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Examining the Determinants of Research and Development Investment in Developing Economies—An Empirical Study of US International R&D

By

Wei He

PhD Candidate

Chapman Graduate School of Business

Florida International University

USA

Introduction

For decades, technological change and innovation, driven by Research and Development (R&D) have been the most important sources of productivity growth and increased welfare (Edquist 2000). This philosophy has been profoundly recognized and employed by both nations and multinational enterprises (MNCs). As the globalization process accelerated and international competition grew fiercer than ever in the late 1990s, more and more multinational corporations adjusted their strategies from technical resource allocation worldwide to global strategic administration (Lee & Chang, 2007). Accordingly, multinational corporations have adjusted their global development strategies from market globalization and production globalization to technique globalization and R&D globalization (Reddy, 2000; Amsden, Tschang & Goto, 2001).

Literature has provided a range of definitions regarding research and development. The simplest and most commonly accepted one acknowledges six types of R&D activities-basic research—applied research, new product development, product adaptation and extension, product support engineering, and process engineering, the first two of which are normally classified as "research" and the last four as "development" (Khurana, 2006). Although research and Development is usually considered as the least and the last internationalized of multinational corporations' (MNCs') value chain while production, marketing and other functions have moved abroad much more quickly (Pearce, 1989; Patel & Pavitt 1991), affiliates of foreign MNCs have begun to play a significant role in conducting innovative activity in a number of countries.

The internationalization of MNCs' R&D activities is not a new phenomenon in the context of international business. What appear to be new are the faster pace of R&D internationalization in recent years and the shifting trend of R&D localization. A more recent phenomenon with respect to internationalization of R&D is that MNCs are increasingly expanding their R&D activities in developing countries, which were not traditionally considered an internal decision subject (Lee, Chou & Chang, 2006). According to the data provided by UNCTAD (2005), in the foreign R&D activities of Swedish MNCs, the share of developing countries and economies in transition (including the new EU members) increased from 2.7% in 1995 to 7.2% in 2003. A survey of 1,554 German enterprises conducted in 2005 by the Deutsche Industrie- und Handelskammertag found that while foreign R&D units were most frequently located in other EU States, about a third of respondents conducted R&D in new EU member countries, South-East Europe or the CIS and 28% in Asia (DIHK 2005). Moreover, surveys carried out by the Japan Bank for International Cooperation confirm that the overall number of "R&D bases" set up by the firms covered in the surveys increased by 70%, to 310, between 2000 and 2004, and that of "R&D bases" in developing countries more than tripled, to 134, with the share of China for the total R&D units rose from 7% to 22% between 2000 and 2004 (UNCTAD, 2005). MNCs also apply different entry modes to expand their R&D overseas. For example, researchers (such as Li & Zhong, 2003) also found that MNCs have taken critical steps to form strategic R&D alliances in developing nations.

The internationalization of R&D has spurred considerable research interest from different disciplines. A number of scholars have examined the host country related factors that are likely to affect MNCs' foreign R&D decisions. Håkanson (1992) found that the overall R&D employment by Swedish firms in a country was positively related with the size of the market and the index of psychic distance from Sweden was negatively related with all types of foreign R&D except for the research resource-oriented R&D. Fors's (1996) work revealed that the extent of

local production and the extent of technological specialization of a particular host country are the only significant factors explaining both the probability as well as the proportion of an OECD country hosting R&D activity from Swedish MNCs. Through analyzing a dataset pooling country-level observations from the Benchmark Surveys of US Direct Investment Abroad, Kumar (1996) found host country market size, technological resources and capability to be significantly affecting R&D activity of US affiliates.

Collectively, these studies provided valuable insights on MNCs' motivations in determining the locations of their foreign R&D activities. However, the majority of these studies considered globalization of R&D as a phenomenon which is "developed country-centric" (Chen, 2004) and developing nations are merely treated as background data (Lee & Chang, 2007). The research emphasis on developed countries somehow weaken their theoretical power in explaining the driving forces of growing R&D internationalization since developing countries have been playing an increasingly important role in the accelerating process of R&D globalization. Correspondingly, this paper aims at examining what are the critical determinants that drive MNCs to locate their R&D activities in developing countries and US MNCs are chosen as the specific research targets. Although the foreign R&D investment by US firms will reflect the particular strategies and global priorities of US-based MNCs, the empirical record should be somewhat reflective of the experiences of other developed countries and to foreign R&D activities of other developed country firms.

Motivations of R&D Internationalization

Market-seeking Foreign R&D

The theoretical foundation of the market-seeking R&D activities dates back to the Product Life Cycle model proposed by Vernon (1966), who argued that firms might gain competitive advantage through exploiting their unique technology. Market uncertainties, dividing consumer tastes, a preference to internalize technological know-how and a fear to reveal core competences to potential competitors led firms to set up their own R&D facilities overseas (Håkanson, 1990; Vernon, 1966). Empirical support for these propositions are found in Ronstadt's (1978) 'technology transfer unit', Pearce's (1989) 'support laboratory' and Chiesa's (1996) 'exploitation laboratories'. According to these findings, overseas R&D is motivated by the need to adapt products and production processes to local markets and resource conditions thus foreign R&D follows the expansion of overseas marketing and manufacturing activity and focuses on local improvements of relatively mature technologies developed in home country facilities (Belderbos, 2003). In this perspective, R&D abroad is essentially technology-transfer and support operations conducted to allow better exploitation of the multinational firm's technologies and attracted by a large market potential for product adaptations and the productivity-enhancing potential of R&D applied to local manufacturing operations (Niosi, 1997). In summary, Kuemmerle (1997) labeled this type of R&D facilities and activities as ***capability exploiting*** (CBE). Correspondingly, in literature foreign R&D activities that focus on market seeking or capability exploiting are usually considered to be motivated by demand factors (Jones & Teegen, 2003), creating the needs that drive the overseas R&D operations by MNCs close to final markets they serve in order to respond the growth potential, local variations and desires of a particular market (Prahalad & Doz, 1987).

