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Determinants of MNE Subsidiaries Decisions to Set Up Own R&D Laboratories - Theory and Evidence

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Determinants of MNE Subsidiaries Decision to set up own R&D Laboratories- Theory and Evidence[1•]

by

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Abstract

We explore the determinants of MNE subsidiaries decisions to set-up own R&D laboratories drawing on evidence from UK regions. In this context, we also test for the interaction between firm's internal and external environments. We also integrate extant IB and strategic management literatures and incorporate recent debates in New Economic Geography (NEG) in specifying the 'external environment'. We find support for the role of firm's 'productive opportunity' and predictions of the NEG on the basis of an analysis of primary data. We discuss implications for managerial practice and government regional policies.

Keywords: MNE subsidiaries, R&D laboratory, internal and external environment, productive opportunity

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1. Introduction

The attraction of inward investment in general and of high-value added activities, such as R&D, in particular, has preoccupied academics and policy makers since long. An important consideration in this context is an MNE subsidiary's decision to set-up its own R&D laboratory in its host locality. The determinant of such a decision can be of significance in informing policy makers on how to attract MNEs, especially in the context of a shifting global landscape that significantly increases the locational choices of MNEs (Buckley and Ghauri, 2004). Recent debates in international business (IB) and strategic management, focused on intra-firm factors and industry factors in forming firm decisions. In addition, the new economic geography (NEG) has broadened the definition of the external environment to include regional knowledge/agglomeration characteristics. Our objective in this paper is to test for intra -and extra- firm factors effecting firms' decisions (Penrose's concept of 'productive opportunity'), drawing on the Resource-based view (RBV) of the firm, the positioning approach of M. Porter and the NEG analysis of the role of the 'regional environment', for the case of MNE subsidiary decisions to set-up their own R&D labs in UK regions.

MNEs are widely viewed as both *"developer(s) and transferor(s) of various kinds of knowledge and skill"* (Buckley and Casson, 1976; p.109) conferring "spillover" benefits to the local economy. This has spurned an increasing number of studies focusing on the determinants of the worldwide (re)location opportunities of R&D activities. Surprisingly little attention has been paid to the strategic interaction between subsidiary characteristics and host environmental competencies in the decision of MNEs to expand their R&D operations. Though R&D functions in foreign locations are still predominantly found in MNEs from industrialized countries, it is widely thought that they will progressively be globally distributed, as opposed to centralized in one country (Pearce, 1989; Cantwell, 1992; Patel, 1996; Cantwell and Janne, 1999; Granstrand, 1999; Hill, 2007). Relevant studies tackling R&D internationalization to date, have been preoccupied with incentives inducing foreign expansion of research units at the country level, based on strategic firm decision making and home and host countries' considerations. Nevertheless, related literature on agglomeration, points to the clustering phenomenon of industrial and hence MNE activities in thinner locations within countries, moving the focus of interest to the sub-regional level. The present paper addresses R&D internationalization decisions of foreign affiliates within UK regions. Our intended contribution is fourfold: first, to test Penrose's concept of 'productive opportunity', drawing on the Resource-based view (RBV) of the firm within thin geographical milieus; second, in the above context, to explore the importance of the embeddedness of subsidiaries and specifically their longevity and their links with domestic research institutions as well as Porter's and more recently NEG predictions of the agglomeration forces and cluster formation. Third, to combine to the literature on competence creating vs. competence exploiting subsidiaries with Porter and NEG in order to assess the drivers of R&D in UK regions. Fourth, to assign a hierarchical order to regional technological competences and subsidiary capabilities, of importance to firm decisions. In this respect, our study provides new evidence on R&D decentralization narrowing the level of analysis to the subsidiary's decision to source in-house technology through own R&D operations in particular small geographic milieus within a nation. Previous studies have examined the determinants of R&D decentralization using both location and subsidiary characteristics, nevertheless, the undertaking of R&D by a subsidiary is quite different from the decision to establish a R&D laboratory which implies commitment to carrying out R&D.

The remainder of the paper is organized as follows: in the next section we provide a brief overview of the relevant literature. Section three poses the hypotheses under investigation and describes the data collection process and associated descriptive statistics. Section four analyses the econometric methodology and model specification. In section five, we discuss empirical findings and interpret results. We conclude with a short discussion of potential implications on regional policy and limitations as well as suggestions for future research.

1. Literature Review

The IB literature has recently recognized the significance of the MNE subsidiary as a unit of analysis (Jarillo and Martinez, 1990; Birkinshaw, 1997, 2001). Following debates on the possibility of MNEs organized in a 'federative' mode, recent research points to increasing control by MNE headquarters (Yamin and Forsgren, 2006). Particular attention within this field has been paid to the apparent trend of R&D activities' expansion on a global scale (Gerybadze and Reger, 1999; Pearce, 1999). It is maintained that the decision to decentralize R&D operations stems from the need of the firm to sustain and augment competitive advantage by tapping into the knowledge base of foreign markets (Florida, 1997; Kuemmerle, 1997, 1999) and thus augment the knowledge base of the MNE group. While a firm's unique capabilities and resources can generate competitive advantage (Barney, 1991) competence development may also rely on relationship building and interaction with local agents.

