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What determines knowledge sourcing from host locations of overseas R&D operations?: A study of global R&D activities of Japanese multinationals

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ABSTRACT

What determines knowledge sourcing from host locations of overseas R&D operations? We investigate factors that influence the extent to which overseas R&D laboratories source knowledge from host locations. Drawing on both the capabilities perspective and the embeddedness perspective, we have developed a conceptual model and then examined it empirically focusing on overseas R&D labs of Japanese multinationals. Statistical findings from negative binomial regressions show that both technological capabilities of the lab and external embeddedness in the local scientific and engineering communities matter.

1. Introduction

The globalization of research and development (R&D) is an important component of the ongoing trend towards globalization of the economy (Guellec and van Pottelsberghe de la Potterie, 2001). According to Gerybadze and Reger (1999), the degree of globalization of R&D measured by various indicators such as the proportion of R&D expenditure has increased substantially since the 1990s in most of the large R&D-intensive multinational corporations (MNCs). Zander (1994) found that in 1990, 40% of all technological activities of a sample of Swedish MNCs were carried out abroad, as compared to only 30% in 1980. Kuemmerle (1999) also found that 32 large MNCs in the pharmaceutical and electronics industries in his survey undertook 25.8% of their R&D efforts outside of their home countries' boundaries in 1995, compared to only 6.2% in 1965.

Recently, the nature of global R&D activities has evolved substantially in many leading MNCs from traditional "home-base exploiting (HBE)" ones to "home-base augmenting (HBA)" ones (Kuemmerle, 1999). In other words, an increasing number of overseas R&D labs have begun to explore new knowledge from host locations and even globally beyond their traditional roles, by exploiting and extending their existing technologies originally developed in their home countries (Birkinshaw et al., 1998; Cantwell and Mudambi, 2005). By acquiring new knowledge abroad, these home-base augmenting labs help MNCs develop technologies and products to serve not only the host market but also the home and the global markets (Ambos et al., 2006).

This trend is salient even among Japanese MNCs, which are latecomers to R&D globalization compared to U.S. and European firms (Asakawa, 2001a). Although the proportion of R&D internationalization by Japanese firms is minimal (Pearce, 1989; Cantwell and Zhang, 2006) and the share of foreign affiliates in industrial R&D remains at less than 5% for Japan (OECD, 2007), Japan's overseas R&D ratio (local R&D expense/domestic R&D expense) increased from 2.9% in 1997 to 4.1% in 2002 (METI, 2003; Nomura Research Institute, 2005).

As MNCs increase their global R&D efforts and expand the roles of their overseas R&D labs, globalization of R&D has drawn growing attention from both academic scholars and practitioners. However, existing studies in this stream have focused largely on economic and political aspects of R&D globalization, and thus they offer little insight into how to manage overseas R&D activities. Penner-Hahn and Shaver (2005) contend that, despite the burgeoning literature that enjoins firms to globalize their R&D in order to access new

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technologies, we know little about the conditions that induce MNCs to do so. In addition, recent research on global R&D activities has largely "missed the opportunity for theoretical advancement that might arise from drawing upon more general theories of innovation and technological progress in organizations" (Frost, 2001: 101). Few studies have investigated mechanisms affecting knowledge acquisition, development, and transfer in global R&D activities (Ambos et al., 2006; Frost and Zhou, 2005).

In this paper, we seek to advance the study of global R&D activities by proposing and testing a model of how overseas R&D labs of MNCs source knowledge from host locations. To take a more theoretical and balanced perspective, we draw on both the capability perspective from evolutionary economics and the embeddedness perspective from organizational theory. Based on this multi-disciplinary framework, we develop hypotheses regarding overseas lab-level characteristics that influence the sourcing of knowledge from host locations.

Focusing on the HBA type of overseas R&D labs of Japanese multinationals, we collect data on these lab characteristics from both lab-level surveys and U.S. patent (citation) data, which we use to trace knowledge flows from host locations to overseas labs. We then employ negative binomial regressions to investigate factors influencing the level of knowledge sourced from host locations. Statistical results support our main hypotheses regarding both lab capabilities and external embeddedness in host locations.

2. Literature review and theory

MNCs spend much of their R&D in foreign countries to develop links to local scientific and technical communities in order to source complementary knowledge (Florida, 1997). Yet, few studies have shown what factors affect how extensively MNCs source knowledge from these countries, even though these labs are apparently an excellent way for MNCs to outsource knowledge. In this section, we first analyze the characteristics and recent trends of global R&D activities of MNCs based on existing literature. Then, drawing on both the capability perspective and the embeddedness perspective, we propose a conceptual model of factors influencing the level of knowledge sourcing from host locations by overseas R&D labs.

2.1. Literature review

Over the past three decades, both the extent to which MNCs perform R&D outside their home countries and the types of R&D they do have changed considerably. During earlier periods of global expansion (the 1960s and 1970s), MNCs first built up foreign sales and manufacturing operations abroad. In later phases (late 1970s/early 1980s), efforts were directed towards supporting foreign subsidiaries with complementary design and development capabilities (Gerybadze and Reger, 1999). Although the trend towards R&D globalization had become apparent in the 1970s, it became a widespread phenomenon only as recently as in the late 1980s thanks to advances in information and communication technologies that served to connect dispersed R&D activities (Gassmann and von Zedtwitz, 1999). As of 1995, the ratio of overseas R&D to total R&D expenditures already exceeded 30% for European MNCs, which were more proactive about foreign R&D activities than Japanese and American MNCs. According to the National Science Board (1996), between 1985 and 1993, overseas investment in R&D by U.S. firms increased three times as fast as domestic R&D, while in the United States, overseas R&D expenses reached 10% of overall R&D investment, up from 6% in 1985.

Further, although MNCs originally focused most of their foreign R&D on adapting home-developed technologies to foreign production conditions (Håkanson, 1989), Dunning (1993) and Shan and Song (1997) found that MNCs have recently accelerated their efforts to explore and develop new technologies overseas. In a recent survey, almost 38% of overseas R&D labs were classified as "home-base augmenting (HBA) R&D labs" seeking knowledge in host locations, while those classified as "home-base exploiting (HBE) labs" still focused on exploiting and modifying technologies developed in the home countries of MNCs (Kuemmerle, 1999). Empirical evidence also supports the knowledge-seeking activities of overseas R&D labs. Singh (2008) found that in technologically advanced countries relative to the remaining countries in his sample, subsidiaries of foreign MNCs gain significantly more than they contribute in terms of knowledge. In March's (1991) terms, an increasing number of overseas R&D labs began to shift their main focus of learning from "exploitation" to "exploration" (Frost et al., 2002; Makino et al., 2002; Cantwell and Janne, 1999).

