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ABSORPTIVE CAPABILITY OF JAPANESE AND EUROPEAN MNCs: BALANCE BETWEEN AUTONOMY AND CONTROL OF R&D SUBSIDIARIES IN THE US

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ABSTRACT

This paper analyzes the capability of Japanese and European multinational companies (MNCs) to absorb technological knowledge from the United States through their R&D operation in the US. Employing the notion of "absorptive capacity", this research defines the capability of a firm to absorb technological knowledge from abroad as "absorptive capability (AC)," and aims to examine the components of AC and their interrelationships using patent and sales data in the context of R&D management of Japanese and European MNCs at home and in the US. This paper also presents the taxonomies to show that a balance of autonomy and control is the key to increasing AC in the US and contributing to the US market sales by utilizing the home and host country technologies.

INTRODUCTION

In the past few decades, the world has seen the emergence of new technologies (e.g., information technology (IT) and biotechnology) that serve as key technologies across sectors. In response to this, the intensity of internationalization of R&D to exploit local knowledge has taken on increasing significance (Cantwell & Piscitello, 2000), while the internationalization of R&D has accelerated and is concentrated heavily in the "triad," i.e., the United States, Japan and several countries of the European Union (EU), with the US as a center (Edler, Meyer-Krahmer, & Reger, 2002). There are clear differences in the degrees of international absorption of technological knowledge by country: Japan and Germany are lagging far behind the UK and Switzerland (Gambardella, Orsenigo, & Pammolli, 2000). At the same time, considerable variances within countries were found, which suggests scope for managerial choice (Patel & Pavitt, 1997).

The key concept of this study is “absorptive capability (AC),” defined as the ability to absorb technological knowledge from abroad. High technology-based multinational companies (MNCs) are increasingly seeking this capability to compete in the global markets, particularly where adopting cutting-edge technologies is crucial. This key construct relies on the notion of “absorptive capacity” introduced by Cohen and Levinthal (1990). The emergence of this “absorptive capacity” construct coincided with the development of the resource-based view of a firm (RBV) and the core competence of a firm, which made it one of the most important constructs in management research over the past decades (Lane, Koka, & Pathak, 2002). Zahra and George (2002), however, argue that existing studies do not always capture the rich theoretical arguments and the multidimensionality of the “absorptive capacity” construct. In particular, prior research devotes little attention to the multiple dimensions of “absorptive capacity” of MNCs to absorb knowledge across national borders, though national institutional differences between the home and host countries may add constraints on “absorptive capacity.”

This study, therefore, aims to fill in these gaps and advance the understanding of the multiple dimensions of the capability of MNCs to absorb technological knowledge from abroad. I rely on the nexus of the literature on international management and the RBV and capabilities of a firm. On the one hand, a number of researchers point to the importance of combinative capability (Kogut & Zander, 1992), which implies a need for sufficient control over subsidiaries to combine their knowledge with knowledge at the headquarters (Ghoshal & Bartlett, 1990). On the other hand, prior studies argue that, for subsidiaries to acquire local knowledge and create a subsidiary-specific value, a certain level of autonomy is necessary so that they may be well embedded in their local network, and thus are able to explore local knowledge (Andersson, Forsgren, & Holm, 2002). Importantly, in coordinating the relationship between the headquarters and subsidiaries, a balance between the *control* and *autonomy* of a subsidiary is regarded as a critical factor in the enhancement and utilization of the knowledge of a subsidiary (e.g., Asakawa, 2001). But prior research using “absorptive capacity” in the analysis of international R&D management has made few attempts to investigate the effects of the conflicting needs of autonomy and control on the AC of MNCs.

In light of these arguments, I build a model of AC including the dimensions (capabilities) concerning autonomy and control in the process of absorption of technological knowledge abroad. I seek to investigate: (1) What capabilities constitute the AC of MNCs to absorb technological knowledge from abroad? (2) How are these capabilities related to each other? The model is examined empirically in the context of international R&D management. The research setting is Japanese and European multinational companies (MNCs) that operate R&D centers in the US in the electronics, automobile, pharmaceutical and chemical industries. I test several hypotheses concerning the relationships between the multiple dimensions (capabilities) of AC by using patent and sales data. My main findings are: (1) The combination of technological knowledge in the US with that in the home country has a significant positive effect on the utilization of US knowledge (increasing sales in the US); (2) The total amount of acquisition of technological knowledge in the US and the autonomy of US R&D subsidiaries both have a positive association with the utilization of US knowledge, but the association is not significant; (3) The autonomy and control of US subsidiaries may have mediating effects on the relationship between acquisition and utilization of US knowledge.

LITERATURE REVIEW

Absorptive capacity

In contrast to the assumptions of neoclassical economic theory, the RBV seeks to understand why firms in the same industry are not identical, and allows for the possibility that critical resources may be immobile. The RBV, in other words, looks inside "the black box" and analyses the key success factors that underlie firm-specific advantages. The related "dynamic capabilities" literature emphasizes *change* and explains why and how some firms are capable of sustaining competitive advantage in rapidly changing business environments. To deal with these environments, managers are required to "integrate, build, and reconfigure internal and external competences" (Teece, Pisano, & Shuen, 1997). "Dynamic capabilities" are not merely skills of individuals, but organizational knowledge and processes embedded in firms, which may be organizational routines (Nelson & Winter, 1982) or learning mechanisms (Eisenhardt & Martin, 2000). Other researchers have used similar concepts, such as "core competences" (Prahalad & Hamel, 1990) and "firm-specific knowledge" (Pavitt, 1991).

The emergence of the "absorptive capacity" construct, which provides a useful perspective for an analysis of the ability of firms to absorb technologies from abroad, coincided with the development of the RBV and its offshoot, the knowledge-based view of the firm. According to Cohen and Levinthal (1990), "absorptive capacity" is the ability of a firm to recognize the value of new external information, assimilate it, and apply it to commercial ends (p 128). They claim that this capacity is largely a function of the firm's level of prior related knowledge. In the analysis of “absorptive capacity” at different levels, they argue an organizational “absorptive capacity” depends not only on the sum of “absorptive capacity” of individual staff, but also on the network of individuals. It is important to note that the simple assimilation of external technologies without internal capability does not work. For high-technology based MNCs to catch up with technological progress in the world, assimilation of outside technology and the cultivation of in-house technological capabilities are essential twin processes (Cusumano & Elenkov, 1994). Prior research using the concept of “absorptive capacity” generally agrees that it is a multidimensional construct involving the ability to evaluate, assimilate, and apply external knowledge, or is a combination of effort and knowledge base (Zahra et al., 2002).

Many studies have operationalized “absorptive capacity,” which has facilitated empirical investigation of what factors influence the ability of a country or an organization to acquire external knowledge. For example, investment in R&D resources (Cohen et al., 1990; Veugelers, 1997), “stickiness” of knowledge (Szulanski, 1996) and connectedness to the scientific community (Cockburn & Henderson, 1998) are shown as key factors that influence the “absorptive capacity” of firms. Zahra and George (2002), however, criticize that empirical work does not always capture the rich theoretical argument and the multidimensionality of the “absorptive capacity” construct. Only a few studies have attempted to expand and elaborate on the original definition of Cohen and Levinthal (Lane, Koka, & Pathak, 2006). Prior research on international R&D activities devotes little attention to the multidimensionality of AC, nor does it elaborate on the original definition of “absorptive capacity” of MNCs as described below, while national institutional differences between the home and host countries may add constraints on a firm’s “absorptive capacity.”

Absorptive capacity and international R&D

Studies concerning “absorptive capacity” from the perspective of cross-border technology absorption have three levels of analysis: country, firm (organization) and people. They are centered primarily on the first two levels, and the two levels of these studies have distinct data sets and do not interact with each other, dealing with different sets of issues (Arai, 2007). On the one hand, researchers often use public data such as technology trade (imports/exports), patents or scientific papers to analyze it at a country or sector level, but they tend to leave a firm as a “black box” (Cantwell et al., 2000; Patel et al., 1997). On the other hand, previous work at a firm level usually relies on interview and questionnaire data and has been weak in the systematic analysis of AC. It has investigated mostly the issues of motivation, location choices and roles of subsidiaries, and only a limited number of researchers have dealt with the coordination, control and communication problems of MNCs regarding R&D activities (Asakawa, 2001; de Mayer & Mizushima, 1989; Håkanson & Nobel, 1993; Håkanson & Zander, 1988; Nobel & Birkinshaw, 1998). Studies on technology sourcing of MNCs analyzes the acquisition of knowledge in the host countries (Almeida, 1996; Frost, 2001), but it hardly touches upon the transfer and combination of the sourced knowledge within MNCs across national borders. Cross-border knowledge absorption and transfer within MNCs has become a subject of study only recently, and the capability of MNCs to manage it successfully has not been well investigated (Foss & Pedersen, 2004).

This paper aims to fill in these gaps in current research and to contribute to the understanding of the multiple dimensions of AC of MNCs. I conceptualize various dimensions (capabilities) of AC and build a model in the next section. To assess the various capabilities with objective criteria to specify what capabilities AC consists of, I examine the model by relying on sales and patent data in the context of R&D management of Japanese and European MNCs at home and in the US.

