The role of internationalization in explaining innovation performance

MARIO I. KAFOUROS [*]
University of Leeds, UK

PETER J. BUCKLEY
University of Leeds, UK

JOHN A. SHARP
University of Kent, UK

CHENGQI WANG
University of Nottingham, UK
and Ningbo University, China

Abstract
Although it has been suggested that innovation has significant consequences for a firm's economic performance, the past empirical findings are mixed, not always confirming this proposition. Extending previous research, this study demonstrates that the reason for previously conflicting results may be an incomplete understanding of the factors influencing the innovation-performance relationship. We argue that not all firms can reap rewards from innovation. Rather, we suggest that firms need to have a sufficient degree of internationalization, i.e. be active in many markets, to capture successfully the fruits of innovation. Initially, the study offers a theoretical framework that explains how and why a higher degree of internationalization, by affecting both innovative capacity and a number of appropriability factors, influences the effects of innovation. Then, utilizing firm-level data, the study empirically tests this proposition. The results confirm that internationalization enhances a firm's capacity to improve performance through innovation. However, they also show that firms are unable to benefit from innovation if their international activity is below a threshold level.

* Corresponding Author: Mario I. Kafouros, Leeds University Business School, Maurice Keyworth Building, University of Leeds, Leeds, LS2 9JT, UK.
Tel: 0044 (0)113 3434588 **Fax:** +44 (0)133 343 4754 **email:** mk@lubs.leeds.ac.uk

1. Introduction

Economic-growth theorists and management scholars have proposed that innovation has a positive impact on corporate performance. That is, increasing investments in innovation allows firms to develop and license new technologies, adopt more efficient production techniques, introduce new products and processes, and consequently become more competitive and increase their economic performance. However, past empirical results are mixed, not always confirming this theoretical proposition. Many studies find the private returns to innovation to be both positive and high (Hall and Mairesse, 1995; Adams and Jaffe, 1996). By contrast, several other studies indicate that although a firm's innovative efforts advance significantly society's pool of scientific knowledge, they make a limited or even negative contribution to the firm's own economic performance (Link, 1981; Sassenou, 1988). Hence, even though a number of studies have evaluated the relationship between innovation and performance, it is often unclear why some firms benefit from their innovative efforts, yet others fail to do so.

Extending past research on innovation, this study develops and tests empirically a framework that links together these apparently conflicting results. Drawing on theoretical knowledge from the disciplines of innovation and international business, it is argued that not all firms are able to benefit from innovation. Rather, it is proposed that the innovation-performance relationship is moderated by a firm's degree of internationalization (DOI), i.e. the extent to which it operates beyond its national borders (Kotabe et al., 2002). In other words, it is suggested that firms need some threshold of internationalization and to be able to access a broad range of markets in order to benefit sufficiently from their new products and processes. Initially, the study offers a theoretical framework that explains why the observed variations in the returns to innovation may be attributed to a firm's DOI. It then

empirically tests this proposition and provides econometric evidence showing that internationalization affects the economic payoff from industrial innovation.

2. Innovation and firm performance

The literature on innovation points out that Research and Development (R&D) leads to the creation of a stock of scientific knowledge (Griliches, 1979; Mansfield, 1984). A firm can use this knowledge in different ways to develop innovations and competencies, and improve its performance. By developing more efficient processes, for example, it can reduce the costs associated with the production of its goods. By introducing new products or by improving the quality of its existing products, it can increase its market share and sales (Mansfield, 1968). A firm can also increase its revenues through the royalty fees it receives from patent licenses. However, R&D also has indirect impacts. Cohen and Levinthal (1990) suggested that innovation increases a firm's ability to capture, assimilate and utilize external knowledge. It has also been argued that innovative firms are qualitatively different from non-innovative firms (Wakelin, 2001), and that R&D drives significant organizational adaptations that favor performance (Kafouros, 2007).

However, although one might expect that the contribution of innovation to a firm's performance would always be positive, frequently this does not occur. Due to intense competition and rivals' imitations, firms do not always appropriate the fruits of innovation, which frequently spill over to society (Arrow, 1962). Furthermore, strategic-management research demonstrates that the innovations of a firm's competitors may neutralize some (or even all) of the gains arising from its own investments in innovation (Porter, 1980; Chen and Miller, 1994). As noted earlier, past empirical studies have confirmed this, with results ranging from a strongly positive relationship between innovation and economic

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performance (Hall and Mairesse, 1995; Adams and Jaffe, 1996; Kafouros, 2005) to an insignificant - or even negative - effect (Link, 1981; Sassenou, 1988).

Trying to explain the variation in the returns to innovation, many writers have argued that because technologically sophisticated firms participate in sectors where the understanding and the scientific knowledge related to innovation is rich and growing, their innovative efforts significantly influence their performance (Clark and Griliches, 1984). Technology-management researchers have also argued that the good infrastructure and understanding of technologies (Kessler, 2003), makes high-tech firms more capable of integrating external research findings in their products and processes (Kafouros, 2006). Empirical findings have supported these propositions, indicating that the returns to innovation tend to be very positive for high-tech firms (Griliches and Mairesse, 1984; Wang and Tsai, 2003). Other scholars have suggested that various factors such as economies of scale and scope, technical expertise and managerial qualities allow large firms to enjoy high returns to innovation (Mansfield, 1968). However, the empirical findings concerning the role of firm size are inconclusive. Some studies indicate that the effects of innovation depend on firm size (Lichtenberg and Siegel, 1991; Cohen and Klepper, 1996), yet others found no evidence of such an association (Griliches, 1980; Wang and Tsai, 2003).