In response to the shift in the role of overseas labs, scholars began to focus more extensively on how MNCs use foreign direct investment (FDI) not only to "push" or exploit their existing advantages in exploiting foreign markets but also to "pull" or explore new resources and capabilities from centers of innovation by acquiring or learning about complementary technologies (Shan and Song, 1997). When knowledge is sticky and remains confined within narrow geographical boundaries (Jaffe et al., 1993), a manufacturing or R&D location serves as an important source of competitive advantage (Almeida, 1996). Firms located in innovative regions such as the Silicon Valley have greater access to new technological knowledge compared to their spatially distant counterparts. MNCs can develop a competitive advantage by being located in overseas technological centers of excellence that offer differentiated streams of new knowledge, so long as they can learn to identify, transfer, and integrate the knowledge that they derive in host locations throughout their operations (Almeida et al., 2002).

Empirical research using industry-level data supports the arguments that MNCs employ FDI to source knowledge. Cantwell (1989) found that MNCs are especially attracted to centers of innovation as a means of broadening their knowledge bases. At the firm level, Almeida (1996) found that U.S. subsidiaries of foreign MNCs use knowledge derived from the regions where these subsidiaries are located significantly more than U.S. firms from the same region. The result shows that MNCs in the semiconductor industry use FDI to access local information channels and source location-specific knowledge. Similarly, Shan and Song (1997) found that in the biotechnology industry, foreign MNCs invest in American biotechnology firms that patent frequently, thus sourcing country-specific, firm-embodied technological advantages. Almeida et al. (2002) showed empirically that in the semiconductor industry, internal mechanisms within MNCs are more effective than markets and alliances for transferring technology across borders.

Iwasa and Odagiri (2004) found that R&D investment contributed to the performance of overseas R&D. According to them, the overseas location's technological capabilities contribute to the lab's R&D performance if the lab has taken up the research role (as opposed to the supporting role). However, because this study focuses on economic analysis, organizational and strategic factors affecting local knowledge sourcing were beyond the scope of the analysis. Penner-Hahn and Shaver (2005) suggested the importance of technological capability in increasing performance of international R&D. However, it was not specified whether the technological capability would be more necessary at the local lab or at the firm level. Frost and Zhou (2005) found that R&D copractice between R&D units was important for reverse knowledge integration from overseas units to headquarters. However, it was beyond their scope to identify the specific role and capability of each overseas unit for reverse knowledge sourcing.

As seen above, despite the growing literature on technology-seeking R&D abroad, few studies have investigated specific mechanisms or factors that influence the level of knowledge sourcing from host locations of overseas R&D labs. Drawing on evolutionary economics and the resource-based view, Song and Shin (2008) empirically examined factors influencing the level of knowledge sourcing from host locations of overseas R&D labs to headquarters R&D labs at home. In this study, we take a further step by investigating what factors determine knowledge flows from host locations to overseas R&D labs themselves.

2.2. Theory and hypotheses

Recent studies have often found capabilities and network structure as key determinants of knowledge outsourcing and transfer. For example, Tsai (2001) found that network position and absorptive capacity are closely related to innovation and performance of business units. Similarly, Frost and Zhou (2005) showed that technical and social dimensions were two main dimensions underlying the process of knowledge integration. They suggested that the former refers to absorptive capacity and the latter refers to social capital developed in embedded relationships.

To examine how characteristics of overseas labs influence the level of knowledge drawn from host locations in their innovative activities, we also develop a conceptual model based on both the capability perspective derived from evolutionary economics and the embeddedness perspective derived from social capital theory. Evolutionary economics views a firm as a set of unique routines and capabilities (Nelson and Winter, 1982). Accordingly, the type and level of firm capabilities at a certain point in time in the evolutionary process would influence a firm's behavior, such as organizational learning and innovation, in the subsequent period. On the other hand, the social capital view of organizational theory highlights the role of interfirm or interpersonal relations in organizational learning and innovation (Burt, 1992). Valuable knowledge is often embedded in social relations and structures (Granovetter, 1985). Thus, how a firm is embedded in a larger community or network to which it belongs often exerts a significant influence on learning and innovation (Saxenian, 1994; Andersson et al., 2001). Given that an overseas R&D lab is embedded in both the internal knowledge network of the host location and the external global network of the parent company, how an overseas R&D lab is embedded in these external and internal networks would also determine the level and type of knowledge outsourced.

Thus, to investigate knowledge sourcing from host locations, we draw on both the capability perspective and the embeddedness perspective. Despite conventional thinking that suggests their importance, no empirical studies show the type and extent of prior capability and/or external/internal embeddedness that contribute to knowledge sourcing. Treating capability and embeddedness as two separate dimensions while considering them simultaneously would help us determine their relative degree of impact on knowledge sourcing.

Fig. 1 summarizes our conceptual model.

2.2.1. Lab capabilities and sourcing of local knowledge

We first develop a hypothesis based on the capability perspective. Among various firm-level factors that influence MNCs' propensity to source knowledge from host locations of overseas R&D labs, MNCs' technological capabilities, especially those of their overseas R&D labs, seem to be most important. To identify, acquire, and assimilate valuable external knowledge, especially tacit knowledge, a firm must possess considerable absorptive capacity (Cohen and Levinthal, 1990) in related technological areas. Cumulative experience with a technology often determines the recipient's absorptive capacity to acquire such tacit knowledge. Firms seek to acquire knowledge externally when there is a significant knowledge gap between them and industry leaders. Yet firms that develop substantial cumulative experiences and knowledge bases are better positioned to acquire target technologies (Leonard-Barton, 1995).

The absorptive capacity view suggests that MNCs with strong technological capabilities at both the overseas lab level and the headquarters level are superior in assimilating and extending knowledge sourced from host locations. Penner-Hahn and Shaver's analysis of international R&D expansions by Japanese pharmaceutical firms (2005) found, for instance, that firms benefit from international R&D when they possess existing technological capabilities in underlying technologies. The absorptive capacity view implies that the level of knowledge sourced from host locations should be higher in MNCs with strong technological capabilities than it is in MNCs with weak technological capabilities, especially at the lab level.

