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Abstract

The objective of this paper is to study the presence of any systematic patterns in overseas laboratory ownership by using a sample of 526 Japanese manufacturing multinationals. Overseas laboratories are considered to play a major role in technological knowledge sourcing from research resources embodied within the host countries. Considering that their characteristics are distinctively different from those of local-support oriented Research & Development (R&D) units, we take into account not only the conventionally examined firm characteristics but also the managerial and technological characteristics in estimating the determinants. Our findings are consistent with the hypothesis that the ownership decision of overseas laboratories by firms is significantly affected by the corporate capabilities to utilise external research resources and the science-orientation of industries as well as R&D intensity, global sales, and overseas experience of firms.

The List of Contents

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Overseas R&D, laboratory, knowledge sourcing, determinants, Japanese firms

1. Introduction

Research and Development (R&D) is one of the fundamental means for enhancing corporate technological capabilities, which is essential for the continual growth of any firm. It is widely recognised that R&D activities are deeply interrelated with other corporate functions such as administration and production. Therefore, they tend to be the last function to be internationalised after the cross-border dispersion of sales and production activities. Conventionally, the primary function of overseas R&D activities is considered to be the support of local sales and manufacturing activities. Overseas R&D facilities adapt the technologies developed in the home country to local input conditions, demand conditions, and regulations. However, the speed of technological progress taking place at globally dispersed centres of excellence is accelerating and there is increasing emphasis on cross-fertilisation across various technological fields. This has necessitated firms, particularly in high-tech sectors, to strengthen their technological competitiveness not only through their internal R&D efforts, but also through an effective utilisation of external research resources regardless of their location. Consequently, *technological knowledge sourcing* (or simply, *sourcing*) from excellent local scientific and technical resources has also been realised as an important motivational factor for overseas R&D activities (Kuemmerle, 1997; Granstrand, 1999; Iwasa and Odagiri, 2002).

Firms, in general, find it difficult to employ research resources from geographically distant countries. Such difficulties are likely to arise from the lack of information on the availability of local research resources, and also from the tacit nature of complicated and advanced technological knowledge. We consider that overseas laboratories can function as an effective means to overcome such distance barriers and allow parent firms to utilise excellent, cutting-edge research resources abroad. Overseas laboratories primarily engage in research activities and the production of technological knowledge with an aim to contribute to the company-wide technological capabilities. They tend to possess adequate capabilities to appreciate locally available scientific and technological knowledge that are of interest to them and take advantage of first-hand contact with local resources. Therefore, overseas R&D laboratories can, potentially, function as representative organisations to undertake sourcing activities. By internalising overseas laboratories, firms gain more opportunities to benefit from local technological knowledge and bring the knowledge out to the company-wide innovation.

This paper purports to study if there are any systematic patterns in overseas laboratory ownership, particularly focusing on the R&D activities of Japanese multinationals. By doing so, we hope to get an insight into the scope of knowledge sourcing from globally dispersed research resources. Most of the empirical studies on the determinants of overseas R&D are mainly concerned with the local-support-oriented activities and focus on the firm's characteristics such as scale of production/sales, technological complexity of products, and overseas experience (Odagiri and Yasuda, 1996; Belderbos, 2003). However, our specific area of interest is the ownership of overseas laboratories, whose characteristics are distinctively different from those of support-oriented R&D facilities. Some surveys (Asakawa, 1996, 2001; Granstrand, 1999) have revealed that knowledge management difficulties have a significant influence on overseas laboratory ownership as prohibiting factors. We, therefore, consider that conventionally examined factors are not sufficient for analysing the determinants of overseas R&D laboratories and take into account the characteristics concerning knowledge management and technology, which are closely related to the research aspect of firms.

We used a sample of 526 Japanese manufacturing multinationals to test our hypothesis that overseas laboratory ownership is affected not only by the conventionally examined firm characteristics but also by managerial and technological characteristics. We will consider parent R&D intensity, company-wide sales, and overseas experience as conventional characteristics. Managerial characteristics are represented by the capability to cope with external research resources: We will proxy this with the familiarity to commissioned research and technology acquisition. Their effects are expected to vary depending on definability of work and predictability of outcome (Odagiri, 2003). Furthermore, we will control for the technological characteristics, represented by science-orientation and support-orientation of industries, using the data on important information sources in commencing an R&D project.

Our estimation results are consistent with the hypothesis: The capability to cope with external research resources, proxied with the familiarity to commissioned research, associates positively with the likelihood of overseas laboratory ownership. Thoughwe have to be cautious in interpreting the estimation results given that our analysis is confined to cross-sectional dimension, this result implies firms that actively employ external resources with low definability and predictability are likely to possess capabilities to manage external research resources and, consequently, quasi-external overseas laboratories in terms of R&D boundaries of firms. Therefore, a higher expectation of benefiting from knowledge sourcing encourages firms to invest in overseas laboratories. Moreover, the importance of information from universities relates positively to the likelihood of acquiring overseas laboratory ownership, while that from customers has a negative effect. These results suggest that firms with a strong science-orientation have a better incentive to own overseas laboratories in order to seek contacts with foreign universities and research institutes; however, this is not true of firms with support orientation.

The sections in this paper are organised as follows. Section 2 discusses the determinants of overseas laboratory ownership, and our hypotheses based on those arguments are presented in Section 3. Section 4 provides a brief discussion on the data and variables used for the regression analysis. The estimation results are described in Section 5, followed by the conclusion in Section 6.

2. Determinants of overseas laboratory ownership

A conventional function of overseas R&D units is to adapt the technology generated at home to the local input conditions, regulations, or tastes of the host countries. By doing so, those units purport to support the production and marketing activities of overseas subsidiaries. Therefore, their activities are referred to as *local-support-oriented*. In many cases, they collocate with the other functional units, such as production or marketing to enable close interactions between them. Information from such internal units is relatively valued at local-support-oriented (support-oriented, hereafter) R&D units. For example, information from the marketing department on the tastes of local customers has much more importance in developing a new washing machine, which is sold at the local market.

On the other hand, the increasing importance of research-oriented overseas R&D activities that aim to benefit from local R&D resources is also recognised today (Kuemmerle, 1997). The representative institution that undertakes such activities is considered to be an overseas laboratory. Thus, we will hereafter focus on overseas laboratories, comparing their objectives and activities to those of support-oriented R&D units.

The overseas laboratories primarily engage in research activities and aim to generate technological knowledge, taking advantage of local research resources. The increasing importance of sourcing activities from host countries reflects the emerging consensus among firms that it is critical to have access to any scientific discovery and technological innovation generated at globally dispersed facilities and, hopefully, use them as a seed for further enhancement of their own technological capabilities. Sourcing is undertaken through various channels, both formal and informal. For example, the subsidiary can hire local scientists or engineers. They can also form collaborative research alliances with local universities. Regarding less formal means, analyses on patent citation confirm that subsidiaries receive knowledge spillovers from neighbouring R&D resources by means of, for example, academic journals or attendance at conferences (Frost, 2001; Branstetter, 2000).

Some literatures point out that the activities of overseas laboratories are partly devoted to product development designed for the local markets (Pearce, 1999). In such a case, close collaboration with local production/marketing units is indispensable for innovation and information from internal units should be appreciated, as in the case of support-oriented R&D activities.

However, overseas laboratories, particularly in the area of biotechnology and electronics, also undertake relatively scientific and basic research. In this case, their objective is to enhance the company-wide technological capabilities, and their target is not confined to the local markets. Scientific and technological knowledge obtained from external research sources can be valued as a source of innovation rather than those obtained from other internal functions. For example, overseas laboratories of pharmaceutical companies can conclude consulting agreements with university scientists, hoping for scientific findings and new drug development. Between overseas laboratories and the headquarters, technological knowledge generated or obtained at the laboratory flows from the periphery to centre, which is contrary to that of support-oriented R&D (Bartlett and Ghoshal, 1990; Gupta and Govindarajan, 1991).

