The Role of International Diversification and Global Reservoirs of Scientific Knowledge in Explaining Performance Outcomes

Mario I. Kafouros[1]
Peter J. Buckley[1]
Jeremy Clegg[1]

ABSTRACT

Integrating insights from the literatures on internationalization and knowledge externalities, we posit that the reservoirs of scientific knowledge residing in different locations around the world have significant power in explaining interfirm performance variations. We assert that the ability to access and exploit such intangible resources differs considerably across multinationals, according to both firm-specific and exogenously-determined factors. Our empirical analysis indicates that the performance-enhancing effect of global knowledge reservoirs is positive and often higher than that of a firm's own knowledge. Whereas some multinationals excel at exploiting such intangible resources, others fail to do so successfully. In this respect, the results indicate that a firm's ability to benefit economically from global knowledge reservoirs is positively associated with (1) its degree of international diversification, (2) the intensity of its own research efforts, and (3) the opportunities pertaining to different industry-specific technological domains.

[1] CIBUL, Leeds University Business School, University of Leeds, Leeds, LS2 9JT, UK

The Role of International Diversification and Global Reservoirs of Scientific Knowledge in Explaining Performance Outcomes

INTRODUCTION

Conventional wisdom in economics and management holds that corporate performance depends not only on firm-specific idiosyncrasies, but also on the environment or market in which the firm competes. However, in an era where firms increase their participation in foreign markets every day, deciphering causal links between performance, firm-specific attributes and environmental conditions is a challenging exercise. The prominence of the internationalization phenomenon (Lu & Beamish, 2001), and the quest for understanding its performance implications for multinational enterprises (MNEs), has received considerable attention (Contractor, Kundu & Hsu, 2003; Gomes & Ramaswamy, 1999). A large volume of studies (Hitt, Hoskisson & Kim, 1997; Kotabe, Srinivasan & Aulakh, 2002; Tallman & Li, 1996) has offered valuable insights into how performance is influenced by a firm's degree of international diversification―the extent to which business activities span national boundaries (Tseng, Tansuhaj, Hallagan & McCullough, 2007). Another prevailing theoretical avenue for understanding interfirm performance asymmetries rests upon the role of external scientific knowledge―the ideas, knowledge and technologies that the R&D divisions of other firms develop. Such knowledge is commonly viewed as a strategically important determinant of performance that may add to firm resources (Mayer, 2006), enrich a firm's own understanding (Buckley & Carter, 2004), bridge distant technological contexts (Rosenkopf & Almeida, 2003), and assist firms in identifying gaps in the technological landscape (Miller, Fern & Cardinal, 2007).

These two research streams have each assisted significantly in developing theory about the drivers of performance. Yet, as little research has attempted to integrate the two literatures or explore their complementarities, they are often viewed as two separate theoretical explanations of interfirm performance variations. This research gap is surprising as it is often argued that international diversification increases organizational learning and permits firms to access new and diverse resources of external knowledge that are critical in the battle for technological leadership and superior performance (Cantwell & Mudambi, 2005; Chesbrough, 2003; Kafouros & Buckley, 2008; Spencer, 2000; Zahra, Ireland & Hitt, 2000). Therefore, previous perspectives that ignore how knowledge-based paradigms and internationalization research inform each other, offer an incomplete account of the implications of international diversification and external scientific knowledge, limiting our conceptualizations of how differences in performance arise. We offer a solution to this problem by suggesting that the two literatures are partial reflections of a larger theoretical gap (that is, the spatial aspects of the internalization of markets for knowledge).

This research gap, and the need for decoding the mechanisms underlying performance, motivate the contributions of this study. Integrating insights from internationalization research and knowledge externalities theory, we seek to better understand how international diversification and external scientific knowledge interact to determine the performance of innovative MNEs. Our framework revolves around the conception that the industrial research and development (R&D) undertaken in foreign markets by other firms, rivals or not, leads to the creation of *global reservoirs* of external scientific knowledge. These reservoirs evolve over time and vary across markets in terms of size, characteristics, and growth. Building on the premise that the knowledge created by one company yields potentially useful opportunities for other firms too (Adams & Jaffe, 1996; Griliches, 1992; Mayer, 2006; Scherer, 1982), we demonstrate that global knowledge reservoirs have significant power in explaining differences in MNEs' performance. Nonetheless, we also posit that as knowledge tends to be geographically localized (Almeida & Kogut, 1999; Jaffe, Trajtenberg & Henderson, 1993), the ability to access and benefit from such intangible resources differs across firms according to their level of international diversification.

This framework, therefore, entails modeling performance outcomes as a function not only of firm-specific attributes, but also of external factors pertaining to the scientific knowledge originating from different industries and countries. To this end, we construct knowledge reservoirs for 18 OECD countries and 15 manufacturing industries. Thus, unlike previous research that typically focuses on knowledge flows within one or between two countries, our analysis captures most of the world's research efforts. To test our framework, these data are supplemented by a firm-level panel dataset of innovative UK MNEs, the research activities of which account for more than 90 percent of the UK's total manufacturing R&D. The use of such data is important as it allows us to offer firm-level evidence linking differences in MNEs' performance to patterns in the evolution of global scientific knowledge.

Furthermore, our framework allows us to clarify what governs MNEs' ability to extract economic rents from global knowledge reservoirs. First, we add to the internationalization and knowledge externalities literatures by investigating if and to what extent MNEs with higher levels of international diversification benefit more from global scientific knowledge. As this approach links the effects of the world's scientific knowledge to international expansion decisions, it stands in direct contrast with macro-level analyses that implicitly assume that all firms, internationalized or not, in a given country reap rewards from such externalities. Second, we enrich prior research on organizational learning by examining the extent to which firms' tendencies to draw upon global knowledge reservoirs depend on the intensity of their own research activities. In contrast to studies that focus on the role of intra-industry knowledge, our analysis incorporates both the knowledge created by close rivals—firms that operate in the same product category—and the knowledge developed by companies in more distant scientific domains. Modeling knowledge externalities in this manner is consistent with research which indicates that firms search for information in a number of distinct technological areas (Griliches, 1992; Jaffe, 1989), rather than in just their own. Third, previous studies have evaluated how paradigm- or industry-specific technological opportunities impact upon firm formation (Shane, 2001) and commercialization (Astebro & Dahlin, 2005). Yet, there is little empirical research concerning the moderating effects of such exogenously-determined opportunity conditions. We shed light on this question by examining if and how the set of technological opportunities in a given industry influence the performance-enhancing effects of global knowledge reservoirs.

HYPOTHESES

Global Reservoirs of Scientific Knowledge and International Diversification

Drawing from international economics (Coe & Helpman, 1995; Branstetter, 2001; Keller, 2002), our theoretical framework takes into account that we do not deal with one country, but with a whole array of firms, industries, and countries. In this respect, instead of attributing performance outcomes to the knowledge stock of one country, we link variation in performance to *global* reservoirs of scientific knowledge that firms in foreign countries develop. These country-specific reservoirs comprise of smaller (industry-specific) stocks of knowledge that evolve over time depending on each country's industrial structure, and on the amount and type of research undertaken in each industry. As such, they inevitably differ in terms of characteristics, size and growth. The increasing privatization of scientific commons (Nelson, 2004) and stronger intellectual property laws make the exploitation of global knowledge reservoirs more important than ever in enabling firms to attain and sustain a positional advantage.