Frost (2001) showed that the strength of a lab's technological capabilities would predict whether the lab-level innovation builds upon home or host country ideas. Overseas R&D labs with weak technological capabilities tend to rely more on knowledge transferred from parent company labs at home. However, as an overseas lab improves its technological capabilities and absorptive capacity, it would be more likely to actively seek knowledge that resides in the host location as a basis of its innovative activities, up to a certain point. Similarly, Håkanson and Nobel (1993) suggested that the technological orientation of overseas R&D labs may evolve over time toward a more autonomous set of activities that are less closely aligned to the existing knowledge base of the parent firm, as they improve their own technological capabilities.

However, above a certain threshold level of lab capabilities, an overseas R&D lab with strong technological capabilities may upgrade itself from the 'local innovator' that mostly seeks knowledge of the host location to the 'global innovator' that explores knowledge globally beyond the boundary of the host location (Medcof, 1997; Nobel and Birkinshaw, 1998; Singh, 2005). Enhanced absorptive capacity of an overseas lab augments the ability to sense and acquire new knowledge from outside host locations that are unfamiliar and distant, while local knowledge becomes redundant at some point, with its value-adding quality declining accordingly.

For example, overseas R&D labs of Japanese companies such as NEC, Hitachi, Kobe Steel, and Mitsubishi Electric evolved from local innovators to global innovators that draw not only on locally sourced knowledge but regionally or globally sourced knowledge beyond the national border (Asakawa and Lehrer, 2003). According to Asakawa and Lehrer, many European R&D centers of Japanese firms play the role of "regional innovation relays," i.e., sensing and extracting regionally dispersed R&D resources and relaying them for global use.

Hence, we propose an inverted U-shaped relationship between technological capabilities of an overseas lab and the level of knowledge sourcing from the host location.

Hypothesis 1. An inverted-U relationship is predicted between an overseas R&D lab's capabilities and the level of knowledge sourcing from the host location; that is, an overseas R&D lab with moderate levels of technological capabilities will source knowledge from the host location more than do overseas R&D labs with lower or higher levels of technological capabilities.

2.2.2. Embeddedness and sourcing of local knowledge

The second perspective that we take to investigate overseas R&D activities is the social capital view of organizational theory that highlights the role of interfirm or interpersonal relations in organizational learning and innovation. The central proposition of social capital theory is that networks of relationships constitute a valuable resource for the conduct of social affairs, providing their members with collectively owned capital (Bourdieu, 1986).

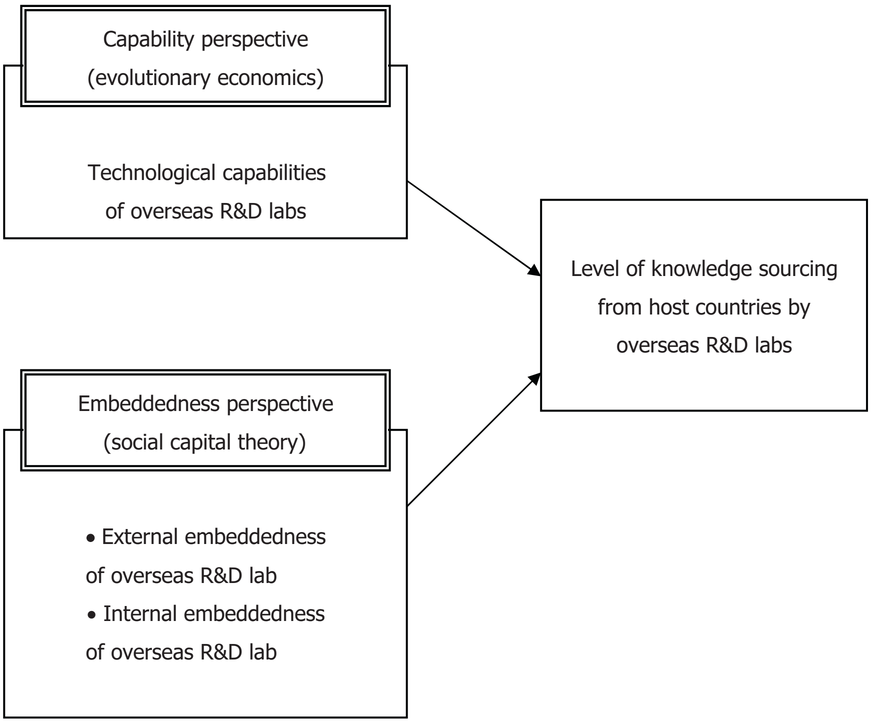

Fig. 1. Research model.

According to Nahapiet and Ghoshal (1998), social capital often plays an important role in the development of intellectual capital, because new knowledge is created through a complex social process of combination and exchange of existing knowledge. As a result, valuable knowledge is often embedded in social relations and structures (Granovetter, 1985), and acquisition and utilization of such knowledge are also social processes (Kogut and Zander, 1992). Thus, how a firm is embedded in the larger community or social network to which it belongs often exerts a significant influence on learning and innovation (Saxenian, 1994). According to Andersson et al. (2001), the degree of embeddedness in the host location influences the innovative capacity of HBA-type overseas subsidiaries.

In this respect, we focus on the embeddedness aspect of the social capital theory. Uzzi (1996) defines embeddedness as closeness in a relationship that reflects the intensity of information exchange and the extent to which resources between the parties in the dyad are adapted. When it comes to an overseas R&D lab, the social networks in which the lab is embedded are two-sided: (1) an external network with research and engineering communities (e.g., universities, research institutes) in the host location, and (2) an internal network within an MNC (Asakawa, 1996a). We call the former type of embeddedness an external embeddedness. Although the latter type of network consists of all the units in the firm, we view the headquarters-lab relation as the most representative form of embeddedness, especially in the context of overseas knowledge sourcing, in which local knowledge is transferred to the headquarters via an overseas R&D center (Asakawa and Lehrer, 2003). We call this type of embeddedness an internal embeddedness. Because of conflicting isomorphic pressures (Rosenzweig and Singh, 1991), the type and level of external or internal embeddedness could facilitate or inhibit social behaviors (Nahapiet and Ghoshal, 1998) such as a lab's propensity to source local knowledge. Along this line, we develop specific arguments regarding the effects of external and internal embeddedness on the sourcing of knowledge from host locations by an HBA-type overseas R&D lab.

2.2.2.1. External embeddedness.

Because of a liability of foreignness (Hymer, 1976), an overseas subsidiary often encounters significant entry barriers to the knowledge network in the host location. However, to obtain contextual and location-specific knowledge, an HBA-type overseas R&D lab should be embedded in the local scientific and engineering communities for closer interactions with them.[3] Singh (2008) pointed out that in the specific context of knowledge diffusion, liability of foreignness could arise from an MNC's inability to get access to tacit knowledge embedded in the regional interpersonal networks. The two-way interaction afforded by a strong tie is often important for assimilating tacit knowledge, because the recipient most likely does not acquire the knowledge completely in the first interaction but needs multiple opportunities to assimilate it (Szulanski, 1996; Hansen, 1999).

