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R&D Offshoring in Multinational Enterprises: Relevance of Transaction Cost and Internationalization Theories

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Relevance of transaction cost and internalization theories

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Abstract

Purpose – The purpose of this paper is to examine recent trends in R&D offshoring by US multinational enterprises (MNEs) against a well-established conceptual framework derived from transaction cost and internalization theories, as well as challenges to it.

Design/methodology/approach – The paper develops and tests a parsimonious model of cross-country variation in R&D performed by affiliates of MNEs based on a 31-country, 15-year dataset of US non-bank majority-owned foreign affiliates (MOFAs).

Findings – Consistent with the implications of transaction cost and internalization frameworks, the findings show that the location of R&D offshoring is significantly determined by ownership of physical assets by MNEs in the host country and host country technological capability.

Practical implications – R&D offshoring can enhance the quality and the quantity of knowledge flows between home country and host country R&D centers. The resulting positive knowledge spill-over effects can increase the welfare and productivity of an MNE and its home country in the long run.

Originality/value – The paper provides a comprehensive explanation for MNEs' R&D offshoring based on transaction costs, internalization framework and technological factors.

Keywords Multinational companies, Research and development, Offshore investments, Transaction costs, Offshoring, R&D internationalization, Internalization, International competitiveness

Paper type Research paper

1. Introduction

Both the academic and the professional literature have focused on the increasing trend towards offshoring of research and development (R&D) and its implications for international competitiveness of firms and countries. The increasingly dispersed R&D activities of multinational enterprises (MNEs) have been the subject of official reports (UNCTAD, 2005b) and many scholarly papers. In addition, it has frequently been

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asserted that MNEs are increasingly outsourcing R&D to third parties, regardless of their location, in order to tap cost advantages and scarce talent to create and sustain competitive advantage.

The theory of the MNE (following Buckley and Casson, 1976) takes the scope of the firm as determined by internalization decisions where the firm grows by absorbing markets for intermediate goods and services until the cost of further internalization outweighs the benefits. The geographical footprint of the firm is determined by location decisions designed to reduce the total costs of operation. This theory is not unchallenged as our review below shows. The R&D function provides a good test of the validity of the theory given current assertions that it is being increasingly outsourced. This paper has two objectives: first, to critically examine basic facts concerning internationalization of R&D and, second, to test extant theories of firm internationalization by examining factors that influence cross-country variation in R&D performed by affiliates of US MNEs towards location choice and integration decisions.

There are several motivations for this paper. In spite of the importance of the issue of R&D offshoring, reliable data on offshoring of R&D is reasonably scarce (Tellis *et al.*, 2009). We believe that there are significant misunderstandings about the impact of R&D offshoring partly due to the confusion created by incorrectly using the terms offshoring and outsourcing interchangeably. By examining the pattern on US multinational R&D activities conducted in foreign countries, we can gain insight into the factors that drive location and level of offshored R&D. Further, studies also differ on the extent to which R&D and manufacturing follow each other. For instance, Yrkkö and Deschryvere (2008), using data from Finnish firms, find little evidence that R&D follows production abroad. This link is important because of the policy implications arising out of the domestic effects of R&D offshoring, which we will discuss in more detail below.

Offshoring refers to the process of sourcing and related coordinating tasks and business functions across national borders (Kotabe *et al.*, 2008; Lewin *et al.*, 2009). Our definition of "offshoring" follows UNCTAD (2005a) in Table I and Kotabe *et al.* (2008). Kotabe *et al.* (2008) refer to two decisions – the location decision and the choice of internal affiliates versus external partners for sourcing an activity. In this paper, our focus is on R&D performed by a foreign affiliate of the same MNE, sometimes referred to as "captive offshoring". This is to be distinguished from externalized offshoring, that is, R&D, performed by a third party provider in a foreign country – either a local company or a foreign affiliate of another MNE – or cooperative R&D with foreign affiliate partners as suggested by Contractor (2009).

The paper is organized as follows. First, the paper presents a conceptual background based on extant theories from the international business (IB) literature. It then examines,

Location of R&D	Internalized	Externalized ("outsourcing")
Home country	R&D kept in-house in the source country	R&D outsourced to third party provider at home
Foreign country ("offshoring")	R&D by a foreign affiliate of the same TNC, called "captive offshoring"	R&D outsourced to a third party provider abroad: to a local company or to a foreign affiliate of another TNC

Source: Constructed from UNCTAD (2005a)

Table I. Offshoring and outsourcing R&D: definitions

broadly, some basic facts on the internationalization of R&D, followed by the presentation and testing of a model of R&D offshoring using pooled 31-country, 15-year dataset of US non-bank majority-owned foreign affiliates (MOFAs). Finally, the paper provides a discussion of results that explain the location of foreign affiliate R&D, including suggestions for future research.

2. Conceptual context

The vast literature on the internationalization of firms provides a solid basis to explore the internationalization of R&D activities. In this section, we review the major conceptual frameworks that have been employed to study firm internationalization, drawing upon the main linkages to R&D internationalization.

The risks arising from market failure associated with innovative activities begin with Arrow (1962) and are elaborated by Nordhaus (1969), Williamson (1975, 1996) and Teece (1981) who emphasized inappropriability (the difficulty firms have in appropriating the fruits of their innovation because of imitation); extreme uncertainty, which makes it impossible to write meaningful contracts; and indivisibility or lumpiness in R&D projects that makes specialization difficult. These are the main reasons why free-standing R&D businesses are difficult to sustain.