Ownership of overseas laboratories allows parent firms to appropriate local scientific and technical knowledge that is not accessible or obtainable from distant facilities. It also allows firms to minimise the inevitable transaction costs in appropriating local knowledge. Thus it can be considered as an act to internalise a distant research facility. By using overseas laboratories, firms find it easier to collect information on the availability of local research resources, to evaluate the information accurately, and conclude contracts if necessary. Proximity to the knowledge source is also important since knowledge tends to be tacit in nature and first-hand communication is required to transfer it. In particular, knowledge transfer from universities, for example by licensing, necessitates firms to have a certain amount of direct interaction with the knowledge creator before any absorption and development process takes place since such knowledge tends to be highly specific and, consequently, tacit in nature. Licensing from university is, in effect, shown to be more geographically constrained than mere citations of university researches (Mowery and Ziedonis, 2001).

Previous empirical studies on the determinants of overseas R&D activities have primarily focused on the activities of support-oriented R&D facilities, reflecting that this is the most prominent form of overseas R&D activities (Belderbos, 2003). By definition, support-oriented R&D activities are highly affected by overseas production and sales activities and also by the technological content of the products developed at home R&D facilities. Thus, the analyses on the determinants of support-oriented R&D activities, in general, focus on firm characteristics represented by scale of production, sales, parent R&D intensity, overseas experience, or entry mode as possible determinants. The empirical studies on such R&D activities have confirmed that these characteristics significantly influence the overseas R&D activities (Hakanson and Nobel, 1993; Odagiri and Yasuda, 1996; Belderbos, 2003).

On the other hand, empirical studies on determinants of overseas laboratories have been limited, though prior studies have found sourcing as an important motivational factor for overseas R&D, particularly in the US and Europe (Odagiri and Yasuda, 1996; Florida and Kenney, 1994). This partly reflects the fact that emergence of overseas laboratories is a relatively recent phenomenon and partly the difficulties in obtaining micro-level data on overseas subsidiaries. Exceptionally, Odagiri and Yasuda (1996), in the industry-level analysis on Japanese firms, have confirmed the importance of firm characteristics, such as the scale of subsidiary activities and parent R&D intensity, as the determinants of the number of overseas laboratories.

However, as evident, overseas laboratories have distinctively different objectives and activities compared to those of support-oriented R&D units. Besides, the outcome of overseas R&D activities is different: knowledge sourcing activities by overseas R&D units positively affect the home technological capabilities, measured by patented inventions, only when firms are committed to relatively research-oriented R&D activities abroad (Iwasa and Odagiri, 2002). In fact, some survey results suggest that conventional firm characteristics cannot fully explain the ownership of overseas laboratories. Even highly R&D intensive, large-scale firms with abundant experience in overseas operation recognise the difficulties in managing overseas laboratories (Asakawa, 1996, 2001). Based on the survey on 24 R&D intensive, large Japanese multinationals, Granstrand (1999) points out that management factors, represented by the high costs of coordination and communication, function as the strongest inhibiting factors in overseas R&D, while at the same time the firms are highly motivated by the establishment of an access to foreign science and technology. Therefore, in addition to the conventionally examined firm characteristics, we will also take into account the factors that are closely related to research and knowledge management when analysing the determinants of overseas laboratories.

3. Hypotheses

Our main hypothesis is that corporate characteristics on knowledge management and industrial characteristics on technology, which are more closely related to research-oriented R&D activities, affect the ownership of overseas laboratories as well as the conventionally examined firm characteristics. In this analysis, absorptive capacity, firm size, and overseas experience will first be examined following the prior studies. In addition to them, we will focus on managerial characteristics represented by capabilities to cope with external research resources as well as technological characteristics depicted by the science- and support-orientation of industries.

(1) Conventional firm characteristics

R&D intensiveness

Firstly, firms with high technological capabilities and absorptive capacity are more likely to own overseas laboratories with the aim of benefiting from external research resources. Higher technological capabilities of firms, which are indicated by high R&D intensiveness, suggest that the firms are likely to be in constant need of exploring the technological frontier. The geographical proximity, which is enabled by overseas laboratory ownership, allows firms to comply with international state-of-the-art technological knowledge more easily.

Simultaneously, in order to reap the benefits resulting from overseas laboratory ownership, firms are required to possess a certain level of absorptive capacity. Such capacity is partly developed through accumulated R&D efforts, and helps firms to search, evaluate, and appropriate local technological knowledge efficiently (Cohen and Levinthel, 1989). Indeed, firms with higher internal knowledge are considered to be capable of exploiting new knowledge generated externally (Arora and Gambardella, 1990), and they have more incentive to utilise it (Mowery and Rosenberg, 1989). Moreover, when the knowledge is generated at a distant location, where the natural, social, and economic environment is heterogeneous compared to that of the home country, transmitting complicated and advanced technological information among the subsidiaries and the parent company is a demanding task (Von Hippel, 1994). Scientific knowledge obtained from research organisations, such as universities, usually necessitates further R&D efforts in order to render it applicable for any practical purpose (Odagiri, Koga, and Nakamura, 2002). These suggest that a high level of absorptive capacity is required for appropriating the benefits from overseas laboratory ownership.

It should be noted that the R&D intensiveness of firms also indicates the size of their R&D activities. When the size of their R&D activities at home is large, firms are more likely to enjoy the economies of scale in R&D at home even after dispersing their R&D activities abroad. Subsequently, they can be more responsive to the possible benefit from overseas R&D activities and have more incentive to own laboratories abroad.

Firm size

Secondly, the size of the firm positively affects the likelihood of overseas laboratory ownership. Larger firms possess a wider scope to apply the fruit of innovation and spread the costs of innovation over their products (Cohen and Klepper, 1996). Therefore, if the consolidated size of the firm is large, the firm can expect greater returns from a given research outcome of the overseas laboratories and has more incentive for ownership. At the same time, the so-called ‘Schumpeter hypotheses’ might be applied to the case of overseas R&D activities: Larger firms with, possibly, a higher degree of diversification should realise more opportunities to apply the output of their R&D compared to smaller firms with a narrow scope of corporate activities. Moreover, large firms have an advantage in terms of financial resources: They tend to have relatively more cash flow within the firm to cover the investments for overseas laboratories which inevitably entails high uncertainty. They are also likely to possess complementary assets, represented by extensive sales network, needed to appropriate the innovation. Some empirical studies confirmed that large firms tend to employ strategies to seek external linkages (Arora and Gambardella, 1990; Odagiri, Koga, and Nakamura, 2002), implying that large firms are more eager to own overseas laboratories in order to gain an easy access to the offshore scientific resources.

Overseas experience

The degree of internationalisation, which refers to the extent of overseas experience, also affects the likelihood of overseas laboratory ownership. Subsidiaries can gather information on the availability of local scientific and technical resources as their overseas experience increases. Furthermore, the costs of coordinating and managing overseas R&D facilities tend to decrease over time (Granstrand et al., 1993). Certain empirical studies have supported the view that the overseas operation encourages 'organisational learning' and the advantage arising from overseas R&D is more likely to be realised. An industry-level analysis by Hewitt (1980) confirmed the positive influence of experience on the overseas R&D ratio. The analyses on the determinants of overseas R&D activities by Japanese manufacturing subsidiaries, which mainly pursue support-oriented R&D, have also supported such a hypothesis (Belderbos, 2003). On the other hand, in their study on the formation of 'centres of excellence' in foreign subsidiaries, Frost, Birkinshaw, and Ensign (2002) emphasize that the age of the units contributes negatively. The survey statistics of Frost *et al.* also exhibits that the average age of research centres is much lesser than the manufacturing centre, which are 19 and 34 years, respectively. These results imply that at a subsidiary level, the effects of overseas experience could depend on the characteristics of each R&D unit, and an expected influence of overseas experience of the firm as a whole is rather ambiguous.

(2) Managerial characteristics

Capability to cope with external research resources

Using internal R&D facilities abroad as a means to utilise overseas research resources rather than the direct purchase of overseas technology by home R&D units is expected to allow firms to economise market transaction costs: such costs are associated with, for example, searching desirable research partners in foreign countries, concluding contracts, and monitoring if partners pursue their task without cheating. However, as Williamson (1975) argues, "transactional limits of internal organisation" also needs to be considered. Indeed, survey results demonstrate difficulties in cross-border management and the consequent under-utilisation of overseas laboratories (Asakawa, 1996, 2001), suggesting that the ownership of overseas laboratories inevitably incurs large internal organisation costs.