Ghoshal and Bartlett (1990) contended that local isomorphism in the form of embeddedness is essential to the acquisition of local knowledge because it allows the lab to gain legitimacy from the local communities. Embeddedness in local communities generates social capital, which, in turn, builds trust relationships that are indispensable in order for the actors to acquire core knowledge from local institutions (Inkpen and Tsang, 2005). Moreover, embedding an overseas lab more closely in the local communities allows the lab to develop knowledge-processing systems similar to those of local research collaborators as a basis of enhanced absorptive capacity (Lane and Lubatkin, 1998). This indicates that locating in the knowledge-affluent region is not enough to access and absorb knowledge; instead, the firm needs to build social relations to benefit from knowledge flow.

For example, Hitachi's Cambridge Lab was given its nickname, the "embedded laboratory," by Professor Lord Alec Broers, Vice Chancellor of Cambridge University, for its extensive research collaboration with scientists at the university. Similarly, Mitsubishi

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[3] Here, our focus is not to test the effect of liability of foreignness but rather to see the impact of the extent of external embeddedness on local knowledge sourcing.

Electric's labs in the United States have generated research outputs based on extensive research collaborations with such U.S. universities as the University of North Carolina for animation technology and the State University of New York for 3D Volume Graphics. In the process, Mitsubishi Electric's U.S. labs frequently exchanged engineers and scientists with these universities. Hence, we hypothesize:

Hypothesis 2. An overseas R&D lab is more likely to source knowledge from the host location when it is more deeply embedded in the local scientific and engineering communities.

2.2.2.2. Internal embeddedness. Since an overseas R&D lab is a subsidiary of an MNC, the embeddedness in the global network of the MNC — especially the type of relationship with the corporate headquarters — exerts an important influence on the level of knowledge sourcing from the host location. Although the headquarters' involvement in lab-level matters may generate positive outcomes as well as negative outcomes, we expect that acquiring external knowledge from the host location would be mostly impeded by a lab's internal embeddedness, for the following reasons. To acquire external knowledge, an overseas lab first should be able to search for and sense the existence of valuable knowledge. Such processes are affected by cognitive patterns of actors in an overseas lab. By reinforcing shared values between the headquarters and the overseas R&D lab, the internal embeddedness of the lab influences its behavioral and cognitive patterns. The headquarters' influence may facilitate cognitive lock-in (Grabher, 1993), which tends to isolate the actors from the outer world (Gargiulo and Benassi, 2000). While internal embeddedness facilitates trust and cooperation among actors (Coleman, 1988), it also tends to create the group-think phenomenon (Janis, 1972), by which any new knowledge and information that does not conform to existing norms may be filtered out. Such a view is consistent with Hansen (1999) in that strong inter-unit ties constrain actors who are immersed in the existing network, which prevents them from searching for knowledge outside their existing contacts. Cognitive lock-in reduces the ability of the actors to unlearn and to recognize new opportunities because of the excessive inward orientation (Bergman, 2008; Belussi and Samarra, 2009). Such logic can be applied to the context of sourcing knowledge from host locations by overseas R&D labs. An overseas lab must be cognitively unlocked from the parent company to search for and sense new knowledge that might deviate from the parent's knowledge base. Internal embeddedness in the network with the headquarters would reinforce cognitive lock-in, which, in turn, would constrain the scope of exploration and thus hinder overseas R&D labs' search for new knowledge from the local environment.

Extant empirical studies seem to support or at least suggest such negative impact. Asakawa (1996a) argues that strong internal linkages of an overseas lab to the headquarters tend to influence behavioral and cognitive patterns of actors in overseas labs, and the isomorphic pressure from the headquarters would be counterproductive in accessing location-specific knowledge. While the overseas R&D lab requires autonomy to foster creativity and new idea generation, the parent firm often demands coordination and control of overseas R&D activities (Ronstadt, 1977; Kuemmerle, 1996, 1997). In his extensive survey of the relationship between overseas R&D labs and parent firms in Japan, Asakawa (2001b) found that strong internal connectivity or embeddedness constrained the autonomy of Japanese overseas labs, thereby lowering the level of knowledge sourcing from host locations. Ambos and Reitsperger (2004) also found that a high level of socialization within the MNC network lowered the chance for an overseas R&D lab to develop technologies successfully at centers of innovation abroad. Likewise, Kurokawa et al. (2007) found that autonomous R&D subsidiaries promoted knowledge flows from local environments to the subsidiary. Studies have shown that strong linkage with a parent firm hinders the acquisition of local knowledge by an overseas lab, while it facilitates the integration of such knowledge into a parent firm's knowledge base. For example, Asakawa and Lehrer (2003) found that the role of regional innovation relay is dominant at the phase of knowledge integrating but marginal at the stage of knowledge accessing. Similarly, Doz et al. (2001) argued that sensing external knowledge requires competent knowledge brokers vis-à-vis local environment, while integrating the acquired knowledge requires a "magnet" function that connects overseas units to the corporate unit. Such discussions are consistent with Hansen (1999), who argued that weak embeddedness facilitates knowledge "search" while strong embeddedness fosters knowledge "transfer." When an overseas R&D unit is searching for and sourcing external knowledge, weak embeddedness with the headquarters can be considered more effective. Hence, we hypothesize:

Hypothesis 3. An overseas R&D lab is less likely to source knowledge from the host location when it is more deeply embedded in the internal network of the MNC.

3. Method

3.1. Data

To test our hypotheses empirically, we focus on the home-base augmenting (HBA) type of overseas R&D labs of Japanese MNCs. Our sample was drawn from Asakawa's (1996b) extensive 1995[4] surveys[5] of 81 overseas R&D labs of 46 major Japanese corporations. In our analysis, we included labs with patents registered in the U.S. only.[6] This is because unlike the HBE type of labs, the HBA type of overseas R&D labs produces patents that are useful for global innovative activities of parent firms. As a result, we included 26 HBA labs from 17 Japanese MNCs. As shown in Table 1, these labs are located either in the United States or Europe as centers of innovation abroad (7 U.S. states and 4 European countries[7]). Following the classification scheme of the U.S. Patent & Trademark Office (USPTO), we defined host locations as states in the case of labs in the U.S. and countries in the case of labs in Europe.

