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MNE Competence-Creating Subsidiary Mandates: An Empirical Investigation

By
John A. Cantwell*
and
Ram Mudambi**

Abstract

Most larger firms report some R&D expenditure. However, the determinants of R&D expenditure are not necessarily the same for all firms, or for all subsidiaries in an MNE. The qualitative nature of R&D behaviour (and hence also the extent of investment in R&D) differs, depending upon whether a subsidiary is assigned a competence-creating mandate. There are two contrasting models. The simple model estimates the R&D/Sales ratio as a direct function of a vector of explanatory variables, where the subsidiary mandate is treated as an exogenous variable, expected to have a positive effect. The strategic model treats the subsidiary mandate as a prior variable chosen strategically by the firm, i.e., the grant of a competence-creating mandate to a subsidiary is not a random event and therefore cannot be used as an exogenous variable. Using data on UK subsidiaries of non-UK MNEs, we find substantial support for the model of strategic choice. Further, we find that the R&D investments of subsidiaries with mandates is both qualitatively and quantitatively different from that of subsidiaries that do not.

* John Cantwell is Professor of International Economics at the University of Reading.
** Ram Mudambi is Associate Professor of Strategic Management at Temple University and Reader in International Business at the University of Reading.

Address for correspondence:
Professor John Cantwell
Department of Economics
University of Reading
PO Box 218, Whiteknights
Reading **RG6 2AA**,UK

Phone: 44-118-987-5123
FAX: 44-118-975-0236
Email: j.a.cantwell@reading.ac.uk

1. Overview

Historically, MNEs located R&D in their affiliates abroad mainly for the purposes of the adaptation of products to local tastes or customer needs, and the adaptation of processes to local resource availabilities and production conditions. In recent years instead, linked to the closer integration of affiliates into international networks within the MNE - at the heart of what is commonly termed the 'globalisation' of production and technology - affiliate R&D has gained a more creative role, to generate new technology in accordance with the comparative advantage in innovation of the country in which the affiliate is located (Cantwell 1995, Papanastassiou/Pearce 1997). This transformation has led to an increase in the level of R&D undertaken in at least some affiliates, and in affiliates in which R&D is expanded there has been an upgrading in the types of research project away from the purely applied towards the more fundamental; although the research undertaken is generally of an (increasingly) specialised kind, to take advantage of the particular capability of local personnel and the other local institutions with which the affiliate is connected.

The shift towards internationally integrated strategies within MNEs is partly associated with a change in the economic environment in the post-war period based on a decline in transport costs and tariffs and the appearance of new communcations technologies, which has created a global economic imperative and the emergence of 'heterarchical' organisational structures in many industries (Doz 1986, Hedlund 1986). It is also grounded on a 'life cycle' effect within what have become mature MNEs, which have now created a sufficient international spread in their operations that they have the facility to establish an internal network of specialised affiliates, which each evolve a specific regional or global contribution to the MNE beyond the concerns of their own most immediate market (Cantwell/Piscitello 1999, 2000). Thus, what began as local market-oriented (import-substituting) affiliates are gradually transformed into more export-oriented and internationally integrated operations. While some of the affiliates within such a network may have essentially just an 'assembly' role, others take on a more technologically creative function and the level and complexity of their R&D rises accordingly. Hence, we expect to find that, on average, R&D-intensity increases with the age of affiliates, as the corporate life cycle unfolds. Indeed, the duration of subsidiary operations appears to summarise a number of experience-related concepts and to function as a good predictor of overall MNE investment (Mudambi 1998), i.e., duration affects not only the ‘quality’ of MNE investment, but its quantity as well.

There is also evidence that R&D-intensive MNEs tend to grant more responsibilities to their subsidiaries. It has been reported that Japanese R&D-intensive firms are more likely to have manufacturing operations in the US (Hennart/Park 1993, 1994). Thus, such MNEs are likely to move along the corporate life cycle more quickly. Given the age of affiliates, those with R&D-intensive parents are likely to be have more highly developed mandates.

The extent to which affiliate R&D grows depends as well on the competitive strength of the MNE and the conditions of its home country environment, on the nature of the international industry of which it is part, and finally (on which we focus in this paper) on conditions in the host country in which it is located, including the economic policies of its government. Historically, it was corporate technology leaders that led the internationalisation of R&D; today, these MNEs lead in the international integration of corporate networks for technology creation (Cantwell 1995). So, competitively stronger MNEs are more likely to locate R&D abroad, and to have a greater variance in the levels of R&D across affiliates, with R&D becoming especially concentrated in sites where local conditions are most conducive to technology creation. The extent of their foreign research depends also on the nature of the industry. The global economic imperative is outweighed in some industries, such as aircraft, by the political imperative to be nationally responsive to governments as customers, or in others such as some kinds of food products, to service highly differentiated local tastes (Doz 1986). The foreign location of R&D increases as well with the extent of international competition in an industry; if there are more centres of excellence, then each major MNE will require a technological base in a wider geographical range of sites outside its own home centre, and international cross-investments between the leading centres will be more intensive. The absolute size of the MNE's home country matters too, since generally it remains the single most important centre for the firm's technological development (Patel 1995); mainly because of the large technological size of the US and Japan in most industries, US-owned and Japanese-owned MNEs have had much lower shares of foreign-located research than have their European-owned counterparts (Cantwell/Harding 1998).

