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Abstract

We examine the impact of the strength of host countries' university research and university-industry collaboration on the propensity of Japanese multinational firms to conduct research and development (R&D) activities in these countries. We consider heterogeneous effects based on the type of R&D activity: basic research, applied research, and development for local markets and for global markets. Drawing on official survey data on R&D facilities of 498 Japanese multinational firms in 24 host countries, we find support for the notion that the strength of university research increases the probability that firms conduct R&D in a host country. Applied research activities are attracted to countries with relatively intensive university-industry collaboration. Moreover, firms from high-tech industries respond significantly more strongly to the presence of university research than those from low-tech industries.

Keywords: Globalization of R&D; Multinational firm; University-Industry linkage; R&D types
JEL classification: F23, I23, O32

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1. Introduction

A large number of studies have provided evidence of an increasing importance of international R&D by multinational firms (UNCTAD, 2005). Empirical studies have suggested that R&D conducted in foreign affiliates is becoming more important vehicles to access local technological expertise abroad and to create new technologies, although it is traditionally focused on adaptation of home-developed technologies to foreign markets (Kuemmerle, 1997). As the importance of technology-sourcing type R&D increases, university research in host countries is receiving more attention as an attractor of foreign R&D since interaction and collaborative research with academia can play a critical role in the creation of new technologies by firms (Alcacer and Chung, 2007; Cantwell and Piscitello, 2005; Hegde and Hicks, 2008).

However, R&D consists of various types of innovative activities such as basic research, applied research, and product development. Existing literature has suggested that the impacts of host country characteristics on the location of foreign R&D by Japanese firms can be different when we distinguish Research activities from Development activities (Shimizutani and Todo, 2008; Iwasa and Odagiri, 2006). However, there is little empirical literature that investigates the effect of university research in host countries on foreign location decisions of Research and Development activities separately.

In this chapter we seek to understand to what extent university research of host countries affects the propensity of multinational firms to conduct Research and Development activities in those countries, focusing on the strength of university research and the intensity of University-Industry collaborations. We identify which type of R&D activities the firms conduct in each host country, using the dataset of 498 Japanese multinational firms in 24 host countries in 1996, which allows us to distinguish the locations of four different types of foreign R&D: basic research, applied research, development for global markets, and development for local markets. We also measure the strengths of university research and the intensity of University-Industry collaborations of host countries using the information on scientific outputs derived from ISI publication database. In the analysis we explore the impact of these host country characteristics, controlling for a broad set of other host country and firm characteristics that have been found to affect international R&D in prior research. In addition, we examine to what extent firms respond differently to countries' university research strengths and the university-industry collaboration intensity depending on the types of the industries which the sample firms belong to.

The remainder of this chapter is organized as follows. The next section provides a brief overview of prior research. Section 3 describes the characteristics of the dataset. The empirical model and variables are described in section 4. Section 5 presents the empirical results and robust checks. Finally we conclude in section 6.

2. Literature review

The extensive literature has shown that locating close to academic research and conducting formal collaborative research with academia increase the innovative performance of firms (e.g. Jaffe, 1989; Acs et al, 1991 and 1994; Gambardella, 1992; Mansfield, 1995; Cockburn and Henderson, 1998; Cohen et al, 2002; Zucker et al, 2002; Belderbos et al, 2004; Fleming and Sorenson, 2004; Link et al, 2007; Leten al, 2007; Cassiman et al, 2008). The pioneering work by Jaffe (1989) showed research expenditures of local universities have a positive impact on the number of corporate patents in the area. Zucker et al (2002) emphasized the role of high-level academic research showing that firms' collaborations with university star scientists in their fields of expertise can improve their R&D productivity.

Accordingly, the countries or regions with excellent academic research can attract firms which intend to conduct R&D. Access to the top level academic research is a factor which affect firms' decision makings on the R&D location. Abramovsky et al. (2007) found that the presence of excellent university research departments in UK regions attracted industrial R&D activities to these regions. Bania et al. (1992) showed that industry R&D laboratories in the US are likely to locate in metropolitan areas with university research as well as state supported science and technology programs.

By locating the R&D close to universities, firms can benefit from them in two important ways (Hall et al, 2003). First, they educate and supply firms with a skilled labor force of scientists and engineers. Second, academic research they perform directly provides useful information and knowledge for firms' innovation. Academic research generates basic scientific knowledge on which firms can draw upon in their applied R&D activities (Klevorick et al, 1995; Mansfield, 1995 and 1998). Academic research enables firms to develop a deeper understanding of the technological landscape (Rosenberg, 1990; Fleming and Sorenson, 2004), to anticipate results of research experiments to avoid costly and time consuming research trials (Fleming and Sorenson, 2004; Fabrizio, 2009), and to evaluate the outcomes of their applied research and to perceive its (economical) implications (Rosenberg, 1990).

In addition to the strength of research, the intensive linkage between academic world and industry is getting more important as a promoting factor of industrial application of knowledge acquired from academic research. Survey research shows that firms to seek foreign R&D consider not only expertise of university faculty but also collaboration with university to be important factors (Thursby and Thursby, 2006). Previous studies demonstrated that strong linkages between universities and firms facilitate firms' technology sourcing from universities (Markiewicz, 2004). Other studies showed that collaborations with universities increases research performance and productivity of firms' R&D activities (Cockburn and Henderson, 1998; Darby and Zucker, 2001).

The intensity of the linkages between universities and firms in a country is to some extent dependent on national institutions on the economic, legal, political, and social activities. Government initiatives such as change of legislation on the university-industry relationship and establishment of organizations and funds encouraging the collaborations can promote strong linkages between universities and firms. For example, Bayh-Dole Act in United States, which allowed US firms to patent and license federally funded research, has radically increased patenting activity of US universities and industry funding for academic research (Mowery and Sampat, 2006). Affected by the institutional environment, the level of university-industry linkages vary across countries (Nelson, 1993).

Research activities through collaborations between universities and firms have somewhat different features from those of the research conducted only by universities. First, the collaborative research tends to aim at applied research rather than basic research. Firm sides have substantial influence on the choice of research topic. The research outputs from the collaborations are intended to be embodied as commercial products to make a profit. Accordingly, outstanding applied research achievement often stems from face-to-face knowledge interchange between academic and industrial researchers involved in the collaborative projects (Balconi and Laboranti, 2006). Hicks and Hamilton (1999) showed the share of applied research in the collaborations between university and industry is much higher than that of the single university research. With the investigation of Canadian publications, Godin and Gingras (2000) similarly demonstrated that university research conducted in collaborations with industry is more applied in all the scientific disciplines. Florida and Cohen (1999) pointed out that the more university faculty involved in industry, the more applied research conducted. Hence, university-industry collaborations are expected to more strongly affect applied research and development conducted by firms rather than basic research.

Second, research outputs from collaboration can be more valuable in terms of usefulness. for example, according to the investigation of Top 1000 most cited academic papers, the co-authored publications by researchers at universities and firms are found to receive greater number of forward citations (Hick and Hamilton, 1999). If we consider more cited patents to be more important inventions (Harhoff et al., 1999), collaborative research would lead to higher quality research outputs.

However, the benefits of academic research are likely to differ across firms since firms possess different capacities to recognize, absorb and utilize academic scientific knowledge (Cohen and Levinthal, 1990; Gambardella, 1992; Liebeskind et al, 1996; Cockburn and Henderson, 1998; Cockburn, 1999; Fabrizio, 2009). Firms cannot exploit scientific research outputs of external organizations for firms’ own research activities without paying any cost. As Cohen and Levinthal (1990) have noted, learning is a cumulative, incremental process which is influenced by capabilities that are already present at the individual and organizational level. The ability of organizations to learn from external research findings depends on the commonality between the organizations’ internal knowledge base and the external research findings which firms intend to exploit in their technology activities (Teece et al, 1997). Hence, firms that want to take advantage of research conducted outside their organizations need to invest in an ‘absorptive capacity’ in the sense of accumulating knowledge and skills to understand and utilize externally generated knowledge (Cohen and Levinthal, 1990; Cassiman and Veugelers, 2006). The creation of an absorptive capacity for external scientific knowledge involves recruiting scientists, granting them resources and providing the right organizational structures for the scientists to identify and absorb external scientific knowledge (Rosenberg, 1990; Pavitt, 1991). Firms which acquired high absorptive capacities through these efforts are expected to benefit more from academic research, and are more likely to attach greater value to host countries' academic research in their global R&D location choices.

Possibly reflecting the role of the absorptive capacity, previous studies showed R&D investment behavior differs across firms depending on firm size (Acs et al., 1994), types of industries firms belong to (e.g. high-tech versus low-tech industries) (von Tunzelmann and Acha, 2006), science orientation of firms technologies (Belderbos et al., 2008), and R&D intensity of firms (Alcacer and Chung, 2006). For example, it is extremely important for firms to keep up with cutting-edge research in high-tech industries. Firms in high-tech sector exploit scientific knowledge originated from public research more frequently (Cohen et al., 2003). Firms are constantly exposed to both highly technological opportunities and risks of technological turbulence, and required to build up a scientific knowledge base to cope with them in high-tech industries (von Tunzelmann and Acha, 2006).[1] Since universities are main suppliers of such scientific knowledge, it is natural for firms in high-tech sectors to create absorptive capacity for utilizing external scientific knowledge and intend to secure access to the university research, although not all firms in high-tech sectors have high absorptive capacities. On the other hand, firms in the low-tech industries may not have necessity to access to high-technologies. Accordingly, they tend to have much weaker connections to the external sources of technologies than in high-tech sectors (von Tunzelmann and Acha, 2006). This may result in the lack of accumulation of knowledge and resources for the utilization of academic research.