We decided to treat states in the U.S. and countries outside the U.S. as equal units of analysis for the following rationales. First of all, we believed that the substantial size difference between U.S. and non-U.S. countries is likely to cause a bias when we examine a hypothesis regarding external embeddedness. In Hypothesis 2, we argue that it is important to be embedded in the local communities to source knowledge from the host location. While firms can transmit and retrieve knowledge from distant spaces, valuable knowledge is often tacit, and transfer of such tacit knowledge

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[4] We intentionally looked for data as old as the mid-90s, since our data for the dependent variable went back to 1999. In addition, the mid-90s is a conventional point in time to examine local knowledge sourcing by Japanese firms whose overseas R&D labs began to generate innovative outputs such as patents. We have observed variations among Japanese firms in the mid-90s in terms of the way they manage their overseas R&D activities.

[5] His sample selection criteria were as follows: the labs were at least one year old as of 1995; they had at least five staff; and they conducted research activities in at least one of the following areas: basic research, applied research, and development.

[6] Because a firm must file a patent in a specific country to gain intellectual property protection in that country, and because the United States is the world's largest technology market, non-U.S. firms routinely file patents in the United States (Albert et al., 1991). Thus, we use the U.S. patent data for more objective comparisons of patent counts of MNCs from various countries with different intellectual property regimes.

[7] The 7 states are California, New Jersey, North Carolina, Michigan, Massachusetts, Pennsylvania, and Ohio, and the 4 European countries are Germany, France, Austria, and Great Britain.

Table 1
Distribution of overseas labs by host country and by industry.

Host country	Number of labs in our sample
U.S.	
CA	9
NC	1
NJ	3
MA	1
MI	1
OH	1
PA	1
Austria	1
France	1
Germany	2
Great Britain	5
Total	26

Industry	Number of labs in our sample
Electronics/Semiconductor	19
Chemical/Pharmaceutical	4
Others	3
Total	26

requires frequent interaction among people (Kogut and Zander, 1992). This is why firms enter the place where knowledge resides to acquire that knowledge. Accordingly, what we mean by local embeddedness here is having close interactions with the local scientific and engineering communities. Knowledge spillover from co-location often arises from unplanned encounters (Ellison and Glaeser, 1997). In particular, informal and unplanned interactions between engineers in a region are emphasized to stimulate rich information flows and cross-fertilization of ideas (Saxenian, 1994). Co-location also reduces the hazards in transaction of intangibles by restraining opportunistic behaviors and stimulating cooperation (Stuart and Sorenson, 2003). Within a shared institutional, social, and cultural space, firms can develop similar organizational routines and cognitions that can facilitate inter-firm learning (Phene et al., 2006). Therefore, the definition of local communities should be aligned with physical proximity to a certain degree. If the definition of local communities is too large, the original meaning of local embeddedness is lost. In this respect, examining whether the knowledge in a host location attracts FDI entry into the U.S., Chung and Alcacer (2002) used the state as the definition of location.

The total land area of France in our sample is 260,558 square miles. Texas has an area of 268,820 square miles, larger than France. The U.S. alone is more than sixteen times larger than Germany and the U.K., the other countries in our sample, put together. Given this size difference, knowledge flows between states in the U.S. and between countries outside of the U.S. can be said to be susceptible to fairly comparable degrees of barrier in terms of physical distance. This partly explains why treating the barrier between the states in the U.S. to be as high as the border between the U.K. and Germany can be justified.

In addition, although all four countries outside the U.S. in our sample are EU member countries, they were not as integrated at the time of survey in 1995 as they are now. It was 1993 when EU was formally established and thus, EU member countries abolished national borders to a limited degree back in 1995. Nowadays, each member country of the EU still keeps its own independent policies, while other policies are commonly shared. Like EU member countries, U.S. states have independent policies in many dimensions. For example, some measures such as tax rates and right-to-work laws are defined at the state level in the U.S., and these differences affect a foreign firm's choice of location. If foreign firms entering into the U.S. consider each state on a different basis rather than treating them indifferently, a state can be the legitimate definition of location for the U.S. Thus, we view each state in the United States as fairly equivalent to a member country of the EU.

Moreover, it is well accepted practice to treat a U.S. state and a non-U.S. country as equal units of analysis in existing studies using U.S. patent citation data. For example, Singh (2008) used the state (for U.S. inventors) or country (for non-U.S. inventors) as an approximation for the inventor's precise geographic location.

We collected data on these lab characteristics from both lab-level surveys conducted by Asakawa and the U.S. patent data. We used the survey data to construct variables regarding embeddedness. Following Hall et al. (2000), Ahuja and Katila (2001), Song et al. (2003), and others, we used U.S. patent data to measure technological capabilities.

To construct a dependent variable, we used U.S. patent citation data. A patent document contains a host of information, including citations to other patents. The list of citations for each patent is arrived at through a uniform and rigorous process applied by the patent examiner as a representative of the patent office. The patent applicant and the lawyer are obliged by law to specify in the application any and all of the "prior art" of which the applicant is aware. The list of patent citations so compiled is available on the patent document, along with information on the patenting firm, inventor, geographic location, and technology types. In principle, a citation of *Patent X* by *Patent Y* indicates that *Patent Y* builds upon previously existing knowledge embodied in *Patent X*. Based on this premise, a series of recent articles have used patent citation data to track knowledge flows (Jaffe et al., 1993; Almeida, 1996; Almeida et al., 2002; Song et al., 2003; Song and Shin, 2008). Thus, through patent documents, one can infer both organizational and technological influences on a particular invention and track knowledge building across people, firms, geographic regions and countries, and time.[8] Using the patent citation data, we traced knowledge flows from host locations to overseas labs.

The unit of analysis in the negative binomial regression is individual patents granted to the 26 R&D labs in our sample. Patents to be studied were selected according to the following steps. We could not take the lab as the unit of analysis because with 26 labs we did not have enough samples at the lab level. To avoid possible violation of independence among observations, we clustered standard errors by lab. Using our data on all patents filed in the United States from 1973 through 1999, we initially retrieved 1043 patents granted to these labs. Among these 1043 patents, for our dependent variable in the regression analysis, we ended up using 284 patents filed by (and then granted to) these labs since 1996, as Asakawa's survey was conducted in 1995. Considering time spent to complete a research project that produces patents, we allowed a time lag of at least one year from the survey time point. Patents filed by 1995 were used to measure technological capabilities of each lab.