Such resources are critical for the firm (Dunning, 1993; Cantwell & Mudambi, 2005;

Singh, 2007) as they may reduce variable costs, enhance output, and contribute to firms' growth (Bayoumi, Coe & Helpman, 1999; Bernstein & Mohnen, 1998). Research on global R&D (e.g., Kuemmerle, 1997) indicates that absorbing research findings from foreign rivals and from clusters of scientific excellence is crucial in order to remain competitive. Conversely, if different firms tap similar stocks of knowledge, uninspiring products are likely to be developed (Santos et al., 2004). Thus, bringing together the knowledge that resides in different locations plays a key role in enriching a firm's own knowledge base and enhancing its performance (Buckley & Carter, 2004; Keller, 2002; Singh, 2007).

Nevertheless, although many studies assume that knowledge can be transferred with ease from one location to another, this is not always the case (Jaffe et al., 1993; Fang et al., 2007). Knowledge spills imperfectly over national borders as it is often integrated either in local engineers and star scientists (Almeida & Kogut, 1999) or in a local context and setting. Empirical findings reinforce this argument, indicating that knowledge diffusion and the production of ideas is geographically localized and spatially-bounded (Jaffe et al., 1993; Almeida & Kogut, 1999; Keller, 2002). Furthermore, although the exchange of tangible commodities may encourage knowledge to spread (Grossman & Helpman, 1991; Salomon & Jin, 2008), tangible assets do not inevitably embody tacit knowledge. Similarly, many MNEs encounter difficulties in transferring knowledge (Fang et al., 2007), whereas less internationalized and domestic firms have little or no incentive to transfer their knowledge abroad. For these reasons, instead of subscribing to the view that the knowledge created in one location travels with ease to other countries, we posit that knowledge reservoirs—or at least a large part of them—are tied to, or close to, the location where they have been created.

An important implication of this assumption is that not all firms can access such intangible resources. Rather, we propose, firms' abilities to enhance performance by deploying global reservoirs of knowledge depends on the level of their international diversification; the higher it is the better their ability to benefit from the knowledge that each country possesses. While this proposition has received little empirical attention, it is strongly supported by theoretical arguments that point to the strong links between international diversification and increased organizational learning (Zahra et al., 2000). Highly international firms have better opportunities to learn because their subsidiaries in disparate host countries improve the process of knowledge accumulation (Lu & Beamish, 2004; Delios & Henisz, 2000; Santos et al., 2004). This facilitates continuous learning that, in turn, assists firms in developing new skills and competencies (Zahra et al., 2000), and in achieving resource positions that their rivals cannot easily imitate (Dierickx & Cool, 1989). The geographically dispersed R&D centres of highly international firms (Cantwell & Mudambi, 2005) collect technical know-how from several countries, and capture ideas from new and diverse markets and scientists (Hitt et al., 1997). Furthermore, cross-border expansion helps firms to find the resources needed to sustain their R&D operations (Kobrin, 1991), and access resources that are often unavailable to domestic firms (Dunning, 1993). In summary, therefore, although we expect global reservoirs of scientific knowledge to enhance performance, we expect such effects to be stronger for firms with higher levels of international diversification. This discussion leads to the following hypotheses:

Hypothesis 1: Global reservoirs of scientific knowledge will have a positive effect on the performance of MNEs.

Hypothesis 2: Global reservoirs of scientific knowledge will have a stronger effect on the performance of MNEs with higher levels of international diversification than for those that are less internationally diversified.

The Role of Firms' Own Research Efforts

Undoubtedly, international expansion may assist MNEs in accessing global reservoirs of knowledge. But accessing knowledge does not necessarily permit multinational corporations to understand, assimilate and benefit from it. In fact, management research suggests that firms often cannot deploy outside knowledge either because they cannot understand its advantages or because they are trapped within their own technological competencies (Edmondson, Bohmer & Pisano, 2001; De Bondt, 1996). Although understanding why multinationals vary in their capacities to draw upon external research discoveries remains an important theoretical and empirical challenge, one prevailing explanation for such differences points to the role that firms' own research efforts play in enhancing organizational learning.

Systematic R&D is commonly thought to be the most important response of firms to the need for understanding and knowing about modern sciences and technologies (Dodgson, 1993). Levin, Klevorick, Nelson and Winter (1987) examined the determinants of knowledge externalities by analyzing 650 responses from 130 lines of business. The evidence indicated that a firm's own R&D was the most effective mean of exploring and learning about the technologies of competitors. The researchers also found that R&D enabled firms to gain access to external technologies by reverse engineering competing products. Reinforcing these findings, research on technological diffusion shows that R&D intensive companies adopt and respond to new discoveries faster than less research intensive organizations (Baldwin & Scott, 1987). By contrast, firms with poor technical know-how face delays and difficulties in adopting new technologies (Attewell, 1992).

Cohen and Levinthal (1990) argue that absorptive capacity—the ability to recognize the value of external knowledge, assimilate and apply it to commercial ends—depends on the firm's prior knowledge and R&D. By undertaking research, they argue, firms provide themselves with valuable background of knowledge that assists them in exploiting external technological know-how and responding quickly to competitors' actions. Empirical evidence provides overwhelming support to the notion of absorptive capacity, indicating that the contribution of knowledge externalities to organizational performance is a function of a firm's own R&D (e.g., Harhoff, 2000). These results are also confirmed at the country-level. For instance, employing a dataset for twelve OECD countries, Griffith, Redding and Van Reenen (2004) found that R&D facilitates the imitation of foreign discoveries and helps countries to stimulate growth through technology transfer. Therefore, we expect to find a positive relationship between the intensity of MNEs' own R&D efforts and their ability to benefit from the technologies that foreign firms develop. Accordingly, we propose a third hypothesis:

Hypothesis 3: Global reservoirs of scientific knowledge have a stronger effect on the performance of more R&D-intensive MNEs than on less research intensive MNEs.

The Role of Technological Opportunities

In the previous sections, we focused on how two idiosyncratic organizational factors—namely international diversification and firms' own research—influence the ability of individual MNEs to benefit from global knowledge reservoirs. However, we have placed little emphasis on the role of a firm's external environment that, according to traditional industrial organization (IO) thinking (e.g., Schmalensee & Willig, 1989), is crucial in explaining performance outcomes. Evidence showing that technological progress rests upon paradigm- or industry-specific opportunity conditions (Dosi, Marengo & Pasquali, 2006) prompts the need for a better understanding of the role of industry variables (Zahra, 1996). Although the *technological opportunities* in a given industry (defined as the set of possibilities for technological advance; Klevorick et al., 1995) can profoundly influence the effects that global knowledge resources have on performance, little research has examined their moderating role.

