Geographic Agglomeration, MNC Characteristics, and Knowledge Acquisition of Japanese R&D Subsidiaries in the United States

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In this study, we examine both locational and organizational factors that influence knowledge acquisition performance of overseas Japanese research and development (R&D) subsidiaries. Using patent citation as a measure of foreign knowledge acquisition, we investigate the effects of geographic agglomeration and multinational corporation parent and subsidiary characteristics on subsidiary learning performance. The results of our analysis show that the level of geographic agglomeration in the host location is positively associated with knowledge acquisition performance of overseas R&D subsidiaries, while technological strength of the parent company and subsidiary age are negatively associated with knowledge acquisition performance.

Key Words: Knowledge Acquisition, Overseas R&D Subsidiaries, Geographic Agglomeration, Firm Heterogeneity

Running head: Knowledge Acquisition of Overseas R&D Subsidiaries

Ⅰ. Introduction

The *raison d'être* of multinational corporations (MNCs) is the efficient knowledge transfer and utilization mechanism of the firm compared to the market (송재용, 윤우진, 2008; Bartlett and Ghoshal, 1989; Buckley and Casson, 1976; Dunning, 1993; Hymer, 1976; Kogut and Zander, 1993). According to foreign direct investment theory, a firm with superior production knowledge expands geographically, transfers its technology, and puts it into production in other locations (김병조, 임주현, 2011; Hennart, 1982; Kogut and Zander, 1993). In this MNC model, effective knowledge transfer from an MNC parent company to its overseas subsidiaries is key to firm success.

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Another view suggests that an equally important source of competitive advantage for an MNC is the heterogeneous knowledge and capabilities of its overseas subsidiaries (Frost, 2001; Håkanson, 1989; Hedlund, 1993). According to this view, an MNC's success depends on how effectively it can explore and acquire local knowledge from host locations and transfer that knowledge to the home country (Cantwell and Hodson, 1991; Håkanson and Nobel, 1993; Kuemmerle, 1999; Shan and Song, 1997; Song and Shin, 2008). In this host-to-home knowledge transfer process, the first step is successful knowledge acquisition on the part of overseas subsidiaries.

To elucidate this knowledge transfer process, we examine the locational and organizational factors influencing knowledge acquisition performance in overseas research and development (R&D) subsidiaries. Among several possible locational determinants, we focus on the level of geographic agglomeration because this factor determines the amount of valuable local knowledge in the host location. An organization's technological capabilities are critical in determining its knowledge acquisition performance (Cohen and Levinthal, 1990; Levinthal and March, 1993; Song and Shin, 2008). Thus, we examine the role of technological capabilities of both the MNC parent company and overseas subsidiaries in knowledge acquisition. In addition, we consider the number of years of experience in the host location because how long overseas R&D subsidiaries have been in operation influences their learning performance (Barkema et al., 1996; Bartlett and Ghoshal, 1989; Chang, 1995).

This study contributes to the existing research on knowledge acquisition in several ways. First, it provides a more complete picture of the learning performance of MNC subsidiaries than has been offered previously by considering the influence of both geographic agglomeration and organizational characteristics. Firms benefit from agglomeration externalities to different extents depending on the heterogeneity of their capabilities (Shaver and Flyer, 2000; Chung and Song, 2004). Therefore both locational and organizational characteristics should be considered in the same model. Second, it presents a more exhaustive organizational model of MNC subsidiary learning by considering firm characteristics at both the parent company and subsidiary levels. Given that the parent company often determines the range and nature of activities of an MNC subsidiary (Birkinshaw and Morrison, 1995; Ghoshal, 1986; Roth and Morrison, 1990), consideration of the characteristics of the parent company is indispensable to an understanding of local subsidiaries' knowledge acquisition performance (김경, 한승두, 2006; 김익수, 김병구, 2010; 안종석, 백권호, 2009; 이응석, 2007; 이재은, 박정민, 송윤아, 2012; 최순규, 2003). Third, using patent citation data, we examine knowledge acquisition performance more directly than in past studies. The conventional approach has been to infer knowledge acquisition performance by measuring changes in productivity or firm innovation (Caves, 1996), which is a very noisy method of measuring knowledge acquisition performance (Aitken and Harrison, 1999; Chung et al., 2003; Haskel et al., 2007). In this paper, we use patent citation data, which provides direct information about the flow of knowledge to establish a clearer link between the explanatory variables and knowledge acquisition performance of overseas R&D subsidiaries (Shaver and Flyer, 2000; Alcacer and Chung, 2007; Singh, 2007; Song et al., 2011).