3.2. *Methods and variables*

We employ negative binomial regressions to investigate the factors influencing the level or the magnitude of knowledge sourced from host locations where overseas R&D labs were established. As an extension of the Poisson regression, a negative binomial regression is used to estimate models of occurrences (counts) of an event when the event has extra-Poisson variation in the form of overdis-

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[8] Although patent citations have been widely used as a way to capture knowledge flows, they have some drawbacks as an accurate measure of such flows. Nevertheless, recent studies that compared patent citation data with direct surveys of inventors found that the correlation between patent citations and actual knowledge flow is high, thereby justifying the use of patent citation as a proxy measure of knowledge flows (Jaffe and Trajtenberg, 2002). Thus, we believe that in spite of some disadvantages, patent citations are probably the best proxy measures of knowledge flows available for empirical studies.

persion. In our negative binomial models, the probability that the number of patent citations will occur n times (with $n = 0, 1, 2, \ldots$) is as follows[9]:

$$\text{Prob}(Y = yj) = e^{-\lambda j} \frac{\lambda_j^{Y_j}}{Y_j!}$$

where $\lambda_j = \exp\left(\sum B_i X_{ij}\right) \exp(\mu_j)$ and $e^{\mu_j} \sim \text{Gamma}\,(1/\alpha, 1/\alpha)$.

For observed counts of patent citations Y_j with covariates X_i for the *j*th patent of an overseas R&D lab *i*.

We clustered standard errors by overseas R&D labs, since our data include multiple observations for each lab. Although employing a longitudinal model is better because it removes the possibility of an unobserved lab heterogeneity driving the results, data constraints did not allow us to do so.

The dependent variable, measured at the patent level, represents the extent of knowledge sourced from the host location.[10] The variable is operationalized as the number of citations that each patent makes to any patent from the host location, with the exception of self-citations made to prior patents of these labs themselves. An increase in this measure indicates an increase in the degree to which a patent builds upon knowledge from the host location of the overseas R&D lab.

As for independent variables, technological capabilities of an overseas R&D lab (Hypothesis 1) are operationalized as the number of U.S. patents granted to the lab prior to the file date of a specific patent. Thus, the proxy measure is time varying. To standardize the variable, we took a log scale.

Following a method suggested by Pugh and Hickson (1976), we measure the degree of external embeddedness (Hypothesis 2) by a composite index that was created based on Asakawa's survey in 1995. The survey included questions regarding interactions with local scientific communities (such as local universities, other research institutions, and local firms) in the form of research contracts, journal publications, joint appointments, and so on. A proxy measure of internal embeddedness (Hypothesis 3) was computed in the same way. We used questions from Asakawa's survey to identify the degree of the parent firm's involvement in the way decisions such as recruitment and performance appraisal of an overseas R&D lab are made.[11] Because items are measured using a 5-point Likert scale, we averaged scores from questions. The higher the score of internal embeddedness is, the more deeply the overseas R&D lab is embedded in the parent firm's network. We tested inter-item reliability for external and internal embeddedness composite indexes by computing Cronbach's alpha and found that inter-item reliability is high enough to construct composite indexes for both variables ($\alpha = 0.5652$ and 0.8318 for external and internal embeddedness, respectively).[12]

As for control variables, we included the total number of citations made by a sample patent, since it influences the extent of citations to the host location. In other words, the more total citations made by each patent, the more likely for the patent to cite any patent from the host location. We also controlled for technological capabilities of the host location. Song and Shin (2008) found that MNCs are more likely to source knowledge from host countries when their host countries have stronger technological capabilities than their home countries. To measure technological capabilities of the host location, we counted the total number of patents granted to the host location in the 10 years prior to the application year of the overseas R&D patent in our sample and then took the log scale. We controlled for technological capabilities of the parent company in the same way. Both capability variables are time varying variables. Finally, we added industry dummies to control for possible industry differences.

4. Results

Table 2 presents descriptive statistics. To check multicollinearity problems among the variables, we computed variance inflation factors but could not find any troubling collinearity. Thus, we included all variables in the regressions. Table 3 summarizes the statistical findings from the negative binomial regressions. Table 3 includes both the base model with control variables only and the full model. The log-likelihood ratio of the full model was significantly improved from the base model, and thus we used the full model for statistical interpretations.

In the full model, the coefficient of the quadratic term of technological capabilities of the overseas R&D lab was highly significant and negative, while the coefficient of the linear term was highly significant and positive, suggesting an inverted U-shaped relationship. The inverted U reached its peak within the observed range for overseas R&D labs' technological capabilities.[13] This result supports Hypothesis 1, suggesting that overseas R&D labs outsource knowledge from the host location more as technological capabilities increase up to a certain point, and then they outsource less beyond a certain threshold level.

External embeddedness was also highly significant and positive. This finding lends support to the idea that an overseas R&D lab that is embedded more deeply in the local scientific and engineering communities is more capable of and more likely to source knowledge from the host location. However, internal embeddedness (Hypothesis 3) was not significant.

Among the control variables, both the total number of citations made by the sample patent and technological capabilities of the host country turned out to be highly significant and positive, as expected. The chemical/pharmaceutical industry dummy was also significant.

To assess the economic significance of this effect, we examined the marginal effect of these independent variables on the dependent variable. Because the negative binomial model is a non-linear estimator, the marginal effect equals $e^{\beta X}\beta$. Therefore, the magnitude of the marginal effect is contingent on the values of the independent variables. We showed the marginal effect, evaluated at the mean of the independent variables, in Table 4. Using the *mfx* command in STATA, we obtained the elasticities of the form

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[9] In the negative binomial model that we specify above, μ_j is an unobserved, omitted variable and e^{μ_j} follows a gamma distribution with mean 1 and variance α as the overdispersion parameter. The larger α is, the greater the overdispersion.

[10] Host location refers to a state for labs in the U.S. and to a country for labs elsewhere.

[11] Internal embeddedness could theoretically include linkages among overseas labs, as well as between the headquarters and overseas labs. However, since the data we used only covers the headquarters–overseas labs relationships, we do not investigate the impact of such (broadly defined) internal embeddedness on local knowledge sourcing.

[12] Schmitt (1996) states that "a problem in the use of alpha arises from researchers' common presumption that a particular level of alpha (usually .70) is desired or adequate . . . when a measure has other desirable properties, such as meaningful content coverage of some domain and reasonable unidimensionality, this low reliability may not be a major impediment to its use" (pp. 351–352). Carmines and Richard (1979) says that "unfortunately, it is difficult to specify a single level that should apply in all situations . . . But the most important thing to remember is to report the reliability of the scale and how it was calculated. The other researchers can determine for themselves whether it is adequate for any particular purpose" (p. 51). Especially, when researchers try to measure a broad concept such as external embeddedness, the loss of reliability is often inevitable. This explains a relatively lower value of alpha for external embeddedness than that for internal embeddedness in our study.