Industries vary considerably in their sources of technological opportunities and in the 'natural trajectories' in which they proceed (Nelson & Winter, 1982). While the introduction of new discoveries is rapid and frequent in industries with high levels of technological opportunities, other industries display limited potential for innovation (Zahra, 1996). Focusing on the supply side of technological progress, Rosenberg (1974) discusses historical cases where the nature and structure of technological paradigms (rather than mere firm-specific factors) shaped the direction of inventive activity and the generation of new scientific knowledge. Similarly, Hambrick and MacMillan (1985) argue that innovation is much like farming: while obtaining yield from fertile fields is relatively easy and inexpensive, yield from less abundant land is much more difficult and costly to achieve. Empirical evidence reinforces these arguments, indicating that technical understanding grows rapidly in industries such as electronics, drugs and aerospace, but very slowly in sectors such as footwear, construction and wood manufacturing (Klevorick et al., 1995). In summary, previous research strongly suggests that the potential for new understanding is liable to be higher in technologically dynamic industries than in traditional, low-technology sectors (Clark & Griliches, 1984).

The fact that industries with high levels of technological opportunities augment or renew the possibilities for technological advance at a rapid rate (Klevorick et al., 1995) may motivate firms that operate in such industries to search actively for outside ideas. In turn, this enhances organizational learning, the exploitation of external knowledge and, consequently, firm performance. Additionally, research on innovation and strategic management indicates that the organizational foundations and innovative capacities of technologically advanced firms differ considerably from those of firms that are less technology intensive (Matheson & Matheson, 1998). Firms in technology intensive industries have good infrastructure and understanding of technologies. These conditions assist them in integrating external research findings in their own products and processes (Kafouros & Buckley, 2008), and in building on the knowledge that companies around the globe transmit. As technology intensive firms often operate in scientific domains where the understanding and knowledge in relation to innovation is rich and growing rapidly (Clark & Griliches, 1984), finding useful external knowledge that complements and extends their own understanding is much easier and less costly. By contrast, because firms in industries with low technological opportunities deploy techniques where the possibility of new technical understanding is low (Clark & Griliches, 1984), the role of external knowledge in explaining performance asymmetries is likely to be less significant.

Furthermore, while unique opportunity conditions in some sectors may improve growth by encouraging firms to enter new markets (Tihanyi, Johnson, Hoskisson & Hitt, 2003), this is rarely the case in industries where the pool of opportunities is replenished only slowly. In addition, the product life cycle model (Vernon, 1966) and previous empirical studies (e.g., Iansiti & West, 1997) suggest that the short life cycles of high-tech products forces firms in technologically dynamic industries to spend heavily on R&D. This condition contributes significantly to scientific advances, generates new starting points, opens up opportunities for others, and promotes the creation of new knowledge and techniques that often feed back on themselves (Klevorick et al., 1995; Cohen, Nelson & Walsh, 2002). In line with these arguments, Audretsch and Feldman (1996) find that knowledge spillovers in the US are more prevalent in R&D intensive industries. Overall, although firm-specific capabilities play a key role in explaining the differential performance-enhancing effects of global scientific knowledge, we expect that the magnitude of such effects will also depend on exogenously-determined opportunity conditions pertaining to different industry-specific technological domains (Dosi et al., 2006). This discussion leads to the fourth hypothesis:

> **Hypothesis 4:** Global reservoirs of scientific knowledge have a stronger effect on the performance of MNEs that operate in industries with higher levels of technological opportunities than for those in industries with lower technological opportunities.

METHODS AND DATA

Sample and Data

To submit our theoretical propositions to statistical testing, we needed (1) firm-level data for various variables including each firm's international diversification, R&D and performance, (2) detailed industry-level data regarding the R&D undertaken in foreign countries by specific industries, and (3) information concerning the *technological distance* between firms—the extent to which the technologies originating from outside industries are useful for each MNE in our sample. Further, because our analysis requires stocks for some variables, we needed these data to be available over a period of time. As no database with such diverse types of information currently exists, collecting the required data was challenging. To this end, we constructed a unique database integrating previously unconnected sources of information.

The first part of our database is a firm-level panel dataset. We employed a multi-industry sample both to increase variance (Baltagi, 2005) and to examine how firms from industries with high and low technological opportunities differ from each other. This sample comprises R&D-active UK manufacturing MNEs, and covers a ten-year period (1995-2004). The primary source of our firm-level operating data on UK firms is Thomson's One Banker. However, some missing observations regarding firm performance, R&D and international diversification were obtained from the R&D and Value Added Scoreboard surveys and original annual reports. Table 1 presents the industrial breakdown for the final sample of 145 firms. These operate in 15 distinct industries and, as noted earlier, account for more than 90 percent of the UK's total manufacturing R&D. Following earlier research on the role of technological possibilities (Griliches & Mairesse, 1984; Klevorick et al., 1995), we also distinguish between industries of high and low technological opportunities. As Table 1 shows, 61 MNEs of the sample belong to low technological opportunities industries such as machinery, textiles and metals. The remaining 84 firms participate in industries, such as electronics and pharmaceuticals, where the possibilities for new technical understanding are high (Klevorick et al., 1995).

-- Table 1 ---
--

In addition, to calculate industry- and location-specific knowledge reservoirs, we needed detailed information on R&D spending for different industries and countries. To this end, our firm-level data were supplemented with information from the OECD Analytical Database. Specifically, we obtained data on the aggregate R&D undertaken in 18 OECD countries and 15 distinct industries that matched those in which the firms of our firm-level sample operate. As the diffusion of knowledge takes time, we collected data for the 1993-2003 period satisfying therefore the need to employ lagged measures of knowledge reservoirs. Table 2 presents data on the R&D undertaken in the UK as well as in 18 other countries. As expected, the distribution of the world's R&D is particularly uneven, both in terms of levels and growth rates. What these aggregate figures do not reveal, however, is that the reservoir of scientific knowledge within a country may be particularly large in one domain or industry, but less significant in another. For example, although R&D spending in

Germany is on average much higher than that in the UK, the size of the knowledge reservoir in the UK pharmaceutical industry significantly exceeds that in Germany.

--- Table 2 ---
--

Nonetheless, the reservoir of knowledge in an industry is not in itself indicative of how much of this knowledge is useful and relevant for firms in other industries (Griliches, 1992). For a computer manufacturer, for instance, the knowledge generated by chemical firms may not be as useful as that created by other companies in the telecommunication industry. This prompts the need to identify the technological distance between the 15 industries of our sample; that is, the extent to which firms in one industry employ the knowledge and technologies that firms in another industry develop (Griliches, 1992). Following previous studies (Goto & Suzuki, 1989; Klevorick et al., 1995; Adams & Jaffe, 1996), we constructed a technological-proximity matrix, using input-output data from the UK Office for National Statistics (ONS). The data included a 122×122 dimensions table with information on the inputs that firms from 122 lines of business employed to produce various products and technologies. From this table, we identified and grouped those products relevant to our analysis into 15 industry groups. For instance, inorganic, organic and other chemical products were incorporated together into the chemical industry. This process therefore resulted in a table of 15×15 dimensions that identified the technological distance between inter-industry senders and recipients of scientific knowledge.