Resource-seeking Foreign R&D

Over the last two decade, scholars have increasingly underlined the importance of research or resource-driven R&D (Cantwell, 1989; Florida, 1997; Chiesa, 1996; Kuemmerle, 1997; Kuemmerle, 1999). These authors proposed that MNCs invest in overseas R&D to augment the current stock of knowledge they hold, which is achieved by tapping into local knowledge (Ambos, 2005). This notion is empirically supported by Ronstadt's (1978) 'global technology unit', Håkanson and Nobel's (1993) 'research units' and Chiesa's (1996) 'exploration laboratories'. In general these foreign R&D activities tend to take advantage of special resources, capabilities or other local competitive advantages that are not equally provided by the home country or can be achieved from the host country with lower costs or through a more efficient manner (Taggart, 1991). Following Kuemmerle's (1999) terminology, this type of foreign R&D activities can be considered as ***capability augmenting*** (CBA). The previous literature usually regards the motivation of foreign R&D that is driven by targeting host country's resource as relating to the supply factors, which are concerned with the ability to access adequate supplies of local scientific talent, local technology and know-how (Jones & Teegen, 2003).

Research Framework and Hypotheses

Market-seeking Related Foreign R&D Determinants

Historically, MNCs located R&D in their affiliates abroad mainly for the purposes of the adaptation of products to local tastes or customer needs, and the adaptation of processes to local resource availabilities and production conditions (Cantwell & Mudambi, 2000). In short, traditionally MNCs establish R&D facilities abroad or conduct R&D investment in their foreign affiliates in order to exploit the market potential of the host country. Previous studies contribute three critical factors that are directly associated with the host country's market potential and generally correspond to the demand factors in relation to foreign R&D. Based on the ideas of Doh et al. (2005), these three factors are host country economic environment, host country institutional environment and the pre-existing presence of foreign MNCs in that market, which particularly corresponds to capturing oligopolistic competitive effects.

Economic Environment

Previous literature (Behrman & Fisher 1980, Pearce 1989, Taggart 1991, Papanastassiou 1997; Jones & Teegen, 2003) has shown substantiated evidence that market/economic factors are critically important in driving foreign direct investment in R&D. Overseas manufacturing operations are often accompanied by or followed by R&D investments as the establishment of production facilities overseas and increase of product complexity require R&D facilities to be created near production sites to give technical support to localized manufacturing (Gassmann & Han, 2004). Consequently, firms can be expected to be located in and to serve those markets with the greatest economic potential return for their foreign investment (Jones & Teegen, 2003). Therefore, it is expected that a positive relationship exists between the overall economic scale of the host country and the decision to operate including R&D in a particular market.

Institutional Environment

In theoretical words institutional environment includes infrastructure, public good aspects, and rationality contexts that relate to a particular nation or society (Dugger, 1996). International business researchers have increasingly incorporated institutional theories in their analysis of both micro-organizational and macro-organizational business phenomena (Westney, 1993). Researchers such as Clarke (2001) have found that the risk of confiscation or forced nationalization and the degree to which established institutions make and enforce laws and adjudicate disputes have significant impacts on R&D expenditures. Since an important function

of governments is to refrain from infringing on private property rights, and to constrain private parties from unfairly expropriating the returns on investment of other private parties (North 1986), MNCs face hazards that originate directly from the location of their overseas R&D activity within a specific political system (Henisz & Williamson 1999).

Researchers focusing on international R&D have provided sufficient evidence of the importance of host country institutions on MNC R&D location and investment decisions (Taggart 1991; Pearce 1999; Oscar & Wallace, 2003). The studies indicate that stronger patent rights, better contract enforcement, efficient civil bureaucracy, and protectionism of local firms are likely to increase the R&D investment (Oscar & Wallace, 2003). Specifically, political and economic stability in relation to risk of change (Eleswarapu & Venkataraman, 2006), incidence of corruption (Hodgson, 2006), protection of private property rights (Zhao, 2006) are three critical indicators of a nation's institutional environment and are directly related to the strategic decisions of foreign R&D investment by MNCs, especially when the MNCs plan to process efficient marketing actions in a given institutional system (Handelman & Arnold, 1999). Previous international business literature generally agree that political stability with low risk of change, low corruption and intellectual property rights protection are positively related to the foreign R&D investment in that country (Doh et al., 2005).

Competitive Environment

Research in strategic management and international business has suggested that FDI decisions are likely to be partly influenced by a MNC's response to the moves of its competitors (Knickerbocker 1973). This effect has sometimes been integrated with the tendency of firms to "bunch" in order to exploit external economies that may include knowledge spillovers among competitors and demand effects that draw both specialized labor and suppliers to a given market (Shaver & Flyer 2000). In the context of international R&D, MNCs are inclined to follow their strategic competitors to establish R&D facilities overseas to support their competition in the targeting markets (Vernon, 1966). Previous industrial researches such as Taggart's (1991) work have found that high levels of competition in the industry contributed to a favorable R&D environment. According to the ideas of Mudambi (1995) in this study aggregate past overall investment in a nation is used as a proxy for the influence of past precedent to control the oligopolistic reaction.

Research Focus of Present Study

While traditional literature has given substantiated evidence that market-seeking factors are critical to affect MNCs' foreign R&D locations, more recent researches (Chiesa, 1996; Florida, 1997; Kuemmerle, 1999) have increasingly stressed the importance of resource-seeking factors in the context of R&D internationalization. From a contemporary perspective, a new phenomenon today in international business is that MNCs from developed nations are increasingly locating their R&D activities in the developing nations (Lee & Chang, 2007; UNCTAD, 2005; Zhao et al., 2005). Correspondingly, the overall objective of the present study is to explore the critical determinants of this phenomenon by particularly examining the relationship between the resource-seeking factors and MNCs' R&D investment in developing nations. Consequently, the core empirical part of this study will focus on developing and testing relevant hypotheses built on the basis of resource-seeking factors while market-seeking factors, which have been widely tested in previous researches, will be regarded as control variables in the study.