Williamson's transaction cost framework (TCF) (1975, 1996), in particular, provides a broad and deep analysis of impediments to market solutions for innovation and considers organizational failures including bounded rationality, opportunism, and information impactedness. The TCF suggests that opportunism combined with information impactedness (i.e. the high cost of transmitting information from seller to buyer) makes market contracts for R&D problematic. This explains why, historically, so much innovative activity has been vertically integrated into the firm. For example, in 2007, 92 percent of company-funded R&D in the US was vertically integrated (National Science Board, 2010). The TCF also suggests that the choice between markets and hierarchy depends on the degree to which assets – in this case technological assets – are firm specific. The greater the firm specificity of technological assets, the more likely it is that hierarchy will outperform the market.

An important variation on TCF is the dynamic capabilities view developed by Teece *et al.* (1997) and Teece (2000), and having its antecedents in Nelson and Winter (1982). It emphasizes the firm's activity to "integrate, build and reorganize internal and external competences to rapidly changing environments" (Teece *et al.*, 1997, p. 516). It further emphasizes specialization in terms of intangible knowledge and other assets that are difficult to replicate. Replicability depends on the degree to which knowledge is tacit (difficult to replicate) or codified (easy replicability). It is the nature of replicability in combination with intellectual property rights (IPRs) that determines whether the appropriability regime is strong or weak. As in the TCF, the dynamic capabilities view encompasses hybrid forms of organizations.

Starting with Hymer (1976), Buckley and Casson (1976) and Caves (1984), a number of scholars have provided the conceptual framework for a robust theory of MNE. Its implications for the internationalization of technological activity – that is, cross-border R&D by MNEs, when it exists, will be largely complementary to foreign direct investment (FDI) – is consistent with the market failure/TCF framework discussed above. Hymer's (1976) work suggested that the appropriability problem (or spillovers associated with technological assets) is one of the main reasons why MNEs substitute

FDI for other forms of cross-border involvement such as trade, licensing, joint ventures, and alliances. The internalization theory proposed by Buckley and Casson (1976) came to the same conclusion and suggested that replacing imperfect markets in intermediate products (especially information intensive ones) combined with least cost location of activities provided the MNE's *raison d'etre*. These strands of literature converge on one key point: that is, the most efficient means of organizing innovative effort is to integrate it vertically within the firm. As shown in Table I, the two parts of internalization theory distinguish externalization (outsourcing) from vertical integration and internationalization versus a purely domestic set of location choices.

This combination of internalization and location factors suggest that an internalized network of knowledge flows represents the optimal means of integrating R&D into the system of innovation of the firm by allowing the two-way transfer of knowledge from and to R&D with marketing and production. The management of these two way flows of knowledge provides an additional theoretical basis for why R&D facilities are internalized. The use of external R&D facilities does not allow these intimate, internally controlled flows of information and risks leakage and appropriation by outsiders. Buckley and Casson (1976, pp. 37-40) suggest that internalization allows coordination of activities linked by the market but subject to significant time lags, avoids bilateral monopoly and crucially avoids "the buyer uncertainty problem" when (particularly in high technology markets) buyer and seller are subject to knowledge asymmetry. Against this are the arguments for externalization – based on increased resource costs, increased communication and management costs and potential political interference against foreign firms (Buckley and Casson, 1976, pp. 41-3). The externalization school argues that coordination is often cheaper through a market relationship because of rising internal management costs resulting from a high degree of vertical integration. Note that from a strategic perspective, competitiveness is at the center of both arguments. This leaves open the spatial dimension of internalization – should the R&D facility be co-located with the production and marketing function? We investigate this new suggestion below.

Antras (2005), in a new TCF/internalization version of the product life cycle theory, has shown that what limits the international fragmentation of the production process and R&D is the incomplete nature of contracts governing international transactions. Thus, the model developed by Antras predicts that if production and R&D move abroad prior to the maturity stage, they move to a wholly-owned foreign affiliate, i.e. they remain internalized within the firm. Internationalization associated with externalization in the form of licensing, contract manufacturing and similar arm's length arrangements will occur only at higher levels of maturity of the product.

Dunning (2000) assembled the various areas of research on internationalization to provide an integrated model of firm internationalization. The framework essentially used firm-specific advantages and host country location advantages to explain location, rate, extent and form of internationalization. While the theory is comprehensive, the majority of the literature on R&D internationalization appears to have focused on two aspects, internalization and location specific advantages. One of the most important elements identified by the ownership, location and internationalization framework (OLI) is the role played by host country institutional and other capabilities in MNE internationalization. In the context of R&D, host country technological competence is an important influence on the MNE's decision to locate R&D activities abroad.

Recently, a strand of literature, taking the opposite view to traditional internalization theories, provides the conceptual and empirical support for the emerging "markets for technology". This view, developed by Arora and Gamberdella (2001) and Baumol (2002), suggests that technological spillovers reflect knowledge transfers through markets. Baumol argues that firms have an incentive for the voluntary dissemination of proprietary technology, as long as the price is right, and offers evidence of growing markets in technology licensing. Markets for technology include transactions for use and diffusion of technology (i.e. intellectual property (IP) that is licensed and its close substitutes) as well as transactions for the creation of new technology – contract R&D, technology alliances of various kinds and various technological services (Arora and Gamberdella, 2001).