2. The Role of Local Competencies

The extent of international technology dispersion will vary between an industry in which one leading MNE predominates (say, IBM in mainframe computers), and an industry in which groups of major rivals coexist (say, pharmaceutical MNEs based in the USA, Germany, Switzerland and the UK). In the former case, technology will be rather more centrally controlled, and its dissemination tends to run in just one direction.

Innovation diffusion outside the MNE is limited to a range of more specialised companies, which typically compete in market segments in which the leader is less involved. In the latter case, the transmission of technology within the MNE way well run in more than one direction, and it may further interact with the efforts of other MNEs including those originating from other centres, for which it becomes an input to their own technology creation.

The location of poles of innovatory capacity in an international industry may affect the nature of the competitive advantages of firms (determining which countries are sources of the strongest MNEs), as well as influencing the location of MNE activity. A shift in the location of innovatory capacity will strengthen the position of the firms, which will increase their stake in the creation of technology. An example of this in recent years is the gradual movement of Japanese firms from the adaptation of existing, to the innovation of new technology in a number of sectors (such as motor vehicles and consumer electronics), and alongside this increased innovativeness they have expanded their activities abroad. In today's international economic environment, MNEs that operate in industries characterised by strong, oligopolistic (or technological) competition normally need a direct presence in each of those countries which hold leading positions in the development of their industry and of associated technologies (Ohmae 1985).

We have suggested that the extent and speed of international technology dissemination by MNEs depends upon the structure of the industry in question, the strengths of the constituent firms and their geographical configuration. Consider first an industry that is located in a number of countries, each of which is home to a group of highly innovative firms. This base of technology creation helps to support a network of exports and international production in each case, though, with the emergence of internationally integrated strategies, each firm also becomes dependent upon the co-ordination of connected activities. Over the last 25 years, this is the kind of industry that has been characterised by the rise of the cross-hauling of investments between these countries harbouring the strongest firms. Such countries become hosts to the greatest levels of international production as well as being homes to MNEs of their own. Such intra-industry trade and production are also usually accompanied by intra-industry technology flows as well.

It is in this kind of industry that those countries that have become poles of innovation tend to build up a position of competitive advantage in international trade or as host to foreign-based MNEs. This position is achieved by the continuous innovation and growth of production of its own firms and also of the affiliates of foreign MNEs, which develop their technology in the light of local knowledge, fields of competence or skills, and customer requirements. Indeed, one reason why MNEs may invest heavily in a centre of excellence is to take advantage of the agglomerative economies offered by a flourishing innovatory environment. By so doing they may advance the technological capacity of the country. The firms of each country tend to embark on a path of technological accumulation that has certain unique characteristics and sustains a distinct profile of national technological specialisation (Rosenberg 1976, Pavitt 1987, Cantwell 1991). Moreover, the kinds of linkages that grow up between competitors, suppliers and customers in any one regional district or country are also, to some extent, peculiar to that location, and imbue the technology creation of its firms (which depends on such linkages) with distinctive features. For these reasons, other MNEs often need to be on-site with their own production and their innovatory capacity if they are to properly benefit from the latest advances in geographically localised technological development, to feed their own innovation (Cantwell 1989, Kogut/Chang 1991). Moreover, due to the complexity of technological learning, and the significance of maintaining face-to-face contacts, the localisation of technological contacts tends to occur at a regional level within host countries (Jaffe/Trajtenberg/Henderson 1993, Almeida 1997, Cantwell/Iammarino 1998).

By contrast, where the technological capacity of a host country is weak in the sector concerned, the investments of MNEs may drive out local competition and reduce local technological capability still further (Cantwell 1987). Foreign-owned affiliates tend to import a higher proportion of their inputs than do indigenous firms, particularly in the early years of their operations, or where they constitute the assembly stages of a globally integrated network. Even where host governments set targets for a gradual increase in the local sourcing of components - particularly those which involve high value added activities (e.g., tubes for TV sets, wafers for microchips, chemicals for pharmaceuticals, etc.) - subsidiaries of foreign companies supplying the parent MNE in its home country may be established to fulfil this function. While this may result in a greater international dissemination of technology, it is quite possible that the design, research and development work remains concentrated in the parent company. Indeed, in supply activities upstream from the original investment (e.g., in Japanese firms operating in the motor vehicles or electronics components sectors in the UK), this is potentially very serious, as the expanding global sales of supplying MNEs allows them to increase their own technological capacity at the expense of local suppliers who are then driven out even more effectively.