Resource-seeking Related Foreign R&D Determinants

Five factors in relation to resource-seeing R&D are included and relevant hypotheses are developed in the following sections.

Scientific Environment

Scientific environment is mainly concerned with the capability of producing scientific output and the availability of qualified personnel. Scientific environment directly corresponds to the supply aspect in the foreign R&D motivation model in previous studies (Doh et al., 2005). Nowadays, many nations have recently experienced a leap in technological innovation and potential for developing and exporting high technology products (NSF, 2004). MNCs that try to establish R&D operations overseas will be attracted to those locations displaying a positive and continued commitment and capability to maintaining or improving their technological competitiveness position (Jones & Teegen, 2003). Therefore, the capability of the host developing nation to continually create high quality scientific research output, which is critical to determine the competitive position of the host country, should be an effective predictor of MNCs' foreign R&D investment in that nation. This leads to the following hypothesis.

H1a: The scientific research output of the host country is positively associated with foreign R&D investment in that country.

Firms conducting R&D in foreign locations have the same general mix needs of human resource skill as any R&D operation and those skills need to meet current skill mix requirements, as well as have access to certain types of human resource capabilities on an ongoing basis (Voelker & Stead, 1999). Researchers like Taggart (1991) notes that the present availability of scientists, technologists and engineers is an important factor in the location decision. Voelker and Stead (1999) found that availability of expertise was a precondition in the process for locating research laboratories overseas. As far as developing nations are concerned, their current expertise might be at a limit level. However, the enormous reserve of trained scientific manpower may provide the nations with splendid future supply of research skills and abilities. Therefore the potential of trained manpower should be positively associated with MNCs' foreign R&D investment.

H1b: The potential capacity of trained manpower of a host developing country is positively associated with foreign R&D investment in that country.

Telecommunication Environment

Similar to scientific environment, telecommunication environment is another resource related foreign R&D determinant that directly corresponds to the supply factors (Doh, et al., 2005). The impact of telecommunications on R&D and innovation is well established in the technology management literature (Allen, 1977) and communications has been viewed as a critical element contributing to the trend to global R&D (De Meyer 1993). Moreover, there is evidence that MNCs establishing R&D operations overseas will be attracted to those locations displaying a positive and continued commitment to maintaining or improving their technological competitiveness in advanced telecommunications infrastructure as represented by computing and Internet capabilities (Doh et al., 2005). Therefore, continued improvement in technological competitiveness as reflected in telecommunications technology should be positively associated with foreign R&D investment (Jones & Teegen, 2003). This leads to the following hypothesis.

H2: The strength of the developing host country's telecommunications infrastructure is positively associated with foreign R&D investment in that country.

Average Labor Cost

Conventional wisdom suggests that lower costs would attract greater R&D-intensive FDI since firms seeking to exploit local science and technical talent and infrastructure would be expected to locate in an environment where they could operate in the most cost-efficient manner (Jones & Teegen, 2003). Rising R&D expenditures, along with intensifying pressures to cut costs and to bring products quickly to the market, are forcing MNCs to look for ways to do research more quickly, outsource non-core work and locate R&D in countries with low-cost and ample scientific manpower, which is more important when MNCs fail to find a sufficient number of skilled people in their home base, especially in science-based activities (UNCTAD, 2005). In consideration of the key roles played by human talent in the R&D process, high minimum investment in the personnel as well as positive impact of reduced unit labor cost on the improvement of productivity resulted from R&D investment (Bobillo et al., 2006), it is proposed that MNCs would prefer to conduct R&D investment in the developing nations where the average labor cost is low.

H3: The national average labor cost is negatively associated with foreign R&D investment in that country.

Potential to be the Regional Economic Center

Contemporarily MNCs are increasingly establishing overseas R&D operations in developing nations to support production and adapt technologies, to be near customers, to cooperate with local partners, to access markets, to improve the local reputation of the company, to launch a product simultaneously, to facilitate rapid scale-up in manufacturing and to overcome protectionist barriers against imports (von Zedtwitz & Gassmann 2002). However, in order to effectively implement the above market targeting objectives, MNCs need to identify a sound R&D location which can be regarded as a regional economic center. In this regional economic center the national markets are highly integrated and hold typical characteristics enabling this particular nation to become the R&D base for the whole region. These unique characteristics are related to special resources the country can provide for the MNCs to target. Typically, these resources include appropriate skills and other aspects of the national innovation system, such as the technical and economic infrastructure, proximity to suppliers and key customers (UNCTAD, 2005). The higher degree a particular country can be positioned as an economically centric country in the region and holds those resources, the more likely MNCs would conduct R&D investment in that country. This leads to the following hypothesis.

H4: The degree of the potential that a host country will become the regional economic center is positively associated with foreign R&D investment in that country.