Dependent Variable

Building on the work of Griliches (1979) and Scherer (1982), our study relies on regression analysis and a logarithmic specification that stems from a widely employed production function (e.g., Adams & Jaffe, 1996; Feinberg & Majumdar, 2001; Knott, Bryce & Posen, 2003). This model has a number of attractive properties. First, instead of relying on flows of R&D, it incorporates in the analysis the role that past research plays in accumulating scientific knowledge. Second, while this econometric specification controls for firms' tangible resources, it also allows us to associate advances in corporate performance with internal and external scientific knowledge and international diversification. Therefore, as the model represents key relationships predicted by our framework, it is ideal for serving our research aims.

Following previous studies (Coe & Helpman, 1995; Wei & Liu, 2006; Kafouros & Buckley, 2008), our dependent variable, corporate performance, is operationalized as each firm's level of *productivity*. Specifically, we constructed a record of productivity over a ten-year period by dividing each individual firm's output (measured by value added) by its number of employees. Measuring performance in this manner has a number of methodological benefits. First, although many previous studies use 'sales' as a proxy for output, sales may not reflect increased output—and thus superior performance—as they ignore economies in the use of intermediate inputs. Empirical evidence provides strong support to this argument showing that the use of sales may lead to biased results (Mairesse & Hall, 1996). Second, although financial measures of performance, such as profitability, are highly sensitive to business cycles and tend to have problems associated with accounting standards and the treatment of royalties and management fees (Buckley, 1996), productivity cannot be manipulated easily.

Independent Variables

Three independent variables are included in the model: international diversification, the stock of internal scientific knowledge, and global reservoirs of scientific knowledge. Following the approach employed by numerous studies (e.g., Grant, 1987; Tallman & Li, 1996; Capar & Kotabe, 2003; Tseng et al., 2007), we constructed a record of each firm's level of *international diversification* over time using the ratio of its foreign sales to total sales (FSTS). Due to data constraints, we have not employed indicators such as the number of overseas subsidiaries (Lu & Beamish, 2004), foreign income to total income (Kotabe et al., 2002), or foreign assets to total assets (Geringer, Beamish & daCosta, 1989) that place emphasis on other facets of foreign activity (Gomes & Ramaswamy, 1999). Nevertheless, the operationalization of FSTS is appealing not only because of its ease of comparison, but also because by incorporating sales from exporting, licensing and foreign subsidiaries, it reflects the fact that—depending on factors such as firm size, experience, resources and industry—firms may adopt different approaches to internationalization.

The second independent variable of our analysis is the stock of *internal scientific knowledge*. As the accumulation of knowledge is a path-dependent process (Dierickx and Cool, 1989; Knott et al., 2003), we operationalized this variable by dividing each firm's aggregate current and past investments in R&D by its number of employees. Integrating in our analysis the fact that a firm's scientific knowledge becomes less valuable over time either because it leaks to outside world or because new understanding replaces old one (Aghion & Howitt, 1992), we controlled for the declining usefulness of previous knowledge by depreciating past research expenditures.[1] This commonly used approach (e.g., Feinberg &

Majumdar, 2001; Knott et al., 2003) is appropriate for our analysis as it assumes that although past knowledge plays an important role, its contribution to performance is not as high as that of the knowledge created more recently.

The third independent variable, *global reservoirs of scientific knowledge*, comprises two types of knowledge. First, there is the *intra-industry* global knowledge reservoir which we constructed for each MNE separately by aggregating the current and depreciated measures of past R&D that firms in 18 countries had carried out over a ten-year period. This reservoir encompassed all private R&D undertaken *within* the industry in which the MNE operates. Each firm's own knowledge stock was subtracted from the total intra-industry reservoir to correct for 'double counting'. Second, we incorporated in the analysis the *inter-industry* reservoir of knowledge—this being the knowledge created by outside industries. Using information on the technological distance between inter-industry senders and recipients of scientific knowledge, we operationalized each MNE's inter-industry global reservoir of knowledge as the *weighted* sum of 252 different reservoirs (18×14 - one for each country and external industry). We estimated reservoirs for each year separately to capture patterns in the evolution of scientific knowledge. In constructing these variables, we also used a two-year lag to allow for the fact that these effects may take some time. Finally, we incorporated both intra- and inter-industry reservoirs in one variable that represents the total knowledge reservoir accessible to each MNE.

Control Variables

Four control variables are included in the model. First, previous research has emphasized the role of industry differences in explaining performance variation (McGahan & Porter, 1997). Therefore, we incorporated 14 dummy variables in the model to capture variations and avoid any biases associated with industry-specific idiosyncrasies. A second variable known to affect value-added and, therefore, corporate performance is a firm's tangible resources. We controlled for these effects using a record of each firm's net fixed tangible assets per employee (Feinberg & Majumdar, 2001). Third, another commonly used control variable is firm size. Although the inclusion of tangible resources may capture some of the effects caused by size, we included an additional dummy variable to separate larger from smaller MNEs.[2] Finally, as discussed earlier, the technological opportunities that a firm faces may stimulate growth. A dummy variable was added to the model to distinguish between industries with high and low technological opportunities.

RESULTS

Table 3 provides correlations and descriptive statistics for the key variables of the model. The correlations between the firm-specific independent variables range between 0.05 and 0.12, suggesting that the possibility of multicollinearity is low. Interestingly, although 'global knowledge reservoirs' is an exogenously-determined variable, its correlation with a firm's own scientific knowledge and intangible resources is slightly stronger at 0.18 and -0.27 respectively. To ensure that this did not generate multicollinearity problems, we estimated the variance inflation factor (VIF) for the main independent variables of the model. These tests revealed that the highest VIF score was 1.3. The fact that this value is significantly lower than the acceptable threshold of 10 suggests that multicollinearity does not pose a serious problem for our analysis.

-- Table 3 --
--

To test the theoretical framework, we performed a series of regression analyses. Following the tradition in panel data models (Baltagi, 2005; Phene & Almeida, 2008), we initially assessed which estimator—random or fixed—is more appropriate for calculating the model. The results of a Hausman (1978) specification test indicated that the random-effects estimator is unbiased and consistent. As the fixed-effects estimator is less preferable in such cases (Fisch, 2008; Phene & Almeida, 2008), we calculated the model using random effects and generalized least squares (GLS). Table 4 reports the regression results for three models. The goodness of fit (R^2) for Model 2 is higher than that for Model 1, confirming that that inclusion of international diversification and global knowledge reservoirs increase its predictive power.[3] Model 2 also indicates that the key relationships predicted by our theoretical framework are all economically and statistically significant in the expected direction. In line with previous studies (e.g., Kotabe et al., 2002; Kafouros and Buckley, 2008), international diversification and the internal stock of scientific knowledge improve firm performance considerably.