One might characterize this strand of literature as providing support for an externalization hypothesis as alternative to internalization hypothesis. There is a clear theoretical tension between the two. Our understanding of global dispersion of R&D would be enhanced by knowing which theory explains better. In the absence of data for total externalization to test the alternative hypothesis, we suggest that internalization or externalization would depend on the level of complexity of the outsourcing operations. In general, complex operations such as design of specialized software are better explained by internalization. On the other hand, R&D activities such as laboratory testing where contracts are easier to write and enforce may be less well explained by internalization. "Offshore outsourcing" of such activities is perhaps better explained by the markets for technology framework of Baumol (2002) and Arora and Gamberdella (2001). However, it is important to note that not all "offshore outsourced R&D" is necessarily of the arms-length type as some may be inclined to assume. Unfortunately, without empirical data on the degree to which the third parties to whom R&D is outsourced are captive or quasi captive, it would be difficult to test internalization hypothesis with respect to outsourced offshore R&D. For example, the most prevalent form of offshoring involves turnkey assignments, characterized by partial vertical integration (Bardhan, 2006).

3. Internationalization of MNE R&D

Recent empirical evidence

The TCF/internalization perspective discussed earlier suggests that R&D should be mostly a vertically integrated (VI) activity in the firm and therefore the least outsourced activity through normal market transactions. We review some well-known facts and empirical research about MNE R&D that generally support this perspective. R&D in MNEs is overwhelmingly located in home countries. Indeed, according to a recent study by Macher *et al.* (2007), R&D offshoring in the semi-conductor industry appears to be nearly absent since 1985. However, in 2008, MOFAs accounted for 16 percent ($37 billion) of their parents' R&D expenditures of $236 billion (Barefoot and Mataloni Jr, 2010); and this share of foreign affiliates has increased since the late 1990s (12.9 percent in 1997). When MNE R&D is located abroad, it follows FDI. In 2008, Europe and Canada together accounted for 71 percent of US manufacturing FDI, and their share of R&D expenditures of non-bank foreign affiliates was 74 percent (Table II).

Gersbach and Schmutzler (2011) corroborate this pattern of MNE R&D location and note further that R&D by foreign affiliates is particularly attracted to:

Region/country	Total assets in manufacturing Amount ($)	%	R&D expenditures in all industries Amount ($)	%
Europe	1,117	59.41	24.15	65.29
Canada	209	11.12	3.04	8.22
Asia and Pacific	327	17.39	7.21	19.49
Of which				
Japan	55	2.93	1.87	5.06
Australia	45	2.39	0.92	2.49
China	66	3.51	1.52	4.11
India	12	0.64	0.58	1.57
Other	149	7.93	2.32	6.27
Latin America other Western Hemisphere	192	10.21	1.47	3.97
Of which				
Brazil	73	3.88	0.79	2.14
Mexico	64	3.40	0.39	1.05
Middle East	23	1.22	1.06	2.87
Africa	12	0.64	0.06	0.10
Total	1,880	100.00	36.99	100.00

Note: Percentages may not add to exactly 100 because of rounding
Source: Constructed from Barefoot and Mataloni, Jr (2010)

Table II. Shares of US direct investment abroad and research and development expenditures: non-bank foreign affiliates, by selected regions/countries, 2008 (amount in billions of dollars)

- large markets with high per capita income;
- locations where firms have manufacturing and sales facilities; and
- countries with a large technical know-how.

Casson (1991, p. 13) suggested that "In historical terms the decentralization of corporate R&D is a quite recent phenomenon". Since FDI is largely concentrated in the developed countries, R&D follows a similar pattern. Developing countries' share of R&D is roughly proportional to their share of FDI. Thus, China and India among the Asian and Pacific countries and all of Latin America, the Middle East, and Africa combined accounted for 12.6 percent of US foreign affiliate R&D compared with their FDI share of 16.2 percent (Table II). Historically, R&D is an input embodied into manufactured products. As a result, R&D has been overwhelmingly concentrated in the manufacturing sector. In 2008, a little over 79 percent of non-bank US MNEs' R&D was in manufacturing. Although this is considerably lower than 90 percent in 1996, it has remained unchanged since 2003 (Barefoot and Mataloni, 2010; Mataloni, 2005). The decline from 1996 is due to the rapid growth of R&D in the non-manufacturing sector, especially in the software segment of the information communications technology (ICT) sector. Contract R&D accounts for a very small fraction (less than 8 percent in 2007) of total company-funded R&D and this ratio has increased from 5 percent in 2001. However, there are sectoral differences with chemicals and scientific R&D services contracting out about 21 and 14 percent of their total R&D, respectively (Figure 1). In contrast to R&D, which is highly integrated, purchases of goods and services from outside suppliers (in all industries except wholesale and retail trade) by the parents of US MNEs were 80 percent of sales in 2008 and have risen from 63 percent in 1997 (Mataloni Jr, 2005; BEA, 2006).

