 2000) presents data for cities rather than countries, more than one observation (per year) is available for some countries. In the case of the U.S, for example, data for Chicago, Houston, Los Angeles, and New York are available. In such cases, we use the average income in all available cities in the same country.

probability of performing innovative R&D relative to the probability of performing no R&D is independent of the probability of performing adaptive R&D. This IIA assumption is violated, if, for example, firms first determine whether or not to perform R&D and then determine whether to perform innovative or adaptive R&D. In this case, we should employ a nested logit model with two branches, rather than a multinomial logit model.[18] To test the IIA assumption, we use a method developed by Hausman and McFadden (1984) and examine whether the results from the original estimation with three choices are systematically different from the results from the estimation in which we assume only two choices and drop one choice among the three.

5. Estimation results

5.1 Benchmark results from multinomial logit estimation

Table 8 presents our estimation results based on the multinomial logit model specified in the previous section. Column 1 shows the results using the data for the period 1996-2001. Columns 2 and 3 display the results using the data for only 1998 and 2001, since these estimations incorporate engineers' income as a regressor. The figures in brackets in Table 8 indicate the marginal effect of regressors evaluated at the average. The last two rows show *p* values from Hausman tests that examine whether the independence from irrelevant alternatives (IIA) discussed just above is satisfied. According to the *p* values, we conclude that the IIA is satisfied so that our use of the multinomial logit specification can be justified. In discussing the coefficients on the regressors, we focus on the results in column 1 because, with the exception of the result for the income level of local engineers, they are virtually the same across columns.

First, parent firms' R&D expenditure-to-sales ratio positively affects the probability of performing adaptive R&D. However, the effect of the same ratio on the presence of innovative R&D is negative and insignificant at the 5-percent level. Since the R&D expenditure-sales ratio can be a proxy for parent firms' knowledge level, this result implies that overseas adaptive R&D utilizes parent firms' knowledge to a greater extent than overseas innovative R&D does. Based on summary

[18] The authors would like to thank two anonymous referees for pointing out this issue.

statistics in Table 7 and the estimate for the size of the marginal effect in the bracket in column 1 of Table 8, an increase in the R&D expenditure-sales ratio of the parent firm by one standard deviation associated with roughly a 3-percentage-point increase in the probability of performing adaptive R&D.[19]

Second, we find that subsidiaries' sales and years of operation in the host country have a positive and significant impact on the probability of performing innovative and adaptive R&D. An increase in the subsidiary's sales by one standard deviation raises the probability of performing innovative and adaptive R&D by 5 percentage points, whereas in the case of the years of operation, the corresponding figures are 3 and 1 percentage points, respectively. Since the probabilities of subsidiaries performing innovative and adaptive R&D in the sample are 14% and 12%, respectively, the effect of subsidiaries' sales is substantial.

This result shows that the size and the experience of subsidiaries influence whether they perform R&D. We suspect that the size effect may partly reflect the tendency that larger subsidiaries can finance their R&D activities more easily. The experience effect arises probably because experienced subsidiaries know the local conditions of the host country, such as implicit government regulations and labor market conditions, better than newcomers so that the cost of R&D is smaller for experienced subsidiaries.

Third, host countries' GDP has a positive and significant effect in the case of both innovative and adaptive R&D. Its effect on innovative and adaptive R&D is large in size: a one-standard-deviation increase in the host country GDP raises the probability of subsidiaries performing innovative R&D by 5 percentage points and adaptive R&D by 3 percentage points. That host country GDP has a greater effect on innovative than on adaptive R&D is an unexpected result, since it is adaptive R&D, i.e. R&D for the adaptation of products to local conditions, that is commonly assumed to be influenced more strongly by local market size than innovative R&D, i.e. R&D for the exploitation of foreign advanced knowledge. This result may be due to our method of distinguishing between subsidiaries performing innovative and adaptive R&D: An overseas

[19] Throughout this paper, when we present the marginal effect of regressors, we use the means of the regressors.

subsidiary is classified as performing innovative R&D even when it actually performed both innovative and adaptive R&D. Therefore, we suspect that the significant positive effect of host countries' GDP on the likelihood of subsidiaries performing innovative R&D actually captures the relationship between host country GDP and adaptive R&D rather than innovative R&D.

Fourth, the ratio of national R&D expenditure to GDP is an important determinant of the likelihood of Japanese MNEs to locate innovative R&D activities in that country, while the same ratio has an insignificant (columns 1 and 3) or smaller (column 2) impact on adaptive R&D. Since the country-level R&D expenditure-GDP ratio can proxy for host countries' knowledge level, this result is consistent with the view that overseas innovative R&D seeks foreign advanced technology while overseas adaptive R&D does not.

Fifth, we find that the probability of performing innovative and adaptive R&D is negatively correlated with the distance from Tokyo to the host country. The following example illustrates the magnitude of the distance effect: The distance from Tokyo to South Korea is 1,200 kilometers, while that to the U.S. is 10,100 kilometers. This difference in distance leads to a difference in the probability of performing innovative R&D in South Korea or the United States by almost 11 percentage points, other elements being equal.