Using a sample of patents granted to R&D subsidiaries of Japanese MNCs located in the United States, we measure the influence of geographic agglomeration and organizational attributes on local knowledge acquisition performance of those subsidiaries. The result suggests that a high level of geographic agglomeration has a positive impact on local knowledge acquisition. Strong technological capabilities of the parent company and subsidiary age have a negative impact on knowledge acquisition, however.

Ⅱ. Theory and Hypotheses

2.1 Geographic Agglomeration and Knowledge Acquisition Performance

Firms tend to co-locate their major activities, especially R&D operations, in close proximity to other firms in the industry eco-system (신현길, 박영렬, 2012; Krugman, 1994; Marshall, 1920). Such geographic agglomeration behavior has been observed among firms in various industry and country settings (한계숙, 김재욱, 최지호, 2007; 한상일, 유평준, 2006; Saxenian, 1996; Takeda, Kajikawa, Sakata, and Matsushima, 2008). One of the major reasons behind geographic agglomeration is the benefit of increased knowledge spillover (Chung and Kalnins, 2001; Diez-Vial and Alvarez-Suescun, 2010; Leahy, Palangkaraya and Yong, 2010; Robinson and Mangematin, 2007). When firms are located in close proximity, they can acquire the proprietary knowledge of other firms. The knowledge generation and consumption process inevitably involves interaction with other firms in the region. Thus, knowledge cannot be completely confined within firm boundaries (Arrow, 1962; Nelson, 1959).

Geographic agglomeration promotes knowledge transfer among firms in a region through micro-mechanisms such as socialization and mobility of engineers. For instance, when engineers socialize at seminars and conferences, local bars, parent–teacher associations, hobby clubs, and other occasions in a region, they exchange ideas and news about the inventions and innovations of their companies (Saxenian, 1996). Engineers moving from one firm to another in a region will also transfer proprietary knowledge across firms (Song et al., 2003).

Geographic agglomeration of manufacturing and R&D operations is also an indication that there are sources of valuable knowledge in a given location. Such locally-embedded knowledge previously attracted many firms, especially R&D organizations, to the location. That is, firms chose the location because sources of valuable knowledge, such as universities and prestigious research institutions, were located there (Porter, 1985). Strong research universities and institutions supply cutting-edge technology and ideas to MNCs that choose to locate R&D subsidiaries in the region. In addition, they provide high-quality engineering and science graduates who can contribute to R&D.

Considering that geographic agglomeration promotes knowledge spillover and indicates valuable locally-embedded knowledge, we expect that R&D subsidiaries in a region with a high level of agglomeration will acquire more local technological knowledge. Therefore we propose the following hypothesis:

Hypothesis 1: A high level of agglomeration is positively associated with local knowledge acquisition by foreign R&D subsidiaries.

2.2 MNC Characteristics and Knowledge Acquisition Performance

Heterogeneity in organizational characteristics also influences the knowledge acquisition performance of overseas R&D subsidiaries. We consider MNC characteristics on both the parent and subsidiary organizational levels. While our focus is on R&D subsidiaries, we examine parent company characteristics as well because they affect R&D subsidiaries' local knowledge acquisition performance. MNC subsidiaries are not completely autonomous entities, but are heavily influenced and guided by their parent companies (Bartlett and Ghoshal, 1989; Birkinshaw and Hood, 1998; Song, 2002). Parent company characteristics are particularly relevant in Japanese MNC subsidiaries, whose parent companies are well known for exerting strong control over the operations of their foreign subsidiaries (Bartlett and Ghoshal, 1989).

2.3 Parent Companies' Technological Capabilities

We expect parent companies' technological capabilities to be negatively associated with local knowledge acquisition of foreign R&D subsidiaries for the following three reasons. First, technologically strong parent companies will be more selective about what local knowledge their foreign R&D subsidiaries should acquire. MNC parent companies are interested in absorbing knowledge from foreign locations to the extent that this knowledge strengthens their knowledge base and innovation capabilities (Cantwell and Hodson, 1991; Dunning, 1993; Kogut and Zander, 1993). Parent companies with strong technological capabilities draw from a relatively smaller pool of valuable technological knowledge in foreign locations because much of this knowledge is of lower quality than their own or already known to them. In contrast, a relatively larger pool of valuable and novel knowledge in foreign locations is available to parent companies with weak technological capabilities. As a result, technologically weak parent companies may be more willing for their R&D subsidiaries to acquire local knowledge in foreign locations.