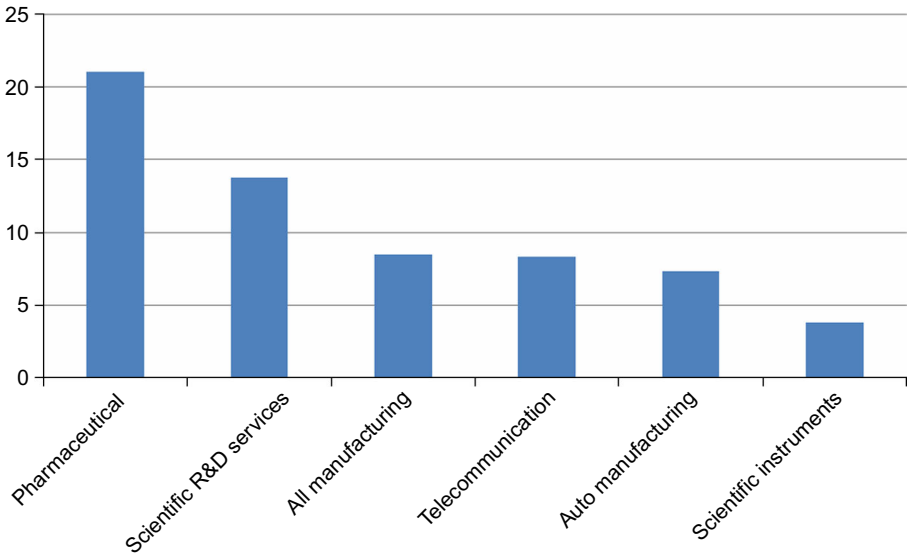

Figure 1.
Ratio of contract R&D to R&D within US companies, selected industries, 2008

Source: Constructed from National Science Board (2010)

From the early 1990s onwards, the literature suggests an increasing trend towards either externalized offshoring or internationalization (or both) of R&D or outsourcing to third parties abroad. Reasons for such a trend include: increased networking among R&D facilities (Casson *et al.*, 1992); a trend towards increased specialization in inventive activity (Arora and Gamberdella, 1994; Dunning, 1994); a trend towards convergence of R&D practice, increasing the importance of host-country technology competences, multiple centers of learning and the decline of centralizing forces such as communication and coordination problems (Gerybadze and Reger, 1999; Pearce, 1999); increased use of technological research networks as a means of corporate technological diversification (Cantwell and Kosmopoulou, 2004); increasing use of technology alliances (Hagedoorn, 2002) and the emerging markets for technology through licensing (Arora and Gamberdella, 2001; Baumol, 2002). Collectively, these and other studies, using a variety of methodologies, focus on the internationalization of innovative activity, the motives for it and the organizational forms employed by the MNEs. The UNCTAD (2005a, b) report on internationalization of R&D appears, in part, to have been inspired by these findings.

The proportion of industry R&D expenditures financed by foreign sources has increased in almost all developed countries. Between 1981 and 2001, it increased about two and half times in the USA (from 6.2 percent to 15 percent); more than three and half times in Canada (from 7.4 percent to 27.0 percent); two and half times in the UK (from 8.7 percent to 21.5 percent); and nearly doubled in the European Union (National Science Board, 2004).

Although, historically, most cross-border R&D has been of the adaptive type, patenting activities of parent companies suggest that this may be changing to more innovative types capable of advanced independent research (Lewin *et al.*, 2009). Cantwell and Kosmopoulou (2004) report that during the periods 1978-1982 and 1991-1995,

US patents of world's largest firms (i.e. all countries except Japan) attributable to research in foreign locations increased from 12.0 percent to 17.0 percent The comparable 1991-1995 figure for eight European countries was in the range of 21.0 percent (Germany) to 67.0 percent (Belgium).

More recently, Lewin *et al.* (2009), using survey data collected by the Offshoring Research Network (ORN) project on 253 companies and 880 different offshore implementations, reported that a surprising fraction of offshoring (26 percent of implementations) involves core innovative activities and that the need to access qualified talent is a strong determinant of decisions concerning offshoring of product development functions.

Internationalization of basic research

In their study of 19 USA, European and Japanese electric and electronic MNEs, Serapio and Hayashi (2004) found increased internationalization of MNE basic research activity. For example, the proportion of papers by the US MNE scientific personnel attributable to authors based outside of the US increased by nearly four times between 1981 and 1998, from 6 to 23 percent (note that the authors based outside the US include those from affiliated as well as unaffiliated R&D facilities). During the same period, the average number of nationalities of US MNE R&D facilities to which authors/co-authors belonged increased about three times, from 5.3 in 1981 to 15.1 in 1998. The nationality record of Japanese and European MNE publications showed a similar trend.

The 2004-2005 UNCTAD survey on R&D internationalization focused on the top 300 MNEs, which account for more than 85 percent of all R&D by the top 700 firms in the R&D Scoreboard by the UK Department of Trade and Industry (DTI). Among other things, the survey showed that the pace of R&D internationalization may be accelerating: 69 percent of the responding firms expected their share of foreign R&D to increase over the next five years. This finding is consistent with the growing share of R&D performed abroad by the MNEs of the US and other industrialized countries (Roberts, 2001). Further, the average firm in the survey spent 28 percent of its budget abroad in 2003, including in-house expenditures by foreign affiliates and extramural spending on R&D contracted to other countries. Countries/regions of origin differ significantly in the degree of R&D internationalization measured by the percentage of MNEs' R&D budget spent abroad. While Western European MNEs had the highest level (41 percent) followed by North American MNEs (24 percent), Japanese and Korean MNEs had the lowest levels – 15 and 2 percent, respectively (Figure 2).