Here, we consider 'quasi-externality' of overseas laboratories as a critical source of internal organisation costs. The overseas laboratories are fully integrated units of the multinationals in terms of shareholding and their R&D activities should be 'internal' to the firm. However, overseas laboratories can be 'quasi-external' in terms of the R&D boundaries of firms. This results in an increase in the internal organisation costs. In order to tap the local science community and source technological knowledge, the laboratory needs to be recognised as one that possesses adequate research capabilities and should be able to contribute to the community as one of its members. In other words, successful sourcing induces laboratories to localise. When the laboratory increasingly sources from local R&D resources, it faces a greater pressure to emulate the organisational structures and processes practiced within the host society, deviating from those of multinationals, in order to make the interaction with local organisations easier[1]. As the organisational gap between laboratories and headquarters widens, coordination between them becomes more difficult (Westney, 1990).

In case of Japanese firms, their overseas R&D activities are generally characterised by strong centralisation tendencies. However, their overseas laboratories are given certain autonomy so as to respect the local originality (Asakawa, 2001). Moreover, as the degree of autonomy of overseas laboratories increases, their external linkages also increase (Asakawa, 1996). This implies that the autonomy granted with the aim to utilising local research resources, not only brings about successful sourcing, but also exerts a strong pull toward the organisational patterns followed within the local societies. As a result, the laboratory becomes a 'quasi-external' unit within the firm, incurring high internal organisation costs.

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1 Westney points out three reasons for this 'isomorphism.' Firstly, similar organisational structures and processes make the inter-organisational interaction easier. Secondly, such a change increases 'legitimacy and acceptability' both inside and outside the constituencies of the subsidiary. Furthermore, given the high uncertainty involved within the business activities, managers are likely to seek successful models in the formulation of organisational patterns.

Next, we hypothesise that the capability to cope with external research resources enables firms to lower internal organisation costs arising from the quasi-externality; thus, encourages firms to own overseas laboratories. Such capability is likely to develop through the experience to cope with external research resources, i.e. familiarity with external research resources. The main providers of external research resources are universities, public research institutes, and private corporations. The resources traded vary from property rights to other relatively routine services. The resource holders act under different legitimacy and cultures and possess different organisational patterns from the user firms. The use of these external resources entails management difficulties but simultaneously provides the opportunities to enhance the capability to deal with them. Therefore, the familiarity with external research resources, through the development of management capabilities, encourages firms to own overseas laboratories and overcome the problems in managing quasi-external organisations.

External research resources can be differentiated on the basis of 'definability' of work and 'predictability' of outcome (Odagiri , 2003). 'Definability' indicates the extent to which the firm can predetermine the work to be procured. 'Predictability' defines the degree to which the firm is able to predict the research outcome. Definability and predictability decrease when (1) the time lag between the conclusion of the contract and actual implementation of the contracted work increases, and (2) the research task is complex. As the definability and predictability of the task becomes low, the difficulty in completing the task increases, and its contribution to the capabilities to cope with external research resources is supposed to be larger.

If we apply this perspective to the activities of overseas laboratories, the definability and predictability of their tasks can be considered as low. Laboratories generally undertake forefront and basic-oriented activities and their research tasks are complex. Thus the potential of their research output is highly uncertain. Given this, we considered that there could be a cross-fertilisation between the experience to utilise external research resources with low definability and predictability and the capabilities to manage quasi-external overseas laboratories. For example, *Eizai*, a Japanese pharmaceutical company acclaimed for its active internationalisation strategy in R&D, also actively employs external research resources. *Eizai* has a research laboratory in Boston and also benefits from a consulting agreement with a researcher at the Howard Hughes Medical Institute in Maryland. Simultaneously, *Eizai* is active in commissioning research to affiliated R&D institutes in Japan (*Eizai Annual Report*, 2002). Therefore, we hypothesise that familiarity with the resources, whose definability and predictability are low, contributes positively to the ownership of overseas laboratories.

(3) Technological characteristics of industry

It has been pointed out that the relative importance of support-oriented and research-oriented activities is crucial to the firm's overseas R&D strategy (Von Zedtwitz and Gassmann, 2002). At the same time, such orientations are likely to be affected by industry characteristics. For example, firms in the pharmaceutical industry tend to undertake research-oriented R&D activities not only in the home country but also abroad.

The science-orientation of industries is hypothesised to affect overseas laboratories ownership positively. In science-oriented industries, science plays an important role in innovation and the importance of scientific information is high. Thus, firms in those industries are eager to seek links with scientific communities, represented by universities and public research laboratories, in order to get first-hand information on new findings and to augment the research activities at in-house laboratories. However, the emergence of scientific findings occurs simultaneously all over the world. Moreover, academic spillovers are more localised than industrial spillovers (Adams, 2001). Arundel and Geuna (2001) also reveals that proximity effects are greatest for the information from publicly-funded research organisations, which include universities, compared to other information sources, such as suppliers, customers, joint ventures, competitors. Considering the above factors, namely, globally dispersed scientific findings and the importance of geographical proximity in sourcing knowledge from academic researches, firms in the industries with strong science-orientation should have more incentive to own overseas laboratories and keep access to scientific discoveries abroad.

On the other hand, the industries, in which internal information from the production or marketing departments is relatively valued as a source of innovation, are considered to be support-oriented. Such industries do not particularly appreciate the knowledge obtained from external research resources via overseas laboratories; therefore, they are less likely to own it. Firms belonging to these industrial sectors find overseas R&D units attached to production or marketing departments more resourceful.

4. Data and Variables

3.1. Data

Since late 1980s, overseas R&D activities undertaken by Japanese firms have been increasing. Broadly speaking, the generation of technological knowledge by foreign affiliates, measured by patents, was not common among Japanese firms (Patel, 1995) and majority of the overseas R&D facilities engaged in adapting technologies developed at home to the local conditions. In effect, the number of Japanese overseas laboratories was small. Among the 19,385 subsidiaries of Japanese firms listed in the Toyo Keizai (1999), only 101 subsidiaries undertook research and development activities exclusively.

The sample firms used in this study have been defined using the data from the *Survey of the Overseas Business Activities* (SOBA) of the fiscal year 1997, conducted by the Ministry of International Trade and Industry (MITI[2]). The survey covered all Japanese firms[3], excluding finance, insurance, and real estate that had a stake in foreign affiliates at the end of 1997 fiscal year[4]. A questionnaire was sent to 3862 parent firms and the

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2 It has been renamed as the Ministry of Economy, Trade and Industry or METI.

3 This includes Japan-based affiliates of foreign firms. Among 530 firms with data available for analysis, 63% are wholly Japanese-owned and 33% have more than 80% Japanese ownership. In order to avoid the possibility of including overseas laboratories which are, in effect, owned by foreign parents, we excluded four firms with more than 50% foreign ownership from the dataset. Thus our sample consists of 526 firms.

4 The definition of a foreign affiliate is a “foreign company in which a Japanese

response rate was 63. 4%. Among 1407 respondent manufacturing firms, we took a sample of 709 firms, based on the availability of information on their R&D activities. We matched the 1997 SOBA data with another database on Japanese foreign affiliates, the *Kaigai Shinshutsu Kigyo Souran* [5](1999 edition) in order to identify the ownership of R&D laboratories. After the matching procedures, our data consisted of 526 parent firms. Among them, 247 firms incurred positive expenditure on overseas R&D activities. Table 1 shows a comparison of the sample firms with that of the respondent manufacturing firms. It reveals that both the average number of subsidiaries and the unconsolidated parent sales are higher among the sample firms, suggesting that our sample is biased to larger firms with a higher tendency for globalisation. The two sets of data have more or less similar industry structures, though a slight inclination towards industries such as pharmaceuticals, chemicals, electronics, and transport machinery is recognised.

3.2. Definition of variables

With the sample above, we will estimate the determinants of overseas laboratory ownership by Japanese firms using the equation below. In addition to the conventional firm characteristics, we take into account managerial and technological characteristics, reflecting distinctly different motivation and characteristics of overseas laboratories compared to those of support-oriented R&D facilities. Probit estimation method is adopted due to the dichotomous nature of the dependent variable (Owns laboratory/Does not own laboratory).

$$
\begin{aligned}
Y_i^* = {} & \beta_0 + \beta_1 RDINT_i + \beta_2 \ln(GSALE_i) + \beta_3 \ln(EXP_i) \\
& + \beta_4 NACR_i + \beta_5 ACR_i + \beta_6 TACQ_i \\
& + \beta_7 UNIV_{is} + \beta_8 PROD_{is} + \beta_9 CUST_{is} + \sum_s \gamma_s D_{is} + \varepsilon_i
\end{aligned}
$$

$$LAB_i = 1 \quad (Y_i^* > 0)$$

company owns at least 10% of the stocks." They consist of subsidiaries and grandchild companies, namely, subsidiaries of subsidiaries.