[13] Reference to the coefficients of the full model of Table 2 shows that the effect of the log-transformed number of patents granted to overseas R&D labs (knowledge sourced from the host location) reached its peak when it is roughly 2.315588 ($= -1.055272/(2 \times -0.2278626)$), which is within the observed range of our data.

Table 2
Summary of descriptive statistics ($N = 284$).

Correlations (correlation, significance)	1	2	3	4	5	6	7	8	9
1. Knowledge sourced from the host location	1.000								
2. Log (technological capabilities of the overseas R&D lab)	−0.072 0.229	1.000							
3. External embeddedness of the overseas R&D lab	0.100 0.091	0.165 0.005	1.000						
4. Internal embeddedness of the overseas R&D lab	0.073 0.221	0.201 0.001	−0.092 0.121	1.000					
5. Total number of citations per patent	0 613 0.000	0 034 0.572	0 114 0.056	−0 026 0.663	1 000				
6. Log (technological capabilities of the host location)	0.247 0.000	0.029 0.626	0.021 0.728	−0.072 0.226	0.165 0.005	1.000			
7. Log (technological capabilities ofthe MNC headquarters)	0.053 0.377	0.345 0.000	−0.363 0.000	0.256 0.000	0.028 0.643	0.075 0.206	1.000		
8. Industry dummy (electronics/semiconductor)	0.084 0.156	0.361 0.000	−0.332 0.000	0.270 0.000	0.031 0.599	0.176 0.003	0.844 0.000	1.000	
9. Industry dummy (chemical/pharmaceutical)	−0.059 0.322	−0.274 0.000	0.065 0.273	−0.114 0.054	−0.005 0.928	0.003 0.967	−0.175 0.003	−0.403 0.000	1.000
Mean	1.232	4.037	1.627	2.866	9.239	10.556	7.771	0.919	0.014
Std. Dev.	2.503	1.020	0.684	0.907	10.933	0.572	1.899	0.273	0.118
Min	0	0	0	2	1	8.108	1.792	0	0
Max	21	5.263	3	4	83	11.111	9.443	1	1

Table 3
Statistical results from negative binomial regression ($N = 284$).

	Base model	Full model
Constant	−13.08494** (5.902061)	−12.87779*** (3.688605)
Control variable		
Total number of citations per patent	.06515*** (.0147246)	.0575523*** (.0153526)
Log (technological capabilities of the host location)	1.188862** (.5740543)	.8785051*** (.3346101)
Log (technological capabilities of the MNC headquarters)	−.0678075 (.1121323)	.0988199 (.1000722)
Industry dummy (electronics/semiconductor)	.1687474 (.8972136)	.6588185 (.6414591)
Industry dummy (chemical/pharmaceutical)	−18.17318*** (1.006509)	−19.91432*** (1.128264)
Independent variable		
Log (technological capabilities of the overseas R&D lab)		1.055272*** (.3990747)
H1 [Log (technological capabilities of the overseas R&D lab)]		−.2278626*** (.0680843)
H2 External embeddedness of the overseas R&D lab		.763709*** (.2866347)
H3 Internal embeddedness of the overseas R&D lab		−.0885926 (.1406876)
Goodness of fit (Log pseudo likelihood)	−355.83926	−340.83161

Significant at $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$. Robust standard errors in parentheses.

$\partial y/\partial x$. Table 4 shows the magnitude of our main variables' effects computed in terms of a unit change in the dependent variable associated with a one standard deviation change or a percentage change (for log-transformed variables) in each independent variable, evaluated at the mean of the data. For example, a percentage change in the technological capabilities of the overseas R&D labs and the square of them (Hypothesis 1) led to a .53 and −.12 change, respectively, in the dependent variable. This indicates that labs with a 10% increase of their technological capability will have 5.3 more patent citations. Labs with a 10% increase in their squared technological capability will, however, have 1.2 fewer patent citations. As for our other main variable that turned out to be highly significant, a one standard deviation change in "external embeddedness of the overseas R&D lab" (Hypothesis 2) resulted in a .39 unit change in the dependent variable.

Table 4
Magnitude of estimated effects from negative binomial regressions.

Control variable	
Total number of citations per patent	.029
Log (technological capabilities of the host location)	.45
Log (technological capabilities of the MNC headquarters)	.05
Industry dummy (electronics/semiconductor)	.26
Industry dummy (chemical/pharmaceutical)	−.67
Independent variable	
Log (technological capabilities of the overseas R&D lab)	.53
H1 [Log (technological capabilities of the overseas R&D lab)]	−.12
H2 External embeddedness of the overseas R&D lab	.39
H3 Internal embeddedness of the overseas R&D lab	−.05

To confirm the robustness of our results, we conducted sensitivity analyses. First, we conducted tests using different time frames. The statistical results did not change much, thereby showing the robustness of our findings. We also modified our dependent variable by including self-citations. Results were mostly the same as in our main analysis.

5. Discussion and conclusion

The intended contribution of this study is to examine the conditions under which an overseas R&D lab is more likely to outsource knowledge from the host location. The results of the statistical tests support our Hypotheses 1 (lab capabilities) and 2 (external embeddedness). However, our hypothesis regarding internal embeddedness was not supported statistically.

This paper suggests some theoretical and practical implications. In addition to addressing a previously unexplored empirical question, this paper advances the theory of how MNCs benefit from technology-seeking FDI. An intriguing argument and finding from this study is that there exists an inverted U-shaped relationship between technological capabilities of the overseas R&D lab and the degree of knowledge sourcing from the host location. This finding has implications for research in globalization of R&D activities, which stresses the importance of external knowledge to innovation. The absorptive capacity view suggests that MNCs with strong technological capabilities are superior in assimilating and extending knowledge sourced from overseas R&D labs, thereby proposing a positive linear relationship between technological capabilities of the lab and knowledge sourced from the host location (Frost, 2001).

