Factors Affecting on the Performance of Overseas R&D

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Abstract

Many companies are trying to acquire innovative technologies and relevant knowledge by sending R&D work overseas. Although recent research has been focusing on the aspects that motivate MNCs to establish offshore R&D facilities, such as cost reduction and market expansion, little is known about external or circumstantial factors influencing the performance of global R&D activities.

Searching for enhancers of offshore R&D facilities, we investigated the relationships between the performance of offshore R&D and the technological capabilities of a parent company, its home country, and its R&D hosting country. Both patent data of EU and the EU R&D scoreboard of 134 overseas R&D labs from 46 MNCs, dating from the period of 2003 to 2005, are used in the analysis. The same time period is applied in calculating the RTA of each country.

Regression analysis results support our main hypothesis that the technological capabilities of the parent company and the hosting country positively affect the performance of overseas R&D.

Key Words: Global R&D, Patent, RTA, Technological Capability

1. Introduction

The advancement of information technology has enabled the globe to connect on a real-time basis by letting people share information and communicate beyond the limits of geographical location, distance or even time difference. Due to that, business grounds of companies have expanded enormously compared to the past and the competition among them has become more intense than ever. Geographical boundaries, which were considered to be an advantage to the local companies, no longer impose hardship on collecting market data for companies overseas, which means the capability of collecting information such as market structures or consumer reports of a certain area cannot keep multi-national conglomerates from entering domestic markets. Furthermore, custom duties no longer provide protection for

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domestic companies since the barriers of the global market are fading away through treaties and organizations like FTA and WTO.

Now, becoming a global frontier is the only way of corporate survival which encourages even relatively smaller companies to spread out abroad in search for hi-tech development resources. It significantly differs from the past when only a small number of huge conglomerates such as Samsung Electronics or Hyundai Motors had built R&D centers overseas that smaller enterprises have already established or are planning to establish R&D centers overseas in recent times. The fact that the number of overseas R&D center establishments of domestic companies grew from less than 10 in the year of 2000 to 180 in 2008, reflects the current trend. What we call globalization movement of R&D appears to apply to patent data as well. We can determine the efficiency of overseas R&D centers by calculating the quantity of inventions that contain an inventor and an applicant with different nationalities. For instance, among the entire granted patents and copyrights of EU, the percentage of this certain type has risen from 10.7% in 1992 to 14.3% in 2000.

Areas of set-up vary as well. Although traditional thinking of technology management focuses on a company's internal capability and process to develop and commercialize technology, we cannot discard the significance of external and circumstantial conditions which include cooperation between the industrial and academic sectors, the size of excellent workforce and the cost of labor. The optimal level of these external and circumstantial conditions will vary among industries (Porter and Stern, 2001). Just as the United States is the optimum location for pharmaceutical research, so is Sweden or Finland for wireless technology (European Commission, 2006). Countries that can provide quality workforce at a lower cost, such as China, India, Russia and etc, are becoming quite popular as offshore R&D headquarters for domestic conglomerates, who used to prefer having their R&D centers in countries with advance technologies like the U.S., Japan or Western Europe. These newly popular countries have a higher market potential based on their massive population and rapid economic growth. When it comes to profit efficiency of investment as well as setting up an R&D base camp with a new market penetration plan, these countries offer something very attractive to many companies.

Launching an R&D center can bring new openings to a business but will also involve substantial expenses and risks (Perrino and Tipping, 1989; Kuemmerle, 1997). Since it generally takes a certain amount of time for an offshore R&D center to blend into the local science community and to utilize the external resources locally available, at some times, setting up an offshore R&D center might cost even more than building a manufacturing facility overseas (Patel and Vega, 1999). Foreign R&D activities no longer function solely as product manufacturing or customer service support facilities. Recently, a majority of them have started to carry responsibilities to monitor and support cutting-edge technologies from host countries and to generate completely new ones, which in many cases trigger an increase of

cost at large. Considering the fact that the sunken cost of offshore R&D facilities can be as large as or even more than manufacturing plants overseas, it is critical to closely examine the efficiency of investment in advance.