Although past research has investigated the effects of factors such as firm size and technological opportunities, it has not examined other firm-specific characteristics that may be needed to capture successfully the value of innovation. As noted earlier, this study focuses on one of these characteristics and suggests that a firm's degree of internationalization affects its ability to benefit from innovation. Before testing this proposition and showing that internationalization moderates the innovation-performance

relationship, the next section draws on a variety of theoretical grounds and explains how and why internationalization is likely to influence the returns to innovation.

3. How does internationalization affect the returns to innovation?

Internationalization can be broadly defined as 'expanding across country borders into geographic locations that are new to the firm' (Hitt et al., 1994: 298). We have deliberately adopted this definition because depending on factors such as firm size and industry, firms may adopt a different internationalization approach. Whilst some firms may prefer to internationalize their production more, others may place emphasis on the internationalization of their business. A more recent phenomenon is the internationalization of R&D network. Even though these measures of internationalization are usually correlated, past empirical evidence indicates that the internationalization of R&D is lower than that of sales (von Zedtwitz and Gassmann, 2002).

One way of understanding how internationalization influences the returns to innovation is to focus on how it affects the factors that determine the economic payoff from innovation. Simplifying the conceptual framework, these factors may be grouped into two categories. The first relates to the factors that influence a firm's ability to produce technological innovations (innovative capacity). R&D departments with high innovative capacity can develop better products and processes, faster and at lower cost and therefore contribute more to a firm's performance. The second category includes the wide range of factors that allow a firm firstly, to better exploit its technological developments and secondly, to protect and appropriate the fruits of innovation. The following subsections explain how internationalization may affect innovative capacity as well as the exploitation

and the appropriability of innovation, and thereby the innovation-performance relationship. The framework is also outlined in Figure 1.

****************************** Figure 1 ******************************

3.1 The connection between internationalization and innovative capacity

Increased R&D competition, along with continually shorter product life cycles, have made the achievement of technological breakthroughs difficult. As a result, the development of innovations requires substantial and diverse resources. Kobrin (1991) demonstrated that internationalization helped to generate these R&D resources. It has also been suggested that internationally diversified firms can improve their innovative capacity by being better able to utilize the wider range of resources available globally (Kotabe, 1990), and which are often unavailable to domestic firms. Furthermore, they can promote innovation by using the specific advantages of different countries (Hitt et al., 1997), and by making contacts and establishing alliances with local suppliers, universities, research centers and competitors (Santos et al., 2004).

In a similar vein, the knowledge-based view of the firm suggests that innovation is an information- and knowledge-intensive process (Nonaka and Takeuchi, 1995). In order to be creative and efficient, R&D teams need to access and retrieve information from as many sources as possible. As highly international firms tend to have geographically dispersed R&D departments (von Zedtwitz and Gassmann, 2002; Kurokawa et al., 2007), they can increase their innovative capacity by utilizing knowledge and ideas from several countries and from a broader group of scientists (Kafouros, 2006). Hitt et al. (1997) demonstrated that the greater knowledge of national idiosyncrasies, available to culturally diverse teams, facilitates coordination. Internationalization can also advance innovative capacity by improving the process of knowledge accumulation and by increasing organizational

learning. Hitt et al. (1997) pointed out that internationalization not only allows a firm to enrich its sources of knowledge, but also provides the opportunity to capture ideas from a greater number of new and different markets, as well as from a wide range of cultural perspectives. Thus, they emphasized, highly international firms can improve their ability to innovate by having greater opportunities to learn.

Kotabe et al. (2002) pointed out that one of the main aims of firms is to minimize the costs associated with innovation. Internationalization can reduce such costs. As highly international firms can access many markets around the globe, they can buy materials and R&D inputs from the cheapest available sources, and locate their R&D and other departments in the most productive regions. Many researchers have suggested that multinational companies can establish their facilities in regions where land, capital and scientific talent are cheap. Granstrand et al. (1993) observe that the salary of a well-educated researcher in India is one-tenth of the corresponding salary of a researcher in Sweden. Similarly, the cost per square meter for a biotech lab in the US is approximately ten times that of the corresponding cost in India.

Internationalization can also improve the ability to innovate by allowing firms to hire better technologists and access skilled technical expertise (Cheng and Bolon, 1993). A higher DOI may improve the quality of new products through network mechanisms that enable a continuous flow of information about the changing needs and requirements of customers (Kafouros, 2006). It may also allow a company to adapt its technologies to the local market needs, thereby improving its responsiveness (Cheng and Bolon, 1993), providing technical support and engaging in local scientific cooperation (von Zedtwitz and Gassmann, 2002).

Nevertheless, researchers often make a distinction between an 'international' and a 'global' innovation network, arguing that the latter requires coordination and integration of dispersed departments (Shenkar and Luo, 2004). Kuemmerle (1997) suggested that only a few companies are able to create a 'cohesive research community'. Similarly, Doz et al., (2001) and Santos et al., (2004) use the term 'metanationalization' to suggest that only those firms that are truly global innovators, can exploit 'localized pockets of technology, market intelligence and capabilities'. For these companies, they argue, technology has become a decisive competitive weapon as they are able to develop more, higher-value innovation at a lower cost.