This has brought us to the consideration of the host country conditions in which the R&D of foreign-owned affiliates is most likely to become substantial, and to gain a creative role with respect to the global technological development strategy of the MNE as a whole. One factor is clearly an adequate local infrastructure, educational system, and science base. The US biotech industry is one example where strong evidence of the effect of this factor has been uncovered (Coombs/Deeds/Mudambi 1999). Another is the innovative and competitive stimulus provided by a local centre of excellence in the industry concerned, which facilitates a more favourable interaction with indigenous firms, and greater opportunities for inter-company alliances for the purposes of technological collaboration and exchange. Within a host country, an all-round regional centre of excellence is likely to attract the research-based investments of a wide variety of foreign MNEs, while more specialised regional centres are attractive mainly as a location for the location of affiliate R&D within the industries for which the local region is best known. Thus, in the Italian case, Lombardia attracts a broad range of foreign-owned R&D facilities, while Piemonte attracts mainly the R&D of foreign-owned motor vehicle companies (Cantwell/Iammarino 1998).

Inter-company technology co-operation and diffusion is more likely to occur where some related technological capacity already exists amongst local firms. Otherwise the presence of MNE subsidiaries may act solely as low value satellites of their parent companies. With reference to the *Le Defi Americain* (Servan-Schreiber 1968) that threatened the long-term competitiveness of European firms in the 1960s, Cantwell (1989) found that a necessary condition for indigenous revival in Britain, Germany and France was the existence of strong technological advantages on the part of local firms. In such cases, inward direct investment led to local technology creation and diffusion, and the competitive stimulation of a new wave of local innovation; the pharmaceutical industry provides an excellent illustration in the UK.

The extent of technological interchange between foreign-owned affiliates and indigenous firms depends upon the impact of affiliate R&D on competitors that have local operations, and upon the impact on suppliers and customers, which in turn relates to the strategic decision of the MNE to buy in certain inputs locally rather than importing them. It also depends upon which products the MNE decides to produce locally, and the technology it chooses to use in its local operations. The potential for a virtuous cycle in which technology diffuses to local firms, whose innovative efforts have spillover benefits to the MNE and cause it to further increase its own R&D, may be greater where it is attracted to locate higher value added activities of a research-intensive kind in the host country, which in turn may well be influenced by the technological traditions of local industry and by the industrial policies of the local government.

In sum, localised technology creation and exchange will be affected by the number and strength of indigenous competitors, the form of linkages with local firms, the relevant host country government's policies towards sourcing inputs and encouraging a higher local proportion in value added, local technological capacity and infrastructure, local managerial skills and the destination of exports from the MNE affiliate.

The ability of MNEs to create new technological competence in a foreign location depends upon the scope for knowledge spillovers in that location, but also on their own internal capacity to establish and manage an internationally integrated network for innovation, and to select the appropriate locations to be part of that network. Some subsidiaries will be chosen to play a local competence-creating role, while others will not. In what follows we are especially concerned with this strategic decision at the level of the corporate group, which might be thought of as the decsion whether or not to grant each subsidiary a competence-creating mandate. The relationship of this decision to other familiar concepts of international corporate strategy in the literature is summarized in Figure 1. The likely effect of the shift towards internationally integrated strategies in MNEs in recent years is that the R&D of groups is likely to become more concentrated in those affiliates that gain a competence-creating and not just a purely competence-exploiting role, that is those that contribute to the integrated innovation network of the firm, utilising the potential of their location for new technology development.

However, it is important to recognise that R&D facilities may well continue at some level in essentially competence-exploiting affiliates and not only in subsidiaries with a competence-creating mandate. As noted above, historically most international corporate R&D was of this kind, having the objective of adapting products for local markets and processes to local resource and production conditions, and much foreign-located R&D in MNEs is still of this kind. Our central argument here is not simply that more R&D will now gravitate to subsidiaries with a competence-creating mandate once the objective is to establish an internationally integrated system for innovation in place of an independent collection of multi-domestic operations with diffused adaptation (although it will), but rather that this new kind of R&D will be differently motivated than in the past, and so qualitatively distinct in its determinants. Our empirical approach aims to examine whether there is such a qualitative difference as well as a quantitative gap in subsidiary R&D-intensity, and if so to ascertain the nature of this qualitative difference in motivations in terms of the factors that influence investments in R&D.

3. Methodology and Data

The Model

Once a firm chooses whether to locate research-based (competence-creating) or assembly-based (competence-exploiting) production at a site, it must then decide the extent of R&D activity it wishes to undertake at the host location. The strategy choice presented here is that of a firm that has already decided on an internationally integrated strategy of competence development through research-based production in selected foreign locations, and is next considering how wide a range of affiliates across which this function is to be implemented, and in which particular subsidiaries. We set up this initial decision as a binary choice under which the parent MNE decides whether or not to give a local subsidiary a competence-creating mandate, by which we mean whether the affiliate will have a higher grade development function in production, which necessitates an accompanying local R&D facility. The decision regarding the level of R&D to site locally is therefore a conditional one, being conditional on whether or not a competence-creating mandate has been granted to the subsidiary. In the modal choice literature on FDI, this conditional approach is fairly standard (Czinkota et al, 1996; Devereux and Griffith, 1997; Grant, 1995; Mudambi and Ricketts, 1998).