Despite the substantial evidence of the important influence of university research and collaborations between academia and industry on industrial innovations, sufficient investigation has not been made into the role of those factors as an attractor of foreign R&D in the context of international R&D location decision. There is some evidence that this role is important, as the strength of local universities, and opportunities to collaborate with academia, rank high as factors determining the attractiveness of future foreign R&D locations in surveys of multinational firms (Thursby and Thursby, 2006). In addition, Florida (1997) reported that more than two-thirds of foreign-affiliated R&D laboratories in the US were collaborating with US universities. Only a handful of empirical studies have examined the relationship between public research and foreign R&D, but have done so at an aggregate level (country/region) or in a single country setting. Cantwell and Piscitello (2005) found a positive relationship between public R&D employment and the aggregate R&D activities of foreign controlled firms across European regions. Hegde and Hicks (2008) found a positive correlation between industry aggregates of US foreign R&D and science and engineering publications of host countries. Alcacer and Chung (2007) found a positive influence of the presence of local university research on foreign firms' propensity to invest into US regions, although their analysis was concerned with manufacturing investments rather than R&D activities. Although there are indications that academic research matters for R&D location choices of multinational firms, the relative importance of this factor in attracting foreign R&D, as compared to the wide range of other host country factors, has not been uncovered in prior work.

[1] In general, high-tech sectors are likely to have strong relationship with science, except for a few engineering-oriented sectors such as automotive industry (Schmoch, 1997).

Furthermore, an overlooked aspect of the foreign R&D location studies is the impact of university research and University-Industry linkages on the different types of R&D activities such as basic research, applied research, and development activities. Research is the process to discover new scientific knowledge, while Development is the process to create new products and processes with commercial value. Since the processes and purposes of the both activities are different, it is not obvious if university research affect both activities in the same manner. For example, in automobile industry, effective interactions between product design and university research is not as important as those between product design and manufacture (Pavitt, 2006). On the other hand, knowledge acquired from university research can play an important role in mapping and broadening perspective even for development activities (Fleming and Sorenson, 2004). Therefore, it would be worth examining the impact of university research on Research and Development activities separately.

Nevertheless, little existing literature has addressed this issue. Shimizutani and Todo (2008) showed that location determinants of foreign R&D by Japanese firms vary between different types of R&D activities: foreign affiliates with research-oriented activities are attracted by countries with technologically advanced countries seeking technology sourcing, while those with development-oriented activities tend to be located in the host country with large market. Iwasa and Odagiri (2004) demonstrated that local technological strength of the host economy positively affects inventive activities of firms whose R&D subsidiaries conduct research activities as a main purpose, while this effect is not observed for the firms with R&D subsidiaries to primarily support local manufacturing and sales activities. Sachwald (2008) classified major location determinants for different types of foreign R&D units, arguing that the most important local characteristics are excellent technological and scientific environment for research laboratories, cost performance of R&D for global development centers, and large local markets for local development centers. However, the impact of university research and University-Industry collaboration on foreign research and development activities by multinational firms has not been empirically examined.

This chapter addresses these questions on the impact of the strength of university research and the intensity of University-Industry collaborations in the host country by examining foreign R&D location choices made by 498 Japanese multinational firms in 24 host countries in 1996, distinguishing the type of R&D activities, namely basic research, applied research, development for global markets, and development for local markets. Furthermore, we explore to what extent there is firm heterogeneity in the responsiveness to countries' university research depending on the types of the industries which the sample firms belong to.

3. Data

To investigate the impact of university research on foreign R&D activities by Japanese multinational firms, we use the data of foreign investments by Japanese multinational firms in 1996. The data source is "Survey of Overseas Business Activities" conducted by the Ministry of Economy, Trade and Industry of Japan for the fiscal year 1996 (the year ending March 31, 1997). The database provides us with information on both parent Japanese firms and the economic activities conducted by their foreign affiliates in host countries, including sales, R&D expenditures, and functions of the affiliates. Thus the use of the database allows us to distinguish different types of R&D activities conducted by foreign affiliates, namely basic research, applied research, development for global markets, and development for local markets. Firms are taken as foreign affiliates if at least 10 percent of their shares are owned by Japanese firms or if more than 50 percent of their shares are owned by subsidiaries of Japanese firms (the definition of the subsidiary is also based on the ownership of more than 50 percent of shares by Japanese firms).

From this survey we first selected parent firms active in manufacturing industries and operating at least one manufacturing affiliate abroad. A further selection had to be made because the response rate for the questions on R&D is relatively low. Thus parent firms are dropped from the sample if reliable data were not available on R&D activities of the affiliates. Using this sample of parent firms, we identified whether and if so which type of R&D activities they conducted in the host countries in which they had affiliates in operation.[2] In total this left us with 498 parent firms active in 24 foreign countries, giving 1452 observations at the level of parent firm and host country.[3]

Concerning the dataset, there would be selection biases in the characteristics of the sample firms to some extent due to the sampling procedure. First, the firms to which the questionnaires were sent in the survey process are multinational firms with at least one foreign affiliate. These multinational firms should be relatively large firms compared to domestic firms. This is in line with the fact that the firms which responded the survey are mainly large firms (77 percent) according to a report based on the survey (MITI, 1991). Second, a possible bias is observed between the sample firms used in the analysis and the whole sample in the source database. For example, when the average sales amount of the sample firms is compared with those of all the firms in the database, the former is 254 billion yen while the latter is 181 billion yen. Therefore, the sample firms are likely to be larger firms in terms of sales size than the whole sample of the database. Considering these facts, the sample firms would be mainly composed of relatively large firms and the result of the analysis should be cautiously interpreted as less representative for smaller multinational firms.

The distribution of R&D investments by our sample firms by host country is in Table 1.[4] In 24 host countries, United States (88) receives the largest number of R&D investment from the sample firms, followed by Taiwan (33), United Kingdom (19) and South Korea (17). United States, East Asia, and Western Europe are main receivers of the investments.

When we look at Research and Development separately, the distribution seemingly reflects regional characteristics. Research orientation (ratio of Research to Development) is relatively higher for European countries, while Asian countries show lower values. This tendency would be driven by relatively frequent operations of Development activities collocated with manufacturing facilities in Asian countries.

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[2] Since all the host countries with reported foreign affiliates of the selected parent firms are contained in the dataset, an observations can be for a host country where a parent firm has no R&D affiliate (e.g. a country with only manufacturing or sales affiliates).

[3] The dataset includes host countries where the sample firms have the affiliates with any function (i.e. sales, manufacturing, R&D etc.), but not countries with no affiliate. This is because the present research intends to investigate whether the sample firms conduct types of R&D at the existing foreign affiliates rather than whether they enter new host country for R&D activities.

[4] Although countries with small numbers of investments are classified into "Others" in Table 1, each country is treated separately in the main analysis.

Insert Table 1 about here

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4. Empirical model and variables

Empirical Model

To investigate the operations of the foreign R&D activities by the multinational firms, we use a Logit model to relate the probability of conducting the foreign R&D to a set of explanatory variables. The information of the database allows us to identify the types of R&D conducted in a host country by a firm, while the amounts of R&D expenditures on different types of activities cannot be disentangled since only total R&D expenditures are reported[5]. Therefore, using the discrete choice model, we would focus on the examination of firms' choices on whether or not they conduct specific type of R&D in a foreign country rather than the amounts of the expenses on it[6]. The error terms are clustered at the parent firm level in each model in order to control for correlations in error terms due to unobserved firm characteristics.

Dependent variable

The dependent variables in our analysis are binary variables to indicate if a parent firm conducts (specific types of) R&D activities in a foreign country. We identify the existence of R&D activities in a host country based on the reported functions of the firms' foreign affiliates in the host country. As discussed in the data section, the Survey of Overseas Business Activities includes a question about what type of function the foreign affiliates of the sample firms conduct. Using this information, we identified the affiliates which conduct four types of R&D activities, basic research, applied research, development for global markets, and development for local markets[7]. The binary dependent variables were constructed based on this classification to carry out the analyses with the dependent variables at the three different classification levels. First, we analyze the impacts on R&D activities in general, where the dependent variable, *R&D*, takes the value one if a firm conducts any of the four types of R&D activities in a host country. The second analysis focuses on the differences between Research and Development. The variables, *Research* and *Development*, were made to indicate if a firm conducts in a host country basic/applied research and development for global/local markets, respectively. Finally, to analyze the differences among the four different R&D activities, the variables, *Basic*

[5] For example, although we can know whether a firm conducts both Research and Development or only one of them in a host country, it is not possible to know how much it spends on each of Research and Development when it conduct both Research and Development.
[6] In addition, the analysis using Heckman's two step selection model suggests that the strength of university research and the intensity of University-Industry collaborations in a host country mainly affect firms' decision-makings on conducting the foreign R&D rather than the sizes of the expenditures.
[7] The affiliates have more than one types of functions in many cases.

Research, Applied Research, Development for Global markets, and Development for Local markets, indicate if a firm operates each type of R&D activities in a host country.

Explanatory variables

Strength of University Research and Intensity of University-Industry Collaborations

The strength of university research of a host country and the intensity of collaborations between universities and firms are the main explanatory variables of interest. To measure these host country traits, we calculate the number of university publications and co-authored publications by researchers from universities and firms in the country at the industry level.

We use information on scientific articles authored by university researchers published in peer reviewed journals recorded in the Web of Science (WoS) publication database. Publications are extracted from the Web of Science database of Thomson Scientific and only papers of the document type article, letter, note and review have been selected. We have extracted all Web of Science publications that are published in the year 1994, and which have at least one author's address in the 24 host countries.

To classify the publications into the categories depending on the type of institute to which authors are affiliated (e.g. university, firm), we adopt the following method. We distinguish publications of university research by processing information on authors' affiliations that are listed on publications. We have performed two subsequent steps. First, we used search strings that contain keywords indicating universities. The search string for universities contains keywords such as *university* and *college*, and name variants in other countries. The search string for firms contains keywords that refer to legal forms and names of the 1000 largest R&D spending firms in the world drawing on the European Innovation Scoreboard (2008). Second, we manually checked affiliations that were not classified by the search strings (giving priority to affiliations listed on many publications), until we could classify for each host country at least 95% of the countries' publications in the categories. When a publication has authors from both universities and firms, the publication was classified as a co-authored publication.