[5] This database serves as a directory of overseas subsidiaries based on a survey complied by Toyo Keizai Inc.

The dependent variable, LAB_i, takes 1 if the firm owns more than one overseas laboratory and 0 if a firm does not own any. The firm is considered to own overseas laboratories if it owns more than one subsidiary whose main activity is exclusively research or development in the *Kaigai Shinshutsu Kigyou Souran* (Toyo Keizai, 1999 edition). We have not included subsidiaries that exclusively engage in software development as research laboratories. It should also be noted that when the chief activity of the subsidiary includes both R&D and other functions, such as sales or manufacturing, we have not considered the subsidiary as a laboratory. This is because the chief task of such subsidiaries is to support the collocating functions, and the decision to own it would be based on factors different from those for laboratories.

By following this procedure, we recognised 47 firms as the owners of overseas laboratories. Nearly 95% of the lab-owners own only a small number of laboratories: 68% of them own only one laboratory, while 26% own two. As an exception, one firm owned six laboratories. Table 2 shows the laboratory ownership pattern of 526 sample firms by the industry. More than 90% of the sample firms do not own any overseas laboratories. There are no overseas lab- owners in glass, cement, and ceramics, and steel and metal industries though these industries account for approximately 13% of the total sample. Among the owners of overseas labs, electronics (23.4%), transport machinery (19.1%), pharmaceuticals (17.0%), and chemicals (14.9%) form the majority. Particularly, approximately half of the pharmaceutical firms own overseas labs, and this confirms the highly research-oriented nature of the industry.

The locations of 68 laboratories are listed in Table 3. Approximately two- thirds of them are located in the US. California attracts the largest number of laboratories (13), followed by Michigan (7) and New Jersey (5). Eight laboratories are located in the UK. Hence, we see a strong geographic concentration in Anglophone countries. In other European countries, 5 laboratories were located in Germany and 3 in France and Netherlands. China attracts 4 laboratories, highest among Asian countries.

Table 4 depicts the entry modes of the overseas laboratories of sample firms. Of 68 laboratories, information regarding the mode of entry is available for 46 laboratories.

The survey by Frost, et al.(2002) on the formation of centres of excellence shows that R&D centres are more likely to be formed within an acquired subsidiary than in a greenfield subsidiary. This supports the view that technology acquisition is a motivational factor for international mergers and acquisitions. However, unlike the survey results, majority of the laboratories owned by our sample firms are greenfield, and the utilisation of local technological resources by acquisition or capital participation seem to be rare.

Explanatory variables are defined as below. The variables, data source, and summaries of the sample data are listed in Table 5. Firstly, the absorptive capacity of the firm as well as the scale of R&D activities are depicted by the R&D intensity, $RDINT_i$. $RDINT_i$ is defined as the ratio of the parent firms' internal R&D expenses to the parent firms' unconsolidated sales. Higher absorptive capacity and sufficient size for economies of scale in home R&D suggests higher incentive to own overseas laboratories; thus, the expected coefficient of $RDINT_i$ is positive. The R&D intensities of parent firms (called home R&D intensity), summarised by lab ownership and industry, are shown in the eighth and ninth columns of Table 2. These figures only include in-house R&D activities within Japan. In comparison to the 'no lab' group, the R&D intensities of the 'with lab' group is higher among the chemicals, pharmaceuticals, general machinery, electronics, and transport machinery sectors. On the other hand, R&D intensities of 'no lab' group are higher in food, oil and coal, and precision machinery sectors. The overseas R&D intensities are obtained as a ratio of the R&D expenditure abroad to the unconsolidated sales of the parent firms. The overseas R&D intensities are considerably lower than at the home R&D intensities, confirming the strong tendency for centralisation among Japanese firms. The only exception is observed in the case of 'with lab' groups in the pharmaceuticals sector.

We also expect the propensity to own an overseas laboratory to be higher when the scale of consolidated firm ($GSALE_i$) is larger. We obtained $GSALE_i$, global sales, by summing the unconsolidated parent sales and the aggregated subsidiary sales, and used its logarithm for the estimation[6].

As stated earlier, the effect of firm-level overseas experience is ambiguous. The units of analysis in former studies are primarily subsidiary-level, and the overseas experience of each subsidiary is used in the empirical analyses. However, this study adopts firm-level experience (EXP_i) and the length of operation of the oldest overseas subsidiaries owned by the firm, as its units. Figure 1 depicts the year of the establishment of the first overseas subsidiaries, which is used as an explanatory variable in our analysis. The substantial increase in subsidiary establishment was observed in the second half of the 1980s. This matches with the so-called 'economic bubble period' in Japan. However, except for that period, the process of subsidiary establishment is almost evenly spread over time. Although the oldest subsidiary in the sample was established in 1936, the continuous establishment of overseas subsidiaries commenced from the end of the 1960s. Figure 2 shows the establishment year of overseas laboratories indicating that a pronounced concentration was observed during the second half of 1980s. Despite the economic depression after the bubble, the establishment of the overseas laboratories continued into the 1990s.

Regarding managerial characteristics of firms, we have introduced three sets of variables namely, commissioned research to non-affiliated organisations and affiliated firms ($NACR_i$, ACR_i), and technology acquisition ($TACQ_i$) as proxies for capabilities to cope with external research resources.

In terms of commissioned research, the firm outsources the research task to a commissioned party, which could either be an affiliated firm or a non-affiliated organisation, such as a university, public research organisation, or research firm. The commissioned party generally undertakes the contracted research task independent of

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6 Although it is preferable is to use consolidated sales to depict global sales, our sample includes non-listed firms and such figures are not available. Note that GSALE, which is the sum of parent sales including exports and the aggregated subsidiary sales, might have a problem of double counting the exports from parent firms. In order to check such a bias, we used parent sales instead of GSALE; however, the main results were unaffected.

the commissioning party. After completion of the research task, the research output and possibly its property rights will be transferred to the commissioning party. The definability of commissioned research is low since the contract has to be signed before the research is undertaken. The predictability is also low, particularly when a relatively-basic research-task is outsourced to universities or research organisations, because the uncertainty of producing any research output is high.

The variables for commissioned research to non-affiliated organisations, $NACR_i$ and to affiliated firms, ACR_i, are the proportion of expenses on each resource to the corporate R&D related expenditure[7]. The denominator is the sum of expenditures on internal R&D, commissioned research (including expenses for foreign organisations), and technology acquisitions (including acquisition from foreign organisations). It should be noted that the expenditure on foreign universities and public research institutions are excluded from the numerator of $NACR_i$ and ACR_i in order to eliminate the possible influence of overseas laboratories ownership on the commissioned researches abroad[8]. Since it is hypothesised that a high reliance on external research resources, which have low definability and predictability, associates positively with overseas laboratory ownership, the coefficients of both $NACR_i$ and ACR_i are expected to be positive. Furthermore, the magnitude of the coefficient of ACR_i is expected to be larger than that of $NACR._i$ since the management difficulties of quasi-external organisations should be similar to those of affiliated firms rather than non-affiliated organisations, which are completely 'external.'

On the contrary, definability and predictability of technology acquisition are high. The

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7 Firm A is considered to be an affiliated firm of firm B, when firm B is either (1) the parent firm of firm A, (2) a subsidiary of firm A, or (3) firm A makes more than 20% but less than 50% of the investments in total shares /capital stock of firm B. The *Basic Survey of Japanese Business Structure and Activities* of MITI has data on 'the proportion of expenses to affiliated firms.' Thus we used this information in dividing the expenses on commissioned research into affiliated firms and non-affiliated organisations.