Capability of Technology Differentiation

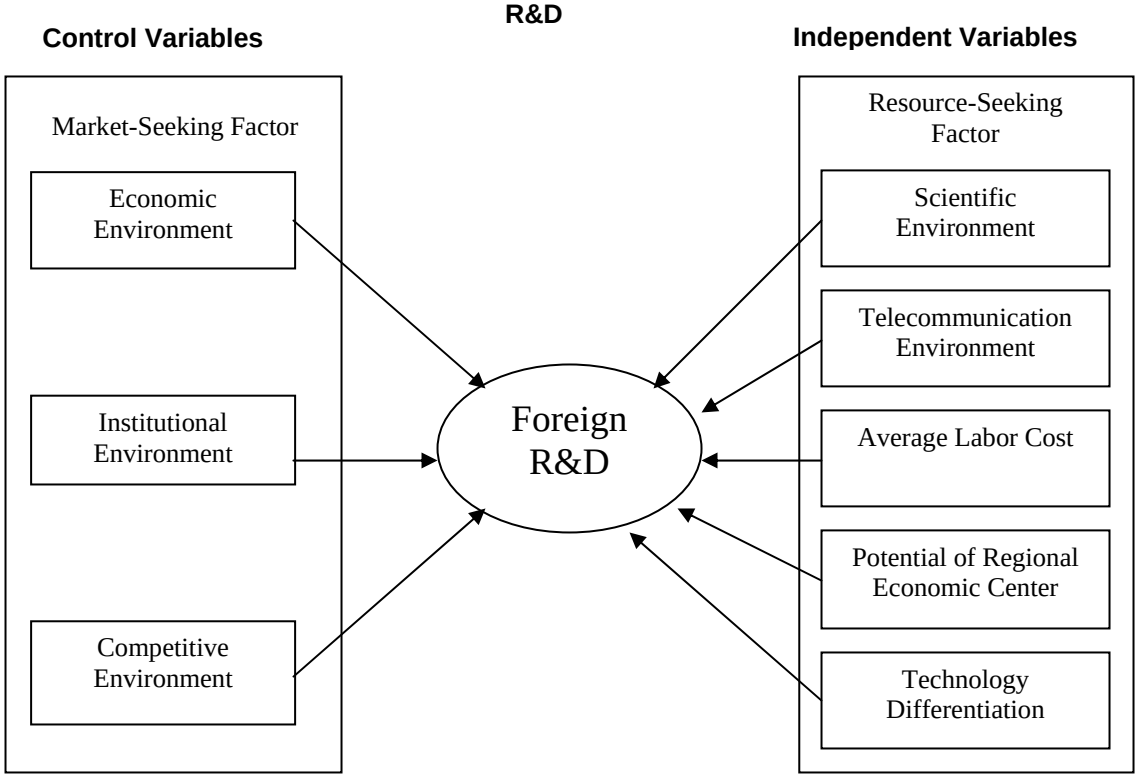
MNCs willing to target a specific market on a long-run base prefer set up foreign R&D operations in the nations that hold certain capability of differentiating transferred technology so as to reduce the degree of technology spillovers from the parent company to the optimal level (Molto et al., 2005). Since technology differentiation does not only relate to the scientific out and research capability, but depends on the tight links between local enterprises and knowledge institutions (UNCTAD, 2005), it is an overall indicator of a host nation’s development potential

responding to R&D investment, especially when MNCs prefer to seeking strategic alliance or cooperative partner when they choose the entry mode for the R&D-intensive investment. Therefore it is proposed that a nation's capability of differentiating transferred technology can have important impacts on MNCs' R&D investment in that nation.

H5: The capability of technology differentiation relating to foreign R&D investment in the host country is positively associated with foreign R&D investment in that country.

Integrating all of the ideas above, the overall model of this study that integrates both market-seeking factors and resource-seeking factors is presented in Figure 1.

Figure 1: Conceptual Model of Research: Determinants of Foreign R&D



Research Method

Data

This study focuses on US MNCs' R&D investment in developing nations and the proposed influential factors. Seventeen nations are selected as the sample representing an approximate total of 170 developing countries in the world. The data is collected from a number of official and academic databases between the year 1999 and 2004. Specifically, the data of foreign US MNCs' R&D investment is collected from Bureau of Economic Analysis, US Department of Commerce. United Nations Conference on Trade and Development (UNCTAD), World Bank, World Trade Organization provide for the study statistical information regarding

country demography, development, trade and FDI. The institutional risk related data are collected from academic and research institutions as well as government resource—Wharton School of Management, Internet Center for Corruption Research and United States Trade Representative. US Patent and Trademark Office provides patent related data for this study.

Measures

Dependent Variables

Three measures are derived for the construct of R&D investment in a given market in this study. The absolute measure is the aggregate R&D expenditures by the non-bank major-owned US affiliates in the host country (RDExpen**)**. In order to adjust for the relative size of the market in determining levels of R&D, two relative measures are developed by dividing RDExpen by the total sales and total employment expense of the non-bank major-owned US affiliates in the host country. Consequently, two ratio dependent variables are created to represent the percentage of R&D expenditure to the total affiliate sales (RDExpSales) and to the employment expense (RDExpEmp) respectively.

Independent Variables

Scientific Environment

In this study scientific environment is examined by two constructs—scientific output and potential of trained manpower of a host developing nation. Scientific output is measured using the number of patents issued by the US to inventors resident in each particular country. This variable displays the number of U.S. patents distributed by the country of origin. In order to adjust for country size, the patent counts are adjusted by the country population size to generate a count per one million population.

The capacity of trained manpower of a host nation is measured by tertiary enrollments in all programs in the host country. Tertiary enrollment is considered as an effective indictor of high level skills of a nation's manpower (UNCTAD, 2005). The comprehensive nature of this measure is also highly conformed to the focus of this study, which is particularly concerned with the potential of future research talent.

Telecommunication Environment

Three items are chosen to form the final index measure of this construct. They are number of telephone lines and cellular mobile phone subscribers per 100 population (CellSubscriber), number of Internet user per 100 population (InternetUser) and number of computers owned by per 100 population (CompuOwn). The three items together construct an overall index measure of a host nation's telecommunication environment (TeleEnvir).

Average Labor Cost

Researchers like Jones & Teegen (2003) point out that the preponderance of workers in MNCs' foreign affiliates may or may not be R&D personnel and many may be production, administrative or other manufacturing related and R&D workers are typically more highly educated and at a higher compensation level than production and manufacturing workers. As average wages in a particular nation might mask the cost of R&D workers per se, this study use workers' annual remittances and compensation of employees (LaborCost) to measure the average labor cost of a host nation. In order to adjust for country size, this item is divided by the country population to generate a normalized measure (LaborCostPercap).