MODEL OF ANALYSIS

Theoretical framework

This paper pays special attention to the tension and the balance between *autonomy* and *control* in identifying multiple dimensions of AC: *Autonomy* facilitates subsidiaries' exploration and assimilation of US technological knowledge, whereas *control* encourages the combination of US knowledge with knowledge in the home country.

New combinations of resources are the key factors for firms' survival. MNCs need to combine the knowledge of globally dispersed units to take advantage of their local expertise. Schumpeter was one of the first scholars to point out that innovation takes place "by carrying out new combinations" (Schumpeter, 1934, p65-66). Many other researchers have subsequently recognized the role of combination in innovation. For example, Kogut and Zander (1992) claim "an analysis of what firms can do must understand knowledge as embedded in the organizing principles by which people cooperate within organizations. ... (F)irms learn new skills by recombining their current capabilities" (p383). In the domain of technological management, Kodama (1992) used the term "technology fusion" and Iansiti (1995) named "technology integration" to describe the combination of technologies. These studies indicate a need for control by the headquarters over subsidiaries to facilitate the process of knowledge combination across borders in order to bring about more innovations.

Importantly prior studies of international management suggest that there is a tension between autonomy and control in terms of headquarters-subsidiary relationships (e.g., Asakawa, 2001). On the one hand, a firm needs to give its subsidiaries enough autonomy to be embedded in the local network so as to explore and assimilate external knowledge worldwide. On the other hand, it is required to control its subsidiaries so as to combine their knowledge with the core knowledge, which usually exists in the country where the firm is headquartered. Yet there are many impediments especially to cross-border knowledge transfer and combination, and firms face various barriers such as linguistic, cultural and cognitive.

To overcome this problem, MNCs must develop appropriate organizational mechanisms to share and combine knowledge across units worldwide. In developing these, MNCs need to adjust not only the organization and management of their US subsidiaries to those of their headquarters, but also their headquarters to their subsidiaries. However, because of the large institutional distance between the home and host countries, some adjustments may not be feasible. As a result, firms may need to exert more control over their subsidiaries to compensate for the organizational difference between the headquarters and subsidiaries, which can lower the level of autonomy and make lose an appropriate balance between autonomy and control. This dilemma between the competing requirements of autonomy and control in order to acquire and transfer local knowledge within a firm can be considered as a key issue concerning AC in the context of international R&D.

Multiple dimensions of AC

Based on these arguments, I propose four capabilities composing AC: AC consists of acquisition and utilization capabilities, and acquisition capability in turn comprises independence and combinative capabilities. Acquisition capability is defined as the ability of a firm to assimilate and acquire technological knowledge in the host country, and utilization capability is the ability to utilize and apply the knowledge to commercial ends. Independence capability centers on the exploration and assimilation of local knowledge in the US, whereas combinative capability enables the integration of host and home country knowledge of a firm. In what follows, I explain each capability in more detail.

First, acquisition capability is defined as the ability to acquire foreign technological knowledge, comprising two subsets, combinative and independence capabilities. Acquisition capability not only involves assimilating, but also searching, recognizing, and evaluating external foreign knowledge before acquisition. Second, one of the two components of acquisition capability, independence capability, is defined as the ability to acquire technological knowledge by foreign subsidiaries independently from the headquarters. Independence capability can be facilitated by the autonomy of US R&D subsidiaries, and it allows the subsidiaries to enjoy independence so that they may adopt organization and management styles that fit the local networks and assimilate more technological knowledge from them (Almeida, 1996; Andersson et al., 2002). In addition, especially in the case of R&D, autonomy of subsidiaries is essential in encouraging innovations, which rely to a large extent on the motivation of R&D staff.

Third, combinative capability, another component of acquisition capability, is defined as the ability to integrate knowledge across national borders within a firm. Organizational absorptive capacity depends not only on the absorptive capacity of individual members of an organization, but also on transfer of knowledge across and within members (Cohen et al., 1990). Researchers have emphasized the importance of combinative capability in different terms (e.g., Iansiti, 1995; Kodama, 1992; Kogut et al., 1992; Penrose, 1995; Teece et al., 1997). To combine the existing technology resources of dispersed units in the processes of technology absorption abroad, it is crucial that the units within a MNC are under sufficient control so that it may integrate and make the most of its globally dispersed knowledge (Ghoshal et al., 1990). Fourth, utilization capability is considered as an ability to apply foreign technological knowledge to commercial ends. Utilization of external technologies is the process of exploitation by applying acquired and internalized technologies to final products or services in the market. The utilization capability is critical, given that the ultimate survival of a firm depends on the profits it can make. The next section presents hypotheses concerning the relationships between these multiple capabilities composing AC.

HYPOTHESES

Hypotheses on the influence of acquisition capability on utilization capability

AC includes an ability not only to assimilate and recognize, but also to exploit external knowledge (Cohen et al., 1990). The first set of hypotheses deals with the effects of knowledge acquisition on utilizing technological knowledge for commercial ends. Firms that acquire more host country knowledge may have more opportunities and interest in utilizing it to increase their sales in the local market. For large high-technology based MNCs in business fields such as electronics/engineering, automotive, pharmaceutical and chemical sectors, the market is global, and in particular, the US markets are often a lead market to test their products. Therefore the primary objective of their US R&D operation is usually to contribute to product development both for the US and global markets. Thus the volume of acquisition of

US technological knowledge may be positively related to improving their sales in the US market. These arguments lead to the following hypothesis:

Hypothesis 1. *The more a firm has acquisition capability abroad, the higher the utilization capability of the firm in the local market is.*

Hypotheses on the influence of combinative and independence capabilities on utilization capability

The next two hypotheses deal with the influence of the subsets of acquisition capability, combinative and independence capabilities, on utilization capability. Combinative capability serves as a key capability for innovation (Kogut et al., 1992; Schumpeter, 1934). Firms' home bases provide dominant sources of competitiveness (Kogut, 1993; Porter, 1990), including technological capabilities (Patel & Vega, 1999). To develop novel products in internationally competitive markets, it is particularly critical that firms are able to combine their core technologies at home with foreign technologies that are not available in the home country. Thus firms that combine more knowledge in the US with home country knowledge may utilize US knowledge and have higher sales in the US market. The following hypothesis is therefore formulated:

Hypothesis 2a. *The more a firm has the combinative capability to integrate US technologies with those of the home country, the higher the utilization capability of the firm in the local market is.*

On the other hand, US subsidiaries with a higher degree of autonomy can respond to the local market more flexibly. If firms' US R&D centers have been obtained as a result of acquisition of US firms, the R&D centers tend to be more independent from the headquarters and to collaborate more with other units of the US subsidiary, which are more focused on the US market. In addition, since the transmission cost of cross-border knowledge sharing is large, it may be that firms which share knowledge more with other units in the US than with the headquarters achieve more efficient use of US knowledge and perform better in the US market. For these reasons, firms with more independent overseas R&D operation may have more utilization capability to commercialize US knowledge in order to increase sales in the local market. Therefore, the following hypothesis is established:

Hypothesis 2b. *The more a firm has the independence capability to acquire local technologies autonomously, the higher the utilization capability of the firm in the local market is.*

Hypotheses on the effect of independence capability on combinative capability

The third set of hypotheses focuses on the relationship between combinative and independence capabilities. These two capabilities have competing characteristics: combinative capability is the ability to integrate US knowledge with home country knowledge, while independence capability is the ability to allow autonomy to US subsidiaries. There are two possible relationships between these two capabilities. One is that the high degree of US autonomy hinders the collaboration between the headquarters and US R&D centers. To facilitate such collaboration for cross-border knowledge combination, certain organizational mechanisms are necessary, but a high respect for the autonomy of US R&D centers may make it difficult to install such mechanisms. The other possible relationship is that more independent US R&D centers can have more valuable knowledge and induce more knowledge combination between the subsidiaries and headquarters. Autonomous R&D centers can be more embedded in the local science and technology networks, resulting in more local specific knowledge acquisition. Consequently, US R&D centers can increase their value and give the headquarters more incentives to collaborate with them. Given these two possibilities, the following hypotheses are proposed. Figure 1 summarizes all the hypotheses.

Hypothesis 3a. *The more a firm has the independence capability to acquire local technologies autonomously, the lower the combinative capability of the firm is.*

Hypothesis 3b. *The more a firm has the independence capability to acquire local technologies autonomously, the higher the combinative capability of the firm is.*

Insert Figure 1 about here.

METHODS

Research setting

These hypotheses are tested in the context of the R&D activities of East Asian (Japanese and Korean) and European (German, Swiss, Dutch, Swedish, and Finnish) MNCs that carry out research activities of their corporate R&D centers in the US as well as in their home countries. All the countries where the MNCs are headquartered are members of the OECD and invest a high percentage of their GDP in R&D. These countries in Europe and Asia share national borders and/or similar backgrounds culturally and historically. The unit of analysis is a firm. I focus on the electronics/engineering, automobile, chemical and pharmaceutical industries. Firms in these industries also have relatively high R&D intensity (R&D expenditure/sales). The propensity to patent differs across industries, and some firms are less interested in filing patents, which makes it difficult to compare the success in developing inventions of firms by means of patent data (von Hippel, 1994). Nevertheless, large MNCs, particularly those in these industries I study, file patents vigorously enough for researchers to use patent data to analyze their R&D activities (Patel et al., 1997).