Finally, according to the results shown in column 2, the average income of engineers has a negative impact on the probability of performing innovative R&D but has an insignificant impact on the probability of performing adaptive R&D. When we include both the distance from Tokyo and the average income of engineers, these results on the effect of the two regressors remain the same.[20]

[20] In the benchmark regression, we drop from the sample overseas subsidiaries that reported positive R&D expenditures but did not report the type of their R&D activities. To check the robustness of the benchmark results, we include these subsidiaries in the sample and consider them as engaging in "unclassified R&D." In other words, in this alternative regression, overseas subsidiaries are assumed to choose one out of four different types of R&D, that is, innovative, adaptive, unclassified, or no R&D, rather than just out of three as in the benchmark regression. However, the modification leaves the results on the probability of performing innovative and adaptive R&D virtually unchanged. In addition, the estimated coefficients on the regressors in the case of unclassified R&D lie between those for innovative and adaptive R&D, confirming that subsidiaries that did not specify the type of R&D in fact performed either innovative or adaptive R&D.

5.2 Results from conditional logit estimation

In the multinomial logit estimation above, we assumed that each subsidiary in a particular country determines whether to perform innovative, adaptive, or no R&D. To check the robustness of the results from the multinomial logit estimation, we assume a completely different decision making process of overseas R&D activities as an experiment. Specifically, we assume that the headquarters in Japan of each MNE first determines to perform overseas innovative or adaptive R&D and then determines the location of the R&D activities among the pool of potential host countries. For the estimation based on these assumptions, we employ a conditional logit estimation rather than the multinomial logit estimation in the benchmark case. Conditional logit estimation is often employed in studies that examine the locational choice of foreign direct investment (FDI), such as Blonigen et al. (2005). Our dataset for the conditional logit estimation consists of 5,317 and 2,288 "entries" to overseas innovative and adaptive R&D by Japanese overseas MNEs, respectively. A Japanese MNE is considered to "enter" overseas innovative (adaptive) R&D in a particular host country when the subsidiary of the MNE in the host country reports a positive R&D expenditure and declares innovative (adaptive) R&D as one of its functions for the first time during the period 1997-2001.

More specifically, we assume that the probability that MNE *i* chooses country *c* to perform innovative and adaptive R&D in subsidiary *q* can be respectively expressed by

$$\text{Prob}(y_{iq}^{I}=c)=\frac{\exp(\lambda^{I\prime}\tilde{\mathbf{x}}_{ic}+\mu^{I\prime}\tilde{\mathbf{z}}_{c})}{\sum_{C}\exp(\lambda^{I\prime}\tilde{\mathbf{x}}_{iC}+\mu^{I\prime}\tilde{\mathbf{z}}_{C})},\qquad \text{Prob}(y_{iq}^{A}=c)=\frac{\exp(\lambda^{A\prime}\tilde{\mathbf{x}}_{ic}+\mu^{A\prime}\tilde{\mathbf{z}}_{c})}{\sum_{C}\exp(\lambda^{A\prime}\tilde{\mathbf{x}}_{iC}+\mu^{A\prime}\tilde{\mathbf{z}}_{C})}$$

where $y_{iq}^{I(A)}$ is the locational choice of subsidiary *q* of MNE *i* performing innovative (adaptive) R&D. $\tilde{\mathbf{x}}_{ic}$ is a vector of variables that represent MNE *i*'s characteristics in country *c* such as sales of its subsidiary in country *c* in the previous year, while $\tilde{\mathbf{z}}_{c}$ is a vector of variables that represent country *c*'s characteristics including its GDP, the ratio of national R&D expenditure to GDP, the distance from Tokyo, and the average income of engineers, as in the benchmark estimation.

Although to estimate a conditional logit function is a frequently approach to examine the locational choice of FDI, there may be the following three possible drawbacks of the conditional logit estimation. First, since many subsidiaries do not report R&D expenditure for some years during the sample period although they do report it for other years, it is not clear whether a certain Japanese MNE enters overseas R&D even when the MNE reports a positive R&D expenditure for the first time during the sample period. Second, conditional logit estimation cannot investigate the effect of variables specific to parent firms, such as their sales and R&D expenditure-sales ratio, that are employed in our multinomial logit estimation. Finally, in the conditional logit estimation we have to examine the determinants of innovative R&D and adaptive R&D separately in two regressions, while in the multinomial logit estimation we can examine the determinants of both types of R&D together in one regression.

The results reported in Table 9 show that host country GDP has a positive and significant impact on the locational choice of both innovative and adaptive R&D, while the R&D expenditure-GDP ratio of the host country has a positive and significant impact on the locational choice only of innovative R&D. The distance from Tokyo and the average income of engineers in the host country have a significant negative impact on both innovative and adaptive R&D in specifications (1) and (2). All these results are consistent with the benchmark results from the multinomial logit estimation.

5.3 Summary and implications

In summary, our findings indicate some differences between the determinants of overseas innovative and adaptive R&D. Most notably, the knowledge level of the host country has a positive impact on the probability that Japanese overseas subsidiaries perform innovative R&D in that country, while it is has no impact on the probability of performing adaptive R&D. In addition, the knowledge level of the parent firm in Japan raises the probability of performing adaptive R&D but not innovative R&D. Thus, overseas innovative R&D is promoted by knowledge in the host country, while adaptive R&D is enhanced by the knowledge of the parent firm. These results imply that innovative R&D utilizes host country's knowledge, whereas adaptive R&D employs the parent firm's knowledge. This implication is consistent with the view that the aim of overseas innovative R&D is to acquire foreign advanced knowledge.[21] Factors that affect the probability of performing both innovative and adaptive R&D include the overseas subsidiary's size and years of operation, the market size of the host country, geographical proximity, and the wage level of local engineers.