8 To be more accurate, this figure may still include the expenses on firms abroad. The SOBA defines a foreign affiliate as a foreign company with more than 10% of its share owned by a Japanese multinational. Therefore, ACR can include the expenses on overseas subsidiaries and NACR can include those of foreign firms with less than 10% of the stocks owned by a Japanese parent firm.

licensee buys technology, mostly by trading the property rights. The licensee needs to possess an adequate absorptive capacity and invest additional R&D efforts before converting the acquired technology into a profitable innovation. However, the research output is already obtained and the property rights are defined before the trade. Thus, unlike commissioned research, the definability and predictably of technology acquisition should be high. The variable for technology acquisition, $TACQ_i$, is defined as the proportion of expenditure on licensed patents owned by domestic organisations[9,10] to R&D related expenditure. Thus, the denominator is the same as that of $NACR_i$ and ACR_i. The payments made to foreign organizations are excluded, once again, in order to eliminate the positive effect of overseas laboratory ownership on technology acquisition from foreign organisations. Since the definability and predictability of technology acquisition are high, $TACQ_i$ is expected to have no particular influence on overseas laboratory ownership.

Despite that, we have to be cautious about the possibility that $NACR_i$, ACR_i, and $TACQ_i$ serve as proxies not only for the management capabilities but also for the absorptive capacity of firms. After controlling internal R&D expenditure by $RDINT_i$, a high $NACR_i$, ACR_i, or $TACQ_i$ indicates large total R&D expenditure including external (procured) R&D. Absorptive capacity is developed through the accumulation of knowledge in certain fields and corporate R&D contributes to the creation of such a knowledge base (Cohen and Levinthal, 1989). Although the main source of absorptive capacity is internal R&D activities, successful absorption of research output obtained by commissioned research or technology acquisition can also contribute to the development of absorptive capacity. Furthermore, the positive effects of $NACR_i$, ACR_i, and $TACQ_i$ on the likelihood of overseas ownership might also result from increased absorptive capacity due to an expansion of total R&D activities.

9 We cannot deny the possibility that this figure includes the payments made to Japanese affiliates of foreign firms.

10 This figure indicates the payments made to licensors in FY1997, and there can be time lag between the actual introduction of licensed technology and the payments. Moreover, the amount of payments can fluctuate with sales if running royalty is adopted. Hence, we cannot deny the possibility that this figure may not correspond to the licensing activities of the firm in FY1997.

Table 6 summarises the average expenditure on external research resources by industry, comparing the figures for 'no lab' with those for 'with lab' firms. In terms of the proportion of 'conducting firms,' 33% of the sample firms, on average, conduct commissioned research to non-affiliated organisations, while only 9% of them spend on affiliated firms. With regard to technology acquisition, 29% of the sample incurs positive expenditure. The difference in the degree of utilising external research resources across industries is large. For example, pharmaceutical firms are distinctively active in such utilisation: 94% of the sample conducts commissioned research to non-affiliated firms, 47% for technology acquisition, while the utilisation of commissioned research to affiliated firms remains to 12% of the sample. It can be seen that the average expenditure of the 'with lab' group on external research resources is much larger than that of the 'no lab' group. Of all the resources, the gap in the total industry figures amounts to more than ten times. At the industry level, these gaps are particularly large among electronics firms: 'with lab' firms spend more than 50 times for any external resource. In terms of the size of average expenditure, the 'with lab' pharmaceutical firms show the largest amount for both affiliated and non-affiliated commissioned research. Interestingly, 'with lab' pharmaceutical firms do not spend much on domestic technology acquisition, whereas 'with lab' firms in electronics industry distinctly expend on it.

As for technological characteristics of industries, we have adopted three variables regarding the importance of information sources in commencing new R&D projects: university (*UNIV*) for science-orientation, and internal production section (*PROD*), and customers (*CUST*) for support-orientation. We use the industry-level survey result of Goto and Nagata (1996)[11]. This survey on R&D activities and innovation of

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[11] The result is presented according to the International Standard Industry Classification (ISIC) for the purpose of international comparison. In this study, we reclassified the results by Japan Standard Industry Classification (JSIC) and matched it with the METI industry codes, which are based on 4 digit JSIC codes. It should be noted that the METI industry codes correspond to the main businesses of the respondent firms. Thus, industry variables used here do not take into account the diversified activities of the sample firms. We would like to thank Akiya Nagata for the helpful comments on this re-aggregation procedure.

manufacturing firms in Japan was based on the *Yale survey* (Levin et. al., 1987; Klevorick et. al., 1995), and implemented in collaboration with the US and European researchers in 1994[12]. The questionnaire was sent to 1219 R&D performing, manufacturing firms with capitalisation of over 1 billion yen. Responses were received from 653 firms (52%). Herein this study, we focus on the source of information in commencing new R&D projects for the past three years. We used the proportion of firms that obtained information from each resource in commencing R&D projects to the total number of firms in the industry.

When the importance of information from universities is high, we consider science-orientation of the industry is high. Therefore, we hypothesise that *UNIV* associates positively with laboratory ownership, because firms with high *UNIV* are expected to realise a higher incentive to own an overseas laboratory in order to be geographically close to foreign centres of excellence. On the other hand, when an industry considerably appreciates the information from internal production, that is, high in *PROD*, we consider the support-orientation of that industry to be high. In this case, the expected sign of *PROD* is negative. We will examine another variable, *CUST*, which measures the industry-level support-orientation with respect to marketing. When the information from customers is valued highly in an industry, it is more likely to be support-oriented; thus, we expect negative effects on LAB_i.

In addition to the above variables, industry dummies are included in the estimation in order to control for the industry influence that could not be covered by the other industry variables, namely, *UNIV, PROD,* and *CUST*. 'The other industry' is used as the base.

5. Estimation results

The empirical findings are consistent with our hypothesis that the likelihood of owning overseas laboratories is associated with managerial characteristics of firms and technological characteristics of industries as well as the conventional firm

12 For the comparative study of the US and Japanese results, see Cohen et.al. (2002).

characteristics. The estimation results of probit regressions are summarised in Table 7 (subscript i in variable names will be suppressed hereafter). We regress the dependent variable, *LAB*, on R&D intensity of parent firm, global sales, overseas experience, familiarity with commissioned research and technology acquisition, and important information sources in R&D.

In all the equations, *RDINT*, the R&D intensity of the parent firm, has significantly positive coefficients. This estimated result is consistent with the hypothesis that technological capabilities, including absorptive capacity of firms, have a decisive influence on overseas laboratory ownership. Although this cross-sectional analysis can only confirm a positive relationship between the ownership likelihood and the R&D intensiveness without indicating the causality between them, the result agrees with the view that absorptive capacity as well as the sufficient economies of scale in R&D at home level increase the scope of appropriating the benefit from overseas laboratory ownership.

From this finding, we can draw some implications on the concern over hollowing-out of the 'source of technological competitiveness' to abroad. The research output of laboratories is expected to affect the technological competitiveness of firms. In that case, the estimation result implies that firms are less likely to own an overseas laboratory unless the parent firm has adequate domestic technological capabilities. In other words, internationalisation of research activities is constrained by the technological capabilities in the home country. It proceeds in a complementary manner, enforcing home and overseas research capabilities simultaneously, rather than substituting home laboratories. Moreover, it is found that firms cannot source external knowledge of a certain field unless they have made R&D investment in that field (Iwasa and Odagiri, 2003). When we consider the complementarity of home and overseas research activities together with this finding, sourcing from the host country does not occur in a unilateral manner: firms cannot simply go abroad and steal the technology they do not have.

The coefficient of global sales, *ln(GSALE)*, also shows a significant and positive association with *LAB* in all the equations. This result implies that when firms penetrate more into foreign markets and their prospect of appropriating the returns from innovated products worldwide improves, they tend to have their own overseas laboratories aboard. Therefore, as the internationalisation of corporate activities advances, establishment of overseas laboratories might increase, and possibly their utilisation of those as a means to source technological knowledge abroad might become increasingly prevalent.

Overseas experience of the firm, the logarithm of *EXP*, exhibits a significantly negative coefficient in all the equations. In other words, the firms that started overseas operation more recently tend to own overseas laboratories compared to the firms with longer experience abroad. Although we have to be cautious about the interpretation of this result since the overseas experience is measured at the firm level and not the subsidiary level, this result agrees with the unit-level analysis on centres of excellence (Frost, et al., 2002). However, it contradicts the analyses on the determinants of demand-oriented overseas R&D activities (Belderbos, 2003). One of the possible explanations for this negative association of overseas experience is that firms, which have recently established international competitiveness and are eager to strengthen it, possibly undertake technology-seeking R&D abroad. Firms that have already established their technological competitiveness within the home country and have started internationalisation from an early period do not find knowledge-sourcing from centre of excellence abroad beneficial enough considering the possible costs.