Second, MNC parent companies with strong technological capabilities not only apply stricter standards in evaluating external knowledge, but may also be proud of their own technology and disdainful about the quality and usefulness of foreign knowledge, often to an irrational extent (Michailova and Husted, 2003). Such perceptions about the value of foreign knowledge may negatively affect foreign R&D subsidiaries' knowledge acquisition. For example, many global automakers have established production facilities in Thailand, which has emerged as "the Detroit of Asia." However, MNC parent companies with strong technological capabilities, such as BMW, may not be keen to obtain local technological knowledge due to their negative evaluation of the quality of that knowledge compared to that of their home country. We expect that parent companies with strong technological capabilities are more likely to undervalue the quality and usefulness of local knowledge and thus to discourage knowledge acquisition on the part of their foreign R&D subsidiaries in host locations.

Third, strong technological capabilities indicate distinct pre-established technological paths (Song and Shin, 2008). When firms have established technological trajectories, their subsequent innovation follows a path-dependent process (Dosi, 1982). As a result, the search for new technological knowledge is constrained by existing technological trajectories and pursued closely along existing trajectories. The search for technological knowledge tends to be home-country based, cumulative, and internal in MNC parent companies with established, strong technological capabilities (Stuart and Podolny, 1996). Such MNC parent companies are "less motivated to absorb new knowledge from host countries where they set up R&D labs" (Song and Shin, 2008: 294). Therefore, when parent companies have strong technological capabilities, they are more likely to engage in narrow and limited knowledge searching, which will negatively affect their foreign R&D subsidiaries' knowledge acquisition.

The influence of parent company characteristics on foreign subsidiary operations is known to be particularly conspicuous among Japanese MNCs, which have traditionally exerted tighter control over their overseas subsidiaries than MNCs from other nations (Bartlett and Ghoshal, 1989; Song et al., 2011). Therefore, we expect that in this study, strong parent company technological capabilities will have a negative influence on knowledge acquisition of foreign R&D subsidiaries.

Hypothesis 2: Strong technological capabilities of parent companies are negatively associated with local knowledge acquisition by foreign R&D subsidiaries.

2.4 Characteristics of R&D Subsidiaries

We hypothesize that there is a negative relationship between strong technological capabilities of MNC parent companies and foreign R&D subsidiaries' knowledge acquisition. The arguments behind this hypothesis may also apply to the technological capabilities of foreign R&D subsidiaries and their local knowledge acquisition performance. Technologically strong R&D subsidiaries may have high technological standards and be more selective in acquiring local knowledge from host locations (Song et al., 2011). Like their parent companies, technologically strong R&D subsidiaries may undervalue and be less open to local knowledge. In addition, technologically strong R&D subsidiaries may have established strong trajectories in innovation and learning, narrowed the scope of their knowledge search, and restricted local knowledge absorption. Hence, we predict that the technological capabilities of foreign R&D subsidiaries will be negatively associated with their own local knowledge acquisition.

Hypothesis 3: Strong technological capabilities of foreign R&D subsidiaries are negatively associated with local knowledge acquisition in the host location.

Another important characteristic of foreign R&D subsidiaries that may affect their local knowledge acquisition performance is the number of years they have operated in the host location. We predict that the age of foreign R&D subsidiaries will be negatively related with their local knowledge acquisition for three reasons. First, foreign R&D subsidiaries absorb more local knowledge in earlier stages than in later stages of their lifecycles (Asakawa and Lehrer, 2003). As time passes, foreign R&D subsidiaries build distinct technological trajectories on which they are more likely to remain in their subsequent knowledge search (Song and Shin, 2008). Therefore, the longer R&D subsidiaries operate in a given location, the narrower the range of local technological knowledge relevant to their expertise.

Second, foreign R&D subsidiaries absorb local knowledge faster in earlier than later stages. When foreign R&D subsidiaries are first established in host locations, there is greater potential for them to absorb valuable new knowledge. However, as they absorb this local knowledge, the amount of potential available knowledge decreases. In essence, foreign R&D subsidiaries' absorption of local knowledge is a self-limiting process. Although it is possible that the growth of the knowledge pool may outpace knowledge absorption, the limitations of their own technological trajectories in later stages of their operation constrain the knowledge search in foreign R&D subsidiaries, as previously discussed.

Third, foreign R&D subsidiaries' dependence on local knowledge as a source of innovation may decrease with time. Foreign R&D subsidiaries largely perform two tasks as knowledge-generating centers within an MNC network: (1) transferring foreign (local) knowledge to the parent company and other foreign subsidiaries, and (2) generating global-scale innovations using diverse knowledge sourced from the entire MNC global network (Birkinshaw and Hood, 1998; Asakawa and Lehrer, 2003; Song et al., 2011). These two roles can be performed simultaneously, but are often performed chronologically within the lifecycle of a subsidiary. That is, foreign R&D subsidiaries' tasks change over time (Birkinshaw and Hood, 1998; Malnight, 1996). In the earlier stage of knowledge acquisition, foreign R&D subsidiaries focus on absorbing local knowledge from their host locations (Almeida, 1996; Shan and Song, 1997) and transferring it to the parent company and other foreign subsidiaries. However, foreign R&D subsidiaries' source of knowledge input does not remain in host locations but diversifies into various locations in the entire global MNC network (Kuemmerle, 1999; Frost et al., 2002; Asakawa and Lehrer, 2003). As a result, sources of technological knowledge used by R&D subsidiaries become more geographically diversified and less reliant on local knowledge from their host countries, as the R&D subsidiaries grow older.