Another theoretical explanation relates to R&D spillovers. According to the relevant literature, both innovative capacity and firm performance depend on the size of the 'pool' of scientific knowledge that a firm can access (Griliches, 1979; Jaffe, 1986; Scherer, 1982). As international diversification allows firms to access a larger pool of scientific knowledge created in different markets, it makes them more capable of borrowing and exploiting new ideas, of imitating other firms' developments, of integrating new research findings in their products and processes, and consequently of further increasing their innovative capacity. Generally, it has been recognized that in order to unlock their economic potential, organizations must search for and exploit external ideas and sources of innovation (Chesbrough, 2003). Similarly, Kuemmerle (1997) argues that in order to innovate with the speed required to remain competitive, firms must absorb new research results from foreign universities, competitors and clusters of scientific excellence. Santos et al. (2004) emphasize that if companies utilize similar knowledge reservoirs, uninspired products are likely to be developed.

On the other hand though, a high degree of internationalization increases the risk of knowledge leakage. It is frequently argued that one of the disadvantages of decentralization is the unwitting dissemination of knowledge from poorly-controlled departments (Fisch, 2003), increasing the likelihood of know-how spillovers to competitors (Sanna-Randaccio and Veugelers, 2007). Indeed, when the knowledge pool within the local economy is poor, the costs from outgoing spillovers may even outweigh the benefits from incoming spillovers (Sanna-Randaccio and Veugelers, 2007). For that reason, many innovation strategists argue that a centralized network is required in order to protect corporate technology.

Another negative consequence of internationalization relates to the substantial cost that the coordination and control of a global network requires. Granstrand et al., (1993) explain that in order to promote learning and avoid duplication, information exchange between individuals, teams and divisions is required. This cost can be substantial as the exchange of tacit knowledge and the creation of trust necessitates personal face-to-face meetings (von Zedtwitz and Gassmann, 2002). As such, both managers and scientists need to travel to different locations in order to visit affiliated suppliers, collaborators and universities. Other writers emphasize that geographical distance between departments also influences communication in terms of frequency, quality and speed (von Zedtwitz and Gassmann, 2002); and that the efficiency of communication between teams decreases exponentially with geographic distance, raising the risk of misunderstandings (Fisch, 2003). Other arguments favoring centralization relate to the economies of scale and 'critical mass' that an R&D site must have in order to operate efficiently (Granstrand et al., 1993). These arguments refer to the expensive instruments and equipment as well as to the

scientists and technologists needed to ensure that the benefits of a new R&D lab will outweigh the vast costs associated with the investment in it.

3.2 The connection between internationalization, and the exploitation and appropriability of innovation

At this point, it is important to distinguish between technological achievement and economic payoff. In the previous section, it was argued that the returns to innovation depend on the ability of a firm to develop technological innovations. However, they also depend on the ability to exploit and appropriate the returns from technological developments (Griliches, 1979), as well as the ability to implement strategies that allow a firm to benefit economically through innovation. As noted earlier, inventors cannot always appropriate the benefits of their research efforts; thus, these may easily spillover to other firms and consumers. In other words, high technological performance does not necessarily go hand in hand with high economic performance. We argue that internationalization is one of those firm-specific characteristics that allow a firm to better exploit and appropriate the benefits of innovation.

Caves (1982) was one of the first to argue that firms that expanded to other markets enjoyed higher returns to innovation. Recently, the work of some other researchers also supported this proposition. Santos et al. (2004) discuss the importance of combining technical know-how and market expertise. Hitt et al. (1997) suggested that firms that operate in a limited number of markets might not be able to cover the costs associated with innovation. Indeed, the substantial costs of such investments, along with the short product life cycles and the fact that the depreciation rate of investments in innovation is usually high (Pakes and Schankerman, 1984; Goto and Suzuki, 1989), might not allow firms with a

limited DOI to benefit from such investments. By contrast, highly international firms could charge premium prices for their products (Kotabe et al., 2002), and offer them to a large number of potential buyers, thereby spreading the costs. Fisch (2003) argues that internationalization allows firms to recognize and react to foreign customer demands, support local production units, and implement incentives or regulations of host governments. Sanna-Randaccio and Veugelers (2007) analyze the importance of similar market-driven motives in relation to higher responsiveness to local differences, understanding of the local context, and proximity to lead users. Moreover, internationalization might lower the risk of R&D by avoiding fluctuations and business cycles specific to a single market or region. Hence, as Lu and Beamish (2004) emphasized, only firms that deployed their intangible assets in many markets could exploit them to their full value.

Another researcher who suggested that the boundaries of a firm might affect the appropriability of innovation was Teece (1986). He argued that the ownership of complementary assets, which needed to be employed to convert a technological success into a commercial one, determined who benefits and who loses from innovation. Hence, he concluded, as internationalization raised the possibility of obtaining such complementary assets (e.g. through international alliances), it was an important strategic variable that provided the opportunity for innovating firms to outperform their competitors. The link between the effects of innovative activity and internationalization is also provided by the framework of the 'internalization' of markets across international frontiers (Buckley and Casson, 1976). The researchers argue that there are distinct advantages in internalizing markets in innovation-intensive intermediate products. These include the ability to forward plan by integrating the outputs of R&D with the marketing and production functions, the

ability to use discriminatory pricing, the avoidance of buyer uncertainty in the (international) market for licenses, as well as the ability to use internal transfer prices internationally to increase appropriation.

Multinational firms can also benefit from economies of scale. Rugman (1981) argued that international diversification could yield a competitive advantage by allowing a firm to perform more activities internally. Nelson (1959) suggested that diversified firms might have more opportunities to exploit any unpredictable outcomes of R&D. Furthermore, innovative firms that operate in many regions can lower production costs and increase their performance by transferring and applying their process innovations to many production plants (Kotabe et al., 2002). Overall then, it may be concluded that internationalization moderates the innovation-performance relationship, influencing the economic payoff a firm receives from innovation.