The number of university publications and co-authored publications between universities and firms at the industry level is calculated in three steps. First, we calculate for each host country the number of each type of publications at the level of 240 scientific disciplines. Information on the scientific disciplines of publications is obtained by using information on the journal issues in which publications are published and the ISI science classification table that assigns journal issues to one or more scientific disciplines (on average journal issues are assigned to 1.5 disciplines). Second, the number of each type of publications at the level of technology field (IPC 4 digit) is calculated by using publication numbers by scientific fields and the science-technology concordance table developed by Van Looy et al (2004). This concordance table is based on citation frequencies between patents (technology classes) and publications (scientific disciplines). It links scientific disciplines to technology fields via a set of probabilities. Finally the publication counts at the technology field level are converted into those at the ISIC industry classification (22 classes) using technology-industry concordance table by Verspagen (1994).

Using this publication data, we construct two explanatory variables of interest. The first variable, the *strength of university research in a host country*, is measured as the number of publications authored by university researchers in the host country in the science field relevant to a firm's industry scaled by the production level of the industry in the host country. The scaling by industry sizes aims at taking into account the possibility of increased costs in knowledge access due to sharing limited knowledge sources with many competing firms in large industries (Jaffe and Adams, 1996). This also serves to reduce the correlations with host country variables such as technology strength, market size, and IPR protection level. Since the Web of Science only includes journals that are peer reviewed, adhere to standards of editorial policy, and have a threshold impact factor, the publication count of universities can be considered a measure of the output of high quality academic research at the level of host countries and industries. Second, we also construct the variable which represents the intensity of collaborative scientific research between universities and firms in the host country. The *intensity of University-Industry collaboration in a host country* is measure as the share of co-authored publications by researchers from host country universities and firms in the total university publications in the host country at the industry level (expressed in percentage point). The information on co-authored publications has been used as a measure of university-industry collaborations in many previous studies (e.g. Fabrizio, 2009).

The distribution of the shares of co-authored publications by researchers from host country universities and firms by country and industry is presented in Table 2.[8] In total, US and European countries show relatively large shares of co-publications (2 to 4,5 percent). Among the other countries, Korea also demonstrates high share (2.8 percent). When we look at the industry level, the differences between industries are to some extent observed. For example, Korea ranks relatively high in Electronics and Motor Vehicle industries where it has large-scale companies. While the United States is a country with the highest shares of co-publications in most industries, it shows prominently large share in the Aerospace industry in which it has strong competitive advantages.

Insert Table 2 about here

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[8] Although Japan is not included as a host country in the main analysis, the shares of co-authored publications in Japan are shown in the table for the reference purpose.

Other Host Country Characteristics

In addition to the variables related to university research and the collaboration intensity, we also include in our analyses a set of host country characteristics that have been found to be main location determinants of firms' foreign R&D in previous empirical works. We include the host country's *technological strength* in an industry, measured by the number of patent applications originating in the host country in the technology field relevant to a firm's industry. In counting the number of the patent applications, we only consider the patents which were applied for to all of European Patent Office, United States Patent and Trademark Office, and Japan Patent Office (Triadic patents) to avoid possible geographical bias. The technological strength of the host country is expected to have a positive impact on multinational firms' R&D location choices. Countries with large and sophisticated markets should also attract more foreign R&D. *Market size* is measured at the level of the main industry of the focal firm. It is defined as the sum of host country production and imports minus exports in the industry. Data are drawn from the OECD STAN database and UNIDO industrial yearbooks. The *wage costs of R&D personnel* in the country is also expected to affect its attractiveness for inward foreign R&D. Yearly gross income levels of engineers are taken as indicator of these wage costs. Data on 1994 wage levels is taken from the UBS 'Price and Earnings' reports.

The analysis takes into account the host country's level of *IPR protection*, by inclusion of the patent rights index from Park and Wagh (2002). This index is constructed based on five aspects of patent laws such as coverage, duration, and enforcement, ranging between 0 and 5, with high scores for IPR systems that are highly aligned with international standards. The IPR data are available for the years 1995. The IPR protection is expected to encourage firms' foreign R&D investments. The likelihood that a host country attracts foreign R&D will also be related to the geographic distance between the host and home country of the focal firm, as the cost of R&D coordination and doing business abroad rises with distance (e.g. Belderbos et al, 2008; Nobel and Birkinshaw, 1998). To capture the effect, *Geographic distance* is measured in hundred kilometers between the capital city of the host country and Tokyo.

Firm Characteristics

Furthermore, we include various firm characteristics both at the level of parent firms and their foreign activities in the host countries. As the variables for parent firm traits, we include the variable *parent firm size*, represented by the sales amount of the parent firm (thousand dollars). We also include the dummy variable of *parent firm basic research* to consider the research orientation of parent firms. This variable takes 1 if a parent firm conducts basic research. If a parent firm conduct basic research, it would be likely to conduct research-oriented R&D abroad.

We add four variables to take into consideration characteristics of a firm's activities in a host country. We first include *firm's experience in the host country*. This variable is measured by years since the establishment of the firm's first affiliate in the host country. Second, to control for sales size of the foreign affiliates in the host country, we include the variable, *sales of foreign affiliates relative to parent sales*. Third, *share of sales by manufacturing affiliates in the total affiliate sales* is also included to control for difference in manufacturing orientation in foreign economic activities among firms. Fourth, we include *export from host country dummy* which takes 1 if affiliates of a firm in a host country export their products to another country. All the firm variables are constructed based on 1995 data, supplemented with values for 1996 in case of missing values.

Finally, industry dummies are added to capture the industry effects based on 22 ISIC classes. All the continuous variables except for share and ratio variables are log-transformed before the regression analysis. Summary statistics and correlations for the variables in the analysis are provided in Table 3 and 4. Most of the correlations between independent variables are moderately low. However, the collaboration intensity shows high correlations with the variables of host country characteristics such as market size, R&D personnel cost, and IPR protection level.[9]

Insert Table 3 and 4 about here

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5. Empirical Results

The results of the Logit analysis relating the probability of firms to conduct R&D activities in a host country to host country and firm characteristics are presented in Table 5. The dependent variable of the first three columns is location choice of R&D activities including both Research and Development activities. Model 1 only includes control variables. The variable of university research strength in a host country is added in Model 2. This variable shows a positive and significant impact. In Model 3, the intensity of University-Industry collaborations is additionally included. The collaboration variable does not show significant effect in this setting, while the university research variable remains significantly positive. Most of the control variables show significant impacts with expected signs. For example, demand and IPR protection level in the host country, firms' experience in the host after establishing the first subsidiary, research orientation of parent firms, and export from the host country have positive impacts, while cost of R&D personnel in the country and distance from Japan negatively affect the location decision of foreign R&D activities by Japanese multinational firms. McFadden pseudo R-squared values for the models range between 26 and 29 percent.

[9] The high positive correlation between collaboration and IPR protection would imply that establishment of strong IPR protection system can enhance the collaborative research between universities and firms in a country.

Insert Table 5 about here

Model 4-6 show the analysis of the location of Research activities, while the location of Development activities is analyzed in Model 7-9. The location decisions of conducting basic and applied research are taken as a dependent variable in the analysis of Research, while those of global and local development are used for Development. The effect of university research strengths is positive and significant for both types of R&D. The marginal effect of the variable evaluated at the mean regressor value is 0.07 for Research, while it is 0.14 for Development. However, statistical tests could not reject the null hypothesis of equality of the two coefficients at the 10 percent significance level. On the other hand, the university-industry collaboration level has a significant impact only on Research. The marginal effect of the intensity of the collaborations is 0.009, suggesting that one percent (the collaboration variable is expressed in percentage point) increase in co-publication share in a host country leads to 0.9 percent point increase in the probability of firms to conduct R&D activities in the host country.

While many control variables are working in the same manner for both Research and Development, some differences are recognized. For example, demand level in the host country is seemingly more important for Development in terms of both magnitude of impact and significance level. This is especially remarkable in the models with both university research and collaboration variables included (Model 6 and 9). This would reflect the importance of local markets for development activities as we see in the next table. Another difference can be noticed in the variable of distance from the home country. Apparently it is working only for Development activities. This is consistent with a reported fact that many development activities are collocated with manufacturing facilities, which Japanese firms are likely to locate mainly in east and south-east Asia.

Further investigation is carried out in Table 6. R&D investment is classified into four fine-grained types: basic research, applied research, global development, and local development. The coefficient of university research variable has positive and significant impacts on all types of R&D activities. University-industry collaboration variable has significant effect only on applied research. This may suggest less basic nature of collaborative research between universities and firms, affecting only applied research, in line with the existing literature. Demand has a significant impact only on local development. This indicates the importance of market sizes of host countries where firms locate development activities targeting the local consumers.

Insert Table 6 and 7 about here

To examine how university research affects different types of firms, analysis is conducted in Table 7 with the sample split into two groups of firms from high-tech and low-tech sectors[10]. High-tech and low-tech sectors are classified according to the average R&D intensity of sectors drawing on Hatzichronoglow (1997). The results show, both for research and development activities, the variable of university research strength in the host country is highly significant for the sub-sample of firms from high-tech sectors, while it has no significant effect for the firms from low-tech sectors. This outcome is in line with the notion that firms from industries requiring different level of technological capabilities have heterogeneous responsiveness to the strength of university research in a host country.

Selection process

We explored the robustness of the empirical results with regard to three additional issues. First, we examined whether the strength of university research and the intensity of University-Industry collaborations affect firms' decisions on conducting foreign R&D in a host country (selection process) or those on the amounts of the R&D expenditures in the country (outcome process). For this purpose, we carried out Heckman's selection model with two step estimation (Heckman, 1976). This method allows us to learn whether there exists sample selection bias in the estimation of the second-stage outcome process due to the first-stage selection process and to estimate the parameters in the second stage with the selection bias corrected. The result of the Heckman's selection model is presented in Table 8.[11] The first three columns show the results of the estimations without exclusion restrictions, while the restriction is considered in the last three columns with three independent variables excluded, which are assumed to be effective only in the selection process[12]. Since the coefficients of the inverse Mills ratios are not significantly different from zero in all the models, the null hypothesis of uncorrelated error terms in the estimations in both stages is not rejected, suggesting that there is no sample selection problem. However, the variable of university research strength shows positive and significant effects only in the selection process, although the collaboration variable is working in both processes. This seemingly suggests that university research in a host country mainly affect the location choices of firms' foreign R&D rather than the decisions on the sizes of the investments. This result would support the approach in the present research which focuses on firms' decisions on whether or not they conduct R&D in a host country using the discrete choice model.