In summary, we hypothesize that foreign R&D subsidiary age will be negatively related with local knowledge acquisition performance because technological trajectories of R&D subsidiaries become increasingly rigid and their knowledge search scope narrower, the valuable local knowledge pool decreases with time, and their knowledge source becomes globally diversified. Therefore, we predict that foreign R&D subsidiaries' acquisition of local knowledge from the host location will be negatively associated with their age.

Hypothesis 4: The age of an R&D subsidiary is negatively associated with local knowledge acquisition in the host location.

III. Methods

3.1 Data

To test our hypotheses, we examined the citation patterns of U.S. patents granted to R&D subsidiaries of Japanese MNCs based in the United States. To trace these patterns, we selected subsidiaries of Japanese MNCs from the 1995 Toyo Keizai Databank directory. In our sample, we included Japanese subsidiaries in the chemical, pharmaceutical, electronics, electric, machinery, and automotive industries, because patenting activities are most active in these six industries. The sample included 123 subsidiaries of Japanese MNCs.

To investigate the effects of knowledge spillover due to agglomeration on knowledge-sourcing activities of Japanese MNCs in the United States, we defined host location by state. We used the state as our level of analysis because detailed economic data are only available at the national or state level. As a result, most, if not all, prior foreign direct investment location studies have been conducted at the state level (Chung and Song, 2004). Japanese subsidiaries in our sample were located in 22 U.S. states.

The main data used in this study were U.S. patents granted to subsidiaries of Japanese MNCs and state-level geographic agglomeration data compiled from the 1997 U.S. Economic Census conducted by the U.S. Census Bureau. To construct our dependent variable, we used U.S. patent citation data. 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, several studies have used patent citation data to track knowledge flows (Jaffe et al., 1993; Almeida, 1996; Song et al., 2003). We used patent citation data to trace the local knowledge flow from the host location to other subsidiaries of Japanese MNCs.

Individual patents were used as the unit of measure in the negative binomial regression analysis in this study. Using the MicroPatent database, we retrieved information on 926 patents granted to the 123 subsidiaries in our sample. We then tracked the citation records of the 926 patents to construct the dependent variable. We used the 1997 U.S. Economic Census data to measure the level of agglomeration of manufacturing and R&D activities in the United States by industry and state. U.S. Economic Census data provide the most complete and accurate picture of the location patterns of industries in the U.S. (Shaver and Flyer, 2000). Following Ahuja and Katila (2001) and Song et al. (2003), we assumed that the number of patents that an organization possesses can be an appropriate representation of its technological capabilities. Therefore, using the number of patents granted, we measured technological capabilities at both the parent company and subsidiary levels. Another independent variable, subsidiary experience, was measured using the age of each subsidiary as indicated by the file dates of its patents.

3.2 Method

To test our hypotheses, we employed negative binomial regression analysis (송재용, 김형찬, 2007). In our models, the probability that a patent citation will occur n times (with n = 0,1,2, …) is as follows:

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

where

$\lambda_j = \exp(\Sigma B_i X_{ij})\ \exp(\mu_j)$ 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 jth patent of an overseas R&D lab i.

3.3 Variables and Measurement

All variables used in this study are summarized in Table 1. The dependent variable (LOCAL), measured at patent level, represents the extent of knowledge sourced by a subsidiary from the localized knowledge pool in the host location. The LOCAL variable is operationalized as the number of citations each subsidiary patent makes to any patent from the host location. An increase in this measure indicates an increase in the degree to which a patent builds upon knowledge that exists in the host location. We constructed the dependent variable from the patents filed in the U.S. Patent and

Trademark Office between 1996 and 1999.

To test our hypotheses, we constructed independent variables as follows. The agglomeration level in the host location (state) of a subsidiary (AGGLO) is operationalized as the number of foreign and U.S. firms in an industry within a state divided by the total number of firms in that industry within the United States. We used a ratio variable instead of a raw count, thus standardizing the agglomeration level, since the number of establishments varies greatly across industries. We used the 1997 U.S. Economic Census data to measure the agglomeration level for the period 1996 to 1999.