Sample

After choosing the home countries and industries of firms to be sampled, I identified the population of the potential sample firms to be studied from the lists that ranked firms of each country or by sector worldwide (e.g., "*OECD Outlooks," "Shushoku-shiki.hou WEB," "Die Zeit," "World Investment Report 2002"*). Then I chose the firms which had research activities of corporate R&D centers in the US and which were accessible to us because I had prior contacts or potential contacts with through mediating people or organizations such as industrial organizations and research institutes. These personal contacts and introduction by local networks were very important because of the sensitivity of the subject of R&D activities. Then I made exploratory semi-structured interviews. Finally 47 observations of 45 firms[1], which I interviewed at least once, are included in the sample as listed in Table 1.

Insert Table 1 about here.

Data

In this paper I use four sets of data: 1) public company data regarding sales and R&D, 2)

[1] Bayer and Merck have chemical and pharmaceutical business units, each of which has its own corporate R&D centers and decision making units at the top level. Therefore these two business units of each firm are treated as separate observations.

patents, 3) interviews and 4) responses to my questionnaires. The data for the statistical analysis consist of sales by region and information on the patent inventors of each firm, whereas the last two are used to interpret the statistical results. First, the public company data on sales and R&D expenditure were gathered from their special reports to the national authorities of the stock markets or US authorities as well as from their annual reports. When these data were not included in published reports, enquiries were made to each company directly.

Second, in this study, the patent data are used as the main source of information to track technological innovations in the dispersed R&D locations of the Japanese and European MNCs. I analyzed a total of 613,583 patents that were granted to the sample firms (including their consolidated subsidiaries) in the study. These were the patents filed first between 1995 and 1999, either with the US Patent and Trademark Office (USPTO), the European Patent Office (EPO), the World Intellectual Property Organization (WIPO) or the national patent offices of the countries where the firms' headquarters are located. Because MNCs often subsequently file patents for the same invention in several countries, I used only the first-filed patents in order to avoid double or triple counting. These data were selected by the EPO which has all the patent data filed in the patent offices above. The numbers of patents granted for the same number of inventions differ in the different patent systems in each region and country. Therefore, I scaled down the number of Japanese and Korean patents by a factor of 4.9 to re-evaluate the volume of inventions.[2]

I chose the patents whose priority date (i.e., the date a patent application was filed in any country that has signed the Paris Convention) was between 1995 and 1999. These dates were chosen primarily because of the comparability of patent data as follows. The first reason is the time lag between inventions and market performance. The average time lag varies across sector. However, it takes at least three to four years according to the interviewees. Since the sales were measured as of 2002, I decided to include patents first filed until the end of 1999. Second, firms' patent strategy had evolved since the early 1990s. German firms, in particular,

[2] To deal with the problem of varying numbers of patents per invention, Eaton and Kortum (1999) used a factor of 4.9 to scale down domestic patents in Japan based on the analysis of Okada (1992). Using the data on the number of claims of inventions, Okada finds that Japanese patents granted to foreigners contain on average 4.9 times as many inventive claims as those granted to Japanese inventors, and others all have a similar average number of claims per patent. In addition, according to the study of EPO, the factor to scale down Japanese patents should be between 3 and 5. In addition, the Korean patent system is very similar to the Japanese one due to their historical assimilation of every Japanese policy, which was confirmed by experts on the patent issue. Hence it is assumed the Korean patents have a similar tendency to those of the Japanese. Therefore I tested the factors of 3 and 4.9, and the principal results were same.

increased their patent filings despite the stable R&D expenditure during the same period. Third, Japanese firms became more intensive in their internationalization in the 1990s, while some companies, particularly in small countries, started to internationalize their R&D activities much earlier (Kuemmerle, 1999). For the last two reasons, it was necessary to limit the data filed after 1995.

The reason for choosing 1999 was that, before November 2000, US law did not allow publication until patents were granted. Because it takes at least two to three years for the patents to be granted, some of the applications filed after 2000 did not appear in the US patent data (Testing with the patent data of several firms showed a sharp decline of the numbers of patents granted that were filed after 2000.). Thus I chose priority dates up to the end of 1999 to make comparison of the US patent data with those of the other places where publications are made 18 months after the priority dates so that, as of the end of 2003, it was possible to obtain the addresses of inventors with priority dates up to the middle of 2002 (The patent data were provided by the EPO in February 2004).

Third, as regards interview information, I conducted extensive semi-structured interviews with over 250 managers in the Japanese and European firms in the three regions, Japan, Europe and the US, from 2001 to 2005. The primary objective of the interviews was to explore and understand the facts because international R&D activities at a firm level with respect to organization and management are still understudied. Fourth, in parallel with the exploratory interviews, I invited the selected firms to participate in my 50-page long questionnaire survey. About 40 firms expressed an initial interest and were visited at least once to conduct structured interviews and the completion of questionnaires at their headquarters or main corporate R&D centers from 2003 to 2004. From the summer of 2003 to the summer of 2004, the questionnaire survey was conducted usually during face-to-face interviews with senior managers at the corporate R&D centers in the home country who were usually to report to the chief technology officer (CTO) or the second to the CTO. Though these primary data of the interviews and survey are useful sources of information, I restrict my attention mainly to analyses of the patent and sales data in this paper and use the questionnaire and interview data only as a reference to interpret the statistical results for this study.

Statistical methods

To test the hypotheses, I conducted bivariate and multivariate analyses. The multivariate regressions included four control variables, sector, region, R&D expenditure and R&D intensity, for the reasons explained in the following section on the construction of measures.

For the multivariate analyses to test hypothesis 1, I used ordinary least squares (OLS). To test hypotheses 2a, 2b, 3a, and 3b, I employed path analysis[3] and also used OLS to test each effect of one variable on the other. Since my model for hypotheses 2a, 2b, 3a, and 3b is essentially a recursive simultaneous equation model (i.e., no variable affects and depends at the same time on another variable), path analyses provide better estimates for hypotheses 2a, 2b, 3a and 3b because they take into account potential correlations among disturbances across equations and give insights into the causal ordering of variables in a system of relationships.

Construction of measures

"Absorptive capacity" is regarded as a complex construct and difficult to measure and operationalize (Lane et al., 2002). Lane, Koka and Pathak (2002) argue that the two dimensions (the ability to assimilate and to commercially apply external knowledge) are even more difficult to operationalize than the two other dimensions (the ability to search and evaluate) because the former two dimensions are fundamentally process-oriented and thus not readily measurable by publicly available archival data. This implies the last three stages - acquisition, combination and utilization - are especially difficult to measure and operationalize. However, this study aims to address this problem by relying on patent and sales data of firms as described in the following.

Acquisition capability. Acquisition capability (ACUS), defined as the capability of a firm to acquire technological knowledge in the US through their US R&D centers, is measured by the proportion of patents which have at least one US inventor to all the patents of a firm first filed at USPTO, EPO, WIPO, or the patent office in the home country. Figure 2 illustrates the measure of this construct by the sum of the shares of b, d, e and g (the letter in each area in the diagram indicates the share of the patents in the area of all the patents of a firm) of the total patents granted to a firm by the above patent offices. Firms with higher acquisition capability are regarded as having a greater capability to make use of US people who embody US knowledge and contribute to new inventions.[4]

[3] I follow the convention of calling this path analysis. Path analysis is referred to as "structural equation model" when the variables in the model are latent and measured with multiple observed variables using factor analysis. In my model there is only one measured variable per concept. (see Barton, J. & Mercer, M. 2005. To blame or not to blame: Analysts' reactions to external explanations for poor financial performance. Journal of Accounting & Economics, 39: 509-533.)

[4] A particular drawback of this measure may be that home country inventors who moved to the US are counted as US inventors and vise versa. However, these people have absorbed the US technological knowledge while they work in the US, and, therefore, the patents contributed by them are regarded as reflecting US

Insert Figure 2 about here.

This measure has often been used by other studies using patent data to evaluate the level of technology absorption of MNCs abroad. However, these studies usually rely on patents granted by a single patent office such as USPTO (e.g., Cantwell et al., 2000) or EPO (e.g., Bas & Sierra, 2002), though where to file patents varies depending on the nationality, industry and strategy of a firm. In addition, they do not distinguish patents contributed solely by host country inventors and patents jointly contributed by home and host country inventors. To address these weaknesses, this study uses patents filed in all the places where Japanese and European MNCs are most likely to file their patents. Moreover, it pays attention to the differences in the patterns of inventors' addresses as follows. To the best of my knowledge, this is the first attempt to use these dimensions of patent data.

Combinative capability. Combinative capability (USCC) is measured by the proportion of all the patents granted to a firm that have both US and home country (and other) inventors (d and g in Figure 2). The proportion of patents co-invented by home and host country people reflects the level of knowledge integration and transfer across countries. Integration of knowledge involves a tacit dimension and is possible only through intensive human contacts enabled by activities such as co-inventions.

Independence capability. Independence capability (USOL) is measured by the proportion of all the patents granted to a firm that have only US inventors (b in Figure 2). It reflects the degree of autonomy of a US subsidiary to explore local knowledge to create subsidiary specific value and to make new inventions in the US independently of its headquarters.