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[10] Parent firms' research orientation, measured by parent firms' engagement in basic research, could be used as another criterion for the sample split. However, we did not adopt this criterion because it lead to unequal sample split due to the fact that more than 80 percent of the parent firms conduct basic research.

[11] As discussed in the previous section, it is not possible to distinguish the amount of the firm's expenses for Research from those for Development in a host country. Thus we assume the whole R&D expenditures by a firm in the host country to be research expenditures if the firm conducts basic or applied research in the country, while R&D expenditures are considered as development expenditures if the firm has no research activities (e.g. Shimizutani and Todo, 2008).

[12] It is not straight-forward to decide which factor is effective only in the selection process. Therefore, specifications with only one or two of the three variables excluded were examined as well. The results for those specifications are not qualitatively different from the results shown in the Table 8.

Insert Table 8 about here

University research and supply of R&D personnel

We also examine the possibility that foreign R&D operations by multinational firms are promoted by the supply of well-educated R&D personnel graduated from universities with high-level research in the host country. Existing literature pointed out that one of the largest contributions of universities to local industrial innovations is the provision of graduates who are trained by prominent researchers and have knowledge on how to conduct research (e.g. Pavitt, 2006; Balconi and Laboranti, 2006). Since countries with excellent university research can also supply a great deal of R&D personnel as university graduates, multinational firms would conduct their foreign R&D in those countries aiming at recruiting high quality employees for R&D. Our results shown in the previous paragraphs might pick up this effect rather than the immediate relationship between university publications and industrial innovations.

We explored this suspicion by considering the supply of R&D personnel in each host country. We extracted from UNESCO-OECD-Eurostat database the number of tertiary education graduates in the science and engineering fields in a host country[13]. With the information, we constructed a variable, *supply of science and engineering graduates relative to industry size*, measured as the number of graduates from tertiary education institutes in science and engineering fields in the host country scaled by the production level of the industry in the host country. The variable is scaled by industry sizes to make it comparable to the university publication variable. Although the host country graduate counts are not at the industry level, they are divided by industry size to consider the relatively costly recruiting activities for university graduates in the industries with many competitors. High correlation between university publication counts and graduate counts (0.45) is reduced after the scaling of both variables (0.13). The results of the regressions with the graduate variable added are presented in Table 9. The impact of university research strengths remains positive and significant, while the intensity of collaborations does not show significant effect. On the other hand, the graduates supply variable shows no significant impact in any model. This result seems to suggest the dominating effect of direct influence of university research on industrial R&D through the University-Industry linkages in the research process.

[13] The information on the graduate counts is not available for China, India, Singapore, Thailand, and Taiwan. Thus the observations for these host countries are dropped in the analysis.

Insert Table 9 about here

At the same time, however, we have a concern that this result might not be really robust. When we include simple count of science and engineering graduates from tertiary education institutes (without scaling by industry production level) as a variable, the significant effect of university research disappears and the graduate variable shows a positive and significant impact. This change is shown in the last three columns in Table 9. In the specification with graduate counts, university publications scaled by graduates counts, and coauthored publications between universities and firms scaled by graduates[14], only the variables of graduate counts shows a significant impact. We additionally assessed the specification with university publication counts and graduate counts together regardless of the high correlation between them. The results also showed that only the graduate count variable has a positive and significant effect. Considering these mixed results, it is not straightforward to know which of the research strength and the supply of R&D personnel attracts foreign R&D.

Research by Public Research Organizations

Finally, we examined the effect of another source of scientific knowledge by capturing research outputs by Public Research Organizations (PROs). PROs are mostly financed by the government and consequently their organizational missions and research targets tend to be determined by the initiative of the government. Therefore, the economic incentives and the processes to allocate resources are quite different from those of universities (Foray and Lissoni, 2010). Thus, the publications by PROs could be regarded as a source of scientific knowledge which is qualitatively different from university research. In addition, research by PROs accounts for considerable shares of national research activities in some countries (e.g. France, South Korea), although their importance compared to universities are declining recently. Ignoring their research output might cause certain bias in the analysis if foreign firms also consider non-university research as valuable sources of scientific knowledge. For this reason, we also take into consideration the impact of PRO research in host countries.

To see the effect of PRO research, we calculated the number of publications authored by researchers affiliated at PROs in each host country. In this calculation, we followed the same procedure as we did for the university publication counts, but with different search string keywords. With this PRO publication counts, we

[14] For the variables of university publication counts and coauthored publication counts, the number of publications per graduate is used to avoid high correlations with the variable of graduate counts.

created a new variable, *PRO research intensity*, measured as ratio of PRO publication counts to total university publication counts in a host country at the industry level (expressed in percentage point).

The results of the analysis with this new variable are reported in Table 10. We additionally included the variable of PRO research intensity in the model. The PRO variable has a positive and significant impact only on research activities, while the magnitude of impact is smaller and the significance level is lower than those of the comparable variable, the collaboration intensity. This result indicates that research conducted by PROs in a host country also can be one of the factors which positively affect the decisions of firms on conducting research activities in the country.

Insert Table 10 about here

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6. Conclusions

In this chapter, we examined the impact of the university research strengths of host countries on the propensity of multinational firms to conduct R&D in these countries. We also investigated to what extent the intensity of university-industry collaborations in a host country can affect the R&D location decisions of the multinational firms. Furthermore, we explored heterogeneous behavior of firms which belong to different types of industries, namely high-tech and low-tech industries. For this purpose, we examined the propensity to conduct foreign R&D of 498 Japanese multinational firms in 24 host countries, drawing on the dataset of foreign investment by Japanese firms in 1996 which allows the distinction between different types of R&D activities. The strengths of university research and the intensity of research collaborations between universities and firms in host counties are measured using the number of ISI publications in a technology field related to the focal firm's industry.

The empirical result gives support for the notion that the probability to conduct foreign Research and Development activities is positively affected by the strengths of university research in the host countries, after controlling for a set of host country and firm characteristics. On the other hand, significant difference in the impact of the university research strengths between research and development is not observed, suggesting university research is equally important to both activities. The result also confirmed the positive impact of the intensity of collaborative research between universities and firms on the location decisions of foreign Research activities, but not on those of Development activities. Furthermore, the intensity of the collaborations is especially a strong attractor of foreign investments in the fields of applied research, as we expect from the applied nature of the collaborative research. We also found further differences in effective location factors between Research and Development. For example, large market size of a host country can be a strong location determinant for foreign Development activities rather than for Research activities. This effect is driven by the operations of development activities for the local markets as expected. Moreover, the analysis revealed the evidence of firm heterogeneity in appreciating the importance of university research for international location decisions of both Research and Development activities. Firms from high-tech industries respond significantly more strongly to host country's strength of university research than firms from low-tech industries.

These findings lead to the following policy implications. First, improving university research will increase the attractiveness of a host county as a location of R&D activities by foreign firms. Thus, when policy makers employ investment measures to attract R&D investments from abroad, it would be beneficial not only to improve the industrial environment but also to strengthen the university research and intensify the university-industry linkages. Second, it is also important for policy makers to consider what type of R&D activity they intend to attract from abroad. Our results suggest that a country with large markets would relatively easily receive R&D investments for adaptation of products to the domestic markets, while applied research tends to be located in a country with intensive research collaborations between universities and firms. Therefore, they are required to take into account both of the characteristics of their own country and the type of target R&D to effectively invite R&D investments by foreign firms.

The study is still subject to a number of limitations. First, the current analysis is based on the information on foreign R&D in fiscal year 1996 and can be regarded as somewhat outdated. Since questions related to types of R&D activities conducted in host countries are not included in the latest versions of the survey (after fiscal year 2001), it is difficult to obtain the information in recent years. Moreover, the data on scientific publications in host countries is currently available to us only for 1990s. In the future research, however, we would update the dataset to a certain extent by supplementing the information from the latest available data. This update also allows us to conduct the analysis with potentially more robust methodologies such as panel data analysis. Second, the mechanism through which host country university research promotes the location of R&D investments by foreign firms is not sufficiently clear. The effect of the university research strengths on the foreign R&D location decisions sometimes disappears when we include the supply of R&D personnel in the analysis. Therefore, further investigation would be required in this respect in the future research.

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Table 1: Distribution of Foreign R&D Operations by Japanese Multinational Firms by Host Country and Type of R&D

Country	Obs.	R&D	Res.	Dev.	Res./Dev.	Basic Research	Applied Research	Dev. for Global Mkt	Dev. for Local Mkt
China	94	14	8	14	0.57	6	8	6	14
France	56	9	6	9	0.67	4	6	7	9
Germany	141	11	7	10	0.70	5	6	5	10
South Korea	61	17	12	17	0.71	12	11	12	17
Taiwan	134	33	21	32	0.66	17	21	17	32
United Kingdom	118	19	11	19	0.58	8	11	15	19
United States	289	88	64	87	0.74	51	63	64	85
Others	559	31	21	31	0.68	12	21	22	30
Total	1,452	222	150	219	0.68	115	147	148	216

Notes: Others include Australia, Belgium, Brazil, Canada, Spain, Hong Kong, Hungary, Ireland, India, Italy, Mexico, Malaysia, the Netherlands, Philippines, Sweden, Singapore, and Thailand.