Potential to be the Regional Economic Center

The total trade value of a host nation (RegionTrade), including both the import from the countries of the defined geographical region and the export to the countries of the defined geographical region is used to measure a nation's potential to become the regional economic center. This variable is divided by the total import and export value of all of the countries locating in the defined geographical region to create the eventual measure (TradeRate), which is able to indicate the current economic position of the original nation in the defined region as well as its competitive advantages over the other countries in the same region.

Degree of Technology Differentiation

Technology differentiation is closely related to a nation's ability to modify, extend, adapt and further develop the existing technology transferred from other nations. This study uses the ratio of high technology exports to the total manufacturing exports as the measure of technology differentiation of a host developing country. Since high-technology exports are products with high R&D intensity, this variable to a certain extent can reflect the nation's capability of revising and further developing the knowledge and technology transferred from the original countries to create extra value.

Control Variable

As this study stresses the resource-seeking related factors that can have impacts on US MNCs' R&D investment in developing nations, the market-seeking related factors are correspondingly defined as control variables.

Economic Environment

Regarding the geographic constraint and location focus of this study, GDP, which measures the value of goods and services produced within the boundaries of a particular nation, is applied instead of GNP for measuring of economic environment. GDP per capita as a normalized variable that concerns the effect of country size is used as the final measure of a nation's economic environment.

Institutional Environment

In this study three variables are initially included to measure the target nations' institutional quality, risk and appropriability. They include a positive measure of low corruption (TranCPI), a positive measure of political constraints (PolConstra) to capture the presence of institutional checks and balances and a rating of intellectual property rights (IPR) protection (US301). Appendix Two provides a detailed summary of the construction and support for these variables. An overall measure (TotalRiskIndex) that integrates all of the three variables is created to examine a subject nation's institutional risk.

Competitive Environment

This is measured by the total inward stock of foreign direct investment (FDIStockInw) divided by the size of the economy of the country (the GDP amount in this study), creating a relative measure (ComEnvir) of foreign asset ownership adjusted for the size of the economy. Hence, this variable captures the cumulative level of MNC investment stock in a given market, and the potential impact of oligopolistic and state-dependent impacts discussed by international business researchers (Yu & Ito, 1988; Li & Guisinger, 1992; Li, 1994) These impacts are involved in this study as they may similarly affect R&D investment from a marketing competitive perspective (Doh et al., 2005).

Methods

The data is analyzed using a combination of bivariate correlation analysis and multiple regression analysis with the three measures (RDExpen, RDExpSales, RDExpEmp) of foreign R&D intensity as the alternating dependent variables. Given the limiting nature of the data set employed, correlations are used to illustrate the sensitivity of findings to variable definitions. Correlations are further used as an initial test of the hypotheses, given the relatively small sample size and the associated methodological challenges to the use of multivariate tests because of the severe constraints imposed by limited degrees of freedom in relation to the small, nation-level, sample.

For the regressions, due to the potential challenges associated with limited cases and degrees of freedom in this study, a limited number of variables are included in the regressions. Two further steps were taken as initiatives for avoiding statistical bias. First, only variables that showed initial promise of significance from the bivariate correlations are included in the regressions. Second, the author generally restricts tests to one category of variables per model. At last a general model that includes composite variables is introduced to test the potential influence of all significant major factors simultaneously.

In addition**,** regional analysis is conducted through analysis of variance to examine how regional difference of subject nations can have impacts on US MNCs' R&D intensity in that nation, as well as impacts on overall market size in terms of foreign affiliate sales and employment expense.

Research Findings and Discussion

Through a series of bivariate correlation and multiple regression tests, it was found that H1a and H1b were partially supported; H2, H3 and H5 were not supported and H4 was fully supported[1]. The results of this study offered sound evidence to support the view that resource-seeking related factors instead of market-seeking related factors provide a strong relationship with, as well as predictive power for the location of foreign R&D activities in developing nations. Although a number of researchers (Kuemmerle, 1997; Belderbos, 2003; Jones & Teegen, 2003) found that market-seeking related—demand factors hold strong predictive power for the location of foreign R&D activities, empirical support was not found by this study. All of the three market-seeking related factors examined did not appear to be correlated with the measure variables of foreign R&D activities in developing nations[2]. On the contrary, two resource-related—supply factors were found to be either relevant or very important factor in determining foreign R&D site locations in developing countries. One tentative interpretation of the stronger support to resource-seeking related factors as the determinants of foreign R&D activities in developing nations is that because of the fast development of global distribution system and wide utilization of advanced information technology, MNCs have been increasingly able to develop or adapt at home new products to serve several different national markets at the same time or even to develop abroad new products for the world market (Belderbos, 2003; Cantwell & Mudambi, 2004). On the other hand, due to the limited resources they can exploited at home countries,

[1]These results are indicated by Exhibit 3, Exhibit 5 and Exhibit 6.

[2] This is supported by Exhibit 4. Due to the insignificant correlations, the market-related factors were not included in the regression models for further testing.

MNCs are increasingly preferring to expanding their foreign R&D activities in developing nations for utilizing the resources and supplies they need for implementing their global strategies (Cheng & Bolon, 1993; Kuemmerle, 1997; UNCTAD, 2005).

For the resource-seeking variables, scientific environment seemed to be a factor that can affect MNCs' decision of foreign R&D activities in developing nations since both scientific output and tertiary enrollment gained partial support as holding relationship with and predictive power for foreign R&D intensity. The statistic results indicate that a host country's tertiary enrollment is a stronger predictor of MNCs' foreign R&D intensity than scientific output, indicating that a nation's reserve of future technological professionals appears to be more attractive to MNCs than the current innovation power since tertiary education is a widely used proxy of high level skills (Sequeira, 2003). This implication can be further illustrated by the growing attention of MNCs in developing Asia, which has already emerged as and will continue to be the main source of new university graduates in the world (UNCTAD, 2005).