-- Table 4 --
--

Furthermore, the results provide support for H1, which suggested that global reservoirs of scientific knowledge are positively related to firm performance. More importantly, the high coefficient for these effects (β=0.14) is similar to that of a firm's own scientific knowledge (β=0.15), emphasizing therefore the importance of exogenously-determined scientific advances in explaining performance asymmetries. To distinguish between knowledge that is technologically close to the firm from that which is distant, Model 3 estimates the effects of intra- and inter-industry reservoirs of knowledge separately. The coefficients of both reservoirs are statistically insignificant, pointing therefore to the value of combining knowledge from both technological neighbors and more distant scientific domains. Indeed, as new products become ever more complex, their development requires a wide variety of technologies, making it increasingly difficult for firms to rely exclusively on only one technological field. As for the control variables, the coefficient of firm size is statistically insignificant. This, however, is not surprising, as the inclusion of firms' tangible resources often captures the effects of size. It also seems that the industry dummy variables absorbed most of the heterogeneity of firms, leading to statistically insignificant effects for the control variable of technological opportunities.

To test the moderating effects and the hypothesized relationships of our framework, we initially separated MNEs that belonged to industries with relatively lower technological opportunities from those that were in industries where the possibilities for new technical understanding were higher.[4] We also split the sample into groups at the median level of international diversification and R&D intensity. Subsequently, we re-estimated the model for each group separately (e.g., Singh, 2007; Salomon & Jin, 2008).[5] As the empirical evidence in Table 5 reveal, the two-group moderator analyses support our conceptualization that the relationship between global reservoirs of knowledge and performance is conditioned by international diversification (H2), firms' own research efforts (H3), and autonomous forces pertaining to the technological opportunities generated in distinct technological domains (H4). In the groups with relatively higher levels of international diversification, R&D efforts and technological opportunities, the effects of global knowledge reservoirs are not only statistically significant and high (β=.21, β=.29 and β=.39 respectively), but are also stronger than the contribution of the firms' own scientific knowledge. By contrast, as the corresponding effects are statistically insignificant in the three other groups, it would appear that not all firms deploy global knowledge resources successfully.

--- Table 5 ---
--

CONCLUSION

The literatures on internationalization, knowledge externalities and internalization have played an important role in advancing theory regarding the determinants of performance. But previous research has not explored how they inform each other, thus limiting our conceptualizations as to how differences in performance arise. To this end, we develop the notion of *global* reservoirs of scientific knowledge, and theorize that superior performance stems from the ability of firms to internalize and exploit such locationally fixed intangible resources. Whereas most firm-level research has documented knowledge externalities within one country (Almeida & Kogut, 1999; Kafouros & Buckley, 2008), in seeking to provide a more complete account of these effects, the current study examines most of the world's research efforts. Combining previously unconnected industry- and firm-level panel data, our empirical analysis provides strong support to the hypothesized relationships, and reveals that patterns in the evolution of global scientific knowledge have significant power in explaining variations in MNEs' performance.

Our framework also allows us to better understand what governs a firm's ability to benefit from the research efforts of others. Although the empirical findings are consistent with previous studies in indicating that international diversification and firms' own research are *directly* connected to performance (e.g., Adams & Jaffe, 1996; Kotabe et al., 2002), they also reveal that these two factors enhance performance *indirectly* by improving the ability of MNEs to access and exploit the scientific knowledge that resides in different locations. Furthermore, we asserted that the performance-enhancing consequences of global knowledge depend on exogenously-determined technological opportunities that are beyond the control of the firm. The empirical results confirm this theoretical prediction, indicating that the effects of global knowledge become greater as technological opportunities increase. These results are also consistent with previous research that indicates the benefits of considering the nature of distinct scientific fields (Dosi et al., 2006; Klevorick et al., 1995; Zahra, 1996) and the supply side of technological progress (Rosenberg, 1974).

Our analysis has important implications for practice. Previous theoretical prescriptions on how to survive intense rivalry have encouraged managers to promote the exploitation of external knowledge (Chesbrough, 2003) and reward people who adopt ideas from outside (De Bondt, 1996). We extend these prescriptions by providing evidence which indicates that scientific knowledge from different locations around the world provides an important means of achieving positional advantages and superior performance. Nonetheless, managers should not assume that all firms can benefit from such resources. In this respect, our findings suggest that managerial strategies about international diversification may influence not only firm performance, but also the effectiveness of other strategic plans that aim at exploiting external reservoirs of knowledge. Therefore, rather than viewing internationalization and innovation strategies as two separate plans, it is advisable for managers to attend to the interactions between them, and plan an active quasi-internalization strategy via diversification that brings the firm into close contact with knowledge reservoirs. Such a strategy enables the multinational firm to transform locationally fixed knowledge into internationally internally transferable knowledge. Likewise, instead of relying on the simplistic assumption that scientific knowledge from abroad will somehow reach all firms in a given country, policymakers should refine science and technology policies in a way that both encourages and enables companies to search actively for scientific advances in other countries.

Furthermore, it is often suggested that although some firms undertake little R&D, they succeed in finding profitable opportunities either by acquiring know-how from outside (Chesbrough, 2003) or by imitating the discoveries of others. By contrast, in showing that (on average) this is not the case, our analysis suggest that ‘free riders’ exist only rarely, and that only those MNEs that invest heavily in R&D really benefit from global knowledge reservoirs. Thus, enhancing the understanding of such resources, and working on the systematic collection of information about newly developed technologies and recently registered patents should be a central part of firm strategy—particularly for organizations that are less R&D intensive. Finally, when innovation strategists reorganize their product offerings or consider entering new product categories, they should take into account that the possibilities for technological advance in a given field may either impose important constraints or present valuable opportunities (Rosenberg, 1974). Although this factor is beyond the control of the firm, managers should respond by directing some of their firms’ efforts towards regions of technology where the possibilities for new understanding are high.

This study also has several important implications for research into internationalization, innovation and, more broadly, performance. First, our empirical findings suggest that scholars should not focus merely on the direct impacts of internationalization. Rather, they should reconsider current thinking by looking at its indirect effects on a firm’s ability to achieve positional advantages. In this respect, we enrich the literature by incorporating the quasi-internalization of the market for external knowledge in internationalization research, and by demonstrating that international expansion decisions interact with external knowledge to determine performance. Second, in linking stocks of internal and external knowledge to firm performance, our study provides empirical support to conceptualizations that underscore the role of knowledge in unlocking a firm's economic potential (Kogut & Zander, 1993; Grant, 1996; Chesbrough, 2003). However, it extends such theories by explaining how access to global knowledge resources permits some MNEs to improve performance. The significant explanatory power of global knowledge reservoirs, which is often higher than that of a firm's own knowledge, emphasizes the importance of incorporating the role of such intangible resources in future theoretical and empirical modeling.