The technological capabilities of a given parent company (PARENTCAP) are operationalized as the number of U.S. patents granted to the parent company as of the year in which each subsidiary patent was filed. According to Ahuja and Katila (2001), an organization's patent portfolio provides a means of capturing its knowledge base; the number of patents obtained by the parent company provides an appropriate measure of its technological capabilities.

In the same way, the technological capabilities of a given subsidiary (SUBCAP) are operationalized as the number of U.S. patents granted to each subsidiary as of the year in which each subsidiary patent was filed. Originally, subsidiary technological capabilities were measured in 1995, since our observations of the dependent variable started at the beginning of 1996. To mitigate possible violations of independence among observations, we increased the capability of each subsidiary by 1 according to the time sequence. In other words, if subsidiary A registered 10 patents in 1995, we used 10 as the subsidiary capability for patent A1 (the first patent filed by subsidiary A) and 11 for patent A2 (the second patent filed by subsidiary A) and so on. To standardize the variables, the patent counts for all technological capability variables were log-transformed. Lastly, subsidiary age (SUBAGE) was measured by the number of years of operation of each subsidiary as of the filing dates of their patents (filing date of a subsidiary patent minus the date of the subsidiary's establishment).

In addition to the independent variables described above, other factors may also influence the knowledge flow to subsidiaries from the host location. First, as a control variable, we included the total number of citations (TOTAL) made by a sample patent, since it influences the extent of citations from the host location; the larger the total number of citations made by each patent, the more likely that the patent will cite a patent from the host location. We also controlled for the technological capabilities of the host location (HOSTCAP). Arguably, MNCs are more likely to source knowledge from the host location when that location has stronger technological capabilities than their home countries. To measure the technological capabilities of the host location, we counted the total number of patents granted to the host location (i.e., state) in the previous ten years. We controlled for industry differences using dummies. Cockburn and Griliches (1988) argue that knowledge appropriability is not constant across industries. Industry differences in knowledge appropriability may affect patent citation patterns. We divided the industries included in our sample into three groups: chemical/pharmaceuticals, electric/electronics, and machinery/automotive. Finally, we added a "manufacturing" dummy, as our sample includes both subsidiaries with R&D operations only and those with both R&D and manufacturing operations together. Our dummy variable takes on a value of one if the subsidiary includes manufacturing and R&D activities, and a value of zero if the subsidiary has R&D activities only.

〈Table 1〉 Variables and Measurement

Variables	Measurement
<u>Dependent Variable</u>	
▪ Degree of local knowledge sourcing (at patent level)	Number of local patents that patent **A1** cited[1] (subsidiary = A, B, C,…; Patents of subsidiary A = A1, A2,…)
<u>Independent Variable</u>	
▪ Level of agglomeration at a given host location	Number of established firms in a focal state (by industry) / total number of established firms in the United States (by industry)
▪ Technological capabilities of a given parent company	Number of patents that a parent company in Japan obtained as of file date for each subsidiary patent
▪ Technological capabilities of a given subsidiary	Number of patents that a U.S. subsidiary obtained as of the end of 1995 (emulating a time-varying effect) (A1 = n, A2 = n + 1, A3 = n + 2…)
▪ Age of a given subsidiary	Age of a given subsidiary as of file date for each subsidiary patent

[1]Local patents are those originating from the host country.

Ⅳ. Results

Table 2 provides descriptive statistics and correlations. Significant correlations were observed among some variables. To check for the possibility of multicollinearity, we calculated variance inflation factor (VIF) values. A high VIF indicates that a given independent variable can be explained by a combination of the other independent variables. Typically, 10.0 is used as a cut-off value for the VIF in various statistical analyses (Kennedy, 2002). As our VIF values fall far short of 10.0, we assumed that in this study, multicollinearity is not a serious problem.

〈Table 2〉 Descriptive Statistics and Correlations (N = 926)

Variables	Mean	S. D.	1	2	3	4	5	6	7
1. LOCAL	1.5273	3.5017	1.0000						
2. TOTAL	17.733	39.745	0.1386*	1.0000					
3. HOSTCAP	10.611	0.9381	0.2240*	-0.0190	1.0000				
4. AGGLO	0.0756	0.0697	0.2968*	-0.0007	0.5490*	1.0000			
5. PARENTCAP	6.8260	2.1600	-0.1378*	0.0990*	0.0451	-0.1952*	1.0000		
6. SUBCAP	3.3694	1.4737	-0.0956*	-0.1129*	0.1862*	-0.2214*	0.3326*	1.0000	
7. SUBAGE	16.800	12.775	-0.1110*	-0.1589*	0.2937*	-0.2235*	0.3646*	0.5794*	1.0000

* significant at $p < 0.05$.