One of the most important findings of this study suggests that the potential of a developing nation to become a regional economic center measured by the nation's foreign trade with the other countries in the same region is an important factor in determining foreign R&D activities in that nation. Form a resource exploiting perspective, trade not only helps to enhance the information exchange between business partners, but also reduces the duplication of R&D effort and increases the productivity of resources by allocating them more efficiently (Grossman & Helpman, 1991). There was other evidence from prior studies suggesting that exporters receive substantial R&D spillovers from their customers (Ben-David & Loewy, 1998; Funk, 2001). A significant trade position of a particular nation within the whole region usually implies that this nation hold strong marketing, informational and human relations with, and other competitive advantages over the other nations locating in the same region. These are critical resources for MNCs that hope to expand their R&D activities in that region and thus are likely to have important influences on those MNCs' decision makers.

Despite the fact that the existence of a significant and predictive relationship between labor cost and foreign R&D investment extends the literature, this study failed to provide substantiated evidence to prove the existence of significant relationship between these two variables. It is apparent that the cost of employing R&D workers is not a significant motivation for MNCs decision makers. This is consistent with previous findings, such as those pointed out by Papanastassiou (1997), who found no significance with the average compensation paid to non-production worker by US subsidiaries in manufacturing, and those found by Voelker and Stead (1999), who discovered that low salaries, finance and other investment costs were not important drivers for the internationalization of development-oriented laboratories.

Another result of this study that seems to be counter-intuitive to the conventional wisdom is that no significant relationship was found between a developing nation's telecommunication infrastructure and foreign R&D investment in that developing nation. Although the correlation analysis suggested that the average labor cost relates to foreign R&D investment, the regressions of separate models did not show any predictive power while the general model showed some predictive power. The somewhat mixed results indicate this as an area needing additional research. A possible explanation could be implied by Voelker and Stead (1999), who proposed that the communications variable incorporates certain operating cost issues thus testing this measure absent a cost component may mask its potential relationship with foreign R&D investment, which is particularly the case of this study.

Finally, the regional analysis of this study revealed that US foreign affiliates' total employment expense varies corresponding to the different geographic regions in the world where an affiliate locates. This variation indicates the development differences between the regions in the world in terms of market size, labor cost and reserve of skilled labor. Correspondingly, MNCs tend to adjust their strategies of foreign R&D investment to adapt to the regional environment. For example, the MNCs' R&D facilities in South America are inclined to modify the original technology to adapt to the regional market as a whole, while foreign R&D activities in some Asian developing nations have begun to take on a more sophisticated role within the global R&D networks of MNCs (UNCTAD, 2005). This is particularly concerned with the special resources and capabilities provided by those countries. The significant relationship between the level of regional foreign trade and foreign affiliates' total employment expense found in this study gives further support to the above argument.

This study addresses some valuable implications for policy decision makers concerned with attracting foreign R&D investment. First, the results of this study to a certain extent prove that scientific environment is a critical factor that can affect MNCs' foreign R&D decisions in a developing nation. Specifically, the capacity of trained manpower is found to be a more important determinant than scientific output. Accordingly, from a policy perspective, those host developing nations' governments wishing to attract R&D investment from abroad are well advised to develop and maintain an effective educational system that is able to continually produce highly educated and skilled R&D workers, scientists and engineers sought by MNCs. Moreover, developing countries that are able to provide a munificent climate for such output are attractive to R&D investors. Second, this study did not found significant evidence to conclude that the telecommunication infrastructure and national labor cost are two critical determinants of MNCs' foreign R&D activities in developing nations. From a resource-exploiting perspective, this result appears to imply that MNCs' strategic decision makers are more concerned with the "soft resources" provided by the developing nations. Especially, MNC managers are more interested in the skills and capabilities of the potential workforce than the R&D costs associated with employing the human talents in the host location. Therefore, host developing nations considering low wage resource availability alone as a factor to attract R&D investment are not likely to be a sustainable strategy. Third, the results of this study strongly support the potential of a host nation to become a regional economic center as a significant determinant of foreign R&D locating in that nation. It is suggested that policy makers of the relevant developing nations take effective actions to support an overall climate for host industrial practitioners to expand foreign trade with their counterparts in other regional countries, to extend the channels of information and technology exchange and consequently to enhance the economically influential power of the host nation to other countries within the concerned region so as to increase the overall attractiveness to foreign R&D investment. Finally, this study indicated that regional factors are likely to be influential to the foreign investment scale in a host nation, which requires a host nation conduct cooperative economic, political and technological policies to its neighbor countries so as to not only exert influence on foreign R&D investment in the nation itself, but achieve a win-win situation for the whole region.

Conclusion

Due to the growing international competition accelerating process of technology innovation, the globalization of research and development activities by MNCs will continue. Using a two-dimension framework, this study found that MNCs expand their foreign R&D activities in developing nations because these nations can provide them important resources and capabilities they need for successful competition in the global market and implementation of their global strategy. While the enormous potential of emerging markets appear to be

significantly magnetic to MNCs, it is important for the developing nations' government, manufacturers and research institutions to continually improve their R&D related resources and innovative capabilities not only for attracting foreign R&D investment from MNCs, but also for increasing their overall global competitive advantages in the long haul.