Utilization capability. Utilization capability (USM), an ability to commercialize acquired knowledge for the US market, is measured by the performance of a firm in the US market, specifically by the share of the total sales of a firm that come from the US market. A

knowledge. In addition, according to the interviews with managers of MNCs, the proportion of expatriates in the US is relatively small (around 5%).

problem with this measure is that it fails to take into account cases where US technologies are used to contribute mostly to the home markets of firms. However, the interviews with firms revealed that the primary target of US R&D centers is usually the US, both home and US or global market including the US because they aim to develop products of which the US is the lead market.

Control variables. Four control variables are included: (1) R&D expenditure (RDE) and (2) R&D intensity (RDI), (3) region and (4) industry. The reasons are as follows. Researchers have recognized differences in AC by country and industry (Cantwell et al., 2000; Patel et al., 1997). Therefore this study also uses the control variables of region (Japan/Korea vs. Europe) and industry (electronics/automobiles vs. pharmaceuticals/chemicals). As for R&D expenditure, firms need internal R&D capability to assimilate external R&D knowledge. Prior research finds firms' R&D investment increases acquisition of external technologies (Lim, 2004; Rosenberg, 1990; Veugelers, 1997). Thus firms' total R&D expenditure is expected to influence absorption of US knowledge positively.

In addition, the R&D intensity (RDI) of a firm is included to capture the differences in firms' commitment to developing their knowledge basis. Cohen and Levinthal (1990) find the positive association between "absorptive capacity" and R&D intensity, whereas applied economists identify three classes of industry-level determinants of R&D intensity, demand, appropriability and technological opportunity conditions, which influence "absorptive capacity" (Cohen & Levinthal, 1989). Thus, including this control measure enables us to better assess the interrelationships between various capabilities being independent of such influence.

The factor analysis, including the variables of the four capabilities as well as R&D expenditure, R&D intensity, total annual sales, total employees and share of R&D people of corporate R&D centers in the US, tells us that R&D expenditure, total annual sales and total employees, belong to one of the two components, whereas R&D intensity is in another, and all the other variables are in the other component (Table 2). R&D expenditure is strongly related to other measures of firm size (total annual sales and total employees), whereas R&D intensity is not. Therefore, I employed R&D expenditure to control the firm size in addition to the other reason given above for using R&D expenditure as a control variable.[5]

[5] I also used the total sales of a firm to control the size of a firm instead of R&D expenditure, but the results were almost same.

Insert Table 2 about here.

RESULTS OF STATISTICAL ANALYSES

Descriptive statistics

Table 3 shows the means of key variables by region and industry. On average, compared in the same industries, European MNCs have higher annual turnover, utilization capability, R&D expenditure and R&D intensity than their Japanese/Korean counterparts. Their share of R&D staff in the US is also higher. US market share and R&D intensity are slightly higher for pharmaceutical and chemical industries in both regions, although turnover and R&D expenditure are higher for electronics and automobile industries. The Japanese/Korean electronics and automobile firms have a higher percentage of expatriates in their US R&D centers on average. In terms of the variables based on patent data, the acquisition capability, combination capability and independence capability of the European firms are much higher than those of the Japanese/Korean firms.

Insert Table 3 about here.

Results of OLS and path analysis

The bivariate correlations are shown in Table 4 and Figure 3. The results of the multivariate regressions with the control variables, region, industry, R&D expenditure and R&D intensity, are shown in Table 5, whereas Figures 4 and 5 summarize the results of ordinary least squares (OLS) and path analysis respectively.[6]

Insert Tables 4 and 5 and Figure 3, 4, and 5 about here.

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[6] White's test for heteroskedasticity was carried out for each regression. No evidence of a problem was detected at the 0.05 level of significance.

The first hypothesis predicted a positive impact of acquisition capability on utilization capability measured by the performance of the US market share of the total sales. The result of the test using the bivariate analyses is consistent with my expectation. However, the result becomes insignificant in OLS. This suggests that a firm which acquires more US technological knowledge does not necessarily have a higher share of US sales of all its sales. Firms vary in making use of US knowledge and turning it into profits.

Hypotheses 2a and 2b predicted a positive effect of combination and independence capabilities on utilization capability. To test these, both OLS and path analysis were used because of the predicted relationships between combinative and independence capabilities in Hypotheses 3a and 3b. The result of the test using the bivariate analyses support these hypotheses, but those of the OLS and path analyses show only Hypothesis 2a has a statistically significant result: There is a significant positive effect of combinative capability on utilization capability (the unstandardized coefficient = 1.468 and $p<0.1$ in OLS; and the unstandardized coefficient = 1.521 and $p<0.1$ in path analysis). In path analysis, a multicollinearity issue needs to be considered, and therefore variance inflation factors (VIFs), which measure the inflation in parameter estimates due to collinearities among independent variables, were calculated. As Table 6 shows, all the VIFs are much smaller than 10, which is the value commonly used to indicate the presence of severe multicollinearity.

Insert Table 6 about here.

It is notable that combination capability, but not acquisition capability or independence capability, has a significant positive effect on utilization capability.[7] The results suggest that to achieve high turnover in the US, acquiring US knowledge is not enough, but combining US knowledge with home knowledge is the key. As mentioned later in the section, R&D expenditure is significantly correlated with utilization capability in the regression analysis controlled by region, sector and R&D intensity. This implies MNCs that have higher utilization capability have a strong R&D capacity at home base which constitutes the competitive advantage of a firm. At the same time, these firms must have a capability to

[7] Since there may be diminishing returns of acquisition capability (ACUS) and independence capability (USOL) to the US sales, Log(ACUS) and Log(USOL) were also used to substitute ACUS and USOL in the hypotheses 1 and 2b respectively, but the results were almost same while the adjusted-R squares improved only by less than 0.01.

combine it with US knowledge, which complementarily strengthens their R&D capacity at home. The statistical results show that the two conditions need to be met to achieve high utilization capability.

To the best of my knowledge, this is the first time it has been possible to demonstrate empirically that combinative capability of cross-border technological inventions constitutes an important part of core competence resulting in actual economic performance in the local market. This supports the argument that combinative capability is the key to innovation and sustaining the competence of firms. It could also imply that there may be certain organizational characteristics which underlie and enable both combinative and utilization capabilities at the same time.

With regard to the relationship between control and autonomy, Hypotheses 3b is supported by the bivariate analyses, but not by the path and OLS analyses at the 0.1 level, although both statistical analyses, bivariate and multivariate, show a positive effect of independence capability on combinative capability. The results of the bivariate correlations show that, when the number of patents of a firm to which only US people have contributed is higher, their combinative capability is also higher. This may imply that US R&D centers which enjoy more freedom may have more attractive knowledge to combine with home knowledge because the subsidiaries may be more embedded in local R&D networks and absorb technological knowledge from them (Andersson et al., 2002).

The result, however, becomes insignificant in the multivariate regression analyses including the four control variables: region, industry, R&D expenditure and R&D intensity. It shows that there is a positive, but not significant, effect of independence capability on combinative capability. This result may suggest trade-offs as well as a positive interrelation, one increasing the other, between the two capabilities. Because there are competing needs between the two capabilities underlying control and autonomy, the two capabilities influence each other in opposite directions, making the positive effect of independence capability on combinative capability insignificant. These may imply that it is desirable and possible to increase both capabilities while it is difficult to strike a right balance between the two capabilities.

Results of control variables

R&D intensity has a significant positive impact on acquisition capability at the 0.1 level when controlled by region, industry and R&D expenditure. This may suggest that firms involved in new rapidly changing technology fields (which require a higher R&D intensity) need to absorb more technological knowledge from the US. The effect of R&D intensity on independence capability is also significantly positive at the 0.05 level, but not on combinative capability. The findings may suggest that firms involved in rapidly changing technology fields need to allow more autonomy of R&D subsidiaries to explore new possibilities in the US.[8]

R&D expenditure has a significant positive effect on utilization capability at the 0.05 level, but does not have a significant impact on acquisition, combinative or independence capability. It is argued that the assimilation of outside technology and the cultivation of in-house technological capabilities are twin processes for high technology based firms (Cusumano et al., 1994). Veugelers (1997) found the positive relationship between R&D investment and the "absorptive capacity" of a firm, pointing out the importance of internal R&D to acquire external R&D knowledge. The result of this study, however, indicates the importance of total volume of R&D expenditure to exploit the US market, but not to acquire technologies in the US. The reason that the volume of R&D expenditure does not have an impact on acquisition capability may be that firms with a strong R&D competence at home do not need to acquire US knowledge and therefore have not developed this capability. These results suggest there is a need for a closer examination of the current arguments concerning the relationship between the in-house R&D and AC of MNCs.