In this respect, the literature on economic geography that focuses on local factors important for the creation of linkages domestically (and thus the subsequent positive externalities), is closely relevant. Drawing on a long lineage of scholars, for example, (Marshall, 1890/1916; Hirschman, 1958; Myrdal, 1957) the theory has lately occupied prominent scholars (Krugman, 1980, 1991; Venables, 1996, Markusen and Venables, 1998; Markusen, 1996). It points to the interaction of local characteristics with firm activities that induce agglomeration of interrelated activities in particular regions. In this context, firm decisions are closely linked to the internal (of the MNE network) environment that contributes to the evolution of competitive advantage of the firm but at the same time they are influenced by factors present at the external environments. The relevance of both the external and the internal environment of firms has first been emphasized by Penrose (1959), who defined the interaction between internal and external, as perceived by firm managers, as a firm's 'productive opportunity'. Birkinshaw and Hood (1998) identify local environment factors, subsidiary choice and headquarters assignment as the three key drivers of the subsidiary's role (formally defined by its charter or mandate) with dynamic feedback effects.

Decentralization of R&D in MNEs has preoccupied many scholars (Håkanson and Nobel, 1993a & b; Howells, 1990; Kuemmerle, 1999; Casson, 1991; Pearce and Papanastassiou, 1999). For Buckley and Casson (1976), *"the search for relevant knowledge in a particular field is also an international operation"* (p. 35). The term "reverse technology transfer" has recently been adopted in the literature, to indicate the potential to generate and/or apply knowledge at any location (Håkanson and Nobel, 2000, 2001; Yamin, 1995, 1999). Cantwell and Mudambi (2005) claim that R&D will tend to be higher in subsidiaries that acquire competence-creating mandates as opposed to those that do not and the award of such a mandate is more likely when the subsidiary is located in a regional center of technological excellence. Simultaneously, the level of competence of a subsidiary has been viewed as highly related to the degree of 'embeddedness' of particular value-added activities in their respective host countries production systems (Kuemmerle, 1999; Dunning, 1996; Cantwell, 1995; Jarillo and Martinez, 1990; Zanfei, 2000; Benito *et al.*, 2003). Dunning and Robson (1988) suggest that MNEs may evolve from country-centered to regional strategies as economic integration deepens. This inevitably induces changes in international sourcing and consequently in technology sourcing patterns.

Despite strong interest, empirical evidence on the role of firm's 'productive opportunity', as it applies to the MNC (subsidiaries) decisions in general and vis-à-vis intra country and inter-regional decisions in particular, is non-existent to our knowledge. The purpose of this paper is to fill this gap, by providing evidence for the central factors that stimulate the establishment of subsidiaries' own R&D laboratories across distinctive regions within the UK. We aim to check the significance of embeddedness and linkage development as well as the economic geography predictions of agglomeration economies for in-house technology sourcing for distinctive types of MNE subsidiaries, with an eye to deriving regional policy implications. According to the early views of the MNE, overseas laboratories were assigned with the single role of assimilating and operationalizing the group's technology in the domestic market. Nonetheless, the wide expansion of R&D labs and their activities, point to the multiplicity of their roles based on the particular needs of the whole group and its relationship to the local environment. Pioneering typologies as to overseas R&D laboratories of MNEs are attributed to Cordell (1971, 1973), Ronstandt (1977, 1978), Håkanson (1981), Hood and Young (1982), Haug *et al*. (1983) Pearce (1994) and Pearce and Papanastassiou (1999). They extend from R&D laboratories, which seem to have solely a supportive role to those that are seen generate new technologies and in independent labs that carry out their own research.

A recent study close to the spirit of our work here is Cantwell and Mudambi (2005). They studied the determinants of R&D intensity between competence-creating and competence-exploiting subsidiaries via responses they obtained through a postal questionnaire carried out in 1994/1995, for investments into the Midlands region for the engineering and engineering – related industry group. Our work complements and extends their study with a separate primary data set of the same period, allowing also for comparisons.

2. Hypotheses Development

We investigate the propensity of subsidiaries to run R&D laboratories in thin geographical areas, i.e., regions of the UK. On the basis of the discussion in the previous section, this decision may rely on both the internal –to the subsidiary- factors, in particular the (perceived) competencies of the subsidiary (according to respondents), and on regional competencies. Such competences can help discriminate between 'higher order' and 'lower order' regions with general technological excellence characterizing the former (Cantwell and Janne, 1999). Following Buckley and Casson (1976), we incorporate three levels of factors: location-specific factors and industry-level factors (external environment) and subsidiary–level factors (internal environment).

2.1 Subsidiary-Level Factors

2.1.1 Embeddedness and Local Linkages

A subsidiary's major decisions are likely to be dependent on its degree of embeddedness to the local milieu, its networking and its ties with local partners. The age of the subsidiary, as it may reflect the degree of its embeddedness in the local environment and consequently its better information and access regarding local needs, input supplies and government initiatives. A subsidiary may be regarded as a platform for the subsequent R&D expansion (Howells and Wood, 1991; Blanc and Sierra, 1999; p.190). In addition, some subsidiaries which may have initially served as market-oriented, or cost-effective units, may have evolved to more autonomous roles. Hence, it can be argued that the greater the local embeddedness of the subsidiary, the higher the likelihood that it will acquire a competence-creating mandate as evidenced by the likelihood of establishing an R&D laboratory (Cantwell and Mudambi, 2005). *AGE* thus indicates the number of years that the subsidiary operates in the host economy.