Table 3 summarizes the statistical findings of the negative binomial regression analysis. Both the base model and the full model have high overall explanatory power ($p < 0.001$, χ^2 = 196.45 and 257.91, respectively). The base model in Table 3 includes control variables only. The full model includes all independent and control variables.

In hypothesis 1, we predicted a positive relationship between the number of local patent citations made by subsidiary patents (LOCAL) and the industry agglomeration level (AGGLO). The hypothesized relationship between the agglomeration level and the knowledge sourcing level of a given Japanese subsidiary at a host location — the state, in this study — was strongly supported ($p = 0.000$). Thus, we can assert that a high level of agglomeration at the state level contributes to the acquisition of local knowledge on the part of the subsidiaries.

As for hypothesis 2, the results of the analysis strongly support our predictions. We expected that the number of local patent citations made by subsidiary patents (LOCAL) would be negatively associated with the technological capabilities of the parent company (PARENTCAP). The coefficient for PARENTCAP turned out to be significant ($p = 0.001$) with negative signs, implying that the strong technological capabilities of a parent company negatively influence the local learning activities of its Japanese subsidiaries.

In hypothesis 3, we proposed a negative relationship between the technological capabilities of a given subsidiary (SUBCAP) and the number of local patent citations made by subsidiary patents (LOCAL). However, the coefficient was not statistically significant ($p = 0.131$). Thus, hypothesis 3 was not supported.

Lastly, in hypothesis 4, we proposed a negative relationship between the age of a given subsidiary (SUBAGE) and the number of local patent citations made by subsidiary patents (LOCAL). Results of the negative binomial regression analysis showed a statistically significant and negative relationship between subsidiary age and local knowledge acquisition ($p = 0.015$). This is evidence that Japanese subsidiaries acquire more local knowledge during the early years in a given host location, supporting hypothesis 4.

Furthermore, the statistical results indicated generally high levels of significance for our control variables. The coefficient for the total number of citations made by a subsidiary patent (TOTAL) turned out to be positive and significant ($p = 0.000$). The technological capabilities of a host location (HOSTCAP) were also positive and highly significant ($p = 0.000$). Industry differences were significant only in the second group, electric/electronics ($p = 0.002$). The negative sign of the coefficient for the electric/electronics group suggests that subsidiaries in this industry tend to learn less from the host location than subsidiaries in other industries.

We reran our regression models on a sample of subsidiaries that perform R&D function only. We found that both the regression coefficients and incremental R^2 of the technological capabilities of a parent company are larger in this sample, which consists of the subsidiaries specialized only in R&D. The regression result based on this sample (Table 4) shows that regression coefficient is -0.173349 ($p=0.000$) and incremental R^2 is 0.0075 ($\chi^2=12.47$, $p < 0.0004$) for the parent technological capabilities variable. In comparison, the regression result using the sample that include subsidiaries performing manufacturing functions shows that regression coefficient is -0.1074741 (p=0.000) and incremental R^2 is 0.004 (χ^2=14.50, p 〈 0.0001) for the parent technological capabilities variable. This result suggests that when technological capabilities of a parent company are strong, the negative effect of the parent's technological capabilities will be more pronounced in the subsidiaries that specialize in R&D than in those perform both R&D and manufacturing.

〈Table 3〉 Statistical Results of Negative Binomial Regression Analysis (N = 926)

	Base Model	Full Model
(Constant)	-8.432113*** (0.7879237)	-6.58125*** (0.9383914)
1. Control Variable		
Degree of total external knowledge sourcing	0.0141606*** (0.0024637)	0.0107946*** (0.0019603)
Technological capabilities of a given host location	0.8136681*** (0.0749587)	0.6733139*** (0.0947315)
Industry dummy (Electric/Electronics)	-0.6162929*** (0.1699199)	-0.5243204* (0.1718871)
Industry dummy (Machinery/Automotive)	-0.2869704 (0.2167087)	-0.1762872 (0.2104318)
Manufacturing dummy	0.3478112* (0.1116402)	-0.1629433 (0.1177304)
2. Independent Variable		
H1 Level of industry agglomeration (by state)		3.88806*** (1.023151)
H2 Technological capabilities of a given parent company		-0.098887*** (0.0291579)
H3 Technological capabilities of a given subsidiary		0.0713842 (0.0472277)
H4 Age of a given subsidiary		-0.0138521* (0.0056956)
Goodness of fit (Log-likelihood)	-1434.7016	-1317.3586

*significant at p 〈 0.05, **significant at p 〈 0.01, ***significant at p 〈 0.001.
Standard errors in parentheses.