Table 2: Shares of Co-authored Publications between Universities and Firms in Total University Publications by Country and Industry

		Industry																					
Country	**Total**	Elec Mach	Electronics	Chem	Pharm	Oil Ref	Ship Build	Motor Vehic	Aerospace	Transport	Steel	Non Ferr Metals	Metal Prod	Instruments	Computer	Machinery	Food	Textile	Rubber Plast	Stone Glass	Paper Print	Wood	Other Prod
Australia	**0.9%**	0.5%	0.8%	1.1%	1.1%	3.4%	0.1%	0.2%	0.2%	0.6%	1.8%	1.6%	0.7%	0.9%	0.7%	1.0%	1.1%	1.0%	0.8%	1.4%	0.9%	1.0%	0.7%
Belgium	**1.7%**	0.9%	0.9%	1.8%	2.1%	2.4%	0.1%	2.8%	0.6%	4.9%	1.0%	0.8%	1.0%	1.7%	1.1%	1.6%	2.0%	1.8%	2.2%	1.5%	1.3%	1.8%	1.5%
Brazil	**0.4%**	0.4%	0.7%	0.5%	0.2%	2.7%	0.2%	0.8%	0.1%	1.2%	0.9%	0.8%	0.6%	0.3%	1.2%	0.6%	0.2%	0.8%	0.4%	3.1%	0.9%	0.7%	0.5%
Canada	**1.9%**	3.8%	3.7%	1.8%	1.3%	4.1%	2.3%	0.9%	2.2%	2.1%	4.8%	4.5%	3.4%	1.6%	1.7%	2.3%	1.5%	2.9%	1.3%	3.2%	4.5%	2.1%	1.8%
China	**0.4%**	0.8%	0.7%	0.2%	0.1%	0.2%	0.0%	0.3%	0.1%	0.1%	0.2%	0.4%	0.7%	0.5%	0.4%	0.4%	0.1%	0.2%	0.1%	0.6%	0.6%	0.1%	0.4%
France	**4.1%**	4.5%	4.3%	4.4%	4.4%	6.4%	0.7%	1.5%	2.5%	2.0%	3.6%	3.8%	4.3%	3.7%	2.5%	4.3%	5.2%	3.9%	3.6%	4.3%	4.8%	4.4%	4.5%
Germany	**2.9%**	3.9%	3.8%	2.9%	2.5%	5.3%	3.7%	1.8%	2.4%	3.1%	6.1%	5.0%	3.6%	2.8%	2.7%	3.2%	2.7%	3.6%	2.3%	4.3%	3.9%	2.4%	3.1%
Hong Kong	**0.5%**	0.5%	0.9%	0.4%	0.1%	1.3%	0.2%	0.1%	0.6%	0.5%	0.4%	0.2%	0.4%	0.4%	1.2%	0.7%	0.2%	0.1%	0.1%	2.9%	1.1%	0.1%	0.5%
Hungary	**3.2%**	3.0%	2.9%	3.2%	4.1%	2.7%	0.2%	1.5%	3.5%	1.6%	3.0%	2.3%	3.4%	3.2%	0.8%	3.1%	2.7%	2.9%	2.9%	2.0%	5.4%	3.7%	2.3%
India	**0.8%**	0.7%	0.7%	1.1%	0.6%	1.4%	0.2%	0.6%	0.5%	0.8%	2.9%	2.2%	1.0%	0.6%	0.7%	0.8%	0.3%	1.9%	0.7%	1.1%	0.9%	0.6%	1.1%
Ireland	**0.6%**	0.4%	0.9%	0.8%	0.6%	0.3%	0.1%	0.1%	0.1%	0.2%	0.9%	0.5%	0.4%	0.4%	1.3%	0.5%	0.5%	1.8%	0.5%	0.5%	0.4%	0.5%	0.9%
Italy	**2.1%**	2.1%	2.4%	2.2%	2.3%	3.3%	0.5%	1.9%	2.3%	2.2%	2.7%	2.4%	2.1%	2.0%	1.5%	2.1%	2.0%	2.0%	2.2%	2.1%	2.1%	2.2%	2.1%
Korea	**2.8%**	4.0%	3.9%	3.3%	1.9%	3.4%	0.4%	4.5%	2.7%	3.9%	4.9%	4.3%	4.0%	2.2%	2.4%	3.1%	1.6%	4.6%	2.4%	5.1%	2.8%	1.9%	3.5%
Malaysia	**1.1%**	0.2%	0.2%	0.9%	1.1%	0.3%	0.0%	0.2%	0.0%	0.1%	0.1%	0.1%	0.5%	1.0%	3.0%	1.1%	1.6%	0.1%	0.8%	0.1%	0.2%	0.7%	1.1%
Mexico	**0.3%**	0.2%	0.1%	0.4%	0.2%	0.6%	0.1%	1.6%	0.6%	2.1%	0.2%	0.2%	0.3%	0.2%	0.1%	0.5%	0.1%	0.9%	0.7%	0.4%	0.2%	0.2%	0.3%
Netherlands	**2.5%**	4.9%	4.2%	2.6%	2.0%	6.3%	0.2%	1.7%	3.1%	1.8%	9.6%	7.4%	4.1%	2.2%	2.0%	2.8%	1.9%	5.2%	1.8%	4.9%	3.4%	1.7%	2.9%
Philippines	**0.0%**	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Singapore	**1.4%**	2.5%	2.5%	0.6%	1.0%	0.3%	0.0%	0.4%	0.3%	0.3%	0.8%	1.3%	1.6%	1.3%	1.7%	1.1%	1.0%	0.5%	0.5%	1.0%	1.1%	0.5%	1.2%
Spain	**0.7%**	0.6%	0.6%	0.8%	0.9%	0.5%	0.1%	0.5%	0.4%	0.8%	0.9%	0.7%	0.7%	0.7%	0.4%	0.7%	0.7%	1.3%	0.9%	1.6%	0.7%	0.8%	0.6%
Sweden	**3.5%**	3.2%	3.1%	3.7%	3.9%	4.1%	1.2%	3.1%	2.0%	4.2%	4.8%	3.5%	3.1%	3.6%	2.0%	3.4%	3.4%	3.2%	3.9%	4.1%	3.8%	3.5%	3.1%
Taiwan	**1.0%**	1.6%	1.7%	1.2%	0.5%	1.7%	0.1%	0.5%	0.3%	0.7%	1.6%	1.3%	1.3%	0.8%	1.1%	1.1%	0.4%	1.9%	0.5%	1.2%	1.6%	0.4%	1.1%
Thailand	**0.2%**	0.0%	0.0%	0.2%	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.2%	0.0%	0.1%	0.1%	0.1%	0.3%	0.0%	0.0%	0.3%	0.1%
United Kingdom	**3.0%**	3.4%	3.4%	3.5%	3.6%	4.4%	1.7%	0.9%	1.7%	2.2%	4.5%	4.8%	3.0%	2.7%	1.5%	3.1%	3.1%	4.9%	2.6%	3.7%	3.9%	2.9%	2.9%
United States	**4.5%**	6.8%	6.4%	4.3%	4.4%	6.2%	5.7%	1.9%	6.2%	4.2%	7.3%	7.4%	5.0%	4.1%	3.9%	4.4%	4.1%	6.0%	3.9%	7.5%	5.7%	3.9%	4.0%
Japan	**8.9%**	11.6%	11.2%	8.9%	8.0%	12.4%	9.0%	10.8%	7.6%	10.5%	11.7%	11.6%	10.8%	8.0%	8.0%	9.9%	9.3%	12.3%	7.3%	14.0%	12.2%	7.6%	9.9%
Total	**3.4%**	**4.5%**	**4.4%**	**3.4%**	**3.4%**	**4.8%**	**3.6%**	**1.5%**	**3.9%**	**3.2%**	**5.0%**	**4.8%**	**3.7%**	**3.2%**	**2.8%**	**3.4%**	**3.2%**	**4.4%**	**3.0%**	**4.8%**	**4.2%**	**3.1%**	**3.2%**

Table 3: Descriptive Statistics and Definitions of Variables

Name	Description	Mean	St. Dev.
R&D (Dep. Var.)	Binary variable denoting if a firm conducts any of the four types of R&D activities in a host country	0.15	0.36
Research (Dep. Var.)	Binary variable denoting if a firm conducts Basic Research or Applied Research in a host country	0.10	0.30
Development (Dep. Var.)	Binary variable denoting if a firm conducts Development for Global Markets or Development for Local Markets in a host country	0.15	0.36
Basic Research (Dep. Var.)	Binary variable denoting if a firm conducts Basic Research in a host country	0.08	0.27
Applied Research (Dep. Var.)	Binary variable denoting if a firm conducts Applied Research in a host country	0.10	0.30
Development for Global Markets (Dep. Var.)	Binary variable denoting if a firm conducts Development for Global Markets in a host country	0.10	0.30
Development for Local Markets (Dep. Var.)	Binary variable denoting if a firm conducts Development for Local Markets in a host country	0.15	0.36
University Research Strength	The number of ISI publications of universities located in a host country in a relevant field to the industry scaled by the production level of the industry in the host country	0.09	0.18
University-Industry Collaboration Intensity	The share of co-authored ISI publications by researchers from host country universities and firms in the total university publications in the host country at the industry level (expressed in percentage point)	2.46	1.88
Technological Strength	Logarithm of the number of Triadic patent applications originating in the host country in the technology field relevant to a firm's industry (thousan patents)	0.13	0.29
Market size	Logarithm of (production + imports - exports) in a host country and sector (million US dollars)	10.33	1.28
Wage costs of R&D personnel	Logarithm of yearly gross income levels of engineers from UBS 'Price and Earnings'	10.69	0.90
IPR Protection	Logarithm of the patent rights index (0-5) from Park and Wagh (2002) for the years 1995	1.25	0.31
Geographic Distance	Logarithm of geographic distance between the capital cities of host countries and Tokyo (hundred km)	4.13	0.72
Firm's Experience in the Host Country	Logarithm of years since the establishment of the firm's first affiliate in the host country	2.41	0.78
Parent Firm Size	Logarithm of the sales amount of the parent firm (thousand dollars)	11.58	1.69
Parent Research Orientation Dummy	Dummy taking the value 1 if a parent firm conducts basic research	0.81	0.39
Sales of Foreign Affiliates relative to Parent Sales	Sum of the sales of foreign affiliates in a host country scaled by the parent sales	0.06	0.13
Share of Sales by Manufacturing Affiliates in the Total Affiliate Sales	Share of sales by manufacturing affiliates in the total affiliate sales	0.45	0.48
Export from Host Country Dummy	Dummy taking the value 1 if affiliates of a firm in a host country export their products to another country	0.81	0.39