Nevertheless the subject of R&D globalization has been researched for over a few decades, lack of data or limited access to actual results have inhibited demonstrative analysis on this issue. However, the fact that offshore R&D activities can now be found in several business types and different sized companies, which expanded their region of launch, not only has provided a wider and easier access to information but also attracted the interest of many national governments and global organizations.

The core element of all business activities is the budget of investment. Manpower and equipment, the so called factors involved in R&D activities can be converted into a monetary amount. This enables us to estimate each company's volume of projected resource with regard to R&D by calculating the amount and percentage of investment. Despite the matter of percentage is out of the question, with the expectance of a greater output in proportion to a greater input, companies still tend to increase the next year's R&D investment budget to build a new lab or to reinforce an existing one. Therefore, not just raising the amount of investment but maximizing the efficiency of investment is imperative. For each company, learning the most legitimate strategy can be the most efficient and effective way to reach the best decision.

Besides revealing the key factors of effective international R&D activities among Fortune's 500, through analyzing the operation status of offshore R&D centers and the outcome of their research, this study aims to put forward an R&D globalization strategy for present or potential companies to operate an offshore R&D facility.

2. Globalization of R&D

Multi-national companies including many major conglomerates possess the ease of access to cutting-edge technology all over the world via massive global networks (Gassmann and von Zedtwitz, 1999). From the late 70s, multi-national companies have started building research centers overseas to support manufacturing plants by locally adapting certain technologies or products developed from the home country. It was in the 1980s when this evolved into common action (Guellec and van Pottelsberghede la Potterie, 2001). Since the late 1990s when the cost of networking around the globe has vastly decreased as a result of the accelerated development of information technology and developing countries like China and India started contributing high quality English-speaking manpower at a competitive cost, the number of increase we could see of offshore R&D centers has never been so dynamic (Bardhan and Mookherjee, 2006). Furthermore, to a greater extent, companies have started

utilizing their overseas R&D centers as the headquarters of new market penetration plan instead of just a lab operated overseas for cost efficiency.

Overseas R&D activities can be analyzed in parallel with offshoring. East Asian countries are preferred as manufacturing sites due to their low cost of labor and production, when countries like India or Singapore are adopted as offshore service support regions considering their fluency of English besides low cost. In order to stretch out the function of R&D to a nonnative level, a candidate country's capability of experienced breakthrough technology is taken into account on top of lower cost of labor. This fact enables China, India, Russia and etc countries to be the most favorable possibilities (Florida, 1997) Research-centered offshore R&D centers seemingly tend to stand nearby recognized research labs, prominent universities or innovative competitors instead of the production sites of their mother companies.

3. Theoretical Backgrounds and Hypothesis

Input elements of R&D activities are manpower, equipment, data, ideas, budget of research, supporting funds of research and etc (Brown and Svenson, 1988; Werner and Souder, 1997; Tsai, 2005). These elements have direct impact on the R&D activities of each company and the resource input leads to a proportionate (commensurate) amount of R&D activity output to a certain degree. A company's accumulated knowledge and experience will upgrade the capability to adopt or benefit in creating a new path to attaining novel technology as well as influence the company's drive for study by having effect on the outcome of an offshore R&D center (Leonard-Barton, 1995; Song and Shin, 2008; Penner-Hahn and Shaver, 2005).

Selecting the location of an R&D center is more critical than ever since environmental infrastructure of research centers, including strong university-industry linkage, a large pool of scientists and engineers, complied amount of knowledge of local scientists will decide the performance of its R&D activity (Ambos and Schlegelmilch, 2008; Davis and Meyer, 2004; Le Bas and Sierra, 2002; Porter and Stern, 2001). The significance of external environment to R&D activity draws the emphasis due to the fact that recent R&D FDI follows the initiative to discover new technology instead of making use of the existing ones.

According to former studies, when an MNC establishes a new R&D facility overseas, the current technological capability of a mother company will aid the subsidiary to acquire local technology or knowledge and create new accomplishments which will act as an advantage to better performance of the MNC's global R&D activity, since R&D activity owns a cumulative and path-dependant quality (Penner-Hahn and Shaver, 2005; Song and Shin, 2008). A study on the connection between knowledge and capability of technology adoption shows that the more the mother company holds capability of advanced technology, the higher the level of acquisition and application of data knowledge at the hosting country (Penner-Hahn

and Shaver, 2005). Therefore, the volume of an overseas R&D center's performance will differ, even with the same amount of financial investments, depending on the mother company's capability of adapting new technology, which lets us reach a hypothesis as the following.