In the model, firms choose to grant a subsidiary a competence-creating mandate when the expected value of such a strategy exceeds the expected value of a purely competence-exploiting strategy of assembly or simple manufacturing in the location in question. The variable of interest is the difference between the expected value of a competence-creating mandate granted to the subsidiary and the expected value of a purely competence-exploiting role. The difference between these two expected values is denoted by $MAND^*_i$. This variable is a function of measurable location, firm and industry attributes, which can be collected together in a vector, $\mathbf{Z}_i$. The actual outcome also involves an error term, e_i, attributable at least in part to unobservable factors (e.g., Buckley and Carter, 1998; Casson, 1996; Caves, 1996). $MAND^*_i$ itself is a latent variable and not observable, but the firm's choice of strategy is observable. This generates a binary choice variable, $MAND_i$, (=1, where the firm chooses to grant its subsidiary a competence-creating mandate and =0, where it does not). This is a dichotomous choice model, and the standard notation used in the literature on limited dependent variables may be used (Maddala, 1983). The choice for the i^{th} firm it is specified by:

$$
\begin{aligned}
MAND^*_i &= \mu' \mathbf{Z}_i + e_i \\
MAND_i &= 1 \quad \text{if } MAND^*_i > 0; \\
&= 0 \text{ otherwise} \qquad (1)
\end{aligned}
$$

The decision regarding the level of R&D expenditure (and hence the R&D/sales ratio) is also determined by firm, industry and location characteristics, with the binary $MAND_i$ variable providing an additive difference. The variables that affect R&D spending can be gathered together in a vector $\mathbf{X}_i$, while $MAND_i$ functions as a dummy variable. Several of the variables affecting the *strategic* choice regarding the granting of a competence-creating mandate also affect the *operational* choice of level of R&D

spending. Thus, many variables will enter both $\mathbf{Z}_i$ and $\mathbf{X}_i$. Denoting the R&D/sales ratio by RD_i, this implies the following specification:

$$RD_i = \beta' \mathbf{X}_i + \theta \, MAND_i + u_i \tag{2}$$

As in (1), the error term in (2), u_i, is attributable in part to unobservable factors, some of which are the same as those determining e_i. This means that u_i and e_i are correlated and that $MAND_i$ suffers from problems of endogeneity. Endogeneity appears because $MAND_i$ is not a 'given' characteristic, but rather a chosen strategy. Firms select between the two categories in $MAND_i$ based on their resources and capabilities. Treating $MAND_i$ as a normal exogenous variable leads to selectivity bias (Heckman, 1979). The effects of selectivity bias appear in both the mean and the variance of the estimator of θ in (2). The estimate of θ is biased in the direction of the correlation between the errors u_i and e_i. The estimated standard error of θ is biased downwards, so the probability that it will appear significant is increased. For a technical treatment of the problem of selectivity bias and its effect on estimation, see Greene (1993). Shaver (1998) provides a detailed description of the problem in the context of the relationship between FDI modal choice and firm survival.

The hypothesis tests involve estimating (1) and (2). If $MAND_i$ is exogenous, (2) may be estimated independently of (1). However, if it is truly endogenous, these estimates suffer from selectivity bias and (1) and (2) must be estimated as a system. Estimating (1) provides a test of the variables that affect the decision with regard to providing the subsidiary with a competence-creating mandate. Examining the system estimates of (2) enables us to test whether this specification is supported by the data. Finally, if the system estimates are supported, we can compare the direct estimates of (2) with the system estimates to assess the effects of selectivity bias.

Data

R&D is a very industry-specific activity. Thus, comparing R&D strategies and expenditure levels across industries is unlikely to be meaningful. The differences in strategies and R&D intensities between firms are likely to be highly industry-specific. These industry effects will almost surely wipe out any more subtle strategic choice effects in a diverse data set. With this in mind, we restrict our focus to a single industry group, so that the strategies and expenditures are generally comparable. We focus on firms in engineering and engineering-related industries.

The current study uses three levels of data: industry-level data, location-specific data and firm-level data. Industry-level data are used mainly for classification purposes and were drawn from Dun & Bradstreet indexes (Dun & Bradstreet 1994, 1995). The engineering and engineering-related industry group roughly corresponds to subsections 24(1&2), 26-32 and 34-35 under the 1992 UK Standard Industrial Classification code (SIC 92). Location-specific data relate to the classification of the local area in terms of Regional Selective Assistance (RSA) program and are based on the relevant Department of Trade and Industry (DTI) assisted areas map (1993). Data comparing location risk characteristics of the host country (the UK) with those in the companies' home countries were drawn from the financial markets publication *Euromoney*. The firm-level data were derived from a large 1995 postal survey of FDI into the UK, supported by telephone and field interviews. The Appendix includes definitions all the variables used in the estimation, along with the source of the data. Descriptive statistics related to all these variables are presented in Table 1.