4. Method and data

4.1 Model

Having explained how and why internationalization may influence the returns to innovation, the next step is to test this proposition empirically. The ideal empirical approach would be to estimate the impacts of internationalization on innovative capacity and appropriability of innovation separately. However, given that it is impossible to find accurate proxies for 'innovative capacity' and 'appropriability', the study estimates the total impact that internationalization has on the economic payoff from innovation. The model adopted here is based on the work of Griliches (1979) who presented a Cobb-Douglas production function that correlated firm output not only with the conventional inputs of capital and labor, but also with the stock of 'R&D capital'. However, this model

has the drawback that because the depreciation rate of innovation is unknown it is difficult to estimate the stock of R&D capital precisely.

For that reason, we have utilized a transformation of this model that has been used widely in the econometric literature, to assess the returns to innovation (Goto and Suzuki, 1989; Hall and Mairesse, 1995; Wakelin, 2001). This transformation (see equation 1 below) associates innovative activity with differences in firm performance (ΔP). The fact that it allows us to assess what advances in performance can be attributed to investments in innovation, makes this model ideal for serving the objective of this research. This specification (also known as 'rate of return') is characterized by a number of attractive properties. Firstly, it uses current R&D expenditure so it is not necessary to estimate the stock R&D capital. Secondly, it calculates directly the rate of return to innovation, i.e. it estimates the marginal product of innovation (rather than its elasticity). Furthermore, it has the advantage of avoiding the possible bias due to simultaneous decisions in relation to firm inputs and outputs (Odagiri and Iwata, 1986). For more technical details concerning how this model is derived, see Goto and Suzuki (1989), Hall and Mairesse (1995) and Wakelin (2001).

$$\Delta P_{it} = \lambda + a \Delta K_{it} + \beta \Delta L_{it} + \rho I_{it} + \sum \gamma D_i + \varepsilon_{it} \qquad (1)$$

Where:

$\Delta X_{it} = X_{it} - X_{it-1}$

P_{it} = economic performance of firm i in year t

K_{it} = a measure of tangible assets of firm i in year t

L_{it} = labor input of firm i in year t

I_{it} = innovative activity of firm i in year t

$\sum D_i$ = a number of dummy/control variables

ε_{it} = error term of firm i in year t

λ = a constant

ρ = rate of return to innovation

a, β, γ = other parameters to be estimated

Assuming that the theoretical framework is valid then (1) the contribution of innovation to the performance of firms with a higher DOI should differ considerably from the corresponding contribution to the performance of firms with a lower DOI, and (2) the extent to which a firm is international should moderate the innovation-performance relationship. To examine empirically our propositions, we initially split the sample into firms with a higher and lower degree of internationalization. We then estimate Equation 1 for each subgroup separately. We finally compare the average returns to innovation for the two subgroups, and determine the extent to which the impact of innovation on performance differs across firms.

Furthermore, the model of Equation 1 was extended by using moderated regression analysis. According to the relevant literature, in order to test whether a variable is indeed a moderator, one should examine whether the regression coefficient between the dependent and independent variables is a function of that moderator (Le et al., 2006), i.e. in statistical terms, that the corresponding interaction variables are significant. Testing the proposition that internationalization influences the payoff from innovation, we estimate Equation 2. This includes a variable of innovative activity, weighted by the DOI of firm i in year t. If the theoretical framework is valid, then the rate of return to innovation (ρ) estimated from Equation 2 should differ considerably from that estimated from Equation 1.

$$\Delta P_{it} = \lambda + a\Delta K_{it} + \beta\Delta L_{it} + \rho I_{it}DOI_{it} + \sum \gamma D_i + \varepsilon_{it} \qquad (2)$$

4.2 Variables

4.2.1 Dependent variable

Measures of performance usually focus on indices that relate to either firm profitability or revenues. Because firms' profitability is highly volatile and sometimes negative, and because the time lag between innovation and profitability is likely to be much longer than that between innovation and revenues, this study utilizes the second one. The dependent variable of economic performance is a deflated measure of each firm's sales revenue per employee (this is also a measure of labor productivity). As emphasized by many previous studies, although financial measures (such as profitability) have problems associated with the handling of royalties, management fees, and accounting standards (Buckley, 1996: 162), labor productivity is less subject to manipulation (Wagner, 2004). One practical problem is that the data include R&D employees twice, once in the conventional input of labor and a second time in the input of R&D. To correct this problem and estimate the returns to innovation more accurately, the R&D employees were subtracted from the total number of employees.

4.2.2 Independent variables

Tangible Assets: This variable is a deflated measure of the available capital services for each firm's employee. This followed the work of Jorgenson (1963) who suggested that the input of tangible assets must be a measure, not of capital stock, but of the services flowing from it. According to this framework, the cumulative stock of capital produces a flow of services that are the conceptual capital input. The ideal method of measuring capital services is to use the so-called rental price, i.e. the cost that a firm pays, either to

other firms or to itself, for having and using a number of assets. Following Griliches (1980), the rental price of capital services was approximated using the depreciation of fixed capital stock, as this is in effect, the actual cost that a firm pays for having and using its capital assets.

Labor Input: This variable was measured by using each firm's number of employees. It is important to explain that because the model is a transformation of the Cobb-Douglas production function and because labor is also included in the variables of firm performance and tangible assets, the coefficient of labor does not represents its contribution to firm performance. Researchers usually include it in the model to test whether the assumption of constant returns to scale (CRS) is valid. One can reject the CRS assumption when regression coefficient of labor is significantly different from zero.