These findings help to explain the actual geographical distribution of the overseas R&D activities of Japanese MNEs. As was seen above, Japanese subsidiaries engaged in innovative R&D tend to be concentrated in the frontier countries, suggesting that economic size (in particular, in the case of the U.S.) and the knowledge level of the frontier countries offset the disadvantages of the greater distance from Japan when compared with the East Asian countries. The relatively large share of subsidiaries performing innovative R&D in South Korea and Taiwan, on the other hand, seems to be due to the high knowledge level in these countries[22] combined with their geographical proximity to Japan. In addition, the rapid expansion of R&D-performing Japanese subsidiaries in China, as we have seen in Table 4(B), may be explained by the fast growth of the Chinese market.[23]

Based on this reasoning, we expect the R&D activities of Japanese MNEs in East Asia to expand further as the region enjoys rapid economic growth and countries move up the technology ladder, thus adding to the advantage of proximity to Japan. In addition, regional free trade arrangements such as the recently established ASEAN Free Trade Area (AFTA) and other agreements currently in the pipeline are likely to lead to greater economic integration that will have effects similar to an increase in national GDP. Therefore, the conclusion of free trade agreements in East Asia is likely to boost the overseas R&D activities of Japanese MNEs even further.

[21] Todo and Shimizutani (2005) obtain similar results, using the same dataset but a different estimation methodology.

[22] The R&D expenditure-to-GDP ratio for South Korea during the period 1996-2001 was 2.5%-3%, whereas the same ratio for Taiwan was around 2%. These figures are comparable to those for the frontier countries.

[23] According to World Bank (2005), China's real GDP increased by almost 50% from 727 to 1,081 billion dollars (at constant 2000 prices) during the period 1995-2003.

6. Conclusion

This paper took advantage of a rich micro-level dataset on Japanese subsidiaries to explore what determines Japanese MNEs' R&D activities abroad. We were able to discern several interesting patterns in such overseas R&D activities since the mid-1990s. First, there was a slight increase between 1996 and 2000 in the share of overseas subsidiaries that perform R&D. Second, Japanese MNEs largely perform innovative R&D in frontier countries, such as the U.S., Britain and France, as well as in the two newly industrialized East Asian economies of South Korea and Taiwan. In other parts of East Asia, including China, Hong Kong, Indonesia, Malaysia, Thailand, and Singapore, the bulk of overseas R&D by Japanese MNEs consists of adaptive R&D, although Japanese MNEs also perform some innovative R&D in these countries.

Our empirical investigation based on a multinomial logit model examined the determinants of overseas R&D by Japanese MNEs, distinguishing between the two types of overseas R&D: innovative and adaptive. We found several differences between the determinants of the two types. Most notably, the ratio of national R&D expenditure to GDP of the host country, representing the knowledge level of the host country, was found to have a positive impact on the probability of performing innovative R&D but no significant impact in the case of adaptive R&D. In addition, the parent firm's R&D expenditure–to-sales ratio, representing the knowledge level of the parent, had an insignificant effect on innovative R&D but a positive effect on adaptive R&D. On the other hand, the probability of performing both innovative and adaptive R&D was positively correlated with the GDP, standing for the size of the market, of the host country. These results suggest that overseas innovative R&D aims at the exploitation of foreign advanced knowledge, whereas the primary role of overseas adaptive R&D is to adapt products and technologies to local conditions using parent firms' existing knowledge when the local market is large. Other important factors that affect overseas R&D decision are overseas subsidiaries' size and years of experience in the host country, geographical proximity to Japan, and the wage level of local engineers. Taken together, these factors provide a plausible and comprehensive explanation of the geographical distribution of overseas R&D by Japanese MNEs.

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Table 1: Number of R&D-Performing Overseas Subsidiaries by Year and Type of R&D

	R&D performing subsidiaries				
Year	Total	Innovative R&D	Adaptive R&D	Unclassified	All subsidiaries
1996	526	255	179	92	2037
	(25.8)	(12.5)	(8.8)	(4.5)	(100.0)
1997	552	261	197	94	2053
	(26.9)	(12.7)	(9.6)	(4.6)	(100.0)
1998	496	234	149	113	1804
	(27.5)	(13.0)	(8.3)	(6.3)	(100.0)
1999	592	268	207	117	2158
	(27.4)	(12.4)	(9.6)	(5.4)	(100.0)
2000	630	267	239	124	2325
	(27.1)	(11.5)	(10.3)	(5.3)	(100.0)
2001	580	216	194	170	2089
	(27.8)	(10.3)	(9.3)	(8.1)	(100.0)
Total	3376	1501	1165	710	12466
	(27.1)	(12.0)	(9.3)	(5.7)	(100.0)

Note: The number of overseas subsidiaries of Japanese firms in each year (or in all years for the last row) is presented. Percentages out of the total number of overseas subsidiaries in each year are given in parentheses. The numbers are based on the original (i.e., not the cleaned) dataset. We restrict our observations to those that reported zero or positive R&D expenditure.