The sample frame for this survey was constructed from Dun & Bradstreet indexes (Dun & Bradstreet 1994, 1995), supplemented by the London Business School company annual report library. The sample frame yielded a preliminary list of 601 firms with personal contact names. Firms where separate data for the parent firm were unavailable were deleted. The final usable sample frame consisted of 568 firms. The survey was mailed out in two waves of 224 and 344 in March and April 1995.

The first (pilot) wave focused on entries into the Midlands region (the most successful region in the UK in terms of attracting FDI), while the second wave targeted entries into the rest of the country. The questionnaire was accompanied by a cover letter explaining the aims of the study, guaranteeing confidentiality and urging response. In order to improve the response rate, the questionnaire had to be short, concise and of current interest or salient to the respondent (Heberlein and Baumgartner, 1978). Ten days after the survey was mailed out, a reminder postcard was faxed to all companies that had not yet responded. Twenty-one days after the survey was mailed out, a second reminder was faxed to companies that had still not responded.

Overall, 244 responses were received to the mail survey (42.96%). Of these, 7 were found to be UK firms mistakenly identified as non-UK firms, and 12 were unusable for various other reasons, leaving 225 (39.61%) valid responses for evaluation. The response rate is well within the range expected for an unsolicited mail survey.

Non-response bias was investigated with the widely used method suggested by Armstrong and Overton (1977). This involved comparing early and late respondents.

Two sets of late respondents were defined corresponding to those who responded after receiving the first reminder and those who responded after receiving the second faxed reminder (the first set includes the second). Each set of late respondents was compared to the early respondents on the basis of six sample measures. The comparisons were carried out using a χ^2 test of independence. In both cases, the responses from early and late respondents were virtually identical.

Survey responses were tested for veracity by comparing postal responses to responses obtained from field interviews. A total of 28 field interviews were carried out. Using a χ^2 test of independence responses from field interviews were found to be virtually identical to those obtained from the postal survey on the basis of four sample measures. Finally, 20 respondents were randomly selected and interviewed by telephone to confirm their survey responses.

4. Estimation and Results

Summarizing the firm-specific data

Two problems arise in using most of the firm-specific variables. First, several of them are categorical and/or ordinal. Second, several of them are highly correlated with one another. Thus, they are unsuitable for direct use as regressors. These problems are addressed by constructing statistical variables to summarize the information content along identifiable dimensions. We do this by running the problem variables through principal component factor analysis. The latent root criterion is used to determine the number of factors (or summary variables) extracted. The rationale is that the variation in each variable is unity after it has been standardized. Thus, each factor should account for the variation in at least one variable if it is to be considered useful from a data summarization perspective (Churchill, 1995). The factor analysis results are presented in Table 2. There are 3 factors with eigenvalues greater than unity. The eigenvalue for the fourth factor is 0.7206. The three factors are termed 'strategic responsibilities' (STRAT), 'external orientation' (EXTERNAL) and 'process responsibilities' (PROCESS), on the basis of the varimax rotated factor loading matrix.

The first factor, STRAT, explains 30.7% of total variance. The extent to which supplier decisions are made by the subsidiary (SUPPLY), the extent to which the subsidiary has responsibility for hiring management staff (HIRE) and for the international marketing function (MKT) and the percentage of subsidiary top management from the host country (UK) all load heavily on this factor.

The second factor, EXTERNAL, explains 26.2% of total variance. The percentage of the subsidiary's output that is exported (WEXPORT), its export experience as a percentage of total tenure (EXPT) and the geographic scope of its output mandate (GSCOPE) are the variables that load heavily on this factor.

The third factor, PROCESS, explains another 14.4% of total variance. The subsidiary's process engineering responsibilities in operations (PROC) and training (TRAIN) are the variables that load on this factor. In interview with managers at several of the responding firms, it became clear that a considerable amount of training that occurred at these subsidiaries is of the operational or process type. This would explain the loading pattern that emerged.

Overall, the three factors account for almost 77% of the variance of all the underlying variables. The communalities of the individual variables are very high as well, with the lowest value in excess of 70% and the highest value near 90%.

Estimating R&D strategy and intensity

There are two possible specifications within which we can estimate R&D intensity. The first consists of specifying the competence-creating strategy to be exogenous. This involves specifying MAND, the competence-creating strategy dummy to be exogenous. When MAND is specified to be exogenous, equation (2) may be estimated directly. These estimates are obtained using ordinary least squares (OLS).

The second specification consists of specifying $MAND_i$ to be endogenous. When it is specified to be endogenous, it is necessary to estimate it within the model, i.e., to jointly estimate equations (1) and (2). If MAND is endogenous, we assume that the decision process is sequential, so that the competence-creating strategy is selected in the first stage and the level of R&D intensity (RD) is selected in the second stage. With this assumption, the joint estimates may be undertaken using single-equation (or limited information) approach. We use two approaches to obtaining joint estimates - a conventional instrumental variables (IV) approach and a selection approach using the so-called 'treatment model'.