Technology licensing

Intra-MNE receipts and payments of royalties and license fees (i.e. the affiliated component) are internal but internationalized technology transactions. Indeed, they constitute the largest component ($79 billion in 2007), accounting for nearly three-quarters of the total affiliated plus unaffiliated components. By contrast, licensing and cross-licensing by MNEs, when it involves unaffiliated firms, clearly represents market transactions. Judging from the US data between 1994 and 2007, receipts and payments from royalties and license fees from the exchange and use of industrial processes and general computer software with unaffiliated foreign companies have more than quadrupled, from $4 billion to $16 billion. Their share of the value of all unaffiliated transactions, which include trademarks and other non-technology items,

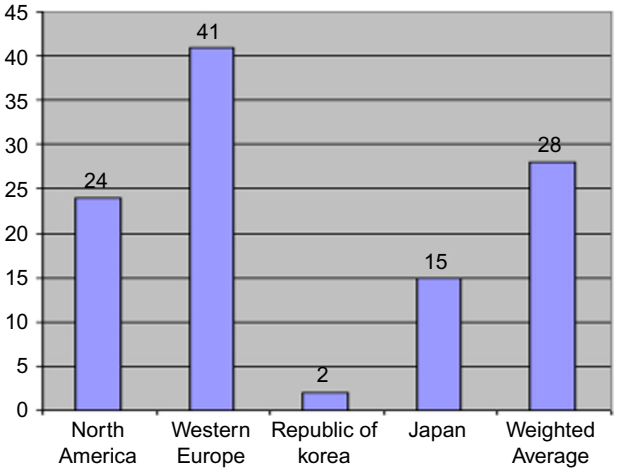

Figure 2.
Degree of R&D internationalization by home region or country 2004-2005 (percent)

Source: UNCTAD (2005b), Figure IV.3, p. 125

has increased from 52 to 56 percent – an indication of externalization as well as internationalization of the MNE technology (Table III).

Thus, while intra-MNE transactions continue to dominate technology licensing activity, there is strong evidence that the share of the unaffiliated technology component is growing. More important, both affiliated intra-MNE transactions and the unaffiliated transactions represent internationalization.

	1994 ($)	2007 ($)	Percentage of change
1. Affiliated	24,209	78,534	224.40
Receipts	20,245	58,881	190.84
Payments	3,934	19,653	399.57
2. Unaffiliated	7,756	29,129	275.57
Receipts	6,437	23,733	268.70
Payments	1,919	5,396	181.19
3. Total, affiliated and unaffiliated	31,965	107,663	236.82
Receipts	26,712	82,614	209.28
Payments	5,853	25,049	327.97
4. Unaffiliated industrial processes and general computer services[a]	4,060	16,201	299.04
Receipts	3,026	12,705	319.86
Payments	1,034	3,496	238.10
Line 1 total as percent of line 3 total	75.70%	72.90%	–
Line 4 total as percent of line 2 total	52.30%	55.62%	–
Line 4 total as percent of line 3 total	12.70%	15.05%	–

Note: [a]2005 data
Source: Constructed from BEA (2006), US International Services, Table F and National Science Board (2010) (millions of dollars)

Table III.
US receipts and payments of royalties and license fees associated with affiliated and unaffiliated foreign companies, 1994-2007

4. A parsimonious model of R&D offshoring

Our hypotheses stem from the previous discussion that highlighted the usefulness of the TCF and internalization frameworks to examine the internationalization of R&D. TCF and internalization theory suggest that R&D outsourcing – except for the most routine sort-through arm's-length contracts will be small. Hybrid forms such as technology alliances tend to mimic vertical integration through long-term relationships. These theories suggest that to the extent that R&D is internationalized, it is most likely to be internalized within the firm rather than through arm's length transactions. Moreover, as noted earlier, R&D is overwhelmingly concentrated in manufacturing. As such, it is best viewed as an input embodied into products and not easily outsourced. The descriptive evidence we have presented supports this proposition. Other researchers have also provided direct or indirect support. For instance, Kuemmerle (1999) demonstrates that firms undertake FDI in foreign markets both to exploit their firm specific skills, but also to acquire technologies from the host country. While he does not test for internalization specifically, his empirical results clearly show a strong link between FDI and R&D in the host country.

This contrasts with the "markets for technology" view, which would see R&D facilities increasingly dissociated from the other activities of the MNE, not integrated with the firm and possibly not co-located. Indeed under this schema, we might expect separate agglomerations of specialist R&D facilities.

In light of the above discussion, we test two hypotheses:

H1. Inter-country variations in R&D performed by foreign affiliates are positively related to variations in the size of their manufacturing assets.

It is important to note that our R&D variable refers to all R&D – manufacturing as well as any non-manufacturing R&D performed by the MOFAs. As such, the hypothesis seeks to explain inter-country variations in total R&D with MOFA manufacturing assets as the dependent variable. One might ask whether our focus here is on the more limited area of "captive offshoring" in manufacturing in light of considerable literature on the rise of externalized offshoring and growing importance of the service sector with respect to offshoring. In terms of the relative importance of R&D performed by foreign affiliates of US MNEs in manufacturing, it continues to command the dominant share of total R&D performed by all industries during the 1993-2008 period. The share of manufacturing R&D showed only a slight decline from 82 percent in 1993, to 79 percent in 2008. With respect to growth in offshoring in the service sector (captive or third party), in the absence of direct data, we have looked at the recently published balance of payments data for R&D and Testing Services category published by the Bureau of Economic Analysis (BEA), US Department of Commerce. Over two-thirds (78 percent) of the total payments in 2009 were for foreign affiliates of US MNEs, and only 22 percent for unaffiliated foreign firms, showing almost no change from 2001. Thus, even in the service sector, captive offshoring appears to be the dominant fraction of total offshoring to foreign countries (BEA, 2006).