PRO Research Intensity	Ratio of PRO publication counts to total university publication counts in a host country at the industry level (expressed in percentage point)	29.04	20.14
Supply of Science and Engineering Graduates (Graduates/Industry Size)	The number of graduates from tertiary education institutes in science and engineering fields in the host country scaled by the production level of the industry in the host country	2.58	4.74
University Publications per Graduate	The number of ISI publications of universities located in a host country in a relevant field to the industry scaled by the number of graduates from tertiary education institutes in science and engineering fields in the host country	0.08	0.14
University-Industry Co-publications per Graduate	The number of co-authored ISI publications by researchers from host country universities and firms in the host country at the industry level scaled by the number of graduates from tertiary education institutes in science and engineering fields	0.002	0.005
Graduate Counts	Logarithm of the number of graduates from tertiary education institutes in science and engineering fields in the host country	10.70	1.12

Table 4: Correlation Table

(1452 obs)

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1 R&D (Dep. Var.)																								
2 Research (Dep. Var.)	0.80																							
3 Development (Dep. Var.)	0.99	0.79																						
4 Basic Research (Dep. Var.)	0.69	0.86	0.68																					
5 Applied Research (Dep. Var.)	0.79	0.99	0.78	0.85																				
6 Global Development (Dep. Var.)	0.79	0.80	0.80	0.78	0.79																			
7 Local Development (Dep. Var.)	0.98	0.78	0.99	0.69	0.78	0.79																		
8 Univ. Research Strength	-0.05	-0.03	-0.05	-0.01	-0.03	-0.02	-0.05																	
9 Collaboration Intensity	0.16	0.18	0.16	0.15	0.17	0.17	0.16	0.03																
10 Technological Strength	0.08	0.08	0.08	0.09	0.07	0.07	0.08	0.35	0.40															
11 Market Size	0.15	0.13	0.15	0.13	0.12	0.11	0.15	-0.02	0.58	0.52														
12 Cost of R&D Personnel	0.01	0.02	0.01	0.02	0.02	0.05	0.01	0.14	0.51	0.25	0.19													
13 IPR Protection	0.08	0.09	0.08	0.08	0.08	0.11	0.08	0.19	0.68	0.38	0.40	0.85												
14 Distance from Japan	-0.01	0.01	-0.01	-0.02	0.01	0.02	-0.02	0.25	0.47	0.32	0.33	0.54	0.64											
15 Host Country Experience	0.12	0.13	0.12	0.11	0.13	0.12	0.12	0.12	0.14	0.14	0.04	0.38	0.31	0.21										
16 Parent Firm Size	0.01	-0.03	0.01	-0.02	-0.03	-0.01	0.01	-0.04	-0.02	-0.16	-0.13	0.07	0.05	0.14	0.14									
17 Parent Res. Orient. Dummy	0.12	0.10	0.12	0.10	0.10	0.10	0.12	-0.05	0.06	0.00	-0.01	0.03	0.02	0.04	0.09	0.10								
18 Affiliate Sales Ratio	0.15	0.13	0.15	0.12	0.14	0.15	0.14	0.01	0.09	0.13	0.19	0.11	0.14	0.02	0.13	-0.18	-0.07							
19 Manu. Sales Share	0.29	0.27	0.29	0.23	0.27	0.22	0.30	-0.18	-0.11	-0.10	0.05	-0.33	-0.27	-0.30	-0.04	-0.15	0.05	0.14						
20 Affiliate Export Dummy	0.14	0.13	0.13	0.11	0.13	0.13	0.13	-0.08	-0.03	0.01	-0.01	-0.03	-0.06	-0.07	0.03	0.06	-0.01	0.06	0.14					
21 PRO Resaerch Intensity	0.08	0.06	0.08	0.04	0.06	0.07	0.08	-0.08	0.14	-0.01	0.01	-0.07	0.04	0.14	-0.05	0.07	0.04	-0.06	0.03	0.00				
22 Graduates/Industry Size	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.13	-0.11	-0.14	-0.45	-0.30	-0.09	-0.13	-0.01	0.05	0.06	-0.07	0.01	-0.03	0.14			
23 Univ. Publications per Graduate	-0.02	-0.01	-0.02	0.01	-0.01	-0.03	-0.02	0.62	0.04	0.64	0.23	0.20	0.22	0.19	0.10	-0.14	-0.09	0.08	-0.11	0.04	-0.09	-0.14		
24 U-F Co-publications per Graduate	0.04	0.04	0.04	0.06	0.04	0.02	0.04	0.48	0.19	0.81	0.37	0.25	0.32	0.21	0.10	-0.16	-0.05	0.13	-0.07	0.05	-0.06	-0.14	0.93	
25 Graduate Counts	0.28	0.23	0.28	0.23	0.23	0.24	0.28	-0.03	0.62	0.45	0.73	0.32	0.61	0.23	0.10	-0.21	0.01	0.21	0.20	-0.03	0.20	0.01	0.06	0.23

Table 5: Logit Analysis of the Propensity to Conduct Foreign R&D: Analysis of R&D, Research, and Development Activities

Dependent Variable: Foreign R&D Operation	R&D			Research			Development		
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9
Univ. Research Strength		2.1676***	2.1003***		2.1304**	2.0131**		2.1807***	2.1163***
		(0.7164)	(0.7169)		(0.8999)	(0.8981)		(0.7165)	(0.7166)
Collaboration Intensity			0.1055			0.2880**			0.1005
			(0.0951)			(0.1270)			(0.0948)
Technological Strength	0.8393**	0.4986	0.4665	0.5645	0.2148	0.1505	0.8384**	0.4946	0.4643
	(0.4044)	(0.4050)	(0.4085)	(0.4926)	(0.4860)	(0.4890)	(0.4030)	(0.4035)	(0.4076)
Market Size	0.2539**	0.3109***	0.2384**	0.2152*	0.2672**	0.0679	0.2490**	0.3065***	0.2371**
	(0.1043)	(0.1064)	(0.1106)	(0.1283)	(0.1295)	(0.1308)	(0.1044)	(0.1065)	(0.1086)
Cost of R&D Personnel	-0.4838**	-0.4427**	-0.4508**	-0.5883**	-0.5612**	-0.5906**	-0.5164**	-0.4759**	-0.4836**
	(0.2014)	(0.2079)	(0.2083)	(0.2470)	(0.2528)	(0.2530)	(0.2027)	(0.2093)	(0.2096)
IPR Protection	1.7245***	1.5535**	1.2558*	1.9388***	1.8034**	0.9480	1.8215***	1.6516***	1.3690*
	(0.5901)	(0.6053)	(0.6870)	(0.7337)	(0.7454)	(0.8555)	(0.6046)	(0.6200)	(0.7118)
Distance from Japan	-0.2622*	-0.3314**	-0.3241**	-0.0805	-0.1444	-0.1211	-0.2609*	-0.3307**	-0.3239**
	(0.1376)	(0.1442)	(0.1451)	(0.1552)	(0.1619)	(0.1637)	(0.1385)	(0.1452)	(0.1462)
Host Country Experience	0.6329***	0.6326***	0.6431***	0.9291***	0.9350***	0.9781***	0.6193***	0.6194***	0.6292***
	(0.1492)	(0.1514)	(0.1547)	(0.1922)	(0.1944)	(0.1973)	(0.1458)	(0.1482)	(0.1508)
Parent Firm Size	0.0750	0.0804	0.0804	-0.0772	-0.0712	-0.0692	0.0858	0.0912	0.0912
	(0.0794)	(0.0795)	(0.0792)	(0.0787)	(0.0790)	(0.0783)	(0.0791)	(0.0791)	(0.0789)
Parent Res. Orient. Dummy	0.9448***	0.9738***	0.9658***	1.0102**	1.0469**	1.0212**	1.0036***	1.0332***	1.0254***
	(0.3668)	(0.3709)	(0.3707)	(0.4515)	(0.4581)	(0.4592)	(0.3678)	(0.3722)	(0.3720)
Affiliate Sales Ratio	1.5935**	1.6265**	1.6608**	1.4338**	1.4834**	1.5882***	1.6530**	1.6861**	1.7183**
	(0.7801)	(0.7709)	(0.7593)	(0.6656)	(0.6550)	(0.6108)	(0.7902)	(0.7809)	(0.7704)
Manu. Sales Share	1.9317***	1.9548***	1.9644***	2.2337***	2.2639***	2.3035***	1.9498***	1.9744***	1.9831***
	(0.2100)	(0.2092)	(0.2110)	(0.2618)	(0.2622)	(0.2677)	(0.2126)	(0.2119)	(0.2133)
Affiliate Export Dummy	1.3576***	1.3844***	1.3879***	1.8725***	1.8978***	1.9158***	1.3113***	1.3396***	1.3425***
	(0.3465)	(0.3472)	(0.3486)	(0.4963)	(0.4970)	(0.5093)	(0.3423)	(0.3435)	(0.3449)
Industry Dummies	Included	Included	Included	Included	Included	Included	Included	Included	Included
Constant	-4.2828*	-4.8233**	-6.2200**	-3.8633	-4.3178	-4.3583	-4.1496*	-4.6897**	-6.1121**
	(2.3208)	(2.3452)	(2.5264)	(2.7369)	(2.7558)	(2.8459)	(2.2900)	(2.3139)	(2.4663)
No. of Observations	1452	1452	1452	1452	1452	1452	1452	1452	1452
No. of Firms	498	498	498	498	498	498	498	498	498
Log Likelihood	-461.13**	-458.86**	-458.23***	-347.36**	-345.67**	-342.43***	-457.37**	-455.07**	-454.50**
McFaden Pseudo R-square	0.258	0.261	0.262	0.280	0.284	0.290	0.257	0.261	0.262

Notes: ***, **, * indicate significance of coefficients at the 1, 5 and 10 percent levels. Standard errors are reported in parentheses.