The strategic decision model specified by equation (1) is estimated using binomial probit. Maximum likelihood estimates of this equation are reported in Table 3. These results identify some industry, location and firm factors that seem to underlie the choice of a competence-creating strategy in the context of FDI. Since we are specifying the decision structure to be sequential, explanatory variables used in this model cannot include any which chronologically follow the competence-creating vs. competence-exploiting mandating decision. This excludes the use of many firm-specific measures.

The fit of equation (1) to the data is very good, as measured by the likelihood ratio test. Three statistically significant influences on the strategic decision regarding the subsidiary competence-creating mandate are identified. A location in a Development area (R1) appears to exert a negative influence on the chance of achieving a competence-creating mandate. It would appear that the negative labor and infrastructural factors associated with a Development area greatly reduce its probability of serving as a research-related hub for an MNE. Having a Japanese parent firm (JAPDUM) seems to increase the probability of gaining a competence-creating mandate. This may related to the strategy of Japanese firms in the European Union as a whole and reflect a synergy with their large-scale operations in US. Cantwell and Mudambi (2000) report similar results. Finally, the factor score STRAT appears to significantly increase the probability of gaining a competence-creating mandate. Thus, the more strategically independent a subsidiary in terms of human resource management and marketing, the more likely it is to be granted an independently creative research-related role as well.

We now turn to our estimates of equation (2). The OLS estimates are compared to the IV estimates in Table 4. The IV estimates are generated using the estimation of MAND from Table 3 as the first stage estimates. Overall, the fit of the OLS estimates is better than the fit of the IV estimates. However, the main difference that emerges from the comparison is the role of STRAT. In the OLS estimates, STRAT is highly significant, while MAND does not appear to be significant. The fact that MAND, the competence-creating strategy, is insignificant in determining RD, the R&D intensity leads to doubts about the OLS specification. In the IV specification, this problem is resolved. STRAT is significant in the first stage estimation of MAND and not in the second stage estimation of RD. Now instead, the endogenously determined MAND is highly significant in the estimation of second stage estimation of RD. Thus, the pattern of significance emerging from the IV estimates appears to be more satisfactory than that emerging from the OLS estimates, which treat MAND as exogenous.

The OLS estimates are compared to the estimates from the treatment model in Table 5. The treatment model enables us to explicitly estimate the selection parameter, λ. As the first stage estimates determining the probability of the strategy selection are probit estimates, the selection parameter is a hazard rate computed from the normal distribution. In the treatment model, the direct effects of strategy selection (MAND) are separated from the indirect effects (λ).

It may be seen that the treatment model performs better than the IV specification in terms of the pattern of regressor significance. Greater financial risk (FINRSK) in the subsidiary's operations seem to reduce RD, but greater size as measured by turnover (SALES) seem to increase it. RD seems to be negatively influenced when the subsidiary represents a product diversification from the parent's main lines of business (DIVERS) and when entry is through acquisition (ACQ). However, as in the IV/OLS comparison, STRAT is significant in the OLS estimation while MAND is not. This pattern of significance in reversed in the treatment model, where STRAT's significance appears in the first stage and MAND is now highly significant in the second stage estimation of RD. Further evidence in favor of the endogeneity of the MAND is provided by the significance of the selection parameter.

When the treatment model is applied to the entire sample, the problem that arises is that the parameters of the regressors are restricted to be the same for subsidiaries that have competence-creating mandates (MAND=1) and those which do not (MAND=0). This restriction may well be questioned. Indeed, testing this restriction using a generalized 'F' test, we find that it is strongly rejected. The way out is to estimate RD separately for subsidiaries that have been granted a competence-creating mandate and those that have not. This procedure is suggested by Shaver (1998), who notes that while the estimates thus obtained are not efficient, they are consistent (in this context, also see Greene, 1993).

These estimates are also presented in Table 5 and they are most interesting, as the estimates for the two types of subsidiaries are radically different. The findings reported in Table 5 demonstrate that the R&D behaviour of subsidiaries with competence-creating mandates is not just quantitatively but also qualitatively different from that of other subsidiaries, in that the determinants of R&D differ. Firms that have a competence-creating mandate display very significant location effects (R1 and R2), while local development characteristics play little role if such a mandate is lacking. Locations in Development and Split areas have a very negative influence on RD for the former category of subsidiaries. This demonstrates that supply-related development characteristics are critical to the success of competence-creating subsidiaries, as their greater degree of research creativity requires a satisfactory educational and skill base locally, and the presence of other innovative enterprise with which to interact. Conversely, the negative influence of FINRSK and the positive effect of SALES for all firms considered together are seen to emanate from subsidiaries that do not have a competence-creating mandate. They do not appear to influence RD for subsidiaries that have a mandate. For competence-creating subsidiaries the size or scale of local production and the variability of local demand matters less.