The effort of firms to augment their R&D competence portfolios on a global scale involves relationship building with academic institutions and research centers of the local market. Due to the relative openness of academic environments, knowledge may be readily diffused into the local environment. Forging links with universities broadens the boundaries of knowledge exploration and speeds up innovation by securing access to scientific researchers. Subsidiaries that are closely interconnected with academic institutions from where they may have sourced their technology in the past are likely to be more prone to set up their own R&D unit in order to collaborate more effectively with their academic partners and absorb, assimilate and "reverse engineer" innovations and ideas developed in those institutions. It is observed that corporate specialists tend to be attracted to areas where other specialists are located, enabling them to tap into existing scientific networks (Davis and Meyer, 2004). The above discussion leads to

Hypothesis 1. The more embedded subsidiaries are (embededness being proxied by longevity and linkages with local knowledge creating partners), the more likely it is that they will establish their own R&D laboratory.

3.1.2. Roles of subsidiaries

Recent subsidiary-level literature has suggested that the greater the extent of subsidiary autonomy, the better the ability of the subsidiary to form favorable external network linkages in its local environment (Andersson and Forsgren, 2000) thus, the stronger the engagement in R&D activities (Cantwell and Mudambi, 2005). A number of authors have classified subsidiaries according to their development and roles assigning different typologies to each group (see Rugman and Bennett, 1982; Poynter and Rugman, 1982; White and Poynter, 1984; Bartlett and Ghoshal, 1986; Birkinshaw and Hood, 2000; Taggart, 1997; Birkinshaw and Morrison, 1996; Pearce, 1995; Crookell and Morrison 1990; Papanastassiou and Pearce, 1999; Holm and Petersen, 2000).Truncated Miniature Replicas (TMRs) are of low autonomy and tend to produce well-established final products already existing in the MNC group value chain. The literature has also identified "implementers" or "branch factories" as those subsidiaries with relatively low autonomy whose main task is to implement the group's existing and already shaped strategy (Bartlett and Ghoshal, 1986; Ghoshal and Nohria, 1993; Young et al. 1994; Taggart and Hood, 1999). Secondly, World Product Mandates (WPMs) have a large degree of autonomy and are assigned with the introduction of innovative products, they are the ones in charge of expanding the product line of the MNC group. WPMs are found on the top of "competence ladder" and correspond to "strategic leaders" (Bartlett and Ghoshal, 1986;) "centers of excellence" (Andersson and Forsgren, 2000); "global innovators" (Gupta and Govindarajan, 1991)[2]. Expanding the above typology, we hereby identify a third type of subsidiary that is attributed a more specialized, narrow product mandate, related to horizontal integration (Papanastassiou and Pearce, 1999; Venables, 1999. We introduce this as the Specialized Miniature Replica (SMR), (though in broad terms it falls within the TMR category). SMRs have little autonomy. The above lead us to

Hypothesis 2: A higher degree of subsidiary autonomy increases the likelihood of engaging in R&D activities as this is evidenced by the establishment of own R&D unit.

3.1.3 Other Firm-Level Factors

Other firm characteristics of significance to subsidiaries' sourcing patterns recognized in the empirical literature (UNCTAD, 2001), are the following.

Size of subsidiary – Size may be an important determinant of innovative activity (one of the major hypotheses attributed to Joseph Schumpeter) (Veugelers, 1996; Smith *et al*.; 2000; Kuemmerle, 1999). The larger the subsidiary, the easier it is believed to be to exploit economies of scale in R&D and the greater the ability to spread risks over a portfolio of projects. In addition, large subsidiaries are easier to create linkages and get access to local pool of inputs. Importantly, they can find more easily necessary funds to expand. We measure the subsidiary's size by the volume of sales as indicated in questionnaire responses *(SALES).* This is in line with Penrose's approach too, albeit in Penrose's (and also in Schumpeter's writings) the causality goes from innovation to size (see Cantwell, 1991; Pitelis, 1991 and Cainelli et al, 2005) for evidence. We return to this issue or causality later.

Export orientation – The more a subsidiary is engaged in exporting part of its production, the higher its underlying competitive strength is likely to be. Such competences will tend to help

[2] See Rugman and Verbeke, 2001 for a thorough discussion on the internal patterns of competence creation in MNC groups).

the affiliate to source its technology inputs from in-house operations, rather than from elsewhere in the group, or from other local sources. It has been shown that more externally oriented subsidiaries have better capabilities in consolidating competitive advantages (Mudambi and Navarra, 2004), and in this respect they are expected to be more prone to advance their own R&D facilities. In addition, Hughes (1986) suggests a positive relation between the two on the grounds of the wider market served by the firm (also Kleinknecht and Poot, 1992).

Entry Mode – The mode of entry of a foreign affiliate into a market can make a difference as to the subsequent decision to engage in R&D functions. In the case of a take-over for example, the existing production facility may already run its own R&D laboratory. Mergers and acquisitions, moreover, are often seen as a means through which MNEs may gain access to technological resources and skills (Grandstrand and Sjolander, 1990; Pearce, 1989). Others point to difficulties of mergers, due to the varying objectives between merged organizations (David and Singth, 1993). A third group considers this to be irrelevant (Paoli and Guercini, 1997). Mudambi and Navarra (2004) contending that entries through acquisition, are likely to be associated with higher levels of knowledge production. Survey evidence has often suggested that most foreign-located R&D in MNEs is the result of acquisitions (Cantwell and Mudambi, 2005). The above leads to the following

Hypothesis 4: Larger subsidiaries are more likely to develop their own R&D operations.

Hypothesis 5: More export-oriented subsidiaries are, the more likely it is for them to develop own R^D operations.

Hypothesis 6: Entry through acquisitions is more likely to engender the creation of own R&D facilities than greenfield investment.

3.3 External Environment

3.3.1 Agglomeration Factors

To proxy agglomeration forces, we include three variables that reflect concentrations of R&D operations.