Innovation: Researchers have used different approaches to operationalize innovation. Some previous studies quantified innovation by measuring the number of each firm's patents or actual innovations (Griliches et al, 1987). These approaches have raised many concerns because the outcomes of industrial research and development are not always successful. In any case, even when the outcomes are successful, they are not always patentable. Similarly, the approach of asking R&D directors about their firm's actual innovations has its own problems because firstly, directors do not always provide objective responses about the technological developments of their own firms and secondly, it is difficult to weight and assess the importance of each innovation appropriately. To avoid such criticisms and following previous similar studies (e.g. Hall and Mairesse, 1995; Wakelin, 2001), innovation in this study is a measure of R&D intensity, i.e. the ratio of the R&D expenditure that each firm spends over its sales.

*Innovation * Internationalization:* To examine whether internationalization moderates the innovation-performance relationship, we estimated a measure of innovation that is weighted by the degree of internationalization. A firm can increase its degree of internationalization in many ways. For instance, it can find representatives in other countries, develop collaborations and export its products. Alternatively, internationalization can be increased by establishing its own subsidiaries in foreign markets. To proxy this variable, researchers have used a wide range of measures including the ratio of foreign sales to total sales, foreign sales to total assets or the number of countries in which a firm operates (Kotabe et al., 2002). Because internationalization does not only relate to the number of markets or regions that a firm has accessed, but also to the size of these markets or regions, we do not use the last proxy. Instead, following the majority of previous studies (e.g. Grant, 1987; Kotabe et al., 2002), and the suggestions of Sullivan (1994) who examined the suitability of these indices, this study quantifies internationalization by using the ratio of foreign sales to total sales.

4.2.3 Control variables

As discussed earlier, the innovation-performance relationship depends on a number of factors. Considerable evidence suggests that the innovative capacities, as well as the organizational and cultural foundations of technologically sophisticated firms, such as pharmaceuticals and electronics, differ from those of low-tech firms such as metals and textiles manufacturers (Harhoff, 1998; Matheson and Matheson, 1998; Wang and Tsai, 2003). Other studies have supported the idea that the returns to innovation depend on firm size (Lichtenberg and Siegel, 1991; Cohen and Klepper, 1996). Additionally, firm performances and characteristics may vary not only over time but also across industries. In

order to capture these variations and avoid biased estimates, a number of dummy variables have been included for high- and low-tech firms, firm size, year and the industry to which each firm belongs.

4.3 Sample

To empirically test whether internationalization affects the returns to innovation, it is essential to use firm-level data. The use of such data is particularly important for this study, as it allows the separation of advances in performance that are result of a firm's specific capabilities from those improvements that are general to the sector as a whole (Wakelin, 2001). For two main reasons, we also decided to use panel data. Firstly, a sample that includes several years is essential in order to capture the international expansion of firms across time, and how this affected the innovation-performance relationship. Secondly, as Kotabe et al. (2002) pointed out, inferences drawn by pure cross-section data are biased by idiosyncrasies associated with that specific period. Thus, only a sample that includes many years can safeguard against any business-cycle biases and any market fluctuations caused by economic recessions or revivals (Kafouros, 2005).

To estimate the model, we used data for the UK manufacturing sector. These were obtained from Datastream, the UK R&D Scoreboard Survey and firms' financial reports. In order to choose the sample, we performed a search based on two criteria: For each firm (1) data should be available for performance, tangible assets, number of employees, innovation and internationalization, and (2) the data should be available for at least 14 years. The search returned a sample of 84 large manufacturing firms for the period between 1989 and 2002 (i.e. 1176 observations). In 2002, the total private R&D investment of the whole UK manufacturing sector was £10.14 billion (ONS, 2002). In that same year, the R&D

expenditures of the 84 firms of the sample accounted for £4.9 billions. So even though the sample does not include many firms, the R&D undertaken by those firms accounted for approximately 50 percent of the total UK R&D investment. Although we had the opportunity to use a larger sample (but for a shorter period), a long time horizon is required in order to capture the international expansion of firms over time.

Table 1 provides details on the industries included in the sample. To estimate the model we used the two-year differences of each variable, because one-year differences tend to be affected by extreme short-term variations of the variables (Mairesse and Sassenou, 1991). Indeed, it was observed that estimates based on one-year differences were unstable. We also took into account the possibility that innovation might take some time to improve performance. Based on the findings of Pakes and Schankerman (1984), we lagged the innovation variable by two years. Table 2 presents means and standard deviations for a number of variables, as well as correlation coefficients for the final variables included in the model. It is important to emphasize that the sample firms are very large, averaging 9347 employees. The fact that the correlation between the *Innovation*Internationalization* and *Innovation* variables is high does not engender any econometric problems, as the model does not include them simultaneously.

****************************** Table 1 ******************************

****************************** Table 2 ******************************

5. Evidence

5.1 Empirical Results

Table 3 reports the regression findings. These resulted from the model described earlier and the method of ordinary least squares (OLS). Both Models 1 and 2 are based on

Equation 1. Although the first one does not include any control variables, Model 2 includes dummies for size, technological opportunities, years and industries. As the results show, the goodness of fit (R^2) for Model 2 is significantly higher than that for Model 1, confirming that control variables are important in order to avoid biases associated with time- and industry-specific idiosyncrasies. Although R^2 is relatively low at 0.29, it is higher than that of many previous studies (Odagiri and Iwata, 1986; Griliches and Mairesse, 1990).