Table 2: Number and Share of R&D-Performing Overseas Subsidiaries by Industry

(A) By Industry; pooled data for 1996-2001

	R&D-performing subsidiaries				All subsidiaries
	Total	Innovative R&D	Adaptive R&D	Unclassified	
Selected industries					
Food	194	115	55	24	516
	(37.6)	(22.3)	(10.7)	(4.7)	(100.0)
Chemical	660	334	192	134	1740
	(37.9)	(19.2)	(11.0)	(7.7)	(100.0)
General machinery	376	143	137	96	2122
	(17.7)	(6.7)	(6.5)	(4.5)	(100.0)
Electrical equipment	828	342	309	177	2979
	(27.8)	(11.5)	(10.4)	(5.9)	(100.0)
Transportation equipment	508	193	218	97	1735
	(29.3)	(11.1)	(12.6)	(5.6)	(100.0)
Precision machinery	106	45	36	25	395
	(26.8)	(11.4)	(9.1)	(6.3)	(100.0)
Total	3376	1501	1165	710	12466
	(27.1)	(12.0)	(9.3)	(5.7)	(100.0)

Table 2: Number of R&D-Performing Overseas Subsidiaries by Industry (Continued)

(B) By Industry; 1996 and 2000

Industry	Year	Share of R&D-performing subsidiaries			
		Total	Innovative R&D	Adaptive R&D	Unclassified
Total	1996	25.8	12.5	8.8	4.5
	2000	27.1	11.5	10.3	5.3
Selected industries					
Food	1996	30.3	19.2	10.1	1.0
	2000	42.4	31.5	7.6	3.3
Chemical	1996	33.1	19.0	8.9	5.2
	2000	36.4	17.9	11.7	6.7
General machinery	1996	18.2	9.2	6.3	2.6
	2000	16.1	5.0	6.7	4.5
Electrical equipment	1996	26.1	11.3	10.5	4.3
	2000	28.2	10.3	11.6	6.2
Transportation equipment	1996	27.8	10.2	12.5	5.1
	2000	31.3	11.5	14.1	5.6
Precision machinery	1996	32.7	14.3	10.2	8.2
	2000	25.6	8.9	8.9	7.8

Note: In Panel (A), the number of overseas subsidiaries of Japanese firms in each industry (or in all industries for the first row) is reported. Percentages out of the total number of overseas subsidiaries in each industry (or in all industries for the last row) are in parentheses. In Panel (B), we only report the shares of overseas subsidiaries of Japanese firms in each industry. We restrict our observations to those that reported zero or positive R&D expenditure.

Table 3: Number of R&D-Performing Overseas Subsidiaries
by Detailed R&D Classification

Type of R&D	Number of R&D-performing subsidiaries			Ratio to the total number of subsidiaries (percentage)		
	In the frontier countries	In East Asia	In all countries	In the frontier countries	In East Asia	In all countries
Innovative R&D						
Basic research	333	473	888	8.1	7.5	7.1
Applied research	423	542	1064	10.3	8.6	8.5
Adaptive R&D						
Development for the world market	452	502	1062	11.0	7.9	8.5
Development for the domestic market	674	782	1635	16.4	12.4	13.1
Design for the world market	445	576	1135	10.8	9.1	9.1
Design for the domestic market	713	912	1827	17.3	14.4	14.7
Total	1360	1426	3376	33.0	22.5	27.1

Note: The frontier countries include Australia, Britain, France, Germany, the Netherlands, and the United States. East Asia includes China, Hong Kong, Indonesia, Malaysia, the Philippines, the Republic of Korea, Singapore, and Taiwan. The total number (ratio) is not equal to the sum of the numbers of all categories since one subsidiary may engage in more than one type of R&D.

Table 4: Number of R&D-Performing Overseas Subsidiaries by Host Country

(A) By Host Country

Host country	Number (share) of R&D-performing subsidiaries				Number of all subsidiaries
	Total	Innovative R&D	Adaptive R&D	Unclassified	
Frontier countries					
Australia	50	16	15	19	287
	(17.4)	(5.6)	(5.2)	(6.6)	(100.0)
Britain	189	79	84	26	558
	(33.9)	(14.2)	(15.1)	(4.7)	(100.0)
France	104	45	32	27	306
	(34.0)	(14.7)	(10.5)	(8.8)	(100.0)
Germany	148	54	63	31	614
	(24.1)	(8.8)	(10.3)	(5.0)	(100.0)
Netherlands	72	25	28	19	266
	(27.1)	(9.4)	(10.5)	(7.1)	(100.0)
United States	960	511	296	153	2091
	(45.9)	(24.4)	(14.2)	(7.3)	(100.0)
East Asia					
China	300	144	89	67	1140
	(26.3)	(12.6)	(7.8)	(5.9)	(100.0)
Hong Kong	67	16	29	22	635
	(10.6)	(2.5)	(4.6)	(3.5)	(100.0)
Indonesia	71	29	23	19	539
	(13.2)	(5.4)	(4.3)	(3.5)	(100.0)
South Korea	241	126	61	54	529
	(45.6)	(23.8)	(11.5)	(10.2)	(100.0)
Malaysia	142	60	43	39	635
	(22.4)	(9.4)	(6.8)	(6.1)	(100.0)
Philippines	53	19	13	21	337
	(15.7)	(5.6)	(3.9)	(6.2)	(100.0)
Singapore	115	44	44	27	826
	(13.9)	(5.3)	(5.3)	(3.3)	(100.0)
Taiwan	345	156	130	59	849
	(40.6)	(18.4)	(15.3)	(6.9)	(100.0)
Thailand	164	59	62	43	834
	(19.7)	(7.1)	(7.4)	(5.2)	(100.0)
Total	3376	1501	1165	710	12466
	(27.1)	(12.0)	(9.3)	(5.7)	(100.0)