R&D lab concentrations – Spillover effects and mimicking behavior may act positively in the decision to establish an in-house laboratory. Thus, the existence of other R&D laboratories in the region may propel further R&D establishments. Innovative activity is indeed highly agglomerated (Jaffe *et al*., 1993; Keller, 2002), in part because proximity enables the exchange of tacit knowledge (Cantwell and Piscitello, 2003). Accordingly the concentration of R&D labs *(AGGLORD)* may be an additional pull factor.

Sectoral concentrations – Concentrations of related and supporting industries or activities within a region is widely acknowledged to be important in the relevant literature (Porter, 1990, Braunerhjelm *et al*., 2000; Paci and Usai, 2000). Managers may find it advantageous to establish their own R&D operating units not because they want to source their own technology in the first place, but because locating near related industries (Porter, 1990; Maskell and Malberg, 1999) may allow them to benefit from technology spillovers. The included variable is symbolized by *AGGLOSE.*

Sectoral R&D concentrations – Another most relevant concentration is that of subsidiaries belonging to the same sector and running at the same time their own R&D laboratory *(AGGLORDSE)*. MNEs need to be on-site with their innovatory capacity to access benefits from localized knowledge (Cantwell, 1989, Almeida, 1996; Cantwell and Iammarino, 1998). This is a case where interconnected firms may benefit the most through direct R&D externalities. This leads to

Hypothesis 7: Agglomerations of activities belonging to the same sector and in particular concentrations of R&D activities either in the same or other sectors are reinforcing factors in the decision of a subsidiary to build its own R&D facilities

3.3.2 Local Competencies

Besides agglomeration variables, the existence of particular local competences may potentially reinforce the decision of a subsidiary to engage in its own R&D operations. According to a study by the French Ministry of Research (Madeuf, 1992) of 30 firms under forwign control, over half emphasized the country's scientific and technological tradition, the availability of skilled researchers and the science and technology infrastructure as the three main benefits of locating R&D in France. In their study, Gerybadze and Reger (1999) concluded that research-intensive companies in fields like genetic engineering and advanced solid-state physics emphasized the significance of access to unique resources and leading research talents in particular areas with strong international reputations. Such competency include the following

R&D personnel – The existence of a pool of R&D personnel in the host region may be a pull factor in the decision to engage in own R&D, since the lab can recruit local skilled workforce. Kuemmerle (1999) termed the presence of researchers the "scientific excellence" of a country, while Florida (1997) considers scientific talent a crucial motivating element for an R&D operation.

R&D expenditures – The amount of R&D expenditures relative to the output of a region may be of interest to subsidiaries wishing to source their technology through the establishment of own R&D. Total R&D spending includes both business R&D spending and the commitment of the region to upgrade technological potential. It is therefore considered a measure of knowledge seeking behavior (Chung and Alcacer, 2002) or else a source of economic knowledge (Audretsch and Feldman, 1996). *RADSHR* thus captures the degree of commitment of a local community to advance its research base.

Technological output – The number of patents registered in a region can be seen as an indication of its innovation potential, and also the effectiveness of local activities to advance technological sophistication. Cantwell and Piscitello (2001) use regional patents to capture the amount of specific knowledge available locally. This may act negatively in cases where subsidiaries are not competitive enough. However, this is likely to apply to the decision to establish a foreign affiliate and not in the subsequent decision to engage in own research once a subsidiary already operates. Maskel (2001) finds that even in the case of protected knowledge by a patent, information often spills over to other firms. The share of innovative output to the regions gross output is hence used *(EPASHR)* to check for possible triggering effects on the decision to engage in own R&D sourcing. There follows

Hypothesis 8: MNE subsidiaries are more likely to establish their own R&D unit in regions with a science base and highly skilled workforce

3.4 Control Variables

3.4.1 Industry-Level Factors

Technology intensity – Broadly speaking, more technologically intensive industries would be expected to be more prone to engage in own R&D research. The source of technology is believed to *"differ substantially by industry and technical field"* (Florida, 1997, p. 86) while high technology competence industries are assumed to affect positively R&D involvement

(Dixon and Seddighi, 1996; Rosenberg and Nelson, 1994). A dummy of 1 is included if sectors are classified as high -tech[3] and 0 otherwise.

3.4.2 Origin

Region of origin The location of research operations may vary according to the country of origin (Le Bas and Sierra, 2001). To account for this we have categorized foreign affiliates coming from Europe, America and the Pacific Rim. Dummies for Europe and America are thus included in our models to tentatively discern potential differentiation.

4. Method

4.1 The sample

The current study uses three levels of data: location-specific data, subsidiary data and industry-level data. Industry level data are used mainly for classification purposes and correspond to 1992 UK Standard Industrial Classification code. The subsidiary-level data were derived from a survey of foreign subsidiaries operating in the UK through a postal questionnaire. Foreign firms operating in the UK were extracted from the Lexis-Nexis database of International Directory of Corporate Affiliations (1992). The sampling process was aimed at subsidiaries with parent - companies enlisted in Fortune 500, thus the final version of the questionnaire was posted to 812 subsidiaries

The survey was conducted in 1994-1995 and the questionnaire was sent via normal post twice within a three months period. Two reminders were faxed to the subsidiaries that had not responded three and six weeks after the survey was first mailed out. The majority of the filled questionnaires were received after the first round. The questionnaires were answered by the

[3] Sectors classified as high-tech are: Aerospace, Electronics, Instruments, Chemicals and Pharmaceuticals, whilst Medium Technology sectors comprise of Automobile, Buildings, Mechanicals, Metals, Rubber, Food and Other industries.

subsidiary's executive officers, however, when this was not feasible the R&D manager replied instead. Overall, we collected 190 replies, which represent a respond rate of 23.3%. This compares favourably with response rates obtained in similar surveys (Harzing, 1997). We excluded one reply due to inadequate information, thus we were finally left with 189 valid responses[4].