While market factors have remained the primary focus of internalization and the TCF literature on R&D internationalization, more recent studies have begun to identify technology factors as an important motivation for locating R&D abroad. For instance, Florida (1997) uses survey data to show that a prime objective of MNEs is to seek technological, and perhaps more crucially, human capital in their decisions to locate

R&D activities in specific markets. On an indirect, but somewhat related note, Kuemmerle's (1999) study demonstrates that FDI in R&D is more likely to be targeted, creating firm specific advantages (as opposed to exploiting them) in host countries with stronger scientific bases. Dunning (1994) makes the strongest case for the importance of host country's technological competence in attracting MNE R&D. As noted earlier, a recent study by Lewin *et al.* (2009) using survey data confirms this conclusion. The results show that the need to access highly skilled science and engineering talent is an important explanatory factor for offshoring innovation decisions. Therefore:

H2. Inter-country variations in R&D performed by foreign affiliates of MNEs are positively related to technological capabilities of host countries.

H1 and *H2* recognize the interdependence of the OLI triad variables (ownership, location and internalization). As Dunning (2009a, p. 5) notes, "This interdependence is particularly apparent when one examines the dynamics of knowledge-intensive MNE activity" (See also Dunning, 2009b). While O facilitates internalization, ownership of assets through FDI is not independent of internalization, especially in the context of knowledge-intensive assets. Indeed, some scholars have suggested that internalization should be the central focus of theories of FDI (Rugman, 1980; Ethier, 1986). This point is particularly important for modeling internalization decision concerning R&D offshoring by the MNEs, which often involves exchange of large volumes of diverse information (Ethier, 1986). Similarly, internalization decision concerning R&D offshoring and, indeed, the decision to engage in FDI itself is influenced by the L variable, that is, by the relative strength of host country's technological capability, which is highly correlated with IPRs. So, we argue that *H1* is a test of internalization theory, given the relative importance of the strength of local science emphasized by Dunning (1994), Florida (1997) and Kuemmerle's (1999). Countries with strong technological competence would have better mechanisms for protection of IP and, therefore, would facilitate internalization to a greater extent.

5. Data

To test these hypotheses, we construct a consistent 31-country, 15-year (1994-2008) data set consisting of data on non-bank majority owned foreign affiliates of US MNEs. This is a unique firm level database.

The model we estimate is of the form:

$$RND_{it} = \alpha + \beta_1 RND_{i,t-1} + \beta_2 ASSET_{it} + \beta_3 TECH_{it} + \sum_{i=1}^{n} \gamma_i Z_i + \varepsilon_{it}; \quad i = 1, \ldots, n; \quad t = 1, \ldots, T$$

RND_{it} = dependent variable: total R&D performed by manufacturing as well as non-manufacturing majority-owned non-bank foreign affiliates (MOFAs) of US MNEs (in US dollars) in the host country i in year t. The data are obtained from the BEA of the US Department of Commerce (BEA, 2006). The data are deflated using the gross value added deflator for non-financial corporate business published by the BEA of the US Department of Commerce (BEA, 2006).

RND_{t-1} = R&D lagged one year. We argue that the presence of a lagged dependent variable is theoretically appropriate, to the extent that decisions concerning R&D location follow FDI in physical assets. In addition, using the lag dependent variable reduces the problem of serial correlation (Fair, 1992).

$ASSET_{it}$ = real manufacturing assets, in US dollars owned by MOFAs of US MNEs in the host country i in year t, a measure intended to test internalization hypothesis. The data are deflated using the gross value added deflator for non-financial corporate business published by the BEA of the US Department of Commerce (BEA, 2006).

$TECH_{it}$ = technology index for host country i in year t: comprises three components – R&D manpower, patents and scientific publications, a measure of host country's scientific and technical capability and one of the drivers of location of MNE R&D. The source of these data is United Nations Conference on Trade and Development in its World Investment Report, 2005 (UNCTAD, 2005a, b) and the Global Competitiveness Report (various years). We view this index not only as a measure of technical and scientific competence, but also the strength of IPRs, since the technology index is highly correlated ($r = 0.93$) with the Index of Patent Rights (Park and Wagh, 2002).

Z_i = set of dummy variables representing each of the countries in the sample.

Table IV shows brief descriptive statistics and correlations between our variables.

6. Results

As shown in Table V, the results confirm both the *H1* and *H2*.

We find strong support for the positive relationship between the assets owned by the MNE in the host country and R&D performed by MOFAs in that country. As one might expect from the predictions of the TCF and the internalization theory, the greater the level of assets in the host country, the greater is the level of R&D in that country. The level of the affiliates' previous year's R&D is also significant, which supports the proposition that the effect of assets and technology index on R&D occurs with a lag. It is important to note that the high adjusted R^2 (0.98) is not due to the presence of lag dependent variable as one might suspect. When we estimate the model without the lag dependent variable, adjusted R^2 is still high (0.97), but with high serial correlation and change in the coefficients of the Asset and Tech Index variables as one would expect.