H1: With the same amount of investment overseas R&D activity performance depends on the mother company's technological capability.

Establishing a new R&D center overseas contains high risk for a company since it takes a considerable amount of time till it reaches the point of seeing actual performance (Zedtwitz and Gassman, 2002) However, companies still carry on building R&D facilities overseas to gain benefits that cannot be obtained in the home country. Infrastructure for research and development such as a co-operative system between academic and industrial sectors, governmental support programs or subsidy are some of the benefits (Ambos and Schlegelmilch, 2008; Davis and Meyer, 2004; Le Bas and Sierra, 2002; Porter and Stern, 2001). According to Granstrand *et al.*, excessive competition, increased opportunities of technological co-operation between countries, improved accessibility to source of technology, faster penetrating speed into foreign markets are the major factors that accelerate R&D activities overseas. He also mentioned that these factors act as a significant environmental element to the R&D centers overseas which influence a company's R&D performance. Pavitt and Patel (1999) stated that the globalization of R&D activity is to be comprehended not only from a business operation point of view but also from the perspective of financial institutions, universities, business and policy agencies, law, culture and social norms that represent regional or national levels. According to Von Hippel (1994), setting up an R&D facility in an area concentrated with pertinent data will help minimize expenses, since regional exchange of data related to innovative activities that are found only in particular areas, costs incremental expenditure. The stickiness between area and data knowledge allows a certain country's or town's resources of a particular field and their technological adaptation capability to be regarded as the same thing. Hence, we can bring out another consequential hypothesis.

H2: With the same amount of investment, overseas R&D activity performance depends on the host country's technological capability.

Pavitt and Patel (1999) stated that a company's innovative activity is significantly influenced by the home country's quality of basic research, workforce skills, systems of corporate governance, the degree of competitive rivalry and local inducement mechanisms. Many researchers agree to this opinion (Carlsson, 2006) and Freeman (1995) proclaimed that nevertheless the globalization process of innovative activities come about, national or regional innovation sys-

tems still possess their magnitude since they comprise the key foundation element of company innovation, networks of relationship. Criscuolo *et al.* (2005) concluded that innovation system resources of the parent company's entire home base region as well as the parent company's technological resources are exploited in a direct or indirect manner when operating R&D activities overseas Yet, offshore R&D activity is secondarily influenced by home country factors which also affect the parenting company's R&D activity. Thus, we can derive the following conclusion.

H3: With the same amount of investment, overseas R&D activity performance depends on the home country's technological capability.

Figure 1 is how we schematize the transactions among influential elements on performance of offshore R&D facilities based on all the reached conclusions.

4. Data set and Measuring Units

Data adopted for hypothesis evaluation has been collected among Fortune's Global 500 companies. Offshore R&D center operation has been confirmed through each company's web-