TAXONOMIES BY FOUR CAPABILITIES COMPOSING AC

Meanings of two taxonomies

In order to advance our understanding of the relationships between the four capabilities examined in the statistical analyses, two types of taxonomies are created based on two pairs of two constructs: (1) acquisition capability and utilization capability and (2) combinative capability and independence capability. The categorizations of existing studies in international R&D management at a firm level usually rely on subjective criteria of researchers such as interviews and questionnaires (Gerybadze & Reger, 1999; von Zedtwitz & Gassmann, 2002). However, in this study, I use more objective criteria, patents and sales, to measure the four capabilities of AC to help elucidate the organizational and managerial characteristics of firms in each category. To explore the characteristics of firms in each category, I rely on the information mainly from the interviewees of MNCs and other sources. Because of the

[8] In addition, R&D intensity has a significant *positive* effect on utilization capability at the 0.1 level, but it has a significant *negative* correlation with the share of the sales in the home country (HOM) and no significant correlations with the share of the sales in the home region (HRM). This implies that the US market is very important especially for firms whose R&D intensity is high.

confidentiality, it is not possible to describe the details of each firm in the taxonomies. Therefore, the main purpose of this section is to explain the common features of the firms included in the same group in the taxonomies and to help understand the meanings of the four capabilities at a firm level.

Taxonomy of firms by acquisition and utilization capabilities

Tables 7 and 8 show the position of each firm with respect to its acquisition and utilization capabilities. The firms are divided into electronics & automobiles (Table 7) and pharmaceuticals & chemicals (Table 8) to control industry differences and then placed into each category depending on whether their acquisition and utilization capabilities are higher or lower than the median.

Insert Tables 7 and 8 about here.

National focus R&D. The firms in the "national focus" group in Tables 7 and 8 have acquisition capability and utilization capability that is below the median. Japanese chemical and electronics firms are mostly of this type. According to the interviewees, the purpose of their R&D activities in the US is primarily to support production, technology monitoring and scanning, often with "listening posts," and/or to absorb a small amount of specific technologies mainly for their home market and to a lesser extent for adaptation to the US market. The firms in this category may have home markets profitable enough to afford the costs of their R&D. In addition, their technologies are mature and do not require the firms to acquire much US knowledge.

These firms, therefore, tend to have little incentive to internationalize their R&D. The low US market share may indicate that the costs of increasing product development capability and marketing/sales capability for the US market would exceed the potential profits in the US market. Therefore their strategy is to focus on their home market and home technologies while the cost of changing the organization to increase acquisition capability and utilization capability is higher than potential benefits.

Technology-oriented R&D. The firms in the "technology-oriented" group have higher acquisition capability and lower utilization capability than the median. There are both

Japanese and European firms in this category. The R&D operations of these firms are technology-driven rather than market-driven. Their exploitation of US technologies in the US market is not as vigorous as the firms with more than average utilization capability. It is possible that they are investing heavily in improving product development and marketing/sales to adjust to the US market although they have not yet succeeded in reaping the economic benefits from acquiring US technologies. Thus they may be in the process of transforming their strategy and organization to those of the firms in the "integrated" group. Alternatively, they may have moved from the "integrated" group recently as their US sales declined, but continue to maintain the previous level of R&D activities in the US.

Market-oriented R&D. The firms in the "market-oriented" group are characterized by below median acquisition capability, but above median utilization capability. These firms tend to have very strong technological capabilities, which are centered on their home countries and exploited in the US market. They have not seen an urgent need to acquire US knowledge yet. Therefore, their R&D activities in the US tend to be more market-driven, i.e., for adaptation to the local market, than "technology-oriented" firms. "Market-oriented" firms have relatively small capabilities for acquiring US knowledge, but may be good at adapting to the US market by integrating US technologies with those at home for new product development. They may well possess the marketing/sales competence needed to sell products in the US. Having attained high sales performance in the US without relying much on US technological knowledge, the firms in this group may have little incentive to acquire more technologies from the US.

Table 8 shows that four automobile companies out of the six in the sample belong to this type. DaimlerChrysler, formed by the merger of a German and an American company in 1998, and Honda are the only exceptions. This suggests that the Japanese and German automobile firms still rely heavily on and exploit home based R&D in overseas markets. The interviews with the managers of the automotive industry revealed that their firms needed to acquire only a narrow range of specific knowledge in the US, such as Internet technologies, complementary to their core technologies at home. As regards the regional difference, comparing within the same industries (Tables 8 and 9), the firms in this category are mostly Japanese firms with the exception of BMW and Volkswagen. This may indicate that Japanese firms rely more on home R&D than their European counterparts to increase their sales in the US market.

Integrated R&D. The last “integrated” group includes firms that have both higher acquisition capability and higher utilization capability than the medians. This means that the firms in this category are both technology and market oriented. They possess substantial technological competence in their US R&D centers and, at the same time, can utilize the acquired US knowledge through their product development and marketing/sales. This suggests that the firms in the “integrated” group have the organization to leverage and exploit both home and US resources more successfully than the firms in the other types.

All the firms from small countries, except for Ericsson, are in this group. In addition, most of them in Table 9 are in pharmaceuticals. This may mean that firms in the pharmaceutical industry need to acquire more US R&D knowledge to be successful in the US market than those in the chemical industry because of more radical technological change, such as the mergence of biotechnologies, in the US. Thus I may speculate that, in the pharmaceutical industry, the home technological advantage is smaller for firms headquartered in Japan and Europe than for firms in the US.

Questions derived from the relationships between acquisition and utilization capabilities. As Tables 8 and 9 demonstrate, there are technology-oriented firms with higher acquisition capability, but lower utilization capability, and there are also market-oriented firms with lower acquisition capability, but higher utilization capability. This corresponds to the statistical results despite the conventional expectation: acquisition capability and utilization capability are not associated with each other significantly. Why do some firms with higher acquisition capability not achieve higher utilization capability? Why can some firms with lower acquisition capability reap higher economic return in the US market? Are there any other reasons besides those explained above? To shed light on this question, I look into the meanings of combinative and independence capabilities at a firm level and explore the implications of the relationships between the two capabilities in the process of the absorption of knowledge from abroad.

Taxonomy of firms by combinative and independence capabilities

In international management, the autonomy of subsidiaries and control by the headquarters are seen as two competing elements. On the one hand, as regards combinative capability, firms leverage and create additional value by combining home and US technologies while such combination may require tighter control by the headquarters. On the other hand, as for independence capability, autonomy may allow subsidiaries to be more embedded in the local science and technology network and to facilitate assimilation of local specific knowledge. The previous section finds that combinative capability has a significant positive effect on utilization capability, the share of the US market of each firm. The effect of independence capability on combinative capability is positive, but not significant. It is, therefore, critical to investigate the relationship between combinative and independence capabilities more carefully for each firm in order to understand the characteristics and relationships of these two conflicting capabilities. As in the previous sections, the position of each firm is shown in Tables 9 and 10, depending on whether the levels of combinative and independence capabilities are above or below the median.

Insert Tables 9 and 10 about here.

Paternalistic partnership. The firms in the “paternalistic partnership” group have lower combinative and independence capabilities than the medians. Most of the firms in this category are Japanese. The firms of this type tend to rely on researchers/engineers in their home countries rather than on US researchers/engineers. This implies that the innovation level of these US centers is relatively low and therefore unattractive to the technological centers in the home country. Their main R&D activity in the US is mostly monitoring, scanning or production support. There may be only a small amount of specific US knowledge that they need for their home markets. The firms in this category have not yet found enough benefits to increase their R&D activities in the US and do not regard them as an important source of their technologies.

Intensive partnership. The firms in the “intensive partnership” group exhibit higher combinative capability and lower independence capability. The technological knowledge in the US is attractive and is necessary for these firms to combine with that at home. Intensive collaborations between US and home R&D staff are required to share technological knowledge. This may imply that their home and US R&D centers are heavily engaged in the same or very closely related fields of technologies and/or co-work for product development with each other. The firms in this group may have more standardized R&D processes to enable such collaboration across national borders more effectively. Some firms in this category may not need to rely on a wide range of US technologies and, therefore, do not allow their US subsidiaries much room to explore their own areas of research independently.

Divided partnership. The firms in the category of “divided partnership” are characterized by lower combinative capability and higher independence capability; their US centers are more independent from the headquarters than the average. This suggests they have a clearer division of labor between home R&D and US R&D. The role of US R&D centers may be mostly one of local adaptation, or the firms may be good at separating development, for example, by dividing into modules to reduce intensive interactions between home and the US. Another reason for the division of labor may be that US R&D centers were obtained as a result of acquisitions of local firms and deal with technologies unrelated to the R&D at home. It could also mean that US subsidiaries have become large and autonomous enough to be self-contained in the US. As a result, they may have gained a bargaining power, and the level of control of the headquarters and sharing knowledge may have declined.

Independent-mutual partnership. The firms in the category of “independent-mutual partnership” have higher combinative capability and higher independence capability. Divided by sector, all the firms from the smaller countries are in this group. The firms in this group are able to integrate home and US knowledge more often than the average, and at the same time have independent technological capability at home and in the US. This may suggest that, while their US R&D centers have broader R&D competence than the average, the R&D centers in the US and at home depend on each other to introduce new products. The extent of independence of US R&D centers in this category may mean that these US centers used to be part of US firms acquired by the Japanese or European firms, which achieved integration between the US R&D and home R&D.

Comparison of the two taxonomies. Interestingly, the comparison of the two taxonomies reveals that all the electronics/engineering and automobile firms in the “independent-mutual partnership” group (higher combinative and higher independence capabilities) excluding Fujitsu, NEC and Ericsson belong to the “integrated” group (higher acquisition and higher utilization capabilities). In addition, all the pharmaceutical and chemical firms in the “independent-mutual partnership” group are identical as those in the “integrated” group except for Schering. This suggests accomplishing both higher combinative and higher independence capabilities may be an important prerequisite for achieving higher acquisition and higher utilization capabilities at the same time, though it may not be a sufficient condition.