Variable		Mean	SD	Minimum	Maximum	Correlation matrix (a)	(b)	(c)
R&D	(a)	644.4	1,168.9	0.99	7,975.2	–	0.911**	0.435*
Assets	(b)	29,297.1	46,612.1	241.5	265,401.9		–	0.379**
Technology index	(c)	0.679	0.259	0.158	1			–

Notes: Significant at: $^{*}p < 0.05$ and $^{**}p < 0.01$; R&D and assets are in millions of constant US dollars

Table IV.
Descriptive statistics

Variable	Coefficient	*t*-value
Intercept	−318.7	−3.4
Lag_rnd	0.67***	21.96
Asset	0.01***	11.14
Tech index	1,077.4***	3.72
Argentina	−399.8***	−3.76
Austria	−635.8***	−3.68
Belgium	−645.1***	−3.73
Brazil	−402.5***	−5.05
Canada	−1,022.7***	−5.6
Chile	−294.1***	−3.15
China	−38.9	−0.65
Columbia	−30.2	−0.54
Finland	−731.1***	−3.52
France	−608.2***	−3.66
Germany	−130.0	−0.67
Greece	−433.9***	−3.38
India	23.0	0.41
Indonesia	99.2	1.52
Israel	−442.4**	−2.55
Italy	−590.4***	−4.48
Japan	−454.8**	−2.38
South Korea	−498.9***	−3.14
New Zealand	−584.7***	−3.66
Norway	−674.2***	−3.63
Philippines	9.6	0.17
Portugal	−424.1***	−3.41
Singapore	−759.1***	−4.37
Sweden	−466.9**	−2.29
Switzerland	−661.1***	−3.33
Taiwan	−681.9***	−3.66
Thailand	−115.0***	−1.94
Turkey	−154.5***	−2.27
Venezuela	−198.0***	−2.8
UK	−350.7**	−2.11
R^2	0.98	
Durbin's H	0.90	

Note: Significant at: $^{*}p < 0.1$, $^{**}p < 0.05$ and $^{***}p < 0.01$

Table V.
Pooled time series cross-section model 1994-2008

The technology index in the host country is clearly a significant variable affecting the location of R&D activities. This is consistent with our earlier discussion on resource-seeking or capability enhancing R&D internationalization. Naturally, the level of R&D conducted in countries with higher levels of technological capabilities is greater. This also provides indirect support to the importance of the IP regimes in R&D location decisions. As we noted earlier, the technology index measure includes a component that is highly correlated to the strength of IP regimes in the host country. In other words, if a country possesses high level of technological capability (represented by scientific manpower, publications and patents), then it is also more likely to have stronger IP rights as well.

We also computed short-run and long-run responses of R&D performed by the affiliates to changes in the assets and technology index from the results of our model. The short-run and long-run asset elasticity of R&D, calculated at the mean values of R&D and assets, are 0.45 and 1.41, respectively. Thus, the response of affiliate R&D to changes in assets is relatively inelastic (i.e. less than proportional to the change in assets) in the short-run and roughly proportional in the long-run. That is, a 10 percent increase in MOFA assets would result in a 4.5 percent increase in R&D in the short run, and a 14.1 percent increase in the long run.

The response of the affiliate R&D has been found to be relatively inelastic to changes in the host country's technological competence (as measured by our technology index) in the short run (1.03), but relatively elastic (i.e. more than proportional to changes in technology index) in the long run (3.40). This implies that a 10 percent increase in the country's technology index would attract 10 percent increase in R&D in the short run, and a 34 percent increase in the long run. In other words, the technological capabilities of the host country combined with IP protection seem to be important factors in explaining inter-country variations in the affiliate-performed R&D and important drivers of internalization of R&D.

Still, we view the results of this empirical exercise as merely suggestive of the relevance of TCF and internalization theory. We do not claim this to be a comprehensive model explaining MNE offshoring behavior, which would require controlling for several other variables, including cost factors. Moreover, our model is not intended to be a forecasting model. Rather, the estimated coefficients and elasticity should be viewed as indicating the direction of the effects.

7. Summary and implications

Summary

This paper has two objectives: first, to critically examine basic facts concerning internationalization of R&D and, second, to seek to test extant theories of firm internationalization by examining factors that influence cross-country variation in R&D performed by affiliates of US MNEs, namely the location and level of such internationalized R&D. Several strands of literature provided the conceptual setting for this paper. The traditional literature on market failures associated with innovative activity (Arrow, 1962), the TCF and its variants (Teece, 2000, Williamson, 1975) and the internalization theory (Buckley and Casson, 1976) emphasize vertical integration and internalization of the MNE R&D. When internationalization of R&D occurs, it is generally confined to foreign affiliates of MNEs. Recent work by Bardhan and Jaffee (2008) which uses survey data provide further support for this conclusion and suggests large firms offshore R&D through foreign affiliates. This result is also supported by the ORN (Duke University) survey, which finds that due to concerns about a possible loss of control over strategically important activities, a majority of companies offshoring product development activities favor offshoring through a fully owned subsidiary, what is also referred to as the captive model of offshoring, over the offshore outsourcing model (Lewin *et al.*, 2009). One of the contributions of our paper is to demonstrate the continued relevance of the captive model of R&D offshoring.