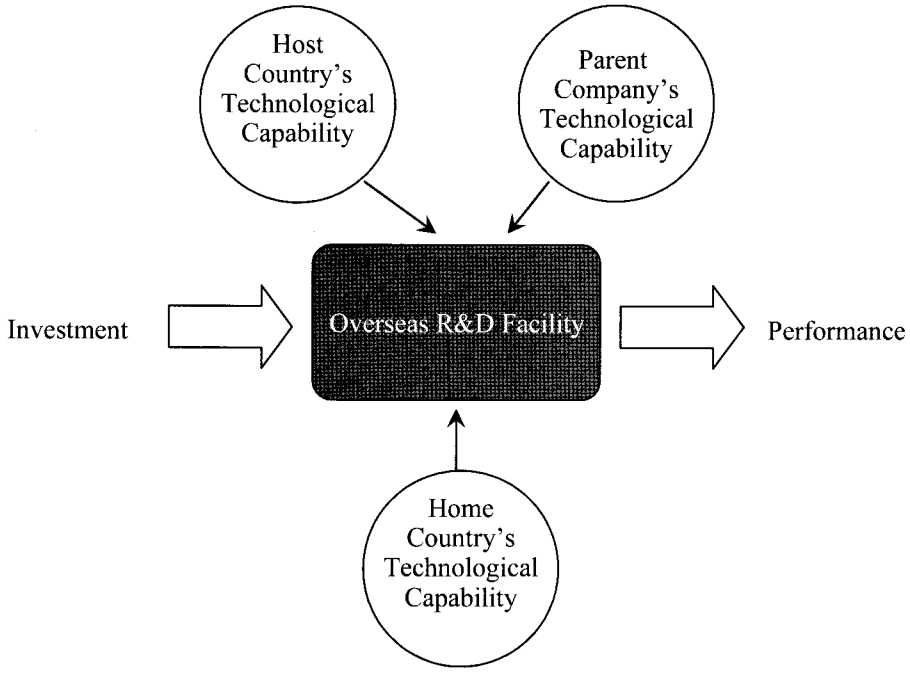

Figure 1. The Factors Affecting on the Performance of Overseas R&D Facilities

site and companies with less than 10 patents granted by the European Patent Office between the three years from 2003 to 2005 have been excluded from this study. Also, after classifying category of business through NACE code3, objects of analysis have been reduced to 4 types of businesses; Pharmaceutical, Petroleum and Chemical Products, Computer and Electronics and Automobile, which involve in the most dynamic R&D activities overseas. Through this process, 402 samples have been collected as a result of selecting 134 offshore MNC R&D centers falling within the 4 business categories and by treating each year's data of 2003, 2004 and 2005 respectively.

Index for measurement used in this study is as the following.

Table 1. Data Summary

Industry		*Home Country*		*Host Country*	
Petroleum and Chemical products	9	Canda	1	Austra	1
				Belgium	1
		Switzerland	2	Cananda	5
				Switzerland	3
Pharmaceuticals	10	Germany	6	China	10
				Germany	20
		Finland	1	Spain	2
				Frace	10
		France	2	United Kingdom	21
Motor vehicles	10	United Kingdon	3	Israel	1
				India	5
		Japan	10	Italy	2
				Japan	13
		South Korea	2	South Korea	1
Computer and Electronic equipment	17	Netherland	3	Netherlands	1
				Norway	1
		Sweden	2	Russia	3
				Sweden	2
		United States	14	Singapore	1
				United States	31
	46	Total	46	Total	134

4.1 Performance of offshore lab and Parent company's technological capability

Measuring performance of R&D is necessarily difficult. First, the outcome of offshore R&D activities not only consist of tangible results such as number of journals, patents or new products but also hypothetical ones that disable objective comparison, like knowledge data accumulation within the organization and increase of research capability. Also, generating analysis data for comparison per company is not easy since companies avoid opening data like numbers of completed projects or newly released products. As a result, objective evaluation standards are limited to the number of patents or journals. Second, how much the outcome of offshore R&D activities contributed to the entire business organization is hard to tell, since R&D function is only one part of the company's integrated process (Kerssens-van Drongelen, 1997).

Even if this is the case, measuring R&D performance is imperative. Measurement is the primary step to manage and reinforce a particular business activity. According to Cordero (1990), companies conducting systematic evaluation on R&D performance have seen increased results of research and development. As to reinforcing a specific activity, guarantee of management is prerequisite and for guarantee of management, understanding of the activity is as well, which makes evaluation essential for knowledge (Karlsson *et al.*, 2004).

The most popular index measuring R&D performance is the number of granted patents. What is unique about patent data is that even though it holds its weakness of neither being able to reflect all the activities connected to the company's technology nor measure the economic value of it, he strength of patent data lies in the ease of access to regularly and accurately updated long-term data from a variety of business categories and areas (Le Bas and Sierra, 2002; Porter and Stern, 2001). The most common type of patent data is either of the United States or of Europe. In the United States, no data is released to the public and the whole process takes more than 2 years for a patent to be granted. However, current data is opened to the public in Europe, being advantageous to researchers (Le Bas and Sierra, 2002). It also helps European patents act as a sort of financial filter since the registration fee of European patents are (Grupp and Schmoch, 1999) five times higher than that of U.S. patents. European patents are not biased toward certain countries that it eliminates the chances of geographical impact (Le Bas and Sierra, 2002). As to research of business administration, European patents can be useful in a more appropriate manner since it is categorized by business types, while U.S. patents are classified in types of technology,

In this study, the number of patents has been selected as the performance barometer of an offshore R&D center. Data for analysis was searched by company name as patent applicant and the lab's country of location as inventing country's nationality in esp@cenet4, the database of the European Patent Office.