CONCLUSIONS AND LIMITATIONS

A number of researchers have used the “absorptive capacity” construct, but its the operationalization has been a problem (Zahra et al., 2002). In addition, only a few studies have expanded and elaborated on the multiple dimensions of the capacity. Above all, the AC of MNCs in R&D management has been an under-studied issue. The results of this paper contribute to the understanding of the multiple dimensions of the AC of MNCs in the context of cross-border technology absorption.

First, I identified four capabilities (dimensions) that together constitute AC and investigated how these four types of capabilities in AC are interrelated. The statistical analyses revealed that there is no significant effect of acquisition capability on utilization capability. The result also shows no significant association between independence and utilization capabilities. This implies the autonomy of the US R&D centers does not necessarily increase US market sales by itself. Instead, I found the significant positive association of combinative capability with utilization capability, suggesting the importance of core technological knowledge at home as well as the critical role of intensive collaboration to integrate and utilize both home and US knowledge in enhancing their economic performance in the US market. It is vital for firms to possess competitive technological advantage at home, which enables them to exploit the US markets especially when combined with US technologies, whereas combinative capability serves as glue to combine the core knowledge at home with the acquired US knowledge. To the best of my knowledge, this is the first time it has been possible to demonstrate empirically that combinative capability of cross-border technological inventions contributes to the actual sales performance in the host market.

Second, the taxonomies discussed in this paper allowed us to seek how the different types of capabilities of AC may be interrelated focusing on individual firms, together with the statistical results and the qualitative information. As shown in Tables 8 and 9, there are firms that have higher acquisition capability, but lower utilization capability. This coincides with the statistical results of the positive, but insignificant effect of acquisition capability on utilization capability. Why are firms which acquire US technologies not necessarily able to exploit them in the US market? The comparison of the two taxonomies shows that firms with both higher combinative capability and higher independence capability are very likely to have both higher acquisition capability and utilization capability. The findings suggest that the key to achieving a high level of utilization as well as a high level of acquisition of US technologies may be the balance between the autonomy and control of foreign subsidiaries.

Given these results of the statistical analyses and taxonomies, I discuss the following. For firms to exploit US technological knowledge successfully, volume of acquisition is not sufficient, though it is a necessary precondition. In order to absorb US technological knowledge effectively, firms need to attain both higher combination and higher independence simultaneously. On the one hand, independence capability is important because firms must allow their US R&D centers to develop their own competence in a way that is broadly independent from the headquarters and to explore and acquire US specific knowledge. On the other hand, it is critical that home and US R&D centers cooperate with each other and combine their R&D competences across borders to exploit the US market. It is very likely that there are mediating effects of combinative and independence capabilities on the relationships between acquisition and utilization capabilities.

Higher independence capability is likely to increase the technological attractiveness of US subsidiaries and motivation of parent firms to combine it with home technologies. The statistical result reveals that combinative and independence capabilities are positively interrelated, though not significantly. In addition, the taxonomy presents most of the firms are located in the “independent-mutual” or “paternalistic” group. Importantly, however, the two capabilities are usually considered as being incompatible from a managerial perspective because autonomy and control are competing elements. The relationship between autonomy and control may correspond to the relationship between exploration and exploitation suggested by March (1991). Autonomy can encourage the exploration of US knowledge whereas control can facilitate the exploitation of US knowledge by combing it with complementary knowledge at home as illustrated by Figure 6. March (1991) argues in organizational learning, there is a tension between exploration and exploitation, and that the excess of one of the two is destructive in the long run. Similarly, the excess of either autonomy or control can be destructive. Thus managers may face a dilemma in coping with the two conflicting needs, autonomy and control, to achieve higher AC by balancing independence and combinative capabilities simultaneously, as is the case for coping with exploration and exploitation.

Insert Figure 6 about here.

The analysis of the relationships between acquisition, independence, combination and utilization capabilities suggests what may be called “positive loop effects.” In the loop, to begin with, firms give more autonomy to subsidiaries to improve their local specific technological knowledge, i.e., enhancing independence capability. Then they start reaping the investment by combining subsidiaries’ knowledge with that at home for cross-border innovations, i.e., increasing combinative capability. This provides a basis for firms to exploit and commercialize US knowledge and to make actual profits. This process, if successful, will encourage firms to invest more in acquiring US technologies and further improve their sales. In the loop, combinative capability is the key to improving utilization capability, while independence capability is the key to enhancing acquisition capability. Both combinative and independence capabilities are critical for the whole process, and the balance between the two needs to be created for sustainable knowledge absorption.

There are several limitations recognized in the statistical analyses. First, the relatively small sample lowers the power to investigate inter-correlations between some of the variables and the reverse effects, i.e., the effects of utilization capability on acquisition, combinative and independence capabilities. Second, the AC measured was absorption of technological knowledge through people’s inventions, which are realized as patents. In addition to the usual disadvantages of using patent data, this limits the analysis of a wider range of AC by other means, such as learning from scientific papers and patents, and reverse-engineering. Third, for more accurate analyses, it may be necessary to analyze the data controlled by technology and country although it is controlled by industry and region in this study. It will, however, require a much larger patent data set and sample size, which we did not have for this study since the number of firms that can afford to establish corporate R&D centers in the US are very much limited. Finally, the use of patent data granted in different patent offices could be a source of bias. To mediate this problem, two factors, 3 and 4.9, were used to scale down the number of Japanese and Korean patents, and the principal results were basically same for both factors.

REFERENCES

Almeida, P. (1996) 'Knowledge Sourcing by Foreign Multinationals: Patent Citation Analysis in the U.S. Semiconductor Industry', *Strategic Management Journal*, 17(Special Issue: Knowledge and the Firm): 155-165.

Andersson, U., Forsgren, M., & Holm, U. (2002) 'The strategic impact of external networks: subsidiary performance and competence development in the multinational corporation', *Strategic Management Journal*, 23(11): 979-996.

Arai, S. (2007) 'Absorptive Capability" of Japanese and European Multinationals: Dilemma in Managing R&D at home and in the United States' PhD. Dissertation, Saïd Business School, University of Oxford.
Asakawa, K. (2001) 'Evolving headquarters-subsidiary dynamics in international R&D: the case of Japanese multinationals', *R&D management*, 31(1): 1-14.
Barton, J. & Mercer, M. (2005). 'To blame or not to blame: Analysts' reactions to external explanations for poor financial performance', Journal of Accounting & Economics, 39: 509-533.
Bas, C. L. & Sierra, C. (2002) 'Location versus home country advantages' in R&D activities: some further results on multinationals' locational strategies', *Research Policy*, 31: 589-609.
Cantwell, J. & Piscitello, L. (2000) 'Accumulating technological competence: Its changing impact on corporate diversification and internationalization', *Industrial and Corporate Change*, 9(1): 21-51.
Cockburn, I. M. & Henderson, R. M. (1998) 'Absorptive Capacity, Coauthoring Behavior, and the Organization of Research in Drug Discovery', *Journal of Industrial Economics*, 46(2, Inside the Pin-Factory: Empirical Studies Augmented by Manager Interviews: A Symposium): 157-182.
Cohen, W. D. & Levinthal, D. A. (1989) 'Innovation and learning: the two faces of R&D', *Economic Journal*, 99(397): 569-596.
Cohen, W. D. & Levinthal, D. A. (1990) 'Absorptive Capacity: A New Perspective on Learning and Innovation', *Administrative Science Quarterly*, 35(1): 128-152.
Cusumano, M. A. & Elenkov, D. (1994) 'Linking international technology transfer with strategy and management: a literature commentary', *Research Policy*, 23(2): 195-215.
de Mayer, A. & Mizushima, A. (1989) 'Global R&D management', *R&D management*, 19(2): 135-146.
Edler, J., Meyer-Krahmer, F., & Reger, G. (2002) 'Changes in the strategic management of technology: results of a global benchmarking study', *R&D management*, 32(2): 149-164.
Eisenhardt, K. M. & Martin, J. A. (2000) 'Dynamic Capabilities: What Are They?', *Strategic Management Journal*, 21(10-11): 1105-1121.
Foss, N. J. & Pedersen, T. (2004) 'Organizing knowledge processes in the multinational corporation: an introduction', *Journal of International Business Studies*, 35(5): 340-349.
Frost, T. S. (2001) 'The geographic sources of foreign subsidiaries' innovations', *Strategic Management Journal*, 22(2): 101-123.
Gambardella, A., Orsenigo, L., & Pammolli, F. (2000) 'Global Competitiveness in Pharmaceuticals. A European Perspective' the Directorate General Enterprise of the European Commission.
Gerybadze, A. & Reger, G. (1999) 'Globalization of R&D: recent changes in the management of innovation in transnational corporations', *Research Policy*, 28(2-3): 251-274.
Ghoshal, S. & Bartlett, C. A. (1990) 'The Multinational Corporation as an Interorganizational Network', *Academy of Management Review*, 15(4): 603-625.
Håkanson, L. & Zander, U. (1988) 'International Management of R&D: The Swedish Experience', *R&D management*, 18(3): 217-226.
Håkanson, L. & Nobel, R. (1993) 'Determinants of foreign R&D in Swedish multinationals', *Research Policy*, 22(5-6): 397-411.
Iansiti, M. (1995) 'Technology integration: Managing technological evolution in a complex environment', *Research Policy*, 24(4): 521-542.
Kodama, F. (1992) 'Technology Fusion and The New R&D', *Harvard Business Review*, 70(Jul/Aug(4)): 70-78.
Kogut, B. & Zander, U. (1992) 'Knowledge of the Firm, Combinative Capabilities, and the Replication of Technology', *Organization Science*, 3(3): 383-397.