Table 4: Number of R&D-Performing Overseas Subsidiaries by Host Country (Continued)

(B) By Host Country, 1996 and 2000

			R&D-performing subsidiaries		
Host country	Year	Total	Innovative R&D	Adaptive R&D	Unclassified
Frontier countries					
Australia	1996	10.2	2.0	6.1	2.0
	2000	14.3	3.6	5.4	5.4
Britain	1996	22.4	10.3	7.5	4.7
	2000	28.7	8.7	13.9	6.1
France	1996	23.5	13.7	5.9	3.9
	2000	36.7	15.0	11.7	10.0
Germany	1996	32.4	16.7	10.8	4.9
	2000	35.6	14.9	17.8	3.0
Netherlands	1996	16.3	7.0	4.7	4.7
	2000	34.0	14.0	12.0	8.0
USA	1996	42.0	23.6	12.1	6.3
	2000	49.4	25.9	17.0	6.5
East Asia					
China	1996	22.1	8.7	7.6	5.8
	2000	27.9	13.2	8.3	6.4
Hong Kong	1996	9.6	2.9	3.8	2.9
	2000	12.3	2.5	6.6	3.3
Indonesia	1996	19.7	9.2	6.6	3.9
	2000	9.7	4.9	1.9	2.9
South Korea	1996	45.1	23.2	12.2	9.8
	2000	44.6	23.8	11.9	8.9
Malaysia	1996	21.6	12.4	6.2	3.1
	2000	22.8	10.2	6.3	6.3
Philippines	1996	18.8	4.2	4.2	10.4
	2000	14.9	6.0	1.5	7.5
Singapore	1996	13.2	4.9	6.9	1.4
	2000	16.2	5.8	7.1	3.2
Taiwan	1996	39.9	18.2	18.2	3.5
	2000	36.9	16.1	16.8	4.0
Thailand	1996	22.4	7.5	8.2	6.7
	2000	15.0	4.6	6.5	3.9

Note: In Panel (A), the number of overseas subsidiaries of Japanese firms in each country is reported. Percentages out of the total number of overseas subsidiaries in each country are in parentheses. In Panel (B), we only report the shares of overseas subsidiaries of Japanese firms in each in industry.

Table 5: Locational Distribution of Overseas R&D by Japanese MNEs

Location		In East Asia				
	Type of R&D	Innovative R&D	Only adaptive R&D	Unclassified R&D	No R&D	Total
In frontier countries	Innovative R&D	3.0	0.5	1.0	7.6	14.2
	Only adaptive R&D	1.0	1.8	1.0	4.9	6.4
	Unclassified R&D	0.3	0.5	1.4	2.6	4.7
	No R&D	1.9	2.2	1.6	69.1	74.7
	Total	6.1	4.9	4.9	84.1	100.0

Note: The table reports the percentage out of the total number of Japanese MNEs (1,527) that have subsidiaries in both the frontier countries and in East Asia. For example, the figure in the top left corner indicates that 3.5% of Japanese MNEs perform innovative R&D both in at least one of the frontier countries and at least one of the East Asian countries. The frontier countries include Australia, Britain, France, Germany, the Netherlands, and the United States. East Asia includes China, Hong Kong, Indonesia, Malaysia, the Philippines, the Republic of Korea, Singapore, and Taiwan.

Table 6: Japanese Overseas Subsidiaries' R&D Intensity by Host Country

Host country	R&D expenditure-to-sales ratio (percentage)			
	Total	Innovative R&D	Adaptive R&D	Unclassified
Frontier countries	0.79	0.30	0.38	0.11
Australia	0.07	0.02	0.02	0.02
Britain	0.76	0.36	0.37	0.03
France	2.16	1.02	0.42	0.72
Germany	0.48	0.18	0.27	0.03
Netherlands	1.44	0.22	0.44	0.78
United States	0.75	0.29	0.40	0.06
East Asia	0.10	0.03	0.04	0.03
China	0.04	0.01	0.02	0.01
Hong Kong	0.06	0.00	0.04	0.01
Indonesia	0.01	0.00	0.00	0.00
South Korea	0.37	0.15	0.08	0.15
Malaysia	0.10	0.04	0.04	0.03
Philippines	0.02	0.00	0.00	0.01
Singapore	0.09	0.03	0.05	0.01
Taiwan	0.74	0.20	0.35	0.19
Thailand	0.02	0.01	0.01	0.00

Note: This table presents Japanese MNEs' R&D intensity by host country defined by the ratio of the total R&D expenditure to the total sales of Japanese MNEs in each host country.