Patent data has also been used to measure the parent company's technological capability. A company's number of granted patents in certain fields is widely applied as the barometer of technological capability in many former studies (Song and Shin, 2008; Hall, Jaffe and Trajtenberg, 2000).

4.2 Capabilities of Host and Home Countries

The technological capability of parent country and host country are measured by each country's RTA index figure per business type. RTA Index represents Revealed Technological Advantage. It was first developed by Soete and then was adopted by Patel and Pavitt (1987) and Cantwell (1989). When 'i' stands for country(or company) and 'j' for field of technology, P_{ij} put together stands for patent of i and j. The following formula shows how RTA can be calculated (Le Bas and Sierra, 2002).

$$\mathrm{RTA}_{ij} = \frac{(P_{ij} / \sum_i P_{ij})}{\sum_j P_{ij} / \sum_{ij} P_{ij}}$$

Since RTA is applied to a country in this research, it can be acquired by dividing the patent ratio of jth technological field in one country with that of all countries in the world. In other words, RTA of a certain country being higher against a certain technology means the country has more competitiveness in that certain field since it implies the certain country holds relatively more patents in the certain field of technology.

4.3 Invesment

Size of investment to R&D activity, the core input element, most directly affects the performance size of R&D activity (Brown and Svenson, 1988; Werner and Souder, 1997; Argyres and Silverman, 2004) So, to objectively analyze other elements else than investment size of R&D activity, this needs to be set as a control variable. Instead of survey data from companies or research labs, already released data have been applied to this study. So, a company's total amount of R&D investment is accommodated to data instead of the amount of investment for each research lab. Due to different level of data source, this explains why investment size of R&D activity is not set as an independent variable but a control variable.

Each company's R&D investment data is from 'The EU Industrial R&D Investment Scoreboard'. 'The Scoreboard' covers all the R&D activities and other financial results of EU and non-EU companies that fall within 1st to 1000th place in R&D investment ranking. R&D investment account was selected to be set as a control variable against performance measurement.

5. Conclusion and Analysis

In this study, a regression analysis model was designed to evaluate the hypothesis through setting the log value of MNC's offshore R&D center performance as dependent variable. Variable statistics and coefficient of correlation between variable are shown in table 2. After

Table 2. Summary of Descriptive Statistics and Correlations

Variable	Mean	Std dev.	1	2	3	4	5
1. R&D Investment (€m)	2565.03	1536.263	-	.104*	.353**	.039	-.023
2. Performance of overseas R&D facility	186.92	289.769	-	-	.082	-.037	.124*
3. Capability of The Parent Company	3249.67	4373.844	-	-	-	-.418**	-.041
4. Capability of The Host Country	1.01	0.388	-	-	-	-	-.151**
5. Capability of The Home Country	0.98	0.346	-	-	-	-	-

주) * Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

calculating the VIF of variables and examining the multicollinearity between independent variables, results show from a minimum of 1.021 to a maximum of 1.286 which proves the multicollinearity issue is settled.

The result of multiple regression analysis is in table 3. In diagram 1, constant and R&D investment are applied as predictor, making R&D investment size, the control variable. While all variables which can be analyzed are set in model 2, both models show high similarity with the value of p less than 0.001. In model 2, technological capabilities of both parent company and host country have positive ß values, and both capabilities were statistically close to each other with the similarity level of 0.05 and 0.01. This result supports our assumptions #1 and #2, that technological capabilities of both host country and parent company affect the performance of an offshore R&D center. In other words, if the parent company invests the same amount of money, the performance of its offshore R&D center is better when the technological capability of the parent company is more superior. The technological capability of the host country where the foreign R&D center is located also contributes performance increase. One thing to note here is that assumption #3, that the technological capability of a host country where a parent company is located contributes to the performance of an offshore R&D center, is invalidated.