As for managerial characteristics, it is confirmed that *NACR* and *ACR*, the ratio of commissioned research to the non-affiliated organisations and affiliated firms respectively, both have positive association with the likelihood of overseas laboratory ownership. These are consistent with our hypotheses: active utilisation of commissioned research, with low definability and predictability, contributes to the development of capabilities to cope with external research resources. Then, such capabilities enable firms to cope with the task of managing overseas laboratories, of which organisational pattern is quasi-external for the firm, and the higher prospect of appropriating the benefits from overseas laboratories raises the likelihood of ownership.

In terms of magnitude, the coefficient of *ACR* is larger than that of *NACR*. This result is also consistent with our hypothesis that the difficulties in managing ‘quasi-external’ overseas laboratories should be more similar to those in managing affiliated firms, rather than completely external non-affiliated organisations. The active utilisation of commissioned research to affiliated firms might encourage the firm to establish concrete methods and channels to transfer the technological knowledge within the firm. However, it should be noted that there is a possibility that *ACR* includes commissioned research to overseas subsidiaries. Thus, a larger magnitude of *ACR*, compared to *NACR*, might suggest that the firms with high reliance on commissioned research to overseas subsidiaries tend to own overseas laboratories, that is, the existence of reverse causality.

The coefficients of technology acquisition from domestic organisations, *TACQ*, are shown to be robustly negative, but they are statistically insignificant. This result agrees with our hypothesis that the familiarity with technology acquisition with high definability and predictability does not contribute to the development of capabilities in external knowledge management; thus it does not have a particular influence on overseas laboratory ownership.

As noted earlier, there is a possibility that the positive influence of *ACR* and *NACR* is a result of increased absorptive capacity: an increase in *ACR* or *NACR*, after controlling internal R&D by RDINT, is equivalent to that of total corporate R&D including external R&D. Then, *ACR* and *NACR* can also be considered as proxies for absorptive capacity, if we assume that internal and external R&D have similar effects on the development of absorptive capacity. However, the estimation results confirm the additional contribution of commissioned research on overseas laboratory ownership: The predicted probability of overseas laboratory ownership measured at the mean of the dataset is 1.7%. An increase of 69 million yen in internal R&D activities, which is 1% of the average internal R&D expenditure, raises the probability by 0.02%, while a similar amount of increase in commissioned research to non-affiliated and affiliated firms contributes an increase of 0.05% and 0.18%, respectively. An additional contribution, at least, can be due to the increased managerial capabilities developed through the active employment of commissioned research, as we have hypothesised.

Recently, the utilisation of external research resources by Japanese firms has become unprecedentedly active, particularly in high-tech industries. In other words, distinctive shifts in the R&D boundaries of firms are observed (Odagiri, 2003). The accelerating speed of technological change, an increase in relative importance of scientific knowledge in innovation of firms, and increased necessity for employing complementary technologies have necessitated the firms to seek external research resources while focusing their technological strength in specific fields. If such a tendency continues, scope for the active employment of overseas research resources by the medium of overseas laboratories could possibly widen.

With respect to technological characteristics of industries, the coefficient of *UNIV* in all equations is robustly positive and is statistically significant. As the importance of information from universities increases, the likelihood of owning overseas laboratories also increases. This result supports the view that the firms in industries with a greater science-orientation tend to appreciate the benefits of geographical proximity to foreign centres of excellence. On the contrary, the coefficients of *PROD* and *CUST*, which represents the importance of internal information on production and marketing, are found to be negative as we hypothesised. Though statistically insignificant in (1), (2), and (3), these results may suggest that firms in industries with greater support-orientation do not find ownership of overseas laboratories beneficial.

Finally, eight industry dummy variables are included in equations (2) and (4) in order to see if the industry effects are sufficiently covered by the industry-level variables, *UNIV*, *PROD*, and *CUST*. Since the dummy variable for miscellaneous is suppressed, the coefficients for industry dummies indicate whether the intercepts for these industries are different from those of the miscellaneous. Most of the industry dummies do not exhibit significant results and the main results are unaffected by the inclusion of dummy variables, excluding *CUST* in equation (4). These results suggest that inter-industry differences in overseas laboratory ownership can be adequately depicted by the science-orientation and the support-orientation of industries.

6. Conclusion

Pioneering technology can never be developed without an accurate grasp of the state-of-the-art scientific and technological knowledge. Rapid progress of such knowledge is observed not only at home but also abroad. Thus, among the firms that are committed to generate break-through knowledge and technologies, effective knowledge sourcing across boundaries is increasingly important. Overseas laboratories of multinational corporations are indeed one of the crucial means to accomplish this task, benefiting from the geographical proximity to local scientific and technological resources.

This paper aimed to study the determinants of overseas laboratory ownership using the unpublished MITI data on 526 Japanese manufacturing firms. As we have examined, the objective and characteristics of overseas laboratories are distinctly different from those of support-oriented overseas R&D units. Therefore, in addition to the conventionally examined firm characteristics, we took into account managerial and technological characteristics, which are closely connected to research aspects of firms, in analysing the determinants of overseas laboratory ownership. The empirical results were shown to be consistent with our hypotheses. With regard to managerial characteristics, the capabilities to cope with external research resources, measured by the familiarity with commissioned research, were found to have a positive association with the ownership. Moreover, it was found that firms were more likely to own overseas laboratories when science orientation of the industry is strong. The other firm characteristics, proxied with the R&D intensity of parent firms, global sales, and overseas experience, were found to have a significant influence.

Overseas laboratories can potentially function as representative facilities to undertake knowledge sourcing on a global basis and contribute to the enhancement of corporate technological capabilities. However, the ownership of overseas laboratory is not yet prevalent even among firms that possess high technological capabilities and have internationalised their corporate activities. Nonetheless, we can infer from our results that there would be a greater scope for sourcing excellent research resources from distant foreign countries as firms develop their capabilities in employing external research resources effectively. Furthermore, active utilisation of overseas laboratories might be further encouraged as the technological fields of firms shift toward technological frontier, and firms increasingly necessitate the use of scientific knowledge in their R&D activities.

By this cross-sectional analysis, we have obtained a clue that the capability-aspect of knowledge management might influence the ownership of overseas laboratories. However, development of corporate capabilities has an evolutionary nature; therefore, it cannot be understood in a static manner. Furthermore, the possibility of simultaneity problem cannot be excluded in this cross-sectional dataset. Inevitable difficulties in measuring abstract concepts have also been realised, and the proxy attempted here should be further improved. Further research needs to be undertaken by improved analytical methodologies for accurately understanding the relation between the technological knowledge sourcing and the capabilities of firms.