Our results support the TCF and internalization framework in terms of the R&D function being internalized within the firm as opposed to increasing externalization and the growth of markets for technology. The significance of our asset variable particularly

emphasizes that R&D in US MNEs remains largely internalized. This is quite consistent with the predictions of the internalization theory and the TCF. Further, our results support the link between production abroad and R&D internationalization. Given that a significant amount of internationalized R&D is of the adaptive R&D type (UNCTAD, 2005a, b), it is not surprising that higher levels of R&D in the host country are associated with higher levels of ownership of manufacturing assets in that country. This is consistent with Kotabe's (1990) view that product development capabilities of MNEs are complemented by the manufacturing innovation capabilities of their foreign affiliates.

Implications

One important, often understated, implication arises from our finding that R&D follows FDI in manufacturing. It has been well established that, since 1990, there has been a very rapid outflow of FDI in manufacturing from the developed countries to the developing countries like China (UNCTAD, 2005a, b). To the extent that this trend continues, our findings suggest that there is likely to be an equally rapid outflow of R&D, also from the developed countries to developing countries with significant technological capability. This implies that concentration of R&D in the home countries in the developed world is likely to decline and become more geographically dispersed. Our results are contrary to the findings of Yrkkö and Deschryvere (2008), based on both statistical and anecdotal evidence from Finnish firms. One possible explanation for this finding is that the extent and nature of R&D offshoring by US multinationals is different from those of other developed countries in Western Europe (Tellis *et al.*, 2009). These authors also find that US multinationals offshore R&D significantly less than their European counterparts.

This finding is particularly critical from a policy perspective given all the negative attention that is often found in the press on offshoring. We believe our results support two important aspects of R&D offshoring that undermine the view that such offshoring results in a net domestic loss to the US economy (e.g. *Business Week*, June 2008). Tellis *et al.* (2009) find that in industries where R&D is globalized, an increase in the number of offshore R&D centers is accompanied by an increase in the number of centers back in the home country as well. This suggests that R&D offshoring results in a net positive effect to the US economy. Moreover, Gersbach and Schmutzler use a two-country model to demonstrate that R&D relocation occurs only when intra-firm communication is well developed. Therefore, we suggest that the quality and quantity of knowledge flows between home country and host country R&D centers may be superior in the captive offshoring model presented in our study, thus benefiting the host country as well as the home country.

A second major aspect of this finding is the productivity effects of relocating R&D. As Yrkkö and Deschryvere (2008) point out, any analysis of the negative impact of R&D offshoring on the home country employment and the like must include a consideration of positive cross-border spillovers. In line with that view, Kiyota (2005) finds that FDI-related R&D offshoring has stronger, more long run positive spill-over effects than import-related R&D. Given our results that US R&D follows FDI, we believe the study offers strong support to a positive view of welfare and productivity gains to US from R&D offshoring. This is an important implication of our study.

From the point of view of the developing host countries, our findings emphasize the importance of providing proper incentives to attract FDI. The results also emphasize

the need for host countries to develop a strong regime of IPRs as well as developing local competence in science and technology.

Our findings also have some key strategic implications for the MNEs. As long as R&D capabilities were home-bound and concentrated in a single geographical location, the organizational capabilities required of MNEs were more closely related to managing marketing, production and other functions dispersed around the world. However, as R&D also disperses geographically, MNEs need to develop organizational capabilities to create, distribute and manage knowledge in dispersed locations. This also raises questions of ensuring the protection of knowledge and core competencies while managing such dispersed innovative activity.

Further, even though service sector R&D while growing rapidly remains a relatively small proportion of total R&D, one might reasonably argue that rapid internationalization of the service sector, in the sense of Dunning's (2000) OLI paradigm, will also result in rapid offshoring of service sector R&D to foreign affiliates. However, unlike the manufacturing sector which is dominated by tangible assets, the service sector – especially the high-technology segment – is dominated by intangible assets, which remain inadequately specified from the standpoint of measurement.

While the TCF/internalization perspective is relevant and useful in understanding internationalization of MNE R&D, there is little doubt that MNE R&D is moving towards an internationally decentralized integrated network-type model that emphasizes local competencies and interdependence, as suggested by Pearce (1999) and others. However, as our results suggest, this form of internationalization must not be confused with offshore-outsourcing to third parties.

Limitations and directions for future research

One limitation of our study is that we do not address sectoral differences with respect to R&D offshoring, especially service versus manufacturing R&D. While service sector R&D internationalization is on the rise, as we noted earlier, the majority of R&D is still concentrated in manufacturing. A second limitation also stems from measurement issues. Very little data are available on the exact nature of R&D being performed by US MNEs, at the aggregate level. Anecdotal evidence and a large amount of descriptive evidence suggest that such R&D is usually of the adaptive type co-located with production facilities. We recognize that our measure of R&D is a macro-measure and also does not allow us to distinguish between small and large firms.

Several avenues for future research emerge from our study. One of the most important questions is sectoral differences in R&D offshoring, especially in light of the fact that the share of service sector R&D has been rising relative to manufacturing R&D within the past decade. R&D in many segments of the service sector (e.g. information technology services) is more likely to be associated with knowledge intensive assets, relative to manufacturing. Second, as Antras (2005) observed, R&D internationalization is characterized by a product life cycle type process. It would be useful to examine whether the stage of the product life cycle influences the extent to which R&D offshoring is internalized. A final area of future research concerns the type of R&D – technology-creating versus adaptive R&D. To the extent that adaptive R&D is likely to be internationalized faster and wider compared to the technology-creating type R&D, it would be useful to study this question empirically with different types of data.

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