Table 7: Summary Statistics

	Mean (S.D.)
Firm-level variables	N=4,561
Ratio of parent firms' R&D expenditure to sales in the previous year (%)	4.36 (3.25)
Subsidiaries' sales in the previous year (trillion yen)	0.0369 (0.166)
Years of operations in the host country	14.7 (9.49)
Country-level variables	
Logarithm of host country GDP deflated by the Japanese price level (trillion yen)	3.23 (1.33)
Host country R&D expenditure-to-GDP ratio (%)	1.25 (0.917)
Distance from Tokyo (thousand kilometers)	9.10 (4.02)
Average gross annual income of engineers (million yen) for 1998 and 2001 only	3.86 (1.88)

Note: The table shows the mean and standard deviation of the regressors.

Table 8: Results from Multinomial Logit Estimation

	(1)		(2)		(3)	
	Innovative R&D	Adaptive R&D	Innovative R&D	Adaptive R&D	Innovative R&D	Adaptive R&D
Ratio of the parent firm's R&D expenditure to sales (%)	-0.003	0.115	-0.018	0.162	-0.013	0.167
	(0.015)	(0.015)**	(0.027)	(0.026)**	(0.027)	(0.026)**
	[-0.002]	[0.011]	[-0.004]	[0.016]	[-0.003]	[0.016]
Sales of the overseas subsidiary (trillion yen)	3.562	3.756	3.455	3.421	3.315	3.283
	(0.484)**	(0.483)**	(0.694)**	(0.697)**	(0.692)**	(0.695)**
	[0.305]	[0.322]	[0.309]	[0.284]	[0.294]	[0.271]
Years of operations in the host country	0.032	0.017	0.035	0.019	0.037	0.020
	(0.005)**	(0.005)**	(0.008)**	(0.009)*	(0.008)**	(0.009)*
	[0.003]	[0.001]	[0.003]	[0.001]	[0.003]	[0.001]
Log of host country GDP (trillion yen)	0.427	0.279	0.359	0.266	0.418	0.319
	(0.045)**	(0.045)**	(0.069)**	(0.071)**	(0.074)**	(0.075)**
	[0.039]	[0.022]	[0.033]	[0.021]	[0.038]	[0.025]
Host country R&D expenditure-to-GDP ratio (%)	0.267	0.130	0.497	0.267	0.393	0.178
	(0.074)**	(0.075)	(0.121)**	(0.133)*	(0.129)**	(0.138)
	[0.025]	[0.009]	[0.047]	[0.019]	[0.037]	[0.012]
Distance from Tokyo (thousand kilometers)	-0.135	-0.053			-0.072	-0.072
	(0.016)**	(0.015)**			(0.034)*	(0.034)*
	[-0.013]	[-0.004]			[-0.006]	[-0.006]
Average income of engineers (million yen)			-0.260	-0.068	-0.165	0.021
			(0.048)**	(0.052)	(0.065)*	(0.067)
			[-0.026]	[-0.003]	[-0.017]	[0.004]
No. of observations	4561		1651		1651	
Log likelihood	-3022.61		-1091.39		-1087.05	
Pseudo R-squared	0.11		0.13		0.13	
Hausman test (omitted choice)						
(Innovative R&D)	0.84		1.00		1.00	
(Adaptive R&D)	1.00		1.00		1.00	

Note: Results are based on multinomial logit regressions that estimate the effect of the regressors on the choice of whether a Japanese overseas subsidiary performs innovative R&D, adaptive R&D, or no R&D at all. Except for "Distance from Tokyo," the regressors are the values of the previous year. The figures in parentheses are standard errors, while those in brackets represent marginal effects at the average. The second last row presents the *p* value from a Hausman test for independence from irrelevant alternatives in which innovative R&D is omitted from possible choices, whereas the last row presents the corresponding *p* value when adaptive R&D is omitted.

Table 9: Results from Conditional Logit Estimation

	(1) Innovative R&D	(2) Adaptive R&D	(3) Innovative R&D	(4) Adaptive R&D	(5) Innovative R&D	(6) Adaptive R&D
Sales of the overseas subsidiary (trillion yen)	0.247	-0.561	0.183	-0.033	0.184	0.090
	(0.200)	(0.735)	(0.207)	(1.043)	(0.207)	(1.032)
Log of host country GDP (trillion yen)	0.515	0.527	0.548	0.500	0.547	0.585
	(0.042)**	(0.064)**	(0.071)**	(0.115)**	(0.082)**	(0.129)**
Host country R&D expenditure-to-GDP ratio (%)	0.190	0.152	0.370	0.254	0.371	0.188
	(0.071)**	(0.107)	(0.137)**	(0.207)	(0.142)**	(0.204)
Distance from Tokyo (thousand kilometers)	-0.062	-0.072			0.001	-0.133
	(0.016)**	(0.024)**			(0.058)	(0.089)
Average income of engineers (million yen)			-0.136	-0.138	-0.139	0.067
			(0.048)**	(0.075)	(0.104)	(0.153)
No. of observations	5317	2288	1833	728	1833	728
Log likelihood	-954.23	-412.40	-315.13	-129.35	-315.13	-128.24
Pseudo R-squared	0.09	0.09	0.13	0.10	0.13	0.11

Note: Results are based on conditional logit regressions that estimate the effect of the regressors on the locational choice of a Japanese overseas subsidiary's performing innovative R&D and adaptive R&D. Except for "Distance from Tokyo," the regressors are the values of the previous year. The figures in parentheses are standard errors.