Third, our study contributes to innovation and knowledge-based paradigms in explaining why some firms excel at exploiting external knowledge, while others fail to do so. Our framework stands in direct contrast with macro-level perspectives that implicitly assume that all firms in a given country benefit from international spillovers. Our findings imply that future theorizing about the relationship between performance and external knowledge should be linked to both exogenous and firm-specific factors such as the degree of internationalization, firms' own research and technological opportunities. A failure to control for such factors may also explain why past findings about the role of knowledge externalities are mixed, ranging from positive and high (e.g., Bayoumi et al., 1999; Branstetter, 2001) to negligible or negative (e.g. Geroski, 1991; Wakelin, 2001). In summary, rather than viewing knowledge externalities theory and internationalization research as two different avenues for conceptualizing why performance asymmetries exist, researchers should consider how they interact and inform each other. Internationalization research may benefit from a better understanding of the indirect benefits of cross-border expansion, whereas innovation and knowledge-based paradigms may benefit by conceptualizing the role of internationalization in explaining the differential effects of external knowledge more successfully. The missing theoretical link is the advantage to the firm arising from the internalization of knowledge externalities.

ENDNOTE

[1] Following previous studies (e.g., Goto & Suzuki, 1989; Feinberg & Majumdar, 2001) in which the depreciation rate usually ranges between 15 and 25 percent, our analysis assumes a 20 percent rate. We should also note, however, that the choice of depreciation rate is not particularly important. As shown later, our results are insensitive to different depreciation rates.

[2] We used the median of sales to separate larger from smaller multinationals.

[3] Although the value of R^2 is relatively low, it is consistent with many previous studies (e.g., Tallman & Li, 1996; Kotabe et al., 2002; Contractor et al., 2003; Lu & Beamish, 2004) in which it ranged between 0.10 and 0.27.

[4] To split the sample into industries of high and low technological opportunities, we followed the tradition in the field of innovation (e.g., Griliches & Mairesse, 1984; Klevorick et al., 1995). Table 1 presents the industrial breakdown for the sample.

[5] Severe multicollinearity problems did not allow us to use moderated regression analysis and include in the model new variables that are weighed by the degree of international diversification and research efforts.

REFERENCES

Adams, J. D. & Jaffe, A. B. 1996. Bounding the effects of R&D: An investigation using matched establishment-firm data. *The RAND Journal of Economics*, 27(4): 700-721.

Aghion, P. & Howitt, P. 1992. A model of growth theory through creative destruction. *Econometrica*, 60: 323-351.

Almeida, P. & Kogut, B. 1999. Localization of knowledge and the mobility of engineers in regional networks. *Management Science*, 45(7): 905-917.

Astebro, T. B. & Dahlin, K. B. 2005. Opportunity knocks. *Research Policy*, 34: 1404-1418.

Attewell, P. 1992. Technology diffusion and organizational learning: The case of business computing. *Organization Science*, 3(1): 1-19.

Audretsch, D. B., & Feldman, M. P. 1996. R&D spillovers and the geography of innovation and production. *American Economic Review,* 86: 630-640.

Baldwin, W. L. & Scott, J. T. 1987. *Market Structure and Technological Change*. London: Harwood Academic Publishers.

Baltagi, B. H. 2005. *Econometric Analysis of Panel Data*. Chichester, England: John Wiley and Sons.

Bayoumi, T., Coe, D. & Helpman, E. 1999. R&D spillovers and global growth. *Journal of International Economics*, 47: 399-428.

Bernstein, J. I. & Mohnen, P. 1998. International R&D spillovers between U.S. and Japanese R&D intensive sectors. *Journal of International Economics*, 44: 315-338.

Branstetter, L. 2001. Are knowledge spillovers international of intranational in scope? Microeconometric evidence from the US and Japan. *Journal of International Economics*, 53(1): 53-79.

Buckley, P. J. & Casson, M. 1976. *The Future of the Multinational Enterprise*. London: Macmillan.

Buckley, A. 1996. *International Capital Budgeting*. Hertfordshire, UK: Prentice Hall.

Buckley, P. J. & Carter, M. J. 2004. A formal analysis of knowledge combination in multinational enterprises. *Journal of International Business Studies,* 35: 371-384.

Cantwell, J. & Mudambi, R. 2005. MNE competence-creating subsidiary mandates. *Strategic Management Journal*, 26: 1109-1128.

Capar, N. & Kotabe, M. 2003. The relationship between international diversification and performance in service firms. *Journal of International Business Studies*, 34(4): 345-355.

Caves, R. E. 1982. *Multinational Enterprise and Economic Analysis*. Cambridge: Cambridge University Press.

Chesbrough H. W. 2003. *Open Innovation: The New Imperative for Creating and Profiting from Technology*. Harvard Business School Press.

Clark, B. & Griliches, Z. 1984. Productivity and R&D at the firm level in French manufacturing. in Griliches, Z. (ed.) R&D, patents, and productivity. Chicago: University of Chicago Press, 393-416.

Coe, D. & Helpman, E. 1995. International R&D spillovers. *European Economic Review*, 39: 859-887.

Cohen, W. M., & Levinthal, D. A., 1990. Absorptive capacity: A new perspective on learning and innovation. *Administrative Science Quarterly*, 35(1): 128-152.

Cohen, W. M., Nelson, R. R., Walsh, J. P. 2002. Links and impacts: The influence of public research on industrial R&D. *Management Science*, 48(1): 1-23.

Contractor, F. J., Kundu, S. K. & Hsu, C. C. 2003. A three-stage theory of international expansion: The link between multinationality and performance in the service sector. *Journal of International Business Studies*, 34(1): 5-18.

De Bondt, R. 1996. Spillovers and innovative activities. *International Journal of Industrial Organisation*, 15: 1-28.

Delios, A., & Henisz, W. J. 2000. Japanese firms' investment strategies in emerging economies. *Academy of Management Journal,* 43: 305-323.

Dierickx, I. & Cool, K. 1989. Asset stock accumulation and sustainability of competitive advantage. *Management Science*, 35(12): 1504-1511.