****************************** Table 3 ******************************

Model 2 is similar to those that previous studies have estimated. As the results indicate, the rate of return to innovation is 0.26 (statistically significant at the 5% level). This suggests that investments in innovation had a significant and positive effect on the performance of UK manufacturing MNEs. The results are consistent with earlier findings. For instance, using a sample of UK firms for the 1988-1992 period, Wakelin (2001) found the returns to innovation to be 0.29. The results are also similar to those of some other studies that found that the payoff from innovation for the US, France and Japan was around 0.30 (Griliches and Mairesse, 1983; Griliches and Mairesse, 1990). The coefficient for the control variable of firm size is statistically insignificant. As the sample comprises only large firms, however, this is not surprising. It also seems that the industry dummies absorbed firms' heterogeneity, thereby leading to a statistically insignificant effect for the high/low-tech control variable.

In order to test whether internationalization affects the capability of firms to benefit economically through innovation, Equation 2 was estimated. As noted earlier, if our research proposition is valid, then the rate of return to innovation estimated from Equation 2 should differ considerably from that estimated from Equation 1. Indeed, the results of

Model 3 confirm this. The estimated returns to innovation increased remarkably from 0.26 to 0.56, and the goodness of fit of the model has been further improved. The good fit of the new interaction variable is also reflected in the statistical significance level, which improved from 5% to 1%. The positive and much higher coefficient suggests that, on average, the returns to innovation become higher as the firm becomes more international. That is, the benefits a firm receives from its innovative activity depend on the extent to which it operates in markets beyond its national boundaries.

To examine the robustness of the findings, we examined their sensitivity to changes in the definitions of tangible assets, as well as to changes in the price indices utilized to deflate the variables. Despite different specifications, the findings remained approximately the same. The findings were approximately the same even when the random-effect estimator was employed. Additionally, a Durbin-Watson test indicated that there was no evidence of positive or negative auto-correlation (d statistic = 2.07). We also investigated the possibility of 'reverse causality'. This problem arises when the independent variables are not exogenously determined (as they should be), but there is a degree of feedback from output to inputs. In other words, although performance may depend on corporate innovation and internationalization, there is also a possibility that those organizations with high performance invest more in innovation and internationalization. In order to examine this, we reversed the model, i.e. we used the variable of 'innovative activity' as dependent variable, and a one-year lagged measure of performance as independent variable. The results indicated that the impact of performance on innovation was statistically insignificant, thereby rejecting the possibility of reverse causality. This result remained the same when a two-year lagged measure of performance was utilized, as well as when 'internationalization' was used as dependent variable.

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To confirm the findings of Table 3, we also examined whether the impact of innovation on performance is greater for firms that are more international. To do so, the sample was divided into firms with higher and lower DOI, and Equation 1 was estimated for each subgroup separately. The value of the 'internationalization' variable of the firms in the sample ranges widely from 0.20 to 0.95. In other words, whilst the foreign sales of some firms comprised only the 20% of their total sales, as much as 95% of other firms' sales were made in international markets.

To divide the sample in two subgroups of lower and higher DOI, following previous studies we used the above and below levels of the median (which was 0.69%). Hence, 42 firms that had a DOI higher than 69% were included in the higher-internationalization group. The remaining firms of the sample, the foreign sales of which ranged from 20% to 69%, were included in the lower-internationalization group. The descriptive statistics for the two subgroups indicated that their R&D-intensity was exactly the same (at 2.6%). Hence, although more international firms may have the incentives to increase their R&D investment as a proportion of sales, the descriptive statistics do not support this. Contrary to our expectations, the descriptive statistics also revealed that the performance of firms with lower DOI was slightly higher than the corresponding performance of higher-internationalization firms.

Table 4 compares the average returns to innovation for the two subgroups. The findings are consistent with those of Table 3. They confirm that internationalization is a firm-specific characteristic that affects the payoff from innovation. Specifically, the rate of return to innovation for the firms with lower DOI is only 0.12 and statistically insignificant, thereby implying that innovation may not contribute to their performance. It appears that because their technological discoveries are not marketed in many countries, the significant

costs associated with innovation dominate the benefits. In line with the previous theoretical discussion however, the relationship is totally reversed in the case of higher-internationalization organizations. The corresponding rate of return for these firms is 0.34 (statistically significant at the 1% level), indicating that internationalization is indeed a factor that allows these firms to profit from innovation.

******************************* Table 4 *******************************

5.2 Discussion

The empirical results given above support our proposition, showing that internationalization moderates the innovation-performance relationship. The analysis demonstrates that highly international firms enjoy high returns to their innovative efforts. This finding is consistent with many theoretical predictions. Although the costs of developing new ideas are similar whether offered to one market or to many (Zachary, 1995), being more international allows a firm to achieve greater returns from innovation by utilizing many markets (Hitt et al., 1997). The results also confirm that firms with high DOI outperform their less internationalized competitors, as they can increase their innovative capacity by engaging in local scientific cooperation, lowering the costs of R&D, and benefiting from new resources, ideas and technologists. Additionally, because investments in innovation depreciate rapidly (Goto and Suzuki, 1989), a firm that markets its inventions in a small number of countries may capture the full value of its innovations only for a short period of time. For this reason, it is particularly important for R&D-intensive firms to be able to exploit the value of their developments by reaching a large number of potential buyers through the operation of internal markets in the MNE (Buckley and Casson, 1976).