Exhibit 1: Descriptive Statistics of Research Variables

	N	Mean	Std. Deviation
RDExpen	17	150.7047	178.2874
AffliSales	17	27732.3856	32583.9622
AffliEmployment	17	2141.3589	2716.2059
RDExpSales	17	.0044	.0038
RDExpEmp	17	.0629	.0672
Population	17	180947377.8235	378384694.2268
GDPPercap	17	9078.0686	8355.1178
TertiaEnr	17	2322628.6398	3461455.6278
LaborCost	17	6173583164.9804	8172567977.4933
LaborCostPercap	17	620.4789	1612.5484
RegionTrade	17	92701.0245	102913.7126
TotRegionTrade	17	2647303725490.1960	1484911647705.5130
TradeRate	17	.0286	.0251
FDIStockOut	17	38319.3640	83846.0479
TraNetStock	17	11.6801	25.1762
RegStockInw	17	2124051.4235	1446069.1152
InwStockRate	17	.0820	.0894
HigTecExport	17	77.0441	160.9986
PolConstra	17	.3522	.2267
TranCPI	17	4.3186	1.8901
US301	17	4.5294	1.6301
TotalRiskIndex	17	4.1234	1.2915
PatentCount	17	390.8431	929.8623
SciEnvir	17	12.3209	26.3098
CellSubscriber	17	54.5912	40.5601
InternetUser	17	15.3941	15.5446
CompuOwn	17	14.6089	17.0632
TeleEnvir	17	28.1981	23.7792
FDIStockInw	17	76070.7299	104051.7891
ComEnvir	17	.4156	.6149

Exhibit 2: Correlation Matrix of Research Variables

	1	2	3	4	5	6	7	8	9	10	11	12
RDExpen	1											
AffliSales	.726(**)	1										
AffliEmployment	0.478	.884(**)	1									
RDExpSales	.661(**)	0.177	0.077	1								
RDExpEmp	.765(**)	0.308	0.041	.866(**)	1							
Population	0.361	0.006	0.023	.636(**)	0.432	1						
GDPPercap	0.220	0.218	0.007	-0.194	-0.059	-0.443	1					
TertiaEnr	0.364	0.060	0.106	.647(**)	0.399	.977(**)	-.496(*)	1				
LaborCost	.573(*)	.503(*)	0.270	0.307	0.368	0.418	0.103	0.400	1			
LaborCostPercap	.524(*)	0.429	0.045	0.020	0.289	-0.185	.530(*)	-0.204	.667(**)	1		
RegionTrade	.701(**)	0.401	0.230	.716(**)	.729(**)	0.389	0.096	0.377	0.157	0.048	1	
TotRegionTrade	0.452	0.467	0.368	.487(*)	.499(*)	0.324	-0.335	0.425	0.139	-0.005	.599(*)	1
TradeRate	.661(**)	0.360	0.194	.664(**)	.687(**)	0.336	0.204	0.304	0.147	0.046	.976(**)	0.459
FDIStockOut	0.350	0.376	0.260	0.128	0.162	-0.104	.533(*)	-0.133	-0.076	0.063	.580(*)	0.275
TraNetStock	-0.246	-0.219	-0.242	-0.048	0.090	-0.105	-0.285	-0.109	-0.281	-0.151	0.150	0.284
RegStockInw	0.476	0.408	0.252	.532(*)	.549(*)	0.372	-0.260	0.467	0.171	0.039	.634(**)	.971(**)
InwStockRate	-0.008	-0.024	-0.023	-0.170	-0.175	-0.124	.540(*)	-0.218	0.051	0.008	0.008	-.567(*)
HigTecExport	-0.131	-0.233	-0.246	-0.338	-0.259	-0.189	0.431	-0.254	-0.128	0.122	-0.272	-.500(*)
PolConstra	-0.242	0.042	0.219	-0.122	-0.179	-0.233	-0.094	-0.166	-.597(*)	-0.459	-0.007	0.289
TranCPI	.543(*)	0.468	0.150	0.078	0.309	-0.308	.875(**)	-0.351	0.305	.675(**)	0.336	-0.009
US301	-0.054	0.233	0.107	-0.361	-0.140	-.548(*)	.692(**)	-.605(*)	-0.023	0.303	0.042	-0.185
TotalRiskIndex	0.101	0.351	0.246	-0.185	-0.013	-.517(*)	.663(**)	-.523(*)	-0.210	0.188	0.178	0.087
PatentCount	0.087	-0.009	0.060	0.458	0.120	0.140	0.024	0.280	0.032	-0.074	0.187	0.293
SciEnvir	.493(*)	0.390	0.150	0.340	0.321	-0.196	.547(*)	-0.105	0.298	.590(*)	0.384	0.316
CellSubscriber	0.407	0.328	0.129	0.126	0.183	-0.394	.816(**)	-0.381	0.002	0.421	0.411	0.063
InternetUser	0.422	0.302	0.075	0.248	0.316	-0.360	.669(**)	-0.311	0.051	0.457	0.362	0.180
CompuOwn	.500(*)	0.425	0.151	0.220	0.287	-0.334	.738(**)	-0.294	0.268	.621(**)	0.394	0.182
TeleEnvir	0.443	0.354	0.126	0.178	0.241	-0.382	.786(**)	-0.355	0.076	.488(*)	0.407	0.119
FDIStockInw	.612(**)	.603(*)	.508(*)	0.329	0.338	0.183	0.359	0.156	0.143	0.053	.752(**)	0.393
ComEnvir	0.381	0.411	0.175	0.082	0.259	-0.234	.555(*)	-0.286	0.049	0.323	.550(*)	0.296

Exhibit 2: Correlation Matrix of Research Variables (continued)