〈Table 4〉 Statistical Results of Negative Binomial Regression Analysis using a Sample of Subsidiaries Performing R&D Function Only (N = 552)

	Full Model
(Constant)	-5.26556** (1.742595)
Degree of total external knowledge sourcing	0.067254*** (0.0015843)
Technological capabilities of a given host location	0.5614967** (0.1757973)
Industry dummy (Electric/Electronics)	-0.4234193 (0.2393218)
Industry dummy (Machinery/Automotive)	-0.0722274 (0.2986653)
H1 Level of industry agglomeration (by state)	6.755011*** (1.771488)
H2 Technological capabilities of a given parent company	-0.173349*** (0.0496782)
H3 Technological capabilities of a given subsidiary	0.1388305 (0.0805659)
H4 Age of a given subsidiary	-0.0159024 (0.0090818)
Goodness of fit (Log-likelihood)	-740.2002

*significant at p 〈 0.05, **significant at p 〈 0.01, ***significant at p 〈 0.001.
Standard errors in parentheses.

Ⅴ. Discussion and Conclusion

In this paper, we examined the relationships among geographic agglomeration, MNC characteristics, and local knowledge acquisition performance of Japanese R&D subsidiaries in the United States. Statistical findings from the negative binomial regression analysis showed a positive relationship between the agglomeration level of the host location and the level of knowledge acquisition of Japanese R&D subsidiaries (hypothesis 1) and a negative relationship between the technological capabilities of Japanese MNC parent companies and the knowledge acquisition of their R&D subsidiaries (hypothesis

2). We also found that R&D subsidiary age is negatively associated with knowledge acquisition (hypothesis 4).

Our finding that the agglomeration level of the host location positively affects the learning of Japanese subsidiaries in the United States reconfirms the benefit of knowledge spillover and geographic agglomeration in R&D activity (Shaver and Flyer, 2000). For example, our data show that Japanese R&D subsidiaries operating in electric/electronics industry located in California region acquire a particularly large amount of local knowledge measured as the number of local patents cited (Table 5). Other cases of a high level of local knowledge acquisition by Japanese R&D subsidiaries were observed in California (machinery/automotive), New Jersey (electric/electronics), and New York (electric/electronics). This finding suggests that MNCs seeking to acquire technological knowledge from foreign locations should consider the level of regional R&D activities in deciding on location. Our analysis also suggests that technological capabilities of MNC parent companies may influence subsidiaries' learning performance negatively. While a MNC parent company's strong technological capabilities may help its foreign subsidiaries to compete with local competitors in host locations, if the foreign subsidiaries' primary goal is to acquire foreign knowledge from host locations, such strong parent technological capabilities may have a negative side effect. Hence, both managers and R&D staffs at both the parent company and local subsidiaries may keep more open attitude toward local foreign knowledge, so that strong technological capabilities of the parent company may not inadvertently hinder foreign subsidiaries' local knowledge acquisition. The negative influence of the age of R&D subsidiaries on their local knowledge acquisition suggests that their focus may change as they mature and become more technologically advanced. The managers and R&D staffs of foreign R&D subsidiaries may consider possible narrowing in their technological trajectories and therefore may spend intentional efforts to overcome such restriction in technological trajectories and decrease in foreign knowledge inflow. For example, in order to continue to acquire new and more local knowledge, foreign R&D subsidiaries may continue to search for opportunities to collaborate with local companies and research institutions (e.g., universities) and recruit local engineers and scientists.

〈Table 5〉 Number of Local Patents Cited by Patents Filed during 1996-1999 by Foreign R&D Subsidiaries (by State and Industry)

State	Industry	Agglomeration Level	Local Patents Cited
CA	Chemical/Pharmaceutical	1404	49
CA	Electric/Electronics	3613	590
CA	Machinery/Automotive	6913	127
CT	Chemical/Pharmaceutical	145	4
CT	Electric/Electronics	419	6
GA	Machinery/Automotive	1037	1
IL	Chemical/Pharmaceutical	682	0
IL	Machinery/Automotive	3568	50
IN	Chemical/Pharmaceutical	278	1
IN	Electric/Electronics	366	1
KS	Chemical/Pharmaceutical	118	1
KY	Chemical/Pharmaceutical	162	0
KY	Electric/Electronics	136	1
MA	Chemical/Pharmaceutical	307	74
MA	Electric/Electronics	745	12
MA	Machinery/Automotive	1592	0
MI	Electric/Electronics	472	25
MI	Machinery/Automotive	5121	14
MN	Machinery/Automotive	1567	3
MO	Chemical/Pharmaceutical	349	16
NC	Chemical/Pharmaceutical	398	3
NC	Electric/Electronics	378	3
NH	Machinery/Automotive	419	0
NJ	Chemical/Pharmaceutical	728	5
NJ	Electric/Electronics	647	159
NY	Chemical/Pharmaceutical	595	20
NY	Electric/Electronics	1017	101
NY	Machinery/Automotive	2262	0
OH	Chemical/Pharmaceutical	636	3
OH	Electric/Electronics	648	3
OH	Machinery/Automotive	4093	0
PA	Machinery/Automotive	3159	0
SC	Electric/Electronics	134	0
TX	Electric/Electronics	975	39
VA	Electric/Electronics	261	3
WA	Electric/Electronics	343	10