Another noteworthy result is that the weighting of innovative activity by the DOI doubled the coefficient of the returns to innovation. An implication for academic research is that the actual returns to such investments may be higher than previous studies have indicated. Hence, those firms that reduce R&D spending because of their low expectations of adequate payoff (Ravenscraft and Scherer, 1982) may be encouraged to increase their investments in R&D again. The study may also assist in resolving the inconsistency of some of the previous findings. As discussed earlier, it is often unclear why whilst some studies find the effects of innovation to be positive and high, other studies find these impacts to be insignificant. Our findings imply that the reason for such conflicting results may be the fact that even though prior research controlled for the effects of technological opportunities and firm size, it did not control for the effects of internationalization.

Interestingly, the findings also show that the impact of innovation on performance is statistically insignificant for firms with lower degree of internationalization. This implies that there is a threshold for these moderating effects, under which the costs of innovation may exceed its potential benefits. Although this threshold may be lower for some industries and higher for others, the fact that the value of DOI for the first subgroup ranges between 20% and 69% implies that this threshold is probably quite high. Nevertheless, one should be very careful when interpreting the findings about the lower-internationalization subgroup. The insignificant returns to innovation do not imply that these firms should reduce their investments in innovation. Although they may not receive any direct economic payoff for their investments, innovation is necessary for firms to remain competitive (Teece, 1986).

The results may also help to explain why the previous findings concerning the effects of firm size are contradictory. The subgroup analysis supports the notion that even

when firms are large, they cannot benefit from innovation unless they are sufficiently international. As firm size and internationalization are inevitably correlated, it is likely that the small-firm subgroups of previous studies included firms that operated in a single market. Hence, as these firms had not only small size but also a lower degree of internationalization, researchers cannot be sure whether variations in the returns to innovation may be attributable merely to firm size, rather than to the degree of internationalization. Nevertheless, one could make the same criticism for this study, i.e. argue that some of the variation of the estimates may be a result of the varying firm size. To show that this is not the case, we used the below and above median of firm sales and divided the data into smaller- and larger-firms. We then estimated the model for each subgroup separately. The findings showed that the payoff from innovation was approximately the same for both subgroups; thereby suggesting that as the sample comprises relatively large firms, the variation of the results of Table 4 is caused by internationalization (rather than by firm size).

6. Conclusions, implications and future research

Although prior studies recognize the importance of innovation in allowing a firm to develop competitive advantages (Artz et al., 2003) and in surviving the battle for technological leadership (Chesbrough, 2007), they often focus on the role of firm size and technological opportunities. This study contributes to the innovation literature by suggesting that another significant firm-specific factor that allows companies to improve performance through innovation is that of 'internationalization'. Initially, the study offered a conceptual framework that explained how and why internationalization, by influencing innovative capacity and appropriability, is likely to affect the returns to innovation. Then,

utilizing a sample of firms with different degree of internationalization and a 14-year time horizon that captured their international expansion, it provided evidence that confirmed the critical role of DOI in reaping rewards from innovation.

The findings suggest that not all firms are able to create additional value by exploiting their research discoveries. Rather, we found that depending on DOI, the impact of innovation on corporate performance can be either positive or insignificant. An implication for theory is that future predictions about the impacts of industrial research should be linked to a firm's degree of internationalization. Similarly, an implication for empirical research is that models that do not control for the effects of internationalization may yield biased results that underestimate the consequences of innovation for firms' economic performance. A third implication of our findings relates to the role of firm size. As discussed earlier, social scientists need to be cautious in attributing variations in the innovation-performance relationship to firm size. Although the size of an organization plays an important role in explaining innovation performance, we found that large firms with low degree of internationalization do not outperform their competitors. This result provides support to the arguments emphasizing that organizations – even the largest – can no longer rely only on their own technologies and knowledge reservoir (Chesbrough, 2007; Santos et al., 2004).

As firms invest vast amounts of money in innovation, the results may update not only scholarly knowledge but also managerial understanding and practice. Even though firms' innovation efforts lead to significant technological and scientific breakthroughs, the analysis demonstrated that only firms with high DOI were able to enjoy the fruits of innovation. This result confirms the argument of Frohman (1982) that large investments in innovation alone do not ensure the successful exploitation of technology as a decisive

strategic weapon. It also suggests that although the potential benefits of such investments are many, to be successful in capturing these benefits organizations need to coordinate innovation strategy with international-business strategy (Kotabe et al., 2002). Therefore, one recommendation to firm strategists is to focus not only on the development of new products and processes but also on the expansion to new markets. That is, before making large investments in innovation, firms should plan a strategy that will ensure that they can successfully exploit their new developments in a wide range of markets.

However, the study has a number of limitations. Firstly, the innovation expenditures reported by firms are the sum of different R&D activities. Researchers could replicate the findings using specific types of innovation, such as process and product innovations or outsourced innovation. Similarly, different measures of performance such as profitability can be used. Secondly, the current study utilized UK data. To generalize the results more reliably, future research should re-estimate the model using data from other countries. Thirdly, the study operationalized 'internationalization' by using the ratio of foreign sales to total sales. This proxy however, does not measure accurately the level of internationalization, despite its wide use by prior studies. Because of limited data availability, it was impossible to reproduce the results using alternative definitions. Future studies could re-estimate the model using more accurate measures for each firm's internationalization of sales, production and R&D network.

Another interesting avenue for future work relates to firms' international-expansion strategy. Out dataset did not indicate what proportion of each firm's foreign sales were exports and what proportion of such sales were generated by subsidiaries. More precise data could allow researchers to examine whether one of these two international expansion strategies is preferable for enhancing the value found in innovation. Utilizing such data,

researchers could also create separate ratios for the US, Europe and Asia, and examine whether the returns to innovation for firms that increased their international expansion in one region outperformed the returns obtained by those firms that increased their international expansion in another region.