Dodgson, M. 1993. Organizational learning: A review of some literatures. *Organization Studies*, 14(3): 375-394.
Dosi, G., Marengo, L. & Pasquali, C. 2006. How much should society fuel the greed of innovators? On the relations between appropriability, opportunities and rates of innovation. *Research Policy,* 35: 1110-1121.
Dunning, J. H. 1993. *Multinational Enterprises and the Global Economy*, Wokingham, UK: Addison-Wesley.
Edmondson, A. C., Bohmer, R. M. & Pisano, G. P. 2001. Disrupted routines: Team learning and new technology implementation in hospitals. *Administrative Science Quarterly*, 46(4): 685-716.
Fang, Y., Wade, M., Delios, A. & Beamish, P. W. 2007. International diversification, subsidiary performance, and the mobility of knowledge resources. *Strategic Management Journal,* 28: 1053-1064.
Feinberg, S. E. & Majumdar, S. K. 2001. Technology spillovers from foreign direct investment in the indian pharmaceutical industry. *Journal of International Business Studies*, 32(3): 421–437.
Fisch, J. H. 2003. Optimal dispersion of R&D activities in multinational corporations with a genetic algorithm. *Research Policy*, 32: 1381-1396.
Fisch, J. H. 2008. Investment in new foreign subsidiaries under receding perception of uncertainty. *Journal of International Business Studies*, 39: 370-386.
Geringer, J. M., Beamish, P. W., & daCosta, R. C. 1989. Diversification strategy and internationalization: Implications for MNE performance. *Strategic Management Journal*, 10: 109-119.
Geringer, M. J., Tallman, S. & Olsen, D. M. 2000. Product and international diversification among Japanese multinational firms. *Strategic Management Journal*, 21(1): 51-80.
Geroski, P. A. 1991. Innovation and the sectoral sources of UK productivity growth. *The Economic Journal*, 101: 1438-1451.
Goerzen, A. & Makino, S. 2007. Multinational corporation internationalization in the service sector: a study of Japanese trading companies, *Journal of International Business Studies*, 38: 149-169.
Gomes, L. & Ramaswamy, K. 1999. An empirical examination of the form of the relationship between multinationality and performance. *Journal of International Business Studies*, 30(1): 173-188.
Goto, A. & Suzuki, K. 1989. R&D capital, rate of return on R&D investment and spillover of R&D on Japanese manufacturing industries. *The Review of Economics and Statistics*, 71(4), 555-564.
Grant, R. M. 1987. Multinationality and performance among British manufacturing companies. *Journal of International Business Studies*, 18(3): 79–89.
Grant, R. 1996. Toward a Knowledge-Based Theory of the Firm. *Strategic Management Journal*, 17: 109-122.
Griffith, R., Redding, S. & Van Reenen, J. 2004. Mapping the two faces of R&D: Productivity growth in a panel of OECD industries. *The review of Economics and Statistics*, 86(4): 883-895.
Griliches, Z. 1979. Issues in assessing the contribution of research and development to productivity growth. *Bell Journal of Economics*, 10: 92-116.
Griliches, Z. 1992. The search for R&D spillovers. *Scandinavian Journal of Economics*, 94: 29-47.
Griliches, Z. & Mairesse, J. 1984. Productivity and R&D at the firm level. in Griliches, Z. (ed.) R&D, patents, and productivity. Chicago: University of Chicago Press, 339-374.
Grossman, G. M. & Helpman, E. 1991. Trade, knowledge spillovers, and growth. *European Economic Review*, 35(3): 517-526.
Hambrick, D. C. & Macmillan, I. C. 1985. Efficiency of product R&D in business units: The role of strategic context. A*cademy of Management Journal*, 28(3): 527-547.
Harhoff, D. 2000. R&D spillovers, technological proximity, and productivity growth - Evidence from German panel data. *Schmalenbach Business Review*, 52: 238-260.
Hausman, J. 1978. Specification tests in econometrics. *Econometrica*, 46(6): 1251-1271.
Hitt, M., Hoskisson, R. & Kim, H. 1997. International diversification: Effects on innovation and firm performance in product-diversified firms. *Academy of Management Journal*, 40(4): 767-798.
Hymer, S.H. 1976. *A Study of Direct Foreign Investment*. Cambridge, MA: MIT Press.

Iansiti, M. & West J. 1997. Technology integration: Turning great research into great products. *Harvard Business Review,* 75(3): 69-79.
Jaffe, A. B. 1989. Characterizing the "technological position" of firms, with application to quantifying technological opportunity and research spillovers. *Research Policy*, 18: 87-97.
Jaffe, A. B., Trajtenberg, M. & Henderson, R. 1993. Geographic localization of knowledge spillovers as evidenced by patent citations. *The Quarterly Journal of Economics*, 108(3): 577-598.
Kafouros, M. I. & Buckley P. J. 2008. Under what conditions do firms benefit from the research efforts of other organizations?. *Research Policy*, 37(2): 225-239.
Keller, W. 2002. Geographic localization of international technology diffusion. *American Economic Review*, 92(1): 120-142.
Klevorick, A. K., Levin, R. C., Nelson R. R. & Winter, S. G. 1995. On the sources and significance of interindustry differences in technological opportunities, *Research Policy*, 24(2): 185-205.
Knott, A. M., Bryce, D. J. & Posen, H. E. 2003. On the strategic accumulation of intangible assets. *Organization Science*, 14(2): 192-207.
Kobrin, S. 1991. An empirical analysis of the determinants of global integration. *Strategic Management Journal*, 12: 17-31.
Kogut, B. & Zander, U. 1993. Knowledge of the firm and the evolutionary theory of the multinational corporation. *Journal of International Business Studies*, 24: 625-645.
Kotabe, M., Srinivasan, S. S. & Aulakh, P. S. 2002. Multinationality and firm performance: The moderating role of R&D and marketing capabilities. *Journal of International Business Studies*, 33(1): 79-97.
Kuemmerle, W. 1997. Building effective R&D capabilities abroad', *Harvard Business Review*, 75(2): 61-70.
Levin, R. C., Klevorick, A. K., Nelson, R. R. & Winter, S. G. 1987. Appropriating the returns from industrial research and development. *Brookings Papers on Economic Activity*, 3: 783-820.
Lu J. W. & Beamish P.W. 2004. International diversification and firm performance: The S-Curve hypothesis. *Academy of Management Journal*, 47(4): 598-609.
Mairesse, J. & Hall, B. 1996. Estimating the productivity of research and development in French and US manufacturing firms: An exploration of simultaneity issues with GMM methods. in Wagner, K. and Van Ark, B. (eds.), International Productivity Differences and their Explanations, Elsevier Science, 285-315.
Matheson, D. & Matheson, J. 1998. *The smart organization: Creating value through strategic R&D*. Boston: Harvard Business School Press.
Mayer, K. J. 2006. Spillovers and governance: An analysis of knowledge and reputational spillovers in information technology. *Academy of Management Journal*, 49(1), 69-84.
McGahan, A. M. & Porter, M. E. 1997. How much does industry matter, really? *Strategic Management Journal,* 18: 15–30.
Miller, J. D., Fern, M. J. & Cardinal, L. B. 2007. The use of knowledge for technological innovation within diversified firms. *Academy of Management Journal*. 50(2): 308-326.
Nelson, R. R. & Winter, S. G. 1982. *An Evolutionary Theory of Economic Change*. Cambridge: 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, 479–496.*
Phene, A. & Almeida, P. 2008. Innovation in multinational subsidiaries: The role of knowledge assimilation and subsidiary capabilities. *Journal of International Business Studies*, 39: 901-919.
Rosenberg, N. (1974) Science, Invention, and Economic Growth. *Economic Journal*, 84: 90-108.
Rosenkopf, L. & Almeida, P. 2003. Overcoming local search through alliances and mobility. *Management Science,* 49: 751-766.
Rugman, A. M. 1979. *International diversification and the multinational enterprise.* Lexington, MA: Lexington Books.