Hypothesis 3, which posited a negative effect of subsidiaries' technological capabilities on their own knowledge acquisition performance, was not supported. A plausible explanation for this lack of empirical support comes from the absorptive capacity view of technological capabilities (김봉선, 김언수, 2009), which states that the level of knowledge sourced from host locations will be higher in MNCs with strong technological capabilities than it is in MNCs with weak technological capabilities, especially at the overseas R&D subsidiary level (Song and Shin, 2008; Song et al., 2011). Frost (2001) showed that the strength of an overseas R&D lab's technological capabilities predicts whether 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, thus, its absorptive capacity, it is more likely to seek knowledge actively in the host location as its innovation base, up to a certain point. Considering that the absorptive capacity argument suggests a positive relationship between technological capabilities and foreign knowledge acquisition, it is possible that there are some contingencies that may support the absorptive capacity-based prediction. For example, we proposed that strong technological capabilities will rigidify the technological trajectories and reduce interests in external knowledge. If firms continue to maintain flexibility in technological trajectories and diverse interest in external knowledge, such firms' strong technological capabilities may effectively serve as absorptive capacities for external knowledge acquisition. Although we could not empirically test such contingencies because they are overly broadening our study's scope as well as require data that we do not have an access to, we believe that testing such contingencies offer interesting questions for future research. Hence we urge future researchers to probe into such contingencies in order to further clarify the relationship between technological capabilities and foreign knowledge acquisition.

Similarly, Håkanson and Nobel (1993) suggested that the technological orientation and activities of overseas R&D labs may become more autonomous over time and less closely aligned to the existing knowledge base of the parent firm as they improve their own technological capabilities. Håkanson and Nobel's (1993) finding suggests that age of foreign R&D subsidiaries may be negatively related to their foreign knowledge acquisition performance. However, to be exact, Håkanson and Nobel's (1993) suggested positive relationship between subsidiary age and foreign knowledge acquisition is based on the increase in the level of autonomy of a subsidiary over time. Hence, if we could control for autonomy of a subsidiary, we may be able to distinguish the effects of age and autonomy of foreign R&D subsidiaries on our dependent variable. Therefore, the level of autonomy may serve as another interesting contingency variable that can help us clarify the relationship between the age of foreign R&D subsidiaries and foreign knowledge acquisition. Again, unfortunately, we do not have such data. We believe that considering this contingency condition will help future researchers to further clarify the relationship between subsidiary age and foreign knowledge acquisition.

The other possible explanation for the failure of our results to support hypothesis 3 is that our measure of subsidiary-level technological capabilities may be inaccurate, based as it was on the number of patents filed. While patent count is considered a more accurate and reliable measure of technological capabilities than the conventional measure of R&D expenditure (Griliches, 1990; Sampson, 2007), the average number of patents at the subsidiary level is so small that the patent count measure may not accurately capture technological capabilities at the subsidiary level, resulting in insignificant values. As noted earlier, however, alternative measures of technological capabilities, such as R&D expenditure, were not possible for the Japanese MNCs in our sample. Therefore, despite the possible inaccuracy, patent count is currently the best method available to measure knowledge flow from host locations to foreign R&D subsidiaries.

Our study suffers from other limitations, most notably, the context of Japanese R&D subsidiaries located in the United States. The characteristics of this context may limit the generalizability of our findings. For example, Japanese MNC parent companies are known for their tendency to exert strong control over their subsidiaries; thus, findings in this context may not be relevant to the context of MNCs from other countries that grant substantial autonomy to their subsidiaries. Therefore, we suggest that future research should examine the role of MNC parent characteristics on subsidiary activities in other national contexts. In spite of its limitations, this study contributes to our understanding of knowledge acquisition by overseas R&D subsidiaries in several ways. First, we provided a more complete picture of the learning performance of MNC subsidiaries by simultaneously considering the influence of geographic agglomeration and firm characteristics. Second, we presented and tested an exhaustive organizational model of MNC subsidiary learning that includes firm characteristics at both the parent company and subsidiary levels. Third, we examined knowledge acquisition performance directly using patent citation data. Future studies can build on our findings to enhance our knowledge of subsidiary learning in foreign countries.

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한글제목◆◆

한글이름◆◆

요 약

한글요약◆◆

Key Words: 기재요망◆◆