Non-response bias was investigated with the Armstrong and Overtin (1977) method, which involved comparing early and late respondents. The comparisons were carried out with the use of a χ^2 test of independence. In all cases, the responses were found to be virtually indentical.

Information from the International Directory of Corporate Affiliations (1992), from where firms were originally extracted, allowed us to identify the specific region of operation of foreign subsidiaries.

The regional breakdown of the UK was based on extant classification of UK National Statistics[5] albeit we chose to merge some neighbouring regions. As the UK National Statistics distinguishes among twelve regions, it would be difficult to obtain reliable results at least for some regions with the existing number of responses. Consequently, we merged some to a total of seven larger regions. These comprise London and Home Counties, Midlands, Northern Ireland, North, Scotland, South and Wales. Both the original and our regional classification are depicted in Table 1, Appendix I.

Data on regional characteristics and particularly local technological competencies were obtained from various issues of the "Regional Statistical Yearbook" published by Eurostat for

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[4] In models presented, it appears that the number of observations is less than that. This is due to the fact that some of the firms haven't given a reply on the specific questions used in the analysis. Thus, we end up with a range of 163-179 firms in the econometric analysis.

[5] (http://www.statistics.gov.uk/)

the early nineties depending the year of availability[6]. Regional agglomeration variables were constructed from the questionnaires.

More than half of the respondent firms (54.2%) indicated that they operate their own R&D laboratory.

Figure 1 shows schematically the distribution of foreign affiliates operating their own R&D laboratories within the boundaries of seven UK regions.

Insert Figure 1 here

The majority of R&D labs are in London and the Home Counties (L&HC) with a share of 33.98%, while North and Midlands are the second and third most populated –in terms of R&D labs- regions with 25.2% and 20.4% respectively. Northern Ireland hosts the least number of subsidiaries with R&D labs. It's worthwhile to note that the South, does not emerge as an attractive base for R&D operations (with a relevant share of only 5.8%) despite its proximity to London.

A classification of R&D facilities was made according to the sector their subsidiaries belong to. Figure 2 presents the distribution of R&D labs based on their operating sector [7].

Insert Figure 2 here

The majority belongs to the Electronics and Electrical Equipment sector followed by Chemicals. From them, the majority of the former is located in the L&HCs and the Midlands, whilst North and L&HC are the most preferred regions for Chemicals.

In total, 65 subsidiaries replied that their primary or major role is WPM. Of these, 49 run their own R&D unit, i.e. a share of 75.4% while 16 do not. A distribution of WPMs that run their

[6] A large number of R&D labs were established in late eighties and early nineties. However, there is a number of subsidiaries that have established much earlier. For comparison purposes we had to stick on a specific time frame. Besides, based on the fact that there is always the possibility of terminating operations if local conditions are not any more favorable, it is logical to assume that R&D labs still operate when the questionnaire took place, it must be due to existing local technological infrastructure.

[7] The respective shares are depicted in Tables 2 and 3 of Appendix A.

own R&D laboratory may be found in Table 4, Appendix B. It is evident that London and the Home Counties again host the majority of them, followed by North, the Midlands and Wales. The distribution follows the one of all types of subsidiaries that host R&D labs comparing the corresponding tables.

An infrormative illustration of the distribution of foreign subsidiaries in our sample operating their own R&D laboratories in respective UK regions is shown in Tables 2-4 of Appendix B. The classification is with respect to total number of affiliates. [8]

4.2 Econometric Techniques

We examine whether a subsidiary operates an R&D laboratory. Thus, we have a discrete choice model where the dependent variable is a binary one taking the value 1 if the answer is 'yes' and 0 if the answer is 'no'. Discrete choice models do not lend themselves readily to regression analysis nevertheless there are models that link the decision or outcome to a set of factors (Greene, 2000). The approach is to analyze these kinds of models in the general framework of probability models:

$$\text{Prob(event } j \text{ occurs)} = \text{Prob}(Y = j) = F[\text{relevant effects: parameters}] \qquad (6.1)$$

Hence,

$$\begin{aligned} \mathbf{Prob}(\boldsymbol{Y} = \mathbf{1}) &= \boldsymbol{F}(\boldsymbol{x}, \boldsymbol{\beta}) \\ \mathbf{Prob}(\boldsymbol{Y} = \mathbf{0}) &= \mathbf{1} - \boldsymbol{F}(\boldsymbol{x}, \boldsymbol{\beta}) \end{aligned} \qquad (6.2)$$

Where $\boldsymbol{x}$ is a vector of factors that explain the decision and $\boldsymbol{\beta}$ is the set of parameters reflecting the impact of changes in $\boldsymbol{x}$ on the probability. Most widely used in such cases is the logistic distribution partly because of its mathematical convenience:

$$\mathbf{Prob}(\boldsymbol{Y} = \mathbf{1}) = \frac{e^{\beta' x}}{1 + e^{\beta' x}} = \Lambda(\boldsymbol{\beta}' \boldsymbol{x}) \qquad (6.3)$$

[8] An analytical breakdown of UK regions may be found in Appendix A.

where *Λ (.)* indicates the logistic cumulative distribution function. The logistic distribution is similar to the normal except in the tails, which are considerably heavier (Greene, 2000)

The model then takes the following form:

$$Y_i = \beta_0 + \beta_j X_1 + \beta_k X_2 + \beta_l X_3 + \beta_m X_4 + \beta_n X_5 + \varepsilon_i \quad (6.4)$$

where Y_i is the binary dependent variable, taking the value of 1 if the respective subsidiary owns an R&D laboratory and 0 if it doesn't. X_1 contains our basic variables of interest, X_2 contains the external environment agglomeration forces, X_3 is a vector of variables capturing the internal to the firm characteristics, X_4 is a vector of variables that indicate the technological sophistication of the external environment, and X_5 contains the control variables discussed above.