	13	14	15	16	17	18	19	20	21	22	23	24
RDExpen												
AffliSales												
AffliEmployment												
RDExpSales												
RDExpEmp												
Population												
GDPPercap												
TertiaEnr												
LaborCost												
LaborCostPercap												
RegionTrade												
TotRegionTrade												
TradeRate	1											
FDIStockOut	.590(*)	1										
TraNetStock	0.151	-0.095	1									
RegStockInw	.499(*)	0.314	0.235	1								
InwStockRate	0.187	0.372	-0.319	-.500(*)	1							
HigTecExport	-0.214	-0.136	-0.190	-0.471	0.052	1						
PolConstra	-0.078	0.339	0.155	0.238	-0.310	-0.126	1					
TranCPI	0.398	.621(**)	-0.258	0.061	0.369	0.264	-0.068	1				
US301	0.176	0.410	0.205	-0.209	0.464	0.077	0.072	.600(*)	1			
TotalRiskIndex	0.223	.674(**)	0.051	0.081	0.194	0.087	.582(*)	.700(**)	.755(**)	1		
PatentCount	0.141	-0.011	-0.114	0.342	-0.234	-0.139	0.073	-0.022	-0.205	-0.055	1	
SciEnvir	0.358	0.356	-0.126	0.382	-0.061	-0.084	-0.090	.621(**)	0.231	0.348	.652(**)	1
CellSubscriber	0.443	.680(**)	-0.237	0.123	0.262	0.258	0.035	.835(**)	0.451	.617(**)	0.332	.774(**)
InternetUser	0.366	0.476	-0.156	0.259	0.072	0.191	-0.013	.746(**)	0.314	.488(*)	.506(*)	.857(**)
CompuOwn	0.400	.581(*)	-0.209	0.253	0.162	0.027	-0.065	.824(**)	0.387	.527(*)	0.421	.924(**)
TeleEnvir	0.428	.630(**)	-0.219	0.187	0.204	0.195	0.001	.834(**)	0.418	.584(*)	0.400	.848(**)
FDIStockInw	.749(**)	.890(**)	-0.203	0.408	0.337	-0.217	0.165	.516(*)	0.239	0.449	-0.041	0.281
ComEnvir	.550(*)	.912(**)	0.033	0.316	0.256	-0.146	0.188	.705(**)	.536(*)	.680(**)	-0.136	0.414

Exhibit 2: Correlation Matrix of Research Variables (continued)

	25	26	27	28	29	30
RDExpen						
AffliSales						
AffliEmployment						
RDExpSales						
RDExpEmp						
Population						
GDPPercap						
TertiaEnr						
LaborCost						
LaborCostPercap						
RegionTrade						
TotRegionTrade						
TradeRate						
FDIStockOut						
TraNetStock						
RegStockInw						
InwStockRate						
HigTecExport						
PolConstra						
TranCPI						
US301						
TotalRiskIndex						
PatentCount						
SciEnvir						
CellSubscriber	1					
InternetUser	.925(**)	1				
CompuOwn	.913(**)	.907(**)	1			
TeleEnvir	.988(**)	.961(**)	.956(**)	1		
FDIStockInw	.532(*)	0.331	0.453	.483(*)	1	
ComEnvir	.694(**)	.526(*)	.643(**)	.663(**)	.780(**)	1

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

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

Exhibit 3: Correlation—Resource-seeking Factors[3]

	RDExpen	RDExpSales	RDExpEmp
SciEnvir (H1a)	***0.493***	0.340	0.321
	0.044	0.182	0.209
TertiaEnr (H1b)	0.364	***0.647***	0.399
	0.151	0.005	0.113
TeleEnvir (H2)	0.443	0.178	0.241
	0.075	0.493	0.351
LaborCostPercap (H3)	***0.524***	0.020	0.289
	0.031	0.939	0.261
TradeRate (H4)	***0.661***	***0.664***	***0.687***
	0.004	0.004	0.002
HigTecExport (H5)	-0.131	-0.338	-0.259
	0.617	0.185	0.315

Highlighted numbers indicate statistically significant**.**

Exhibit 4: Correlation—Market-seeking Factors

	RDExpen	RDExpSales	RDExpEmp
GDPPercap	0.220	-0.194	-0.059
	0.395	0.456	0.823
TotalRiskIndex	0.101	-0.185	-0.013
	0.701	0.476	0.962
ComEnvir	0.381	0.082	0.259
	0.132	0.753	0.315

[3] The numbers of the second line in each row represent the relevant p value.

Exhibit 5: Regression Analysis of Research Variables

	Model 1			Model 2			Model 3		
	RDExpen	**RDExpSales**	**RDExpEmp**	**RDExpen**	**RDExpSales**	**RDExpEmp**	**RDExpen**	**RDExpSales**	**RDExpEmp**
SciEnvir (H1a)	0.96	5.89E-05*	0.001						
	[0.674]	[2.387]	[1.623]						
TertiaEnr (H1b)	3.16E-05**	7.49E-010**	8.49E-09						
	[3.489]	[3.993]	[1.933]						
LaborCostPercap (H3)				0.032	4.68E-08	1.20E-05			
				[0.986]	[0.078]	[1.167]			
TradeRate (H4)							3761.95*	0.1**	1.842**
							[2.646]	[3.44]	[3.661]
TranCPI	63.153			32.717			31.326		
	[3.001]			[1.179]			[1.662]		
Adj. R^2	0.656	0.586	0.292	0.34	0	0.083	0.53	0.441	0.472
F	8.265**	9.928**	2.887	3.61	0.006	1.363	7.883**	11.834**	13.404**
N	17	17	17	17	17	17	17	17	17
t-statistics in square brackets									

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

Exhibit 6: General Model of Regression Analysis

	General Model		
	RDExpen	**RDExpSales**	**RDExpEmp**
SciEnvir (H1a)	0.012	4.12E-05	0
	[0.009]	[1.365]	[-0.359]
TertiaEnr (H1b)	1.62E-05	5.91E-010**	5.37E-09
	[2.07]	[3.237]	[1.415]
LaborCostPercap (H3)	0.062**	-1.30E-07	1.54E-05
	[3.156]	[-0.292]	[1.608]
TradeRate (H4)	3834.258**	0.06*	1.656*
	[3.304]	[2.202]	[2.941]
Adj. R^2	0.766	0.713	0.612
F	9.826**	7.46**	4.742*
N	17	17	17
t-statistics in square brackets			

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

*. significant at the 0.05 level (2-tailed).

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