Table 6: Logit Analysis of the Propensity to Conduct Foreign R&D: Analysis of Basic Research, Applied Research, Development for Global Markets, and Development for Local Markets

Dependent Variable: Foreign R&D Operation	Basic Research	Applied Research	Development for Global Markets	Development for Lobcal Markets
Univ. Research Strength	3.0075***	2.0283**	2.5171***	1.7991**
	(0.9117)	(0.8975)	(0.7509)	(0.7290)
Collaboration Intensity	0.1793	0.2909**	0.1582	0.1023
	(0.1544)	(0.1315)	(0.1275)	(0.0953)
Technological Strength	0.5587	0.1262	0.0448	0.4772
	(0.5711)	(0.4915)	(0.4914)	(0.4140)
Market Size	0.2057	0.0628	0.1363	0.2472**
	(0.1491)	(0.1296)	(0.1204)	(0.1102)
Cost of R&D Personnel	-0.4080	-0.6193**	-0.4735*	-0.4633**
	(0.2878)	(0.2514)	(0.2516)	(0.2132)
IPR Protection	0.8453	0.9418	1.6480*	1.2785*
	(0.9905)	(0.8683)	(0.9311)	(0.7220)
Distance from Japan	-0.5076***	-0.0811	-0.2367	-0.3314**
	(0.1844)	(0.1656)	(0.1586)	(0.1468)
Host Country Experience	0.8544***	0.9957***	0.6323***	0.6296***
	(0.2173)	(0.1989)	(0.1738)	(0.1526)
Parent Firm Size	-0.0549	-0.0677	0.0503	0.1006
	(0.0860)	(0.0773)	(0.0827)	(0.0793)
Parent Res. Orient. Dummy	1.3803**	1.1192**	0.9929**	1.0700***
	(0.5741)	(0.4655)	(0.4248)	(0.3829)
Affiliate Sales Ratio	1.6180***	1.6367***	2.0101***	1.5891**
	(0.5605)	(0.6118)	(0.7638)	(0.7051)
Manu. Sales Share	2.0352***	2.3590***	1.8035***	2.0231***
	(0.3224)	(0.2669)	(0.2387)	(0.2091)
Affiliate Export Dummy	1.8407***	1.8383***	1.8446***	1.3019***
	(0.5466)	(0.5048)	(0.4954)	(0.3435)
Industry Dummies	Included	Included	Included	Included
Constant	-5.2547	-4.3095	-6.2369**	-6.3783**
	(3.2524)	(2.7760)	(2.7347)	(2.4941)
No. of Observations	1452	1452	1452	1452
No. of Firms	498	498	498	498
Log Likelihood	-291.42***	-336.82***	-357.08***	-450.44***
McFaden Pseudo R-square	0.275	0.292	0.253	0.262

Notes: ***, **, * indicate significance of coefficients at the 1, 5 and 10 percent levels. Standard errors are reported in parentheses.

Table 7: Logit Analysis of the Propensity to Conduct Foreign R&D: Split Sample Analysis of Research and Development Activities by Technological Characteristics of Firms' Industries (High-Tech vs Low-Tech)

Dependent Variable: Foreign R&D Operation	Research		Development	
	Firms from High-tech Sector	Firms from Low-tech Sector	Firms from High-tech Sector	Firms from Low-tech Sector
Univ. Research Strength	3.5341***	-2.2402	3.1534***	0.2099
	(1.1985)	(1.4193)	(0.9660)	(1.3483)
Collaboration Intensity	0.2879	0.2535	0.0468	0.0923
	(0.2469)	(0.1632)	(0.1339)	(0.1320)
Technological Strength	0.3209	-0.3104	0.5002	-0.0010
	(0.7653)	(0.8099)	(0.6217)	(0.6813)
Market Size	0.2733	0.0153	0.4307**	0.1531
	(0.2350)	(0.1857)	(0.1686)	(0.1523)
Cost of R&D Personnel	-0.4465	-0.4450	-0.3712	-0.3594
	(0.4367)	(0.3167)	(0.3295)	(0.2656)
IPR Protection	-0.0289	1.1014	0.9132	1.4247
	(1.5324)	(1.2195)	(1.0353)	(1.0744)
Distance from Japan	-0.3190	0.0196	-0.5943***	-0.1405
	(0.2697)	(0.2215)	(0.2117)	(0.2048)
Host Country Experience	1.0966***	0.7995***	0.6159***	0.5223**
	(0.3413)	(0.2370)	(0.2249)	(0.2082)
Parent Firm Size	-0.0766	0.0162	0.1478	0.1212
	(0.1122)	(0.1070)	(0.1120)	(0.1133)
Parent Res. Orient. Dummy	1.4404*	0.7839	1.5905***	0.7272
	(0.7896)	(0.5628)	(0.5896)	(0.5202)
Affiliate Sales Ratio	0.2969	8.5775***	0.9474*	7.9650***
	(0.6820)	(1.9119)	(0.5095)	(1.9627)
Manu. Sales Share	2.0793***	2.7834***	1.5755***	2.5659***
	(0.4185)	(0.4050)	(0.3107)	(0.3289)
Affiliate Export Dummy	1.3080**	2.6114***	0.9605**	1.7497***
	(0.6597)	(0.9218)	(0.4551)	(0.5959)
Industry Dummies	Included	Included	Included	Included
Constant	-4.6657	-7.3811**	-5.7969	-8.2348**
	(4.4203)	(3.7025)	(3.5798)	(3.3457)
No. of Observations	730	722	730	722
No. of Firms	223	275	223	275
Log Likelihood	-155.61***	-170.69***	-227.02***	-210.29***
McFaden Pseudo R-square	0.258	0.367	0.236	0.339

Notes: ***, **, * indicate significance of coefficients at the 1, 5 and 10 percent levels. Standard errors are reported in parentheses.

Table 8: Heckman's Selection Model with Two Step Estimation on the Propensity to Conduct Foreign R&D

Selection Equation

	R&D	Research	Development	R&D	Research	Development
Univ. Research Strength	1.1226**	1.1374*	1.9475*	1.1226**	1.1374*	1.9475*
	(0.5141)	(0.5864)	(1.1168)	(0.5141)	(0.5864)	(1.1168)
Collaboration Intensity	0.0625	0.1662***	-0.1010	0.0625	0.1662***	-0.1010
	(0.0518)	(0.0623)	(0.0938)	(0.0518)	(0.0623)	(0.0938)
Technological Strength	0.2374	0.0051	0.6799	0.2374	0.0051	0.6799
	(0.2456)	(0.2893)	(0.4154)	(0.2456)	(0.2893)	(0.4154)
Market Size	0.1381*	0.0783	0.3752***	0.1381*	0.0783	0.3752***
	(0.0740)	(0.0868)	(0.1405)	(0.0740)	(0.0868)	(0.1405)
Cost of R&D Personnel	-0.2292*	-0.3336**	-0.0321	-0.2292*	-0.3336**	-0.0321
	(0.1205)	(0.1472)	(0.1975)	(0.1205)	(0.1472)	(0.1975)
IPR Protection	0.6304	0.5284	0.2579	0.6304	0.5284	0.2579
	(0.4133)	(0.5134)	(0.6952)	(0.4133)	(0.5134)	(0.6952)
Distance from Japan	-0.1957**	-0.1161	-0.4723***	-0.1957**	-0.1161	-0.4723***
	(0.0853)	(0.1006)	(0.1533)	(0.0853)	(0.1006)	(0.1533)
Host Country Experience	0.3402***	0.5575***	0.1093	0.3402***	0.5575***	0.1093
	(0.0764)	(0.0979)	(0.1196)	(0.0764)	(0.0979)	(0.1196)
Parent Firm Size	0.0447	-0.0188	0.1413**	0.0447	-0.0188	0.1413**
	(0.0343)	(0.0420)	(0.0566)	(0.0343)	(0.0420)	(0.0566)
Parent Res. Orient. Dummy	0.5373***	0.5826***	0.4815*	0.5373***	0.5826***	0.4815*
	(0.1534)	(0.1943)	(0.2657)	(0.1534)	(0.1943)	(0.2657)
Affiliate Sales Ratio	0.9653***	1.1049***	0.5779	0.9653***	1.1049***	0.5779
	(0.3062)	(0.3562)	(0.4408)	(0.3062)	(0.3562)	(0.4408)
Manu. Sales Share	1.0976***	1.3414***	0.6749***	1.0976***	1.3414***	0.6749***
	(0.1189)	(0.1520)	(0.1975)	(0.1189)	(0.1520)	(0.1975)
Affiliate Export Dummy	0.7305***	0.9431***	0.2237	0.7305***	0.9431***	0.2237
	(0.1642)	(0.2244)	(0.2254)	(0.1642)	(0.2244)	(0.2254)
Industry Dummies	Included	Included	Included	Included	Included	Included
Constant	-8.3161	-7.7375	-5.1269**	-8.3161	-7.7375	-5.1269**
	(0.0000)	(0.0000)	(2.2224)	(0.0000)	(0.0000)	(2.2224)

Resultant Outcome Equation

	R&D	Research	Development	R&D	Research	Development
Univ. Research Strength	-0.9035	-1.0409	16.4362	0.8002	0.9574	6.6971
	(2.4062)	(2.9038)	(71.0354)	(1.5461)	(1.8413)	(5.1485)
Collaboration Intensity	0.3067**	0.1969	0.2412	0.3351***	0.3448**	0.7509***
	(0.1350)	(0.3321)	(3.8196)	(0.1064)	(0.1602)	(0.2563)
Technological Strength	-0.6933	-0.9190	2.1973	-0.5606	-0.9943	-1.3985
	(0.7165)	(0.7209)	(26.2981)	(0.5699)	(0.6711)	(1.4274)
Market Size	-0.1356	0.0186	1.0906	0.1049	0.2412	-0.7860*
	(0.2938)	(0.2878)	(13.9578)	(0.1829)	(0.2220)	(0.4413)
Cost of R&D Personnel	0.6940	0.9211	0.2926	0.5590*	0.7099*	0.4970
	(0.4870)	(0.7333)	(1.9310)	(0.3253)	(0.4093)	(0.6986)
IPR Protection	-1.4192	-1.9123	-0.9211	-0.8219	-1.4634	-2.5210
	(1.4676)	(1.7132)	(9.9611)	(1.0355)	(1.3202)	(2.2758)
Distance from Japan	0.4102	0.4225	-2.4314			
	(0.3624)	(0.3269)	(17.1566)			
Host Country Experience	0.0943	-0.0691	1.0015	0.4142*	0.4994	0.4809
	(0.5661)	(1.0693)	(4.0170)	(0.2356)	(0.3957)	(0.3853)
Parent Firm Size	0.5811***	0.7239***	1.1655	0.6414***	0.7173***	0.4484***
	(0.1045)	(0.1180)	(5.2928)	(0.0795)	(0.1032)	(0.1651)
Parent Res. Orient. Dummy	-0.5703	-0.5663	2.1683			
	(0.9323)	(1.2116)	(18.4231)			
Affiliate Sales Ratio	3.1170**	3.8638*	6.1818	3.7969***	4.6771***	3.0209
	(1.5632)	(2.1228)	(21.7396)	(0.9196)	(1.1475)	(2.1895)
Manu. Sales Share	-0.4765	-0.5370	2.1237	0.5446	0.8298	-1.5030
	(1.7054)	(2.5093)	(25.4653)	(0.5611)	(0.8265)	(0.9597)
Affiliate Export Dummy	-0.3988	-0.8201	1.6443			
	(1.2209)	(1.9902)	(7.7478)			
Industry Dummies	Included	Included	Included	Included	Included	Included
Constant	-10.8366	-13.9641	-36.2597	-15.9792***	-19.1311***	4.0188
	(8.0903)	(8.7571)	(292.9048)	(4.0761)	(4.9597)	(9.3902)
rho	-0.6045	-0.7195	1.0000	0.2023	0.1170	-0.7800
Sigma	1.6600	1.7870	5.1767	1.4596	1.4426	1.5628
Inverse Mills Ratio	-1.0035	-1.2857	5.1767	0.2953	0.1688	-1.2190
	(2.1254)	(2.5731)	(44.0794)	(0.5632)	(0.6882)	(1.1147)
No. of Observations	1453	1329	1278	1453	1329	1278