More specifically, X_1 contains *EMBED, LINK and the role of the subsidiary,* X_2 contains agglomeration forces, X_3 includes *SIZE*, *PROPEXP, ENTRY,* X_4 accounts for *RDPERSHR, RADSHR* and *EPASHR,* whilst X_5 controls for home origin and sector intensity.

The estimation of binary choice models is based on the method of Maximum Likelihood (ML) where each observation is treated as a single draw from a Bernoulli distribution (Greene, 2000).

In order to isolate the preferred model we followed the 'general to specific' method (Hendry, 1987, 1995). This involves starting from the most general specification and gradually removing the least significant variables, until we reach our 'preferred' from the data model (using statistical criteria significance tests, regression diagnostics and misspecification tests). The gradual elimination of the non-significant variables led as to the 'preferred equation' (No 1.1)[9].

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[9] For comparison and robustness check we also followed another methodology, the one proposed by Sala-i-Martin (1997). Although his work refers primarily to testing for growth, his methodology is arguably applicable in other models. Sala-i-Martin suggests that in order for one to be sure whether her variables of interest are robust and significant, she must follow the following procedure: First, always keep in the model the two or three variables that according to theory and empirical testing affect the dependent variable (first set of variables)[9]. Then add other variables of interest in the model that are to be tested (second set of variables). Now, from the

A number of econometric tests have been performed in order to test for robustness of our results. To start with, we tested for specification error in our models, none of which turns out to suffer from this problem. Then we proceeded to goodness-of-fit tests.

In order to account for potential multicollinearity problems we calculated the *variance-inflation factor* (VIF) and the *condition number* (C.N.) (Greene, 2000, Maddala, 1977a, 1992). Belsley, Kuh and Welch (1980) argue that *condition numbers* less than 20 are not indicative of a problem. Serious collinearity was detected between the *RDPERSHR* and *RADSHR* variables as well as between *AGGLOSE* and *AGGLORDSE*. To resolve this problem, the respective variables were orthogonalized and used in regressions. Both the *VIFs* and *C.N.s* (for models that we already have encountered orthogonal variables) are reported at the bottom of the tables[10].

To compare various models and finally answer our research questions, we used the Bayesian Information Criterion (BIC′) rather than the pseudo-R^2s (McFadden's R^2 – likelihood-ratio index can be as low as zero). The pseudo-R^2s provide only limited information as to the comparability of models and can only be used for nested models. In contrast, the BIC′ is advantageous in that it can be used to compare even non-nested models and it uses the likelihood ratio chi-square. The smaller the BIC′, the better it is. Depending on the absolute difference of BIC′s between two models, it is possible to conclude in favor of one model vs. another (UCLA web courses)[11].

The Likelihood Ratio (LR) test shows that the models tested are robust in all cases.

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pool of variables that have been occasionally found in the literature that influence the dependent variable, choose different combinations of three variables and add these combinations to the above model (third set of variables). With such a testing, if one's variables of interest turn out to be persistently significant, then it is arguably the case that those variables are robust. In our estimation, there is no particular theory and empirical evidence to provide variables that belong to the first set of variables above.

[10] Analytical tables with the eigenvalues of the variables are available upon request.

[11] http://www.gseis.ucla.edu/courses/ed231c/notes3/fit.html

5. Discussion of Results

Our results confirm our hypotheses. In particular, embeddedness in local milieu and existence of collaborations with scientific institutions and research centers locally are of particular importance for the decision of a firm to establish own R&D facilities. Hypothesis 2 is also reaffirmed as to the higher propensity of competence-creating subsidiaries to establish own R&D laboratory as WPM comes out persistently significant while this is not the case for TMRs and SMRs. Moreover, specific agglomeration of R&D concentrations of the same sector, acts as a catalyst to this decision. Beyond our basic hypotheses, firms' propensity to export and mode of entry (if it is a takeover) are factors that influence that decision[12].

Synergistic interface is perceived of great relevance for the future success of a new R&D operation (Cantwell, 1991; Taggart, 1991, Cantwell and Piscitello, 2003). Those factors are the ones to manifest significant outcomes for the rest of models.

Insert Table 1 here

Concerning the region of origin, (whether subsidiaries belong to European, American or Pacific parent) this seems to make no difference here, (although in general there is support in the literature in favor of more research orientation of Japanese firms). Technology intensity of the particular sector is non-significant either. However, we must stress here that the rest of the results remain the same, pointing to their robustness.

Overall, the results are in line with the New Economic Geography (NEG) predictions of the cumulative causation mechanisms of knowledge externalities spurring agglomerations of interconnected operations sharing common interests and specialisms. Internal factors reflecting subsidiary competencies are placed in the priority list with the embeddedness element and established linkages providing support to the role of firm 'productive opportunity'.

[12] The above results are confirmed when using the methodology suggested by Sala-i-Martin.