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TABLES and FIGURES
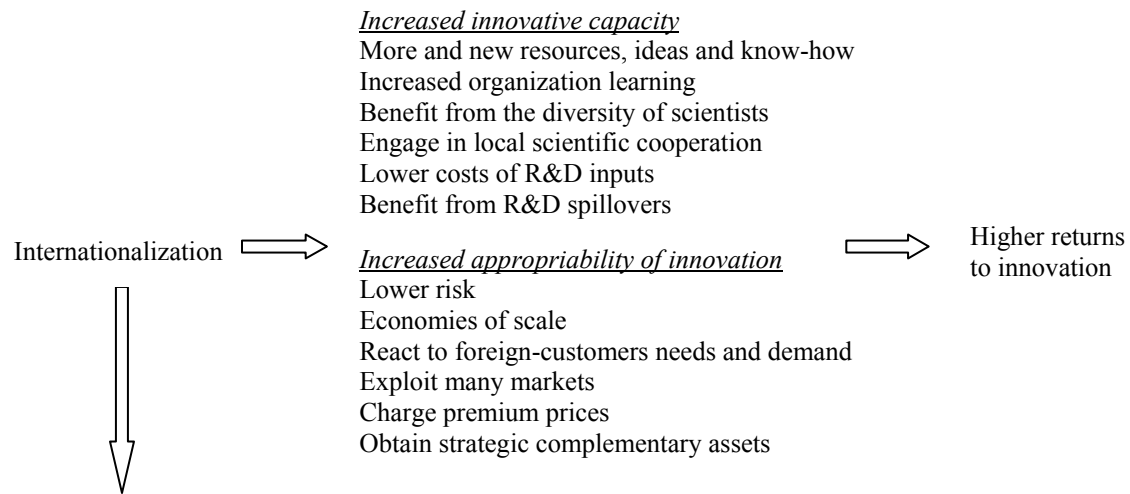
Figure 1 The main implications of internationalization

Increased innovative capacity
More and new resources, ideas and know-how
Increased organization learning
Benefit from the diversity of scientists
Engage in local scientific cooperation
Lower costs of R&D inputs
Benefit from R&D spillovers

Internationalization

Increased appropriability of innovation
Lower risk
Economies of scale
React to foreign-customers needs and demand
Exploit many markets
Charge premium prices
Obtain strategic complementary assets

Higher returns
to innovation

Challenges of internationalization
Increased risk of knowledge leakage
Difficulty of communication (frequency, quality, speed)
Increased coordination costs
Lower economies of scale for R&D sites

Table 1
Sectoral Analysis (84 UK manufacturing firms, 1989-2002)

	SIC 80 Code	No of Firms
Metal Products	22 & 31	2
Minerals	23 & 24	3
Machinery & Mechanical Engineering	32	23
Motor Vehicle Parts	35	6
Paper & Printing	47	2
Rubber and Plastics	48	2
Other Manufacturing	49	2
Chemicals and Pharmaceuticals	25	16
Electrical & Electronics	34	15
Telecommunication	344	4
Aerospace	364	5
Instrument Engineering	37	4
	Total	_84_

Table 2

Descriptive statistics and correlations [a]

	Mean	S.D.	2	3	4	5
1. Δ Performance [b]	0.025	0.111	0.39	-0.41	0.03	0.05
2. Δ Tangible assets [b]	0.048	0.151		-0.55	-0.03	-0.03
3. Δ Employees [b]	-0.002	0.152			0.14	0.14
4. Innovation	0.026	0.025				0.89
5. Innovation*Intern.	0.015	0.017				
Performance	95 910	95 130				
Tangible assets	24 440	18 440				
Number of Employees	9 347	16 526				
Internationalization	0.65	0.22				

[a] Correlations greater than 0.15 are significant at the 0.01 level

[b] 2-year differences of the variables

Table 3

Regression results for firm performance (84 UK manufacturing MNEs, 1989-2002)

	Model 1		Model 2		Model 3	
	coeff.	s.e.	coeff.	s.e.	coeff.	s.e.
Tangible assets	0.16**	0.023	0.21**	0.026	0.21**	0.026
Labor	-0.21**	0.024	-0.21**	0.024	-0.21**	0.024
Innovation	0.23*	0.121	0.26*	0.116		
Innovation*Internationalization					0.56**	0.185
Firm size	-0.006	0.007	-0.002	0.007	-0.002	0.007
High/Low tech dummy	0.021**	0.007	-0.012	0.007	-0.015	0.017
Time dummies			yes		yes	
Industry dummies			yes		yes	
R^2	0.22%		0.29%		0.31%	
R^2-adjusted	0.22%		0.28%		0.29%	

*$p<0.05$,   **$p<0.01$, A number of time and industry dummies are included in the models.
However, because these dummies are many, their coefficients are not shown in the table.

Table 4

Regression results for firms with lower and higher degree of internationalization (DOI)

	firms with lower DOI		firms with higher DOI	
	coefficient	s.e.	coefficient	s.e.
Tangible assets	0.16**	0.038	0.11**	0.024
Labor	-0.17**	0.034	-0.10**	0.026
Innovation	0.12	0.156	0.34**	0.105
Firm size	-0.006	0.011	0.003	0.005
High/Low tech dummy	-0.02	0.021	0.002	0.016
Time dummies	yes		yes	
Industry dummies	yes		yes	
R^2	0.23%		0.30%	
R^2-adjusted	0.20%		0.26%	

*$p<0.05$, **$p<0.01$, A number of time and industry dummies are included in the models. However, because these dummies are many, their coefficients are not shown in the table.