Kogut, B. B. (Ed.). (1993) *Country Competitiveness: Technology and the Organizing of Work*, Oxford University Press.
Kuemmerle, W. (1999) 'Foreign direct investment in industrial research in the pharmaceutical and electronics industries - results from a survey of multinational firms', *Research Policy*, 28(2-3): 179-193.
Lane, P. J., Koka, B., & Pathak, S. (2002) *A Thematic Analysis And Critical Assessment Of Absorptive Capacity Research*, Proceedings of the Academy of Management conference.
Lane, P. J., Koka, B., R., & Pathak, S. (2006) 'The reification of absorptive capacity: a critical review and rejuvenation of the construct', *Academy of Management Review*, 31(4): 833-863.
Lim, K. (2004) 'The relationship between research and innovation in the semiconductor and pharmaceutical industries (1981–1997)', *Research Policy*, 33(2): 287-321.
March, J. G. (1991) 'Exploration and exploitation in organizational learning', *Organization Science*, 2(1): 71-86.
Nelson, R. R. & Winter, S. G. (1982) *An evolutionary theory of economic change*: Belknap Press of Harvard University Press.
Nobel, R. & Birkinshaw, J. (1998) 'Innovation in Multinational Corporations: Control and Communication Patterns in International R&D Operations', *Strategic Management Journal*, 19(5): 479-496.
Patel, P. & Pavitt, K. (1997) 'The technological competencies of the world's largest firms: Complex and path-dependent, but not much variety', *Research Policy*, 26(2): 141-156.
Patel, P. & Vega, M. (1999) 'Patterns of internationalisation of corporate technology: location vs. home country advantages', *Research Policy*, 28(2-3): 145-155.
Pavitt, K. (1991) 'Key Characteristics of the Large Innovating Firm', *British Journal of Management*, 2(1): 41-50.
Penrose, E. T. (1995) *The theory of the growth of the firm* (third edition ed.), Oxford: Oxford University Press.
Porter, M. E. (1990) 'The competitive advantage of nations', *Harvard Business Review*, March-April: 73-93.
Prahalad, C. K. & Hamel, G. (1990) 'The core competence of the corporation', *Harvard Business Review*, May-June: 79-91.
Rosenberg, N. (1990) 'Why do firms do basic research (with their own money)?', *Research Policy*, 19(2): 165-174.
Schumpeter, J. A. (1934) *The Theory of Economic Development*, Cambridge, USA: Harvard University Press.
Szulanski, G. (1996) 'Exploring Internal Stickiness: Impediments to the Transfer of Best Practice Within the Firm', *Strategic Management Journal*, 17(Special Issue: Knowledge and the Firm): 27-43.
Teece, D. J., Pisano, G., & Shuen, A. (1997) 'Dynamic Capabilities and Strategic Management', *Strategic Management Journal*, 18(7): 509-533.
Veugelers, R. (1997) 'Internal R & D expenditures and external technology sourcing', *Research Policy*, 26(3): 303-315.
von Hippel, E. (1994) 'Sticky Information'' and the Locus of Problem Solving: Implications for Innovation', *Management Science*, 40(4): 429-439.
von Zedtwitz, M. & Gassmann, O. (2002) 'Market versus technology drive in R&D internationalization: four different patterns of managing research and development', *Research Policy*, 31(4): 569-588.
Zahra, S. A. & George, G. (2002) 'Absorptive capacity: A review reconceptualization, and extension', *Academy of Management Review*, 27(2): 185-203.

TABLE 1
Companies in sample

Country	Electronics/Engineering	Automotive	Pharmaceuticals	Chemicals	Total
Japan	Canon, Epson, Fujitsu, Fuji-Xerox, Hitachi, Mitsubishi Electric, NEC, NTT DoCoMo, OKI, OMRON, Matsushita Electric Industrial, Sharp, Sony, Sumitomo Electric Industries, Toshiba (15)	Honda, Nissan, Toyota (3)	Eisai, Fujisawa, Takeda, Yamanouchi (4)	Hitachi Chemicals, Mitsubishi Chemicals, Sumitomo Chemicals (3)	25
Korea	Samsung, LG (2)				2
Germany	Bosch, Infineon, Siemens (3)	BMW, DaimlerChrysler, Volkswagen (3)	Bayer, Boehringer-ingelheim, Merck, Schering (4)	Bayer, BASF, Degussa, Merck (4)	14
Switzerland	ABB (1)		Roche, Novartis (2)		3
Netherlands	Philips (1)				1
Finland	Nokia (1)				1
Sweden	Ericsson (1)				1
Total	24	6	10	7	47

Note: Bayer and Merck are divided into chemical and pharmaceutical divisions.

TABLE 2
Factor analysis (Rotated component matrix)

	component	
	1	2
Total turnover	-.166	.950
Total employees	-.136	.922
RDE	.109	.970
RDI	.724	-.269
ACUS	.843	-.086
USCC	.722	-.070
USOL	.855	-.119
USM	.652	.305
USR	.658	.001

Note: Turnover, share of sales by region and country, employees, RDE and RDI are based on the consolidated data as of 2002. USR is a share of R&D personnel in US corporate R&D centers of a firm's corporate R&D centers in the world.
Sources: USR and USE are from individual firms, patent data are from the EPO, and the rest are from company reports.

TABLE 3
Means by region and industry

	Industry (Number of sample firms)	Turnover (US$ million)	Sales in US (US$ million)	Employees	RDE (R&D expenditure) (US$ million)	RDI (R&D intensity)
East Asia	Electronics & Automobile (20)	37827.3	9389.7	112083.1	2015.9	0.055
	Chemicals& Pharmaceuticals (7)	6715.4	767.5	17137.3	569.5	0.100
Europe	Electronics & Automobile (10)	47075.0	15950.3	176318.9	3003.4	0.092
	Chemicals& Pharmaceuticals (10)	13453.4	4348.1	56984.4	1374.8	0.115
All		29975.3	8428.7	99867.1	1874.2	0.082

	Industry (Number of sample firms)	ACUS	USCC	USOL	USM (%)	HOM (%)	HRM (%)	USR (%)	USE (%)
East Asia	Electronics & Automobile (20)	0.032	0.003	0.028	19.4	55.7	62.8	4.6	19.3
	Chemicals& Pharmaceuticals (7)	0.058	0.016	0.041	19.1	64.6	71.1	4.7	5.9
Europe	Electronics & Automobile (10)	0.118	0.015	0.098	22.9	17.1	48.2	9.0	6.8
	Chemicals& Pharmaceuticals (10)	0.298	0.039	0.237	31.1	10.4	41.9	16.1	6.4
All		0.111	0.015	0.089	22.6	42.5	56.5	8.1	12.6

Note: Turnover, share of sales by region and country, employees, RDE and RDI are based on the consolidated data as of 2002.

HOM is market share of a firm in home country;

HRM is (market share of a firm in home region) - (market share of a firm in home country);

USR is share of R&D personnel in US corporate R&D centers of a firm's corporate R&D centers in the world;

USE is share of expatriates in US corporate R&D centers of a firm.

Sources: USR and USE are from individual firms, patent data are from the EPO, and the rest are from company reports.

TABLE 4
Means, standard deviations, and correlations

	1	2	3	4	5	6	7	8	9	10
1. ACUS										
2. USCC	.614***									
3. USOL	.991***	.509***								
4. USM	.315**	.448***	.272*							
5. HOM	-.551***	-.430***	-.553***	-.731***						
6. HRM	-.423***	.373**	-.408***	-.845***	-.856***					
7. RDE	-.028	-.035	-.018	.287*	-.439***	-.411***				
8. RDI	.608***	.439***	.601***	.319**	-.429***	-.419***	-.093			
9. USR	.461***	.410**	.439***	.435***	-.489***	.403**	.037	.426***		
10. USE	-.204	-.181	-.200	-.195	.236	.271	-.019	-.280	-.155	
Mean	.111	.015	.089	.226	.425	.565	1874	.082	.081	.126
s.d.	.150	.022	.126	.127	.283	.218	1517	.050	.088	.200