6. Concluding Remarks, Limitations and Implications

Our results are in line with the RBV view that intra-firm factors are important determinants of a firm's decisions, but also lend support to the idea that the external environment matters. The last mentioned included the industry (Porter, 1980), but also the regional milieu. While firm and industry-related factors are harder to be effected by local policy makers, the regional milieu is more amenable to (local) government intervention. In this sense our results provide useful hints as to the sort of factors that policy makers should target, if they wish to influence an MNE subsidiary's decision to set-up an R&D lab locally. While our results are derived in the context of different regions with a particular developed economy, we submit that they could be indicative of the sort of considerations/policy tools that can be used by host countries to attract high value added FDI/MNE activities, such as R&D.

Troubling is the observation that a certain degree of local development is a prerequisite for the attraction of high-level MNC activities thus further development- pointing to cumulative causation. Alongside, increased centralisation of MNC decision making, by MNC headquarters (Yamin and Forsgren, 2006), this way tend to hinder the developmental prospects of less favoured regions, or countries, see Dunning and Narula (2004). At the same time, however, the possibility of diagnosing and upgrading local clusters and/or sub-national systems of innovation/centres of excellence and of forging linkages, (UNCTAD, 2001) and provides a useful tool that may help perseverent capable (local) government to break the underdevelopmnent cycle.

These follow evident implications for managerial practise too – namely if MNE top management considers using subsidiaries as local knowledge champions and/or if subsidiary management considers operating theior own labs, they should select locations which satisfy the characteristics discussed in this paper.

Our study has various limitations. First, our database is rather dated. While we aknowledge this caveat, this is not uncommon in such studies. Importantly, we can think of no obvious reason why the sort of decision we are exploring here, might have changed in the past ten years or even if it has, knowing the determinants of such decisions in the 1990s could still be interesting, especially if found to differ from MNE decision to date. For exapmle, Cantwell and Mudamni (2005) and Davis and Meyer (2004) are good exapmples of them using a questionnaire survey in 1994/1995 and 1996/1997 respectively. A more recent survey would be of great usefulness and would enable comparisons as to the dynamic evolvement of the local-subsidiary-industry framework developed in this study over time. Another limitation of our analysis concerns the issue of causality, notably in the context of the relationship between size and R&D. We were not able to test for bi-causal links, which is a limitation. Also we proxied intra-firm factors with size and export orientation,while in line with the RBV, it would be helpful for more fine features of intra-firm determinants to be used. This remains a problem for the RBV as a whole (see Pitelis, 2007). We do hope to address such limitations in future work and motivate others to do so.

Table 1. Econometric Results: Dependent Variable: RDLAB (1/0), Logit estimation General-to-specific methodology

	(1)	(2)	(3)	(4)
EMBED	0.774	0.765	0.727	0.715
	2.30**	(3.17)***	(3.13)***	(3.33)***
LINKS	0.732	0.714	0.652	0.649
	(1.88)**	(1.90)**	(1.78)*	(1.82)*
AGGLOSE	0.087			
	(0.28)			
AGGLORD	0.04	-0.018		
	(0.93)	(-0.62)		
AGGLORDSE	1.197	0.207	0.193	0.182
	(3.66)***	(2.52)***	(2.96)***	(3.00)***
SALES	0.131	0.166	0.158	
	(0.85)	(1.22)	(1.19)	
PROPEXP	0.026	0.023	0.025	0.022
	(2.75)***	(2.95)***	(3.42)***	(3.32)***
NEWCOM	-0.09			
	(-0.12)			
TOVER	0.966	1.033	0.989	0.959
	(1.16)	(1.93)**	(1.88)*	(1.88)*
RDPERSHR	0.324	-0.002		
	(1.21)	(-0.02)		
RADSHR	-0.256)			
	(-0.64)			
EPASHR	86.36	48.471	56.56	
	(1.17)	(0.82)	(1.16)	
WPM	1.476	1.493	1.555	1.5
	(2.73)***	(2.94)****	(3.26)***	(3.35)***
TMR	-0.473	-0.198		
	(-0.99)	(-0.46)		
SMR	0.292			
	(0.58)			
TECHINT	0.845	0.216		
	(1.61)*	(0.47)		
EU	-0.454			
	(-0.64)			
AM	-0.271			
	(-0.43)			
Constant	-7.2	-5.981	-6.296	-5.016
	(-4.15)***	(-3.90)***	(-5.32)***	(-5.41)***
N	163	163	164	170
Pseudo R2	0.3691	0.2908	0.2880	0.2661
LR chi2	82.58	65.07	64.78	61.65
BIC´	9.112	-3.948	-23.985	-30.834
Pearson chi2	186.98	209.31	213.89	218.75
Mean VIF	2.07	1.74	1.16	1.09
C.N.	25.58	30.02	14.69	10.47

Note: The BIC´ uses the likelihood ratio chi-square. The smaller the BIC´, the better it is. Depending on the difference of BIC´s between two models, we conclude in favor of one model vs. another.
The scale shown below can assist in interpreting the difference in two models (http://www.gseis.ucla.edu/courses/ed231c/notes3/fit.html).