The negative influence of DIVERS appears for subsidiaries that have a competence-creating mandate, and the negative influence of ACQ appears for subsidiaries that do not. Again, these are very important results in the light of other recent research in the areas of corporate diversification and mergers and acquisitions. Other evidence has suggested that whereas at one time product diversification and technological diversification were complementary (or more precisely, they were different representations or ways of measuring of the same phenomenon), in more recent times they may be substitutes as a wider range of technologies is now needed to support a narrower range of products (Cantwell and Piscitello, 2000). This is indeed what our findings here suggest: that with a competence-creating mandate, a higher extent of product diversification tends to be a hindrance to investing in the creation of new technologies. However, this effect does not apply to subsidiaries without this competence-creating function, for which the overwhelming goal in research is to adapt products (whether they are distinctive to that subsidiary or not) to the relevant markets. Meanwhile, cross-border acquisitions may broadly speaking be divided into those motivated mainly by financial considerations, and those that are motivated by new asset acquisition and a synergy of complementary productive resources. Hence, as shown in Table 5, in competence-creating subsidiaries the latter motives dominate and acquisitions or greenfield ventures behave little differently in their need for research, but in the absence of such a mandate the tendency is for acquired firms to eliminate R&D duplication and to become more focused on the better exploitation of existing assets.

There is one other especially notable difference in the two sets of estimates of Table 5. This is that while for all firms taken together the degree of strategic independence of the subsidiary cannot be separately distinguished from the effect of the competence-creating mandate, once firms with or without the mandate are divided STRAT has a significant effect on R&D within the mandated group, but not for other firms. This might be thought of as a kind of cumulative effect. That is, once a firm has been given a competence-creating mandate, its capacity to fufill that mandate will be strengthened by the extent to which the subsidiary is able to develop its own independent strategy, which will facilitate its own greater local creativity and warrant increased local R&D. Yet crucially this effect of subsidiary strategic independence is absent if the subsidiary itself is not mandated to be a constituent part of an internationally integrated network within its corporate group. Other observations are that both Japanese (JAPDUM) and US (USDUM) parentage seem to increase RD for subsidiaries with a mandate, but not for subsidiaries without one. Finally, the selection parameter is significant and positive for subsidiaries with a mandate, but is not significant otherwise. In contrast, when the subsidiaries are grouped together, the selection parameter appears significant and negative.

5. Concluding Remarks

Our findings are consistent with other studies that have pointed to the emergence of global networks for innovation within MNEs in recent years (Cantwell 1995). In this literature, it has been proposed that an affiliate can contribute more creatively to technology generation within such a network, the better is the local infrastructure in the location in which it is sited, which increases its potential skill base and local linkages with other innovative firms and research institutions; the wider is the functional scope of its mandate, which broadens its potential role within the MNE network; and the more mature it is, having had time to evolve away from a principally domestic orientation and towards more closely internationally integrated relationships.

We suggest that the decision regarding the grant of a competence-creating mandate to an MNE subsidiary is an endogenous one. Thus, subsidiaries obtain or do not obtain such mandates depending firm-, industry- and location-specific factors. We find that treating the mandating decision as endogenous rather than exogenous gives us a clearer picture of MNE R&D investment behavior. We show that the R&D investments of subsidiaries with competence-creating mandates is both qualitatively as well as quantitatively different from that of subsidiaries without such mandates. In particular, supply-related local development potential and the degree to which subsidiaries are separately granted strategic independence both positively influence R&D in competence-creating subsidiaries, but not in other kinds of affiliate. There is also a trade-off between technology-creating investments and product diversification in subsidiaries with competence-creating mandates unlike in other affiliates, but no effect of the choice between acquisition vs. greenfield modes of investment in the asset-seeking subsidiary unlike the negative impact of acquisition on local R&D in other affiliates. These findings are very much in line with our expectations, but we believe they are novel results from our appropriate modelling of MNE R&D strategy decisions.

Figure 1

Alternative views of the competence-creating vs. competence-exploiting subsidiary mandate decision in the contemporary international business literature

Competence-creating subsidiary mandate	*Competence-exploiting subsidiary role*
Research-related production (Cantwell, 1987)	Assembly-type production
Strategic asset-seeking investment (Dunning, 1995, 1996)	Market-servicing investment
Element of internationally integrated MNE innovation network (Porter, 1986, Doz, 1986, Bartlett and Ghoshal, 1989, Cantwell, 1994)	Either element of multi-domestic strategy or non-innovating part of an internationally integrated network
Home-base augmenting investment (Kuemmerle, 1999)	Home-base exploiting investment
Contributor to organizational heterarchy (Hedlund, 1986)	Lower order part of organizational hierarchy