Notes: ***, **, * indicate significance of coefficients at the 1, 5 and 10 percent levels. Standard errors are reported in parentheses.

Table 9: Logit Analysis of the Propensity to Conduct Foreign R&D: Analysis of the Supply of R&D personnel

Dependent Variable: Foreign R&D Operation	R&D	Research	Development	R&D	Research	Development
Univ. Research Strength	2.7976***	2.6021***	2.8013***			
	(0.8511)	(0.9654)	(0.8536)			
Collaboration Intensity	0.0331	0.1598	0.0418			
	(0.1248)	(0.1498)	(0.1242)			
Graduates / Industry Size	-0.0028	-0.0257	-0.0050			
	(0.0138)	(0.0329)	(0.0142)			
Univ. Publications per Graduate				4.9421	4.6323	4.8530
				(3.1279)	(4.4406)	(3.1740)
U-F Co-publications per Graduate				-87.0274	8.9477	-85.9930
				(85.0481)	(113.0389)	(85.8518)
Graduate Counts				0.9470***	0.7038**	0.9427***
				(0.2780)	(0.3161)	(0.2808)
Technological Strength	0.4675	0.2004	0.5310	0.4564	-0.5639	0.5217
	(0.5296)	(0.6534)	(0.5298)	(0.8508)	(1.0646)	(0.8550)
Market Size	0.3123*	0.1085	0.2891*	-0.4432*	-0.3374	-0.4579*
	(0.1716)	(0.1945)	(0.1720)	(0.2453)	(0.2480)	(0.2469)
Cost of R&D Personnel	-0.9483**	-1.0120*	-1.0303**	0.0463	0.0158	-0.0278
	(0.4523)	(0.5250)	(0.4459)	(0.5227)	(0.6207)	(0.5280)
IPR Protection	2.6983***	2.4719*	2.7679***	1.9296**	1.9420	2.0435**
	(0.9280)	(1.2957)	(0.9543)	(0.9716)	(1.4042)	(0.9879)
Distance from Japan	-0.1844	0.0029	-0.1853	0.1089	0.2445	0.1111
	(0.1859)	(0.2050)	(0.1857)	(0.1971)	(0.2194)	(0.1972)
Host Country Experience	0.5294***	0.8707***	0.5293***	0.5455***	0.8935***	0.5429***
	(0.1918)	(0.2399)	(0.1918)	(0.1913)	(0.2334)	(0.1911)
Parent Firm Size	0.1697*	-0.0014	0.1748*	0.1630	-0.0076	0.1684*
	(0.0963)	(0.0967)	(0.0965)	(0.1010)	(0.0977)	(0.1012)
Parent Res. Orient. Dummy	1.1205***	1.0278*	1.0993***	1.0976***	0.9931*	1.0753***
	(0.3980)	(0.5253)	(0.3990)	(0.3940)	(0.5215)	(0.3948)
Affiliate Sales Ratio	2.8706***	2.9953***	2.8657***	2.9715***	3.0111***	2.9683***
	(0.8968)	(0.8013)	(0.9065)	(1.0402)	(0.8430)	(1.0512)
Manu. Sales Share	2.0740***	2.4709***	2.0988***	1.9877***	2.4001***	2.0106***
	(0.2659)	(0.3104)	(0.2689)	(0.2642)	(0.3072)	(0.2678)
Affiliate Export Dummy	1.8688***	2.3858***	1.8286***	1.8725***	2.3394***	1.8289***
	(0.4394)	(0.6182)	(0.4364)	(0.4365)	(0.6000)	(0.4328)
Industry Dummies	Included	Included	Included	Included	Included	Included
Constant	-4.5650	-1.7499	-3.5510	-18.1538***	-16.0402**	-17.3239***
	(5.5783)	(6.1055)	(5.4121)	(6.5243)	(7.2456)	(6.5353)
No. of Observations	1123	1123	1123	1123	1123	1123
No. of Firms	442	442	442	442	442	442
Log Likelihood	-312.6214	-240.8348	-311.0853	-308.2317	-239.8253	-306.8568

Notes: ***, **, * indicate significance of coefficients at the 1, 5 and 10 percent levels. Standard errors are reported in parentheses.

Table 10: Logit Analysis of the Propensity to Conduct Foreign R&D: Analysis of the Intensity of PRO Research

Dependent Variable: Foreign R&D Operation	R&D	Research	Development	Basic Research	Applied Research	Development for Global Markets	Development for Local Markets
Univ. Research Strength	2.1098***	2.0443**	2.1233***	3.0338***	2.0549**	2.5327***	1.8070**
	(0.7171)	(0.8955)	(0.7167)	(0.9138)	(0.8946)	(0.7516)	(0.7288)
Collaboration Intensity	0.0995	0.2678**	0.0955	0.1629	0.2716**	0.1538	0.0975
	(0.0943)	(0.1210)	(0.0937)	(0.1486)	(0.1258)	(0.1221)	(0.0943)
PRO Research Intensity	0.0031	0.0092*	0.0027	0.0067	0.0085	0.0066	0.0025
	(0.0047)	(0.0054)	(0.0048)	(0.0061)	(0.0055)	(0.0048)	(0.0048)
Technological Strength	0.4601	0.1066	0.4593	0.5361	0.0844	0.0351	0.4719
	(0.4091)	(0.4941)	(0.4081)	(0.5740)	(0.4956)	(0.4903)	(0.4145)
Market Size	0.2333**	0.0607	0.2325**	0.2058	0.0567	0.1198	0.2431**
	(0.1097)	(0.1315)	(0.1080)	(0.1491)	(0.1302)	(0.1199)	(0.1098)
Cost of R&D Personnel	-0.4014*	-0.4540*	-0.4407**	-0.2932	-0.4933*	-0.3774	-0.4233**
	(0.2124)	(0.2634)	(0.2128)	(0.3066)	(0.2610)	(0.2510)	(0.2158)
IPR Protection	1.2516*	0.9757	1.3639*	0.8185	0.9691	1.6182*	1.2748*
	(0.6807)	(0.8267)	(0.7058)	(0.9623)	(0.8410)	(0.8994)	(0.7167)
Distance from Japan	-0.3415**	-0.1643	-0.3387**	-0.5411***	-0.1210	-0.2693*	-0.3453**
	(0.1461)	(0.1655)	(0.1471)	(0.1842)	(0.1670)	(0.1583)	(0.1477)
Host Country Experience	0.6563***	1.0256***	0.6406***	0.8837***	1.0392***	0.6669***	0.6403***
	(0.1578)	(0.1950)	(0.1545)	(0.2146)	(0.1967)	(0.1763)	(0.1564)
Parent Firm Size	0.0761	-0.0815	0.0875	-0.0635	-0.0787	0.0410	0.0971
	(0.0799)	(0.0786)	(0.0797)	(0.0860)	(0.0777)	(0.0833)	(0.0802)
Parent Res. Orient. Dummy	0.9712***	1.0413**	1.0302***	1.3968**	1.1376**	1.0040**	1.0747***
	(0.3712)	(0.4592)	(0.3724)	(0.5723)	(0.4649)	(0.4241)	(0.3832)
Affiliate Sales Ratio	1.6818**	1.6608***	1.7364**	1.6608***	1.7038***	2.0622***	1.6059**
	(0.7605)	(0.6056)	(0.7716)	(0.5606)	(0.6070)	(0.7601)	(0.7064)
Manu. Sales Share	1.9706***	2.3304***	1.9885***	2.0532***	2.3832***	1.8199***	2.0281***
	(0.2117)	(0.2694)	(0.2142)	(0.3257)	(0.2693)	(0.2414)	(0.2100)
Affiliate Export Dummy	1.3906***	1.9311***	1.3450***	1.8497***	1.8516***	1.8566***	1.3040***
	(0.3490)	(0.5134)	(0.3452)	(0.5473)	(0.5084)	(0.4963)	(0.3438)
Industry Dummies	Included	Included	Included	Included	Included	Included	Included
Constant	-6.7081***	-5.9084**	-6.5343***	-6.4985*	-5.7460**	-7.1715***	-6.7738***
	(2.5761)	(2.9361)	(2.4998)	(3.3867)	(2.8626)	(2.6799)	(2.5239)
No. of Observations	1452	1452	1452	1452	1452	1452	1452
No. of Firms	498	498	498	498	498	498	498
Log Likelihood	-458.0292	-341.2325	-454.3616	-290.9617	-335.8329	-356.4083	-450.3120

Notes: ***, **, * indicate significance of coefficients at the 1, 5 and 10 percent levels. Standard errors are reported in parentheses.