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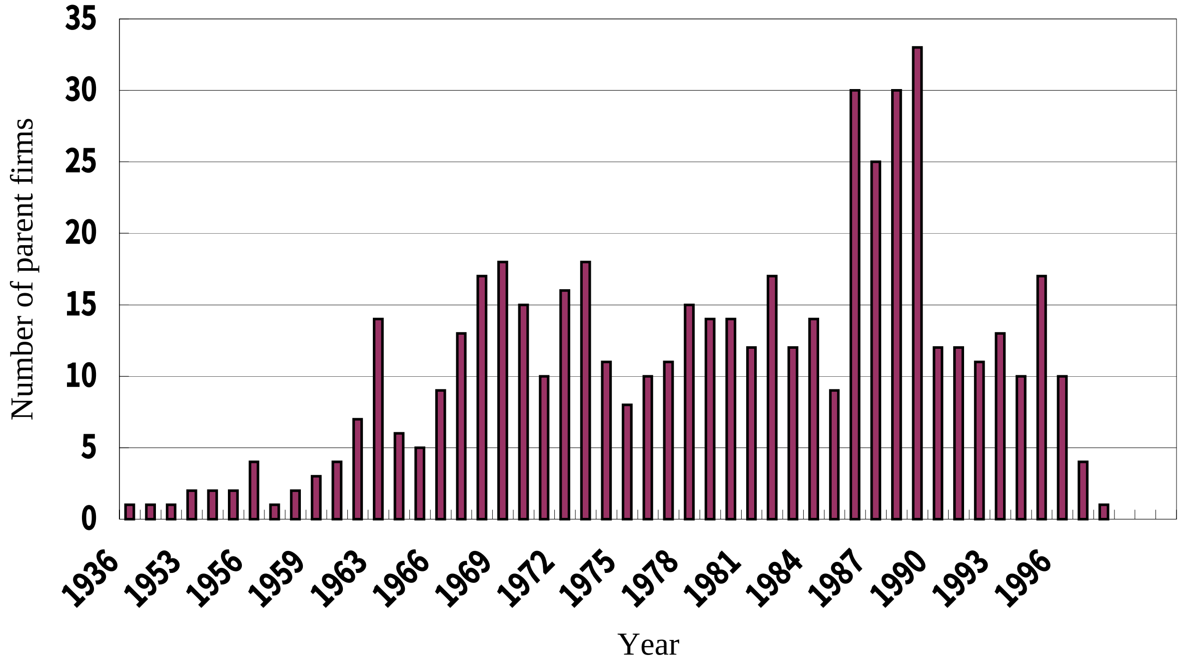
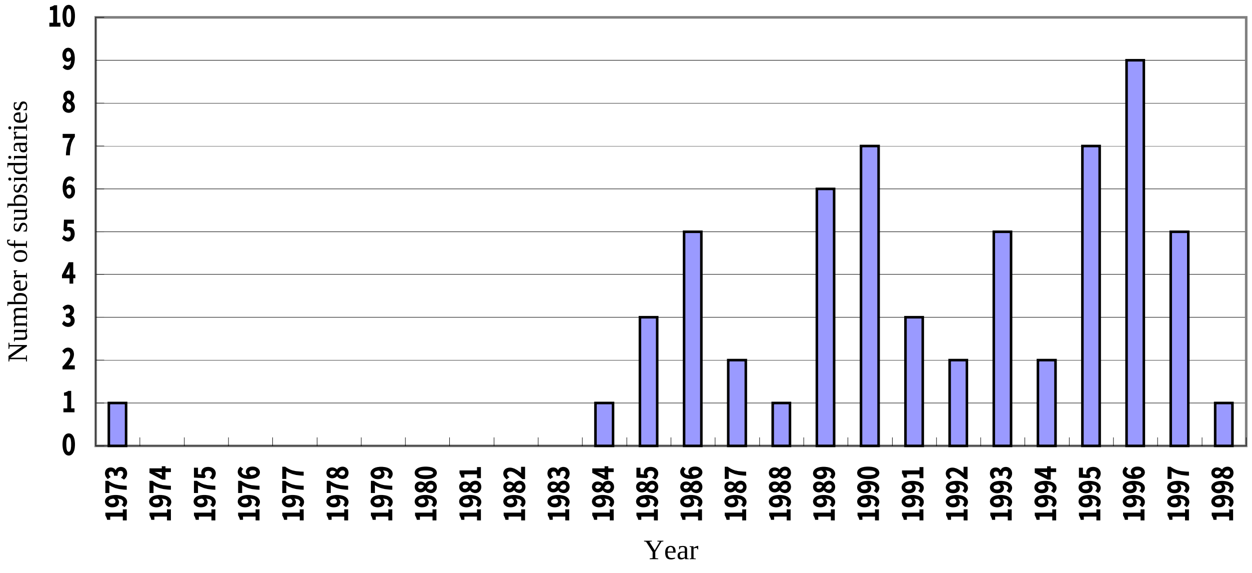
Figure 1. Establishment of the First Overseas Subsidiary



Sources: Calculated by the author from the *Survey of Overseas Business Activities* .

Figure 2. Establishment Year of Overseas Laboratories



Sources: Calculated by the author from the *Survey of Overseas Business Activities* .

Table 1. Sample Firms and All Manufacturing Firms with Subsidiaries Abroad: A Comparison

	Our Sample	Industrial Composition	All Manufacturing with subsidiaries abroad	Industrial Composition	(A)/(B)
Number of Subsidiaries	(A)		(B)		
Mean	8.048		5.713		1.41
Std.Dev.	13.884		11.252		
Min	1		1		
Max	207		207		
Parent Sales (unconsolidated)					
Mean	178,657.4		135,053.4		1.32
Std.Dev.	421,694.0		447,470.2		
Min	1,264		0		
Max	4,874,526		7,769,486		
Number of Parent Firms by Industry					
		(A)		(B)	
Food	24	4.6%	78	5.5%	0.82
Chemicals	68	12.9%	140	10.0%	1.30
Pharmaceuticals	17	3.2%	33	2.3%	1.38
Oil and coal	6	1.1%	15	1.1%	1.07
Glass, cement and ceramics	18	3.4%	48	3.4%	1.00
Steel and metal	48	9.1%	136	9.7%	0.94
General machinery	55	10.5%	159	11.3%	0.93
Electronics	113	21.5%	250	17.8%	1.21
Transport machinery	81	15.4%	178	12.7%	1.22
Precision machinery	13	2.5%	46	3.3%	0.76
Other manufacturing	83	15.8%	324	23.0%	0.69
Total	526	100%	1407		

Source: Calculated by the author from the *Survey of Overseas Business Activities* .

Table 2. Industrial composition and R&D intensities of sample firms: Ownership of overseas laboratories

	Number of parent firms						Home R&D intensity		Overseas R&D intensity	
		%	no lab	%	with lab	%	no lab	with lab	no lab	with lab
Food	24	4.6%	22	4.6%	2	4.3%	1.10%	0.91%	0.25%	0.10%
Chemicals	68	12.9%	61	12.7%	7	14.9%	4.30%	4.51%	0.09%	0.79%
Pharmaceuticals	17	3.2%	9	1.9%	8	17.0%	8.46%	10.60%	0.51%	10.62%
Oil and coal	6	1.1%	5	1.0%	1	2.1%	0.52%	0.34%	0.01%	0.08%
Glass, cement and ceramics	18	3.4%	18	3.8%	0	0.0%	2.85%		0.06%	
Steel and metal	48	9.1%	48	10.0%	0	0.0%	2.19%		0.03%	
General machinery	55	10.5%	51	10.6%	4	8.5%	3.65%	6.69%	0.05%	0.70%
Electronics	113	21.5%	102	21.3%	11	23.4%	5.00%	6.62%	0.18%	0.73%
Transport machinery	81	15.4%	72	15.0%	9	19.1%	3.48%	4.83%	0.08%	0.71%
Precision machinery	13	2.5%	11	2.3%	2	4.3%	6.31%	4.05%	0.18%	0.48%
Other manufacturing	83	15.8%	80	16.7%	3	6.4%	1.50%	1.79%	0.16%	0.08%
Total	526	100%	479	100%	47	100%				

Notes: R&D intensities are obtained by R&D expenses of parents or subsidiaries/ unconsolidated sales of parent firms.
Home R&D expenses do not include payments to commissioned R&D, licensing, and overseas R&D.

Source: Calculated by the author from the *Survey of Overseas Business Activities* and the *Basic Survey of Japanese Business Structure and Activities* .

Table 3. Location of overseas laboratories

Country / State	Number of laboratorie	
Brazil	1	
China	4	
France	3	
Germany	5	
Israel	1	
Italy	1	
Korea	1	
Netherlands	3	
Taiwan	1	
UK	8	
US	40	
of which		
Arizona		1
Illinois		4
Ohio		3
California		13
New Jersey		5
New York		2
Nevada		1
Pennsylvania		1
Massachusetts		2
Michigan		7
Washington		1
Total	68	40

Source: Calculated by the author from the *Survey of Overseas Business Activities* and *Toyo Keizai*

Table 4. The entry mode of overseas laboratories

	Green Field	Joint Venture	Capital Participation	Acquisition	Total
Food					
Chemicals	5	1		1	7
Pharmaceuticals	7	2			9
Oil and coal	1				1
Glass, cement and ceramics					
Steel and metal					
General machinery	3				3
Electronics	9	1		2	12
Transport machinery	11		1		12
Precision machinery	1				1
Other manufacturing		1			1
Total	37	5	1	3	46

Note: Among 68 sample laboratories, information on entry mode is available for 46 of them.