Appendix Table A1: Number and R&D Intensity of R&D-Performing Overseas Subsidiaries by Year

	Amount of R&D expenditure (billion yen)			Ratio of R&D expenditure to sales (%)		
Year	Total R&D	Innovative R&D	Adaptive R&D	Total R&D	Innovative R&D	Adaptive R&D
1996	268	131	138	0.23	0.11	0.12
1997	375	155	220	0.30	0.12	0.17
1998	402	146	256	0.32	0.12	0.21
1999	531	199	332	0.37	0.14	0.23
2000	583	219	364	0.34	0.13	0.21
2001	489	140	349	0.28	0.08	0.20
Total	2648	989	1659	0.31	0.12	0.19

Notes: These numbers above are based on the original data sets without our cleaning processes. Innovative R&D is defined as basic or applied research, whereas adaptive R&D is defined as development, design, or unclassified R&D.

Appendix Table A2: Number and R&D Intensity of R&D-Performing Overseas Subsidiaries by Host Country

	Amount of R&D expenditure (billion yen)			Ratio of R&D expenditure to sales (%)		
Country	Total R&D	Innovative R&D	Adaptive R&D	Total R&D	Innovative R&D	Adaptive R&D
Developed countries						
Australia	6	2	4	0.04	0.01	0.03
France	166	71	96	1.09	0.46	0.62
Germany	98	32	66	0.38	0.13	0.26
Netherlands	238	59	178	0.66	0.17	0.50
United Kingdom	169	87	82	0.44	0.23	0.21
United States	1421	566	855	0.50	0.20	0.30
Less developed countries						
China	94	24	69	0.15	0.04	0.11
Hong Kong	11	1	10	0.05	0.00	0.05
Indonesia	10	3	7	0.02	0.01	0.02
Korea	61	24	37	0.39	0.16	0.23
Malaysia	70	22	48	0.19	0.06	0.13
Philippines	7	2	5	0.03	0.01	0.02
Singapore	24	9	15	0.08	0.03	0.05
Taiwan	127	37	91	0.49	0.14	0.35
Thailand	23	10	13	0.04	0.02	0.02

Notes: These numbers above are based on the original data sets without our cleaning processes. Innovative R&D is defined as basic or applied research, whereas adaptive R&D is defined as development, design, or unclassified R&D.

Appendix Table A3: Summary Statistics

Variable	Description	Mean	Standard deviation	Min.	Max.
Firm-level variables (N = 1992)					
$R\&D$	R&D expenditure of the overseas subsidiary (percentage of its sales)	0.741	4.269	0.000	79.319
$R\&D_I$	Innovative R&D expenditure of the overseas subsidiary (percentage of its sales)	0.391	3.651	0.000	79.319
$R\&D_A$	Adaptive R&D expenditure of the overseas subsidiary (percentage of its sales)	0.349	2.264	0.000	49.881
$\ln A$	Log of the TFP level of the subsidiary firm	1.833	0.959	-3.467	5.357
$\ln Y$	Log of sales of the subsidiary firm	8.666	1.678	0.318	13.362
$\ln A^P$	Log of the TFP level of the parent firm	2.226	0.540	-0.367	4.361
$\ln Y^P$	Log of sales of the parent firm	11.837	1.752	7.002	15.286
Country-level variables (N = 156)					
$\ln A^{host}$	Log of the aggregate TFP level of the host country	6.153	0.374	5.189	6.775
$\ln Y^{host}$	Log of the aggregate GDP of the host country	12.953	1.252	9.677	16.034
$\ln DIS$	Log of the distance between Japan and the host country	8.918	0.594	7.054	9.829

Note: Innovative R&D is defined as basic or applied research, whereas adaptive R&D is defined as development, design, or unclassified R&D.

Appendix Table A4: Determinants of Overseas R&D Intensity

		(1)	(2)	(3)	(4)	(5)	(6)
	Dependent variable	*R&D$_I$* Innovative R&D intensity		*R&D$_A$* Adaptive R&D intensity		*R&D* Total R&D intensity	
Independent variable	Description	Tobit	AGLS	Tobit	AGLS	Tobit	AGLS
ln*A*	Subsidiary's TFP	-1.083	-2.047	-0.213	-0.601	-0.714	-1.371
		(0.410)**	(0.749)**	(0.211)	(0.384)	(0.252)**	(0.458)**
lnA^P	Parent firm's TFP	0.490	0.639	1.252	1.811	1.048	1.478
		(0.797)	(1.016)	(0.393)**	(0.495)**	(0.479)*	(0.605)*
lnA^{host}	Host country's TFP	3.428	3.694	0.752	0.835	2.055	2.165
		(1.061)**	(1.078)**	(0.525)	(0.533)	(0.628)**	(0.636)**
lnY^{host}	Host country's GDP	1.668	1.697	0.676	0.692	1.163	1.184
		(0.285)**	(0.289)**	(0.139)**	(0.139)**	(0.168)**	(0.168)**
ln*DIS*	Distance to the host country	-1.505	-1.336	-0.044	0.022	-0.509	-0.393
		(0.612)*	(0.619)*	(0.324)	(0.328)	(0.376)	(0.381)
Number of observations		1992	1992	1992	1992	1992	1992
Log likelihood		-1583.34		-1748.54		-2854.16	

Note: Standard errors are in parentheses. ** and * denote statistical significance at the 1 and 5 percent levels, respectively. In all specifications, year and industry dummies are included, but the results are not reported. AGLS denotes the Amemiya Generalized Least Squares estimation. Innovative R&D is defined as basic or applied research, whereas adaptive R&D is defined as development, design, or unclassified R&D.