However, unlike conventional arguments regarding absorptive capacity, our statistical results show that the linear relationship would not hold above a certain threshold level of lab capabilities. Our results indicate an evolution of an HBA-type of overseas R&D lab, consistent with observations made by scholars such as Medcof (1997), Nobel and Birkinshaw (1998), and Asakawa (2001a). According to Asakawa and Lehrer (2003), leading Japanese firms such as Canon, Hitachi, Sharp, and Toshiba diversified knowledge sources for a “regional-for-global” innovation. Although they are predominantly located in the United Kingdom, these labs are not considered local units. These firms now face a challenge of how to integrate their globally or regionally pooled knowledge assets into the parent firms’ global innovation networks.

As these observations suggest, an MNC headquarters may have incentives to transform technologically competent overseas R&D labs from the “local innovator” that mainly seeks knowledge from the host location to the “global innovator” that explores knowledge globally beyond the boundary of the host location. For example, Mitsubishi Electric’s U.S. laboratories, while embedded in local research clusters, continue to source knowledge through a wide scope of interactions with local universities within their regions as well as with major universities from other countries.

This finding may reflect the Japanese context in the time period studied. Japan’s economic downturn in the 1990s made the Japanese firms’ headquarters tighten their control over their overseas R&D operations, to make sure they contribute to the firms’ innovative activities and new product development for global markets. Many overseas R&D labs that were established in the late 1980s and early 1990s were facing increasing pressure from the business units to contribute to business performance (Westney, 1993).[14]

Our results also show that sourcing knowledge from the host location is more likely when an overseas R&D lab is embedded more deeply in the local scientific and engineering communities. The importance of external embeddedness in the local communities suggests a positive effect of social capital on learning. The result is consistent with Almeida’s (1996) argument that in order to learn from the host location, MNCs should tie themselves into the local social networks and hire engineers locally. Thus, our finding that confirms the importance of external embeddedness in learning from the host location advances the existing literature on the globalization of R&D.[15]

Contrary to our expectation that the impact of internal embeddedness on knowledge sourcing would be negative and significant, our result was not statistically significant. We can think of several plausible explanations for why the expected negative effect of internal embeddedness was cancelled out by the overlooked positive effect. First, given that another important source of an overseas lab’s knowledge is the parent firm’s knowledge, the way in which new knowledge is created is the combination of the newly sourced local knowledge and the existing stream of internal knowledge that the overseas lab draws on. Therefore, an overseas lab’s understanding about the stream of knowledge in its parent firm is very critical because it can facilitate the lab’s activities of sourcing knowledge from host location. If an overseas R&D lab is distant from the extant knowledge stock of the parent firm and searches for new knowledge only in the host nations, it might not be able to find the proper use of newly acquired knowledge.

Internal embeddedness can have another positive impact on the overseas lab’s operations. It can help a lab experience less friction with its parent company during daily coordination processes.[16] Given that the distant subsidiaries in a multinational corporation usually have to devote considerable time to handling issues that may result from the communication barrier with headquarters, mutual understanding enabled by internal embeddedness would free up more time for local lab management to focus on creating new knowledge and sourcing related knowledge from the local environment during the knowledge creation process. Thus we conjecture cautiously that internal embeddedness of the overseas lab would not impede external knowledge sourcing as much as we had initially expected.

Empirically, we believe that this is the first attempt to investigate systematically how characteristics of overseas R&D labs can influence knowledge sourcing from the host location. In this study, drawing on both the primary data — lab-level surveys — and the secondary data — U.S. patent data — we employed direct measures of lab capabilities and embeddedness, unlike most prior studies that used case studies because of data constraints. Moreover, unlike most previous empirical studies of knowledge-seeking FDI, this paper attempted to measure the degree of knowledge sourcing from the host location more directly by tracing the level of knowledge flows captured by patent citation counts. Furthermore, by taking multiple theoretical perspectives — the capabilities perspective from evolutionary economics and the embeddedness perspective from organizational theory — this paper offers a more comprehensive and balanced understanding about the globalization of R&D that is becoming more essential to the competitive advantages of MNCs.

However, this paper has some limitations. Primarily, because of data constraints, we could not conduct research using the lab per se as a unit of analysis, and instead we used patents from the lab as the unit of analysis. Moreover, data constraints made it impossible for us to conduct a longitudinal analysis. As a result, we could not conclude strongly that laboratory characteristics drive the results, since there is still some possibility that laboratory characteristics and the citation patterns may both be the results of unobservable firm choices.

In addition, one might wonder if failed laboratories (ones that did not have patents in the United States) were excluded from

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[14] Such a period effect may be unique to Japanese firms, because the U.S. and European firms have generally been operating their overseas R&D for a much longer period of time and their overseas labs have thus already gone through the transition from local to global labs.

[15] We hypothesized and empirically confirmed a linear relationship between external embeddedness and knowledge sourcing from the host locations. The result implies that external embeddedness is indeed important in order for a local lab to source knowledge from the host locations of overseas R&D operations. However, a question remains as to the relative importance of external knowledge sourced from the host location, as compared to that sourced from other foreign locations, for the success of overseas HBA-type labs, which could be an interesting topic for future research.

[16] We thank an anonymous reviewer for this invaluable insight.

the analysis, thereby skewing the results.[17] It is true that these labs were excluded, because we focused on HBA labs that produced patents that were useful for global innovative activities of parent firms and defined them as labs that were capable enough to register patents in the USPTO. However, we think that there is a very low possibility of any potential bias from this omission because our unit of analysis is at the patent level. Also, because we did the patent-level analysis, it was not technically possible for us to include "failed" HBE-type labs. Nonetheless, we acknowledged such potential biases as a limitation.

Finally, we should admit that because of data constraints — Asakawa's survey was conducted in the mid-1990s, and our U.S. patent data ended in 1999 — our data were somewhat outdated. Nevertheless, as we elaborated in footnote 2, we believe that our data are suitable for examining the impact of subsidiary capabilities and embeddedness on knowledge sourcing, largely because the mid-1990s represents the turning point after the collapse of the Bubble Economy and the long economic recession in Japan. As we explained earlier, since many Japanese firms needed to reassess the value of developing technological capabilities of their overseas R&D labs and of deepening external and internal linkages held by the overseas labs, we can observe substantial variations in the firms' approaches to tightening their overseas R&D activities; some were tightening their overseas R&D activities much more rapidly, whereas others were much slower in accommodating the shift (Asakawa and Westney, 2005). Moreover, some Japanese firms began to encourage overseas R&D labs that had been established in the 1980s and thus accumulated substantial local capabilities and experiences needed to evolve into global innovators, thereby increasing variations among Japanese subsidiaries. Future research is encouraged to update and expand the data to trace how the evolution of overseas R&D labs influences knowledge sourcing from host locations over time.

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