Control variable also showed statistical similarity. The total investment to R&D activity of a company has a positive regression coefficient against the performance of offshore research facilities and, for model #1 and #2, it shows statistical similarity of 0.01 and 0.05, respectively. As a result, an increase in a company's total investment to R&D directly leads to a better performance of global R&D activities, which makes the reason of control justified.

6. Discussion and Conclusion

Summarizing the analysis results,

Table 3. Results of Multiple Regressiona

Model	*Variable*	*Model Statistics*	*β*	*t*	*Sig.*
1	(Constant)	$F = 9.635^{**}$		30.203	.000
	R&D Investment		.154	3.104	.002
2	(Constant)	$F = 11.255^{**}$		10.887	.000
	R&D Investment		.118	2.264	.024
	Capability of The Parent Company		.117	2.173	.030
	Capability of The Host Country		.272	5.648	.000
	Capability of The Home Country		.043	.857	.392
3	(Constant)	$F = 8.652^{**}$		2.716	.007
	R&D Investment		.879	3.151	.002
	Capability of The Parent Company		.384	3.394	.001
	Capability of The Host Country		.042	.392	.695
	Capability of The Home Country		.044	.349	.727
	R&D Investment × Capability of The Parent Company		-.892	-2.666	.008
	R&D Investment × Capability of The Host Country		.261	2.402	.017
	R&D Investment × Capability of The Home Country		-.007	-.051	.959

주) a. Dependent Variable: Performance of overseas R&D facility.

** Significant at the 0.01 level (2-tailed).

(1) When the mother company's technological capability is better, so is the performance of offshore R&D.

(2) When the host country's technological capability is better, so is the performance of R&D.

This study is of high significance since it not only put together theoretical evidence on what controls the success (or failure) of MNC's global R&D activities but also offered a solution to practical issues that former studies couldn't confirm due to limited access to data by adopting solid data instead of pre-planned artificial data.

According to the conclusion of this study, rather than a company's motivation, its already accumulated technological capability, contributes to the offshore R&D center's adoption of knowledge and creativity by adding positive effect on performance enhancement, which is quite the opposite finding from the general idea that offshore R&D performance is minor when a parent company's technological capability is superior, due to its lesser motivation toward global R&D activity. Therefore, to develop R&D performance overseas, MNCs need to

make constant efforts to advance technological capability of the main headquarters as well. In other words, expecting lucrative offshore R&D activity performance is difficult when R&D activity at the parent country is dull. To overcome the shortcomings of technological capability, it is far more effective for companies to reinforce the R&D capability of the main headquarters before targeting global R&D activity that consumes a gargantuan amount of investment.

In addition, it has been proven that the technological capability of the host country plays an important role in gaining better performance from a company's offshore R&D activity. Just as elements like low cost of labor and amount of government subsidies, the host country's current technological capability is another critical element we cannot overlook when selecting an area for an offshore R&D center. Furthermore, linear connection between the R&D activity region's technological capability and R&D performance can be applied not only to offshore R&D activity but also to parent country's R&D activity at the same time. As a result, we can conclude that for a company to enhance its own R&D performance, it is encouraging to work together with its community or government to strengthen technological infrastructure rather than making efforts building up self-competitiveness.

It is meaningful that this study comprehensively investigated and analyzed conditional elements affecting offshore R&D activity performance of MNCs for the first time. This research also provides useful tactical instructions for companies which will develop R&D activity in foreign countries, using real data, not materials indirectly collected through interviews with managers and/or results from polls, to investigate what kind of elements are considered for companies to advocate a certain region for the purpose of research initialization and R&D FDI, during pre-research period.

The limitations of this study are as the following. Due to limited information, neither a broader time period of data could be analyzed nor was it perfectly objective in terms of selecting samples from different types of business. Also, other consequential items resulting from R&D, except for the number of patents, were not included in the analysis. Replacing size of R&D investment, a control variable, with company-level data might have contaminated the precision of analysis as well. Above all, a detailed and in-depth analysis is required in addition to understand the interactions between R&D investment capability and technological capability of a parent company.

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