Note: * $P < .1$
** $P < .05$
*** $P < .01$

TABLE 5
Results of ordinary least squares (OLS) analyses

	Dependent variables								
	H1	H2a	H2b	H3	H3				
	USM	USM	USM	USM	USCC	USM	ACUS	USCC	USOL
Independent variables									
ACUS	.009 (.045)								
USCC		1.468* (.746)		1.521* (.774)					
USOL			.024 (.193)	-.060 (.191)	.055 (.038)				
Sector	.069 (.045)	.038* (.045)	.071 (.044)	.040 (.045)	.202** (.009)	.046 (.050)	.280 (.204)	.021* (.012)	.031 (.047)
Region	-.018 (.032)	.003 (.039)	-.018 (.042)	-.002 (.042)	-.011 (.008)	-.013 (.044)	-.360* (.177)	-.021* (.010)	.123*** (.041)
RDE	3.376E-05** (.000)	3.062E-05** (.000)	3.403E-05** (.000)	3.060E-05** (.000)	2.254E-06 (.000)	3.868E-05** (.000)	4.654E-05 (.000)	3.075E-06 (.000)	1.961E-06 (.000)
RDI	.522 (.411)	.386 (.383)	.524 (.193)	.441 (.426)	.054 (.085)	.964* (.479)	3.424* (1.943)	0.130 (.114)	1.078** (.445)
Adj-R2	.180	.250	.179	.233	.372	.241	.323	.293	.440

Note: Sector (pharmaceuticals and chemicals = 0, electronics/automobile = 1).
Region (Europe = 0, Japan/Korea = 1).
First row: Unstandardized coefficients. Second row: Standard errors in parenthese.
* P < .1; ** P < .05; *** P < .01

TABLE 6
Variance inflation factors (VIFs)

Dependent variables	Independent variables	VIF
USM	USCC	2.162
	USOL	1.786
	Sector	1.817
	Region	1.629
	RDE	1.378
	RDI	1.676

Note: USM, RDE and RDI are based on the consolidated data as of 2002.
Sector (pharmaceuticals and chemicals = 0, electronics/automobile = 1).
Region (Europe = 0, Japan/Korea = 1).

TABLE 7
Acquisition and utilization capabilities (electronics/engineering & automobile industries)

Acquisition capability (ACUS)

Utilization capability (USM)	Low	High
High	**1A: Market-oriented** Canon (JE), LG (KE), Nissan (JA), Toyota (JA), BMW (DA), Volkswagen (DA)	**1B: Integrated** Sony (JE), Samsung (KE), Infenion (DE), Siemens (DE), Philips (NE), ABB (CE), Nokia (FE), Honda (JA), DaimlerChrysler (DA)
Low	**1C: National focus** Fuji-Xerox (JE), Hitachi (JE), Matsushita Electric (JE), NTT DoCoMo (JE), Sumitomo Electric (JE), Toshiba (JE), OKI (JE), Omron (JE), Bosch (DE)	**1D: Technology-oriented** EPSON (JE), Fujitsu (JE), Mitsubishi Electronic (JE), NEC (JE), Sharp (JE), Ericsson (SE)

(J = Japanese, K = Korean, D = German, C = Swiss, N = Dutch, F = Finnish, S= Swedish, E = electronics & engineering, A = automobiles, P = pharmaceuticals, C = chemicals)

TABLE 8
Acquisition and utilization capabilities (pharmaceutical & chemical industries)

Acquisition capability (ACUS)

Utilization capability (USM)	Low	High
High	**1A: Market-oriented** Fujisawa (JP), Takeda (JP)	**1B: Integrated** Eisai (JP), Bayer (DP), Boehringer-Ingelheim (DP), Schering (DP), Novartis (CP), Roche (CP), Bayer (DC)
Low	**1C: National focus** Yamanouchi (JP), Hitachi Chemicals (JC), Mitsubishi Chemicals (JC), Sumitomo Chemicals (JC), BASF (DC), Degussa (DC)	**1D: Technology-oriented** Merck (PC), Merck (DC)

TABLE 9
Combinative and independence capabilities (electronics/engineering & automobile industries)

Combinative capability (USCC)

Independence capability (USOL)	Low	High
High	**2A: Divided partnership** Canon (JE), EPSON (JE), OKI (JE), Sharp (JE)	**2B: Independent-mutual partnership** Fujitsu (JE), NEC (JE), Sony (JE), Samsung (KE) Infenion (DE), Siemens (DE), ABB (CE), Philips (NE) Ericsson (SE), Nokia (FE), Honda (JA), DaimlerChrysler (DA)
Low	**2C: Paternalistic partnership** Fuji-Xerox (JE),Hitachi (JE), Mitsubishi Electronic (JE), NTT DoCoMo (JE), Sumitomo Electric (JE), Toshiba (JE), LG (KE), Omron (JE), Nissan (JA), Toyota (JA), Volkswagen (DA)	**2D: Intensive partnership** Matsushita Electric (JE) Bosch (DE), BMW (DA)

TABLE 10
Combinative and independence capabilities
(pharmaceutical & chemical industries)

Independence capability (USOL)	Combinative capability (USCC): Low	Combinative capability (USCC): High
High	**2A: Divided partnership** Merck (DP), Schering (DP), Merck (DC)	**2B: Independent-mutual partnership** Eisai (JP), Bayer (DP), Boehringer-Ingelheim (DP) Novartis (CP), Roche (CP), Bayer (DC)
Low	**2C: Paternalistic partnership** Fujisawa (JP), Takeda (JP), Hitachi Chemicals (JC), Mitsubishi Chemicals (JC), Sumitomo Chemicals (JC)	**2D: Intensive partnership** Yamanouchi (JP) BASF (DC), Degussa (DC)

Figure 1 Hypotheses

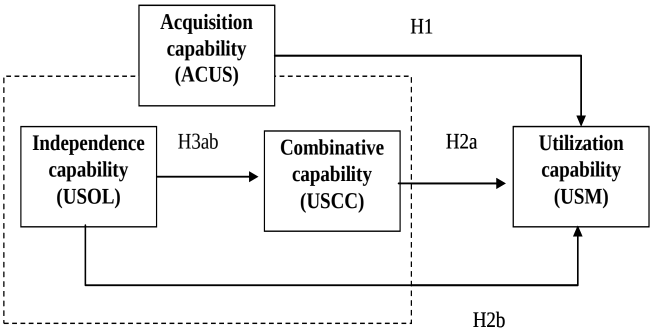

Figure 2 Measures using inventors' addresses of patents

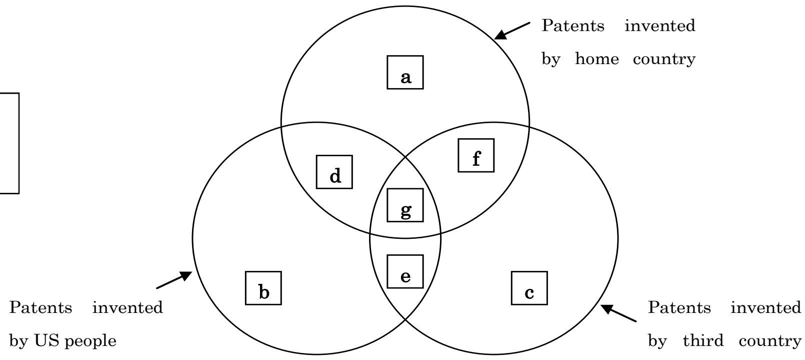

Figure 3 Result of correlations

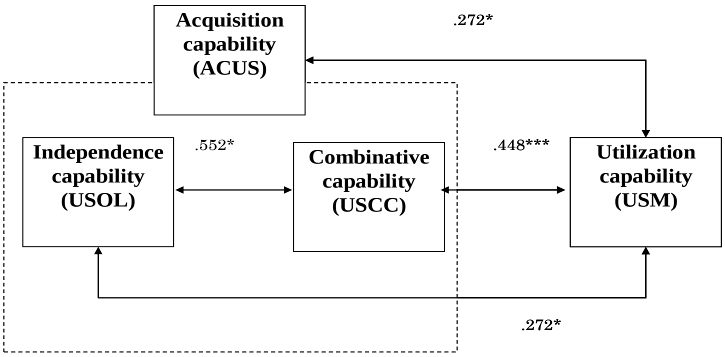

Figure 4 Result of OLS

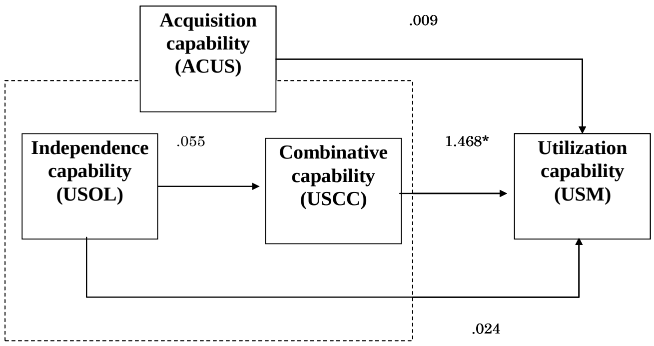

Figure 5 Result of path analysis

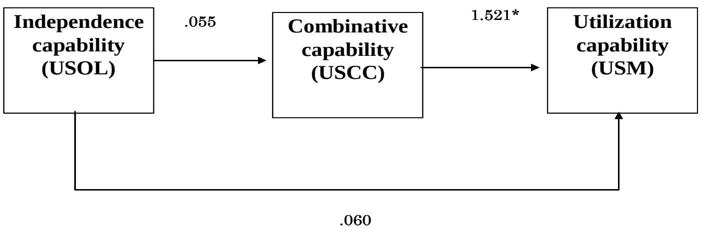

FIGURE 6 Conceptual framework