Source: Calculated by the author from the *Survey of Overseas Business Activities*

Table 5. List of variables, data source, and data summary

(obs=526)

Variable	Description	Data source	Mean	Std. Dev.	Min	Max
- Dependent variable -						
LAB	LAB=1 if the firm owns any overseas R&D lab	Toyo	0.0894	0.2855	0	1
- Conventional firm characteristics -						
RDINT	R&D intensity of parent firm (1997parent R&D expenses/1997 parent unconsolidated sales)	SOBA 1998, BSA	0.0310	0.0294	0	0.1818
ln(GSALE)	Logarithm of SALE		11.0824	1.5727	7.2457	16.0768
EXP	The number of months since the establishment of the first overseas subsidiary	SOBA 1999, Toyo	221.7034	129.4085	12	744
ln(EXP)	Logarithm of EXP		5.1456	0.7989	1.0986	6.6134
- Managerial characteristics -						
NACR	The ratio of commissioned research to non-affiliated organisations in total R&D related expenses	BSA	0.0344	0.1308	0	1
ACR	The ratio of commissioned research to affiliated companies in total R&D expenses	BSA	0.0099	0.0575	0	0.8
TACQ	The ratio of licensing payment to domestic organisations in total R&D related expenses	BSA	0.0161	0.0988	0	1
- Technological characteristics -						
UNIV	The importance of information from university in launching new project in the industry	Goto and Nagata	0.3939	0.1349	0.2348	1
PROD	The importance of information from internal production division in launching new project in the industry	Goto and Nagata	0.5816	0.1419	0.2070	1
CUST	The importance of information from customers in launching new project in the industry	Goto and Nagata	0.7536	0.1535	0.3450	1
SUPRD	Dominance of support type overseas R&D activities in the industry	SOBA 1993	0.4125	0.1481	0.0750	0.7143

BSA: *The Basic Survey of Japanese Business Structure and Activities* (1998 edition)
SOBA: *The Survey of Overseas Business Activities* (for each edition)
Toyo: *Kaigai Shinshutsu Kigyo Souran* (1999 edition)
Goto and Nagata (1996)

Table 6. Averages expenditures on external research resources, by industry and by overseas lab ownership (in million yen)

	Commissioned research								Technology acquisition			
	to affiliated				to non-affiliated							
	no lab (A)	with lab (B)	(B)/(A)	% of conducting firms	no lab (A)	with lab (B)	(B)/(A)	% of conducting firms	no lab (A)	with lab (B)	(B)/(A)	% of conducting firms
Food	0.7	14.9	22.5	8%	184.9	195.6	1.1	38%	41.9	488.0	11.7	29%
Chemicals	13.7	279.5	20.4	12%	195.4	1,457.9	7.5	51%	72.5	204.0	2.8	35%
Pharmaceuticals	87.4	1,153.3	13.2	12%	737.6	4,259.3	5.8	94%	236.7	54.9	0.2	47%
Oil and coal	0.0	0.0		0%	319.8	0.0	0.0	67%	46.0	26.0	0.6	50%
Glass, cement and ceramics	6.3		0.0	11%	15.6			22%	69.4			17%
Steel and metal	26.5		0.0	6%	55.4			27%	23.5			33%
General machinery	76.6	447.3	5.8	11%	97.1	171.0	1.8	27%	11.8	400.0	33.9	33%
Electronics	6.9	348.2	50.6	6%	20.3	1,390.6	68.5	20%	27.9	1,379.8	49.5	35%
Transport machinery	23.5	452.2	19.3	7%	178.7	944.3	5.3	37%	6.4	37.2	5.8	25%
Precision machinery	54.6	136.8	2.5	15%	39.1	5.7	0.1	31%	11.4	61.5	5.4	38%
Other manufacturing	18.4	96.5	5.2	13%	28.9	868.2	30.0	23%	9.1	10.0	1.1	13%
Total	23.8	456.7	19.2	9%	103.9	1,527.0	14.7	33%	31.0	428.4	13.8	29%

Notes: 1. The expenditures on commissioned research do not include those to foreign universities and research institutes

2. Zero external R&D performing firms are included in the calculation of the averages.

3. % of conducting firms is obtained for each industry by 'number of firms with positive figures in idustry regardless the laboratory ownership/ number of firms in the industry'.

Source: Calculated by the author from the *Survey of Overseas Business Activities* and the *Basic Survey of Japanese Business Structure and Activities*.

Table 7. Estimation results:

Dependent variable: LAB=1 if the firm own more than 1 overseas research laboratory

	(1)	(2)	(3)	(4)
RDINT	11.5694	11.1929	12.9522	11.9119
	(3.43)***	(2.93)***	(4.09)***	(3.20)***
ln(GSALE)	0.6538	0.6563	0.6367	0.6561
	(8.05)***	(7.78)***	(7.82)***	(7.81)***
ln(EXP)	-0.3106	-0.3137	-0.2917	-0.3270
	(-2.46)**	(-2.32)**	(-2.26)**	(-2.43)**
NACR	1.3393	1.3899	1.3381	1.2932
	(1.93)*	(1.95)*	(1.83)*	(1.82)*
ACR	4.2320	4.3466	4.3021	4.5627
	(4.42)***	(3.93)***	(4.43)***	(4.16)***
TACQ	-0.2770	-0.3384	-0.2671	-0.3649
	(-0.17)	(-0.19)	(-0.15)	(-0.20)
UNIV	1.4258	2.3006	1.1951	2.1766
	(2.23)**	(2.04)**	(1.72)*	(2.01)**
PROD	-0.7791	-1.8897		
	(-1.05)	(-1.55)		
CUST			-0.9098	-2.9545
			(-1.40)	(-2.73)***
food		0.1210		-0.5547
		(0.20)		(-0.82)
chemical		0.0310		0.2739
		(0.05)		(0.59)
pharmaceutical		-0.8180		-1.1578
		(-0.68)		(-1.10)
oil		0.0712		-0.5011
		(0.09)		(-0.60)
machine		0.0047		0.4493
		(0.01)		(0.95)
electronics		0.3287		0.6786
		(0.75)		(1.65)*
transport		0.4785		0.6052
		(1.12)		(1.42)
precision		0.0337		0.0171
		(0.04)		(0.02)
Constant	-8.3213	-8.2014	-7.9512	-7.1171
	(-7.53)***	(-6.31)***	(-6.77)***	(-5.67)***
No. of observations	526	526	526	526
Log Likelihood	-94.76	-93.00	-94.31	-90.81

Notes: In parentheses are z statistics. They are calculated based on robust standard errors to correct for heteroscedasticity. The level of statistical significance is as follows: *** 1%, ** 5%, *10%.

Appendix Table. Correlation coefficients

(obs=526)

	Correlation coefficients									
Variables	LAB	RDINT	ln(GSALE	ln(EXP)	NACR	ACR	TACQ	UNIV	PROD	CUST
LAB	1									
RDINT	0.3062	1								
ln(GSALE)	0.3693	0.2396	1							
ln(EXP)	0.0996	0.1336	0.4407	1						
NACR	0.0851	-0.0904	0.0095	0.0027	1					
ACR	0.0911	-0.0007	-0.0207	0.0257	0.0087	1				
TACQ	-0.0137	-0.0891	-0.0006	-0.0117	-0.0269	-0.0191	1			
UNIV	0.2249	0.2809	0.0422	-0.0343	0.1159	-0.0342	0.0058	1		
PROD	-0.1793	-0.2983	-0.0409	0.0216	-0.0731	-0.0696	-0.0014	-0.1828	1	
CUST	-0.1873	-0.072	-0.0722	0.0609	-0.1278	-0.0214	0.0233	-0.2832	0.6913	1

要旨

企業が海外の研究資源から知識を得ようとする際、海外に保有する研究所が大きな役割を果たすことが知られている。本論文は日本の製造業企業５２６社をサンプルとして、企業の海外研究所保有になんらかの系統だったパターンが見られるかどうかを検証するものである。ここでは、海外研究所の特性が、現地での製造・販売活動のサポートを主な目的とする海外研究拠点と異なる点に注目し、企業の研究開発集約度や規模、海外での操業経験といった企業特性に加えて、企業の知識マネージメント能力や、産業ごとの技術の性質の影響を分析に取り入れた。分析の結果、研究集約度が高く、国際レベルでの企業規模が大きく、外部の研究資源への対応能力が高く、サイエンス性向が高く現地サポート性向が低い産業に所属する企業ほど、海外研究所を保有する傾向が見られることが確認された。現時点の日本企業の海外研究所保有は限定的なものであるが、今後企業の研究開発における境界が変化し、サイエンス型知識の重要性が増すにつれて、海外研究所の利用、さらにそれを経由した現地の研究資源の活用可能性が増すことが、この研究結果によって示唆される。