Rugman, A.M. 1981. Inside the Multinationals: The Economics of Internal Markets. New York: Columbia University Press.
Rugman, A. M. & Verbeke, A. 2003. Extending the theory of the multinational enterprise: Internalization and strategic management perspectives. *Journal of International Business Studies*, 34: 125-137.
Salomon, R. & Jin, B. 2008. Does knowledge spill to leaders or laggards? Exploring industry heterogeneity in learning by exporting. *Journal of International Business Studies*, 39: 132-150.
Santos, J., Doz, Y. & Williamson, P. 2004. Is your Innovation Process Global?. *Sloan Management Review*, 45(4): 31-37.
Scherer, F. M. 1982. Inter-industry Technology Flows and Productivity Growth. *The Review of Economics and Statistics*, 64(4): 627-634.
Schmalensee, R. & Willig, R. D. 1989. *Handbook of industrial organization.* Amsterdam: North-Holland.
Schmookler, J. 1966. *Invention and Economic Growth*. Cambridge MA: Harvard University Press.
Singh, J. 2007. Asymmetry of knowledge spillovers between MNCs and host country firms. *Journal of International Business Studies,* 38: 764-786.
Spencer, J. W. 2000. Knowledge Flows in the Global Innovation System: Do U.S. Firms Share More Scientific Knowledge than their Japanese Rivals?. *Journal of International Business Studies,* 31(3): 521-530.
Tallman, S. B. & Li, J. 1996. Effects of international diversity and product diversity on the performance of multinational firms. *Academy of Management Journal*, 39(1): 179-196.
Teece, D. J. 1986. Profiting from technological innovation. *Research Policy*, 15: 285-306.
Tihanyi, L., Johnson, R. A., Hoskisson, R. E. & Hitt, M. A. 2003. Institutional ownership differences and international diversification: The effects of boards of directors and technological opportunity, *Academy of Management Journal,* 46 (2): 195-211.
Tseng,C. H., Tansuhaj, P., Hallagan, W. & McCullough, J. 2007. Effects of firm resources on growth in multinationality. *Journal of International Business Studies,* 38: 961–974.
Vernon, R. 1966. International investment and international trade in the product life cycle. *Quarterly Journal of Economics*, 80: 191-207.
Wakelin, K. 2001. Productivity growth and R&D expenditure in UK manufacturing firms. *Research Policy*, 30: 1079-1090.
Wei. Y. & Liu, X. 2006. Productivity spillovers from R&D, exports and FDI in China's manufacturing sector. *Journal of International Business Studies*, 37: 544–557.
Zahra, S. A. 1996. Goverance, ownership, and corporate entrepreneurship: The moderating impact of industry technological opportunities. *Academy of Management Journal,* 39(6): 1713-1735.
Zahra, S. A., Ireland, D. R. & Hitt, M. A. 2000. International expansion by new venture firms: International diversity, mode of market entry, technological learning, and performance. *Academy of Management journal*, 43(5): 925-950.

TABLES

Table 1 Industrial breakdown of the sample (145 MNEs)

	No of Firms
Industries of low technological opportunities	
Metal Products	5
Household Products	4
Machinery	26
Motor Vehicle Parts	5
Textiles	3
Paper	3
Plastics	2
Miscellaneous	13
Total	**61**
Industries of high technological opportunities	
Chemicals	16
Pharmaceuticals	13
Computing	5
Electrical & Electronics	32
Telecommunication	4
Aerospace	8
Instruments	6
Total	**84**

Table 2 R&D spending in the manufacturing sector ($ millions)

Country	R&D in 1995	R&D in 2003	Annual Growth (%)
USA	104237	129126	2.71
Japan	51517	75263	4.85
Germany	24898	36431	4.87
France	15339	20663	3.79
UK	11481	16796	4.87
Korea	8407	15816	8.22
Sweden	4090	6800	6.56
Canada	4048	6365	5.82
Italy	5490	6105	1.34
Netherlands	2863	4061	4.47
Spain	1891	3844	9.27
Belgium	2331	3222	4.13
Finland	1235	3042	11.93
Australia	1817	2442	3.77
Denmark	842	1856	10.39
Czech Republic	624	863	4.14
Norway	544	853	5.78
Ireland	517	654	2.98
Poland	539	464	-1.85

Source: The R&D expenditures in order to create this table were obtained from the

OECD Analytical Database.

Table 3 Descriptive statistics and correlations [a]

	Mean	s.d.	1	2	3	4
1. Performance	40194	28417				
2. Internal Scientific Knowledge	16775	31110	0.29**			
3. Global Reservoirs of Knowledge [b]	230.5	239.9	0.05*	0.18**		
4. International Diversification	0.54	0.24	0.12**	0.05	0.02	
5. Tangible Resources	27784	25373	0.33**	0.12**	-0.27**	0.08**

[a] The monetary values are expressed in British Pounds (£).

[b] Expressed in £ billions.

* significant at the 0.05 level (two-tailed); ** significant at the 0.01 level (two-tailed)

Table 4 Results of regression analysis 1995-2004 (dependent variable = performance)

	Model 1	Model 2	Model 3
Internal Scientific Knowledge	0.17*** (0.02)	0.15*** (0.02)	0.15*** (0.02)
Global Reservoirs of Knowledge (total)	-	0.14* (0.06)	-
Global Reservoirs of Knowledge (intra-industry)	-	-	0.09 (0.10)
Global Reservoirs of Knowledge (inter-industry)	-	-	0.06 (0.10)
International Diversification	-	0.07*** (0.02)	0.07*** (0.02)
Tangible Resources	0.21*** (0.02)	0.23*** (0.02)	0.23*** (0.02)
Technological Opportunities	0.12 (0.14)	0.04 (0.12)	0.08 (0.25)
Firm Size	0.01 (0.02)	0.01 (0.02)	0.01 (0.02)
Industry Effects [a]	Included	Included	Included
R^2	0.23	0.27	0.27

N	145	145	145

* $p<0.05$; ** $p<0.01$; *** $p<0.001$

a: Although not reported, the model includes 14 dummy variables to control for industry effects.

Table 5 Results of regression analysis of firm performance: The moderating role of international diversification, R&D efforts and technological opportunities (1995-2004)

	International Diversification		R&D Efforts		Technological Opportunities	
	lower	higher	lower	higher	lower	higher
Internal Scientific Knowledge	0.14*** (0.03)	0.14*** (0.02)	0.18*** (0.02)	0.10*** (0.03)	0.06*** (0.02)	0.18*** (0.02)
Global Reservoirs of Knowledge (total)	0.14 (0.10)	0.21*** (0.06)	0.04 (0.07)	0.29** (0.09)	-0.04 (0.06)	0.39*** (0.10)
International Diversification	0.07* (0.03)	0.04 (0.03)	0.01 (0.02)	0.15*** (0.03)	-0.01 (0.03)	0.10*** (0.03)
Tangible Resources	0.17*** (0.04)	0.34*** (0.02)	0.18*** (0.03)	0.30*** (0.04)	0.11*** (0.03)	0.33*** (0.03)
Technological Opportunities	0.02 (0.17)	-0.01 (0.17)	0.09 (0.14)	0.01 (0.21)	-	-
Firm Size	0.01 (0.03)	-0.01 (0.02)	0.01 (0.02)	0.01 (0.03)	0.01 (0.01)	0.03 (0.02)
Industry Effects [a]	Included	Included	Included	Included	Included	Included
R^2	0.13	0.41	0.46	0.20	0.42	0.24
N	72	73	73	72	61	84

* p<0.05; ** p<0.01; *** p<0.001

a: Although not reported, the model includes a number of dummy variables to control for industry effects.