Appendix Table A5: Determinants of Overseas R&D Intensity in R&D-intensive Industries

		(1)	(2)	(3)	(4)
	Dependent variable	$R\&D_I$ Innovative R&D intensity		$R\&D_A$ Adaptive R&D intensity	
Independent variable	Description	Tobit	AGLS	Tobit	AGLS
$\ln A$	Subsidiary's TFP	-1.513	-2.688	-0.165	-0.563
		(0.519)**	(0.968)**	(0.244)	(0.451)
$\ln A^P$	Parent firm's TFP	-0.049	-0.377	1.171	1.954
		(0.975)	(1.250)	(0.444)**	(0.562)**
$\ln A^{host}$	Host country's TFP	3.740	3.984	0.750	0.833
		(1.298)**	(1.318)**	(0.590)	(0.601)
$\ln Y^{host}$	Host country's GDP	1.971	1.978	0.768	0.797
		(0.356)**	(0.359)**	(0.158)**	(0.159)**
$\ln DIS$	Distance to the host country	-1.850	-1.570	-0.048	0.023
		(0.752)*	(0.766)*	(0.370)	(0.375)
Number of observations		1654	1654	1654	1654
Log likelihood		-1280.67		-1544.64	

Note: The subsample for R&D-intensive manufacturing industries is used for regression. Standard errors are in parentheses. ** and * denote statistical significance at the 1 and 5 percent levels, respectively. In all specifications, year and industry dummies are included, but the results are not reported. AGLS denotes the Amemiya Generalized Least Squares estimation. Innovative R&D is defined as basic or applied research, whereas adaptive R&D is defined as development, design, or unclassified R&D.

Appendix Table A6: Determinants of Overseas R&D Intensity
Using an Alternative Definition of Innovative and Adaptive R&D (1)

		(1)	(2)	(3)	(4)
	Dependent variable	$R\&D_I$ Innovative R&D intensity		$R\&D_A$ Adaptive R&D intensity	
Independent variable	Description	Tobit	AGLS	Tobit	AGLS
ln$A$	Subsidiary's TFP	-0.885	-1.758	-0.293	-0.654
		(0.371)*	(0.676)**	(0.202)	(0.368)
lnA^P	Parent firm's TFP	1.166	1.563	0.875	1.353
		(0.712)	(0.908)	(0.383)*	(0.480)**
lnA^{host}	Host country's TFP	3.295	3.534	0.449	0.522
		(0.955)**	(0.969)**	(0.503)	(0.510)
lnY^{host}	Host country's GDP	1.659	1.690	0.540	0.553
		(0.257)**	(0.259)**	(0.134)**	(0.134)**
lnDIS	Distance to the host country	-1.219	-1.080	-0.060	0.002
		(0.555)*	(0.562)	(0.312)	(0.315)
Number of observations		1992	1992	1992	1992
Log likelihood		-1804.34		-1553.15	

Note: Standard errors are in parentheses. ** and * denote statistical significance at the 1 and 5 percent levels, respectively. In all specifications, year and industry dummies are included, but the results are not reported. AGLS denotes the Amemiya Generalized Least Squares estimation. Innovative R&D is defined as basic/applied research or development for the world market, whereas adaptive R&D is defined as development for the domestic market, design, or unclassified R&D.

Appendix Table A7: Determinants of Overseas R&D Intensity
Using an Alternative Definition of Innovative and Adaptive R&D (2)

		(1)	(2)	(3)	(4)
	Dependent variable	$R\&D_I$ Innovative R&D intensity		$R\&D_A$ Adaptive R&D intensity	
Independent variable	Description	Tobit	AGLS	Tobit	AGLS
$\ln A$	Subsidiary's TFP	-1.083	-2.047	-0.624	-0.999
		(0.410)**	(0.749)**	(0.294)*	(0.536)
$\ln A^P$	Parent firm's TFP	0.490	0.639	1.794	2.817
		(0.797)	(1.016)	(0.548)**	(0.687)**
$\ln A^{host}$	Host country's TFP	3.428	3.694	0.534	0.572
		(1.061)**	(1.078)**	(0.725)	(0.731)
$\ln Y^{host}$	Host country's GDP	1.668	1.697	0.894	0.940
		(0.285)**	(0.289)**	(0.193)**	(0.195)**
$\ln DIS$	Distance to the host country	-1.505	-1.336	0.256	0.305
		(0.612)*	(0.619)*	(0.460)	(0.465)
Number of observations		1992	1992	1992	1992
Log likelihood		-1583.34		-1273.17	

Note: Standard errors are in parentheses. ** and * denote statistical significance at the 1 and 5 percent levels, respectively. In all specifications, year and industry dummies are included, but the results are not reported. AGLS denotes the Amemiya Generalized Least Squares estimation. Innovative R&D is defined as basic/applied research, whereas adaptive R&D is defined as development or design (excluding unclassified R&D).