Absolute Difference Evidence
0-2 Weak, 2-6 Positive, 7-10 Strong, >10 Very Strong

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APPENDIX A

Figure 1. Regional breakdown of R&D laboratories

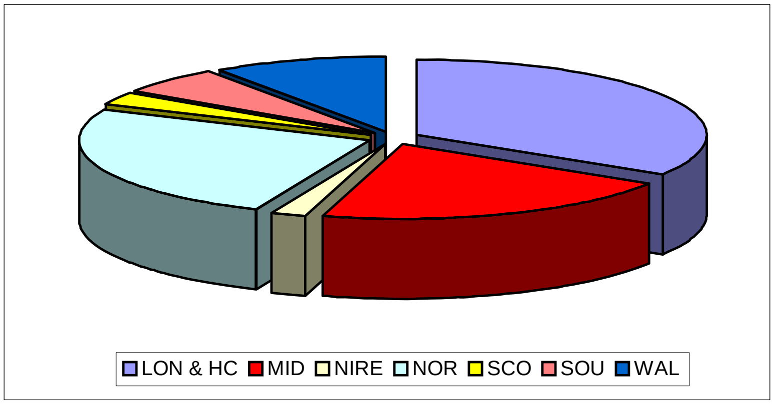
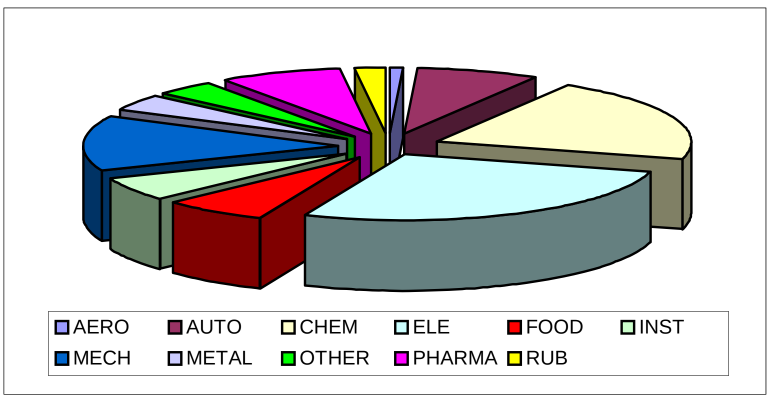


Figure 2. Sectoral breakdown of R&D laboratories



APPENDIX B

Table 1. Regional Characteristics for selected variables

REGION	VARIABLE		
	RDPERSHR	RADSHR	EPASHR
LONDON&HC	11.71	3.96	0.35
MIDLANDS	8.6	2.46	0.20
NIRE	2.91	1.23	0
NORTH	8.17	2.83	0.44
SCOTLAND	5.62	2.07	0.25
SOUTH	11.22	3.26	0.31
WALES	3.38	1.33	0.25

Table 2. Distribution of foreign affiliates having an R&D laboratory by host UK region

REGION	TOTAL
LON & HC	33.98%
MID	20.39%
NIRE	1.94%
NOR	25.24%
SCO	2.91%
SOU	5.83%
WAL	9.71%
GRAND TOTAL	**100.00%**

Table 3. Distribution of foreign affiliates having an R&D laboratory by sector

SECTOR	TOTAL
AERO	0.97%
AUTO	7.77%
CHEM	20.39%
ELE	27.18%
FOOD	6.80%
INST	5.83%
MECH	13.59%
METAL	3.88%
OTHER	3.88%
PHARMA	7.77%
RUB	1.94%
GRAND TOTAL	**100.00%**

Table 4. Distribution of WPM foreign affiliates having an R&D laboratory by host UK region

REGION	WPMs with R&D lab
LON & HC	32.65%
MID	18.37%
NIRE	2.04%
NOR	28.57%
SCO	4.08%
SOU	4.08%
WAL	10.20%
GRAND TOTAL	**100.00%**

Note: The sectoral classification is as follows: High technology Sectors include Aerospace, Electronics, Instruments, Chemicals and Pharmaceuticals, whilst Medium Technology sectors comprise of Automobile, Buildings, Mechanicals, Metals, Rubber, Food and Other industries.

APPENDIX C

Table 1. Description and Source of Variables

VARIABLES	DESCRIPTION
INTERNAL ENVIRONMENT-	
SUBSIDIARY ROLES	
I. Firm characteristics	
SALES	Logarithm of sales of million UK currency, Q.R.
AGE	Number of years the subsidiary has been established in host country, Q.R.
PROPEXP	Share of production exported, Q.R.
NEWCOM	Dummy=1 if it is a greenfield investment, 0 otherwise, Q.R.
TOVER	Dummy=1 if it is a take-over, 0 otherwise, Q.R.
II. Sector	
HIGH-TECH	Dummy=1 if it is a high-tech sector, 0 otherwise, Q.R. and authors' calculations
III. EMBEDDEDNESS & LINKS	
EMBEDDEDNESS	No. of years of establishment in logs, Q.R. and authors' calculations
LOCAL LINKS	Dummy=1 if the subsidiary cooperates with universities and research centers and 0 otherwise, Q.R.
I. Technology	
RDPERSHR	Share of R&D personnel in total employment, Regional Statistical Yearbook, Eurostat and authors' calculations
RADSHR	Share of R&D expenditures in host region GDP, Regional Statistical Yearbook, Eurostat and authors' calculations
EPAGDP	Share of patents registered in the region to GDP, Regional Statistical Yearbook, Eurostat and authors' calculations
II. Agglo	
AGGLORD	Number of affiliates having an R&D lab in the region, Q.R. and authors' calculations
AGGLOSE	Number of affiliates belonging to the same sector in the region, Q.R. and authors' calculations
AGGLORDSE	Number of affiliates belonging to the same sector and having an R&D laboratory, Q.R. and authors' calculations
CONTROL VARIABLES	
II. Origin	
EUROPE	Dummy=1 if parent is European, 0 otherwise, Q.R.
AMERICA	Dummy=1 if parent is American, 0 otherwise, Q.R.