Appendix

Variable definitions

VARIABLE	DEFINITION	SOURCE
Dependent variables		
MAND	0, the UK is granted a competence-creating mandate*	Survey, supplemented by company annual reports
	1, otherwise	
RD	UK subsidiary's R&D/sales ratio, 1994	Survey, supplemented by company annual reports
Industry variables		
ELEC	1, if UK subsidiary is in an electrical engineering and related industry	***Business Register***
	0, otherwise	
MECH	1, if UK subsidiary is in a mechanical engineering and related industry	*Business Register*
	0, otherwise	
CHEM	1, if UK subsidiary is in a chemical engineering and related industry	*Business Register*
	0, otherwise	
Location variables		
RLOCRSK	Relative country risk, home country/host country (U.K.); average, 1993-1994	*Euromoney***
R1	1, if UK subsidiary is in a Development area***	DTI
	0, otherwise	
R2	1, if the UK subsidiary is in a Split Development/Intermediate area***	DTI
	0, otherwise	
Firm variables		
ABROR	UK subsidiary's ROR on capital less parent firm's corporate ROR on capital, 1994	Survey, supplemented by company annual reports
FINRSK	Variance of UK subsidiary's rate of return on capital, 1986-1994	Survey, supplemented by company annual reports
SALES	UK subsidiary turnover, 1994 (£million)	Survey, supplemented by company annual reports
DIVERS	0, if entry into the UK is in parent's main line of business @	Survey, supplemented by company annual reports and DTI data
	1, otherwise	
ACQ	1, if entry into the UK is through acquisition	Survey, supplemented by DTI data
	0, otherwise	
DT	Duration of UK subsidiary operations (years)	Survey, supplemented by company annual reports

USDUM	1, if parent firm HQ is in the US 0, otherwise	Survey, supplemented by company annual reports
JAPDUM	1, if parent firm HQ is in Japan 0, otherwise	Survey, supplemented by company annual reports
SUPPLY	Extent to which decisions on suppliers are made in the UK (7 pt. Likert scale)	Survey
HIRE	Extent to which UK subsidiary has responsibility for hiring management staff (7 pt. Likert scale)	Survey
TOPMGMT	Percentage of UK subsidiary top management (directors and above) from host country (UK)	Survey, supplemented by company annual reports
MKT	Extent of responsibilities in the international marketing function (7 pt. Likert scale)	Survey
WEXPORT	Exports as a percentage of UK subsidiary output	Survey, supplemented by company annual reports
EXPT	Years of exporting as a percentage of total duration of UK operations	Survey, supplemented by company annual reports
GSCOPE	Geographical scope of UK subsidiary's output mandate – (1) UK only; (2) UK and mainland Europe; (3) Worldwide	Survey, supplemented by company annual reports
PROC	UK subsidiary's process engineering operational responsibilities (7 pt. Likert scale)	Survey
TRAIN	Extent to which UK subsidiary has responsibility for training in process engineering (7 pt. Likert scale)	Survey

* MAND is generated on the basis of the functional scope of the UK subsidiary's output mandate. Output mandates were categorized as: (1) Sales and service; (2) Assembly; (3) Manufacturing; (4) Product development; (5) International strategy development. A competence-creating mandate is operationalized as a subsidiary whose output mandate is either (4) or (5).

** *Euromoney* risk index, which includes economic performance, political risk, debt indicators, debt default, credit ratings, access to bank, short-term and capital market finance, and the discount on forfeiting

*** Based on the Department of Trade and Industry (DTI) Assisted Areas map (revised, August 1993).

@ The parent firm's main line of business is defined to be its largest non-UK sales segments whose cumulative contribution to the entropy index of diversification just exceeds 60%. This definition is based on Hitt *et al* (1997).

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Table 1

Summary statistics

VARIABLE	MEAN	S.D.
Dependent variables		
MAND	0.2444	0.4307
RD	4.1822	2.7963
Industry variables		
ELEC	0.4267	0.4957
MECH	0.4089	0.4709
CHEM	0.1644	0.4307
Location variables		
RLOCRSK	1.4808	1.0830
R1	0.4089	0.4927
R2	0.1200	0.3257
Firm variables		
ABROR	–0.6821	3.9101
FINRSK	3.6927	5.1599
SALES	374.6445	327.7262
DIVERS	0.2089	0.4074
ACQ	0.6311	0.4836
DT	9.8889	5.5050
USDUM	0.2044	0.4042
JAPDUM	0.0711	0.2576

Table 2

Factor analysis of firm-specific qualitative variables
Varimax Rotation

Variable	**Factor Loadings**			*Communality*
	Factor 1 STRAT	*Factor 2* EXTERNAL	*Factor 3* PROCESS	
SUPPLY	**0.884**	0.330	0.241	0.804
HIRE	**0.812**	–0.057	–0.164	0.791
TOPMGMT	**0.809**	0.021	0.027	0.754
MKT	**0.792**	0.124	–0.002	0.760
WEXPORT	0.018	**0.860**	0.061	0.814
EXPT	0.204	**0.891**	0.084	0.802
GSCOPE	0.020	**0.902**	0.203	0.891
PROC	0.117	–0.026	**0.898**	0.712
TRAIN	0.004	–0.102	**0.794**	0.735
Eigenvalue	3.6847	2.1784	1.3084	-
Variance	3.0008	2.4226	1.3802	6.8875
% Variance	0.307	0.262	0.144	0.768

Loadings of variables associated with particular factors are shown in bold.

Table 3

Estimating the probability of a subsidiary competence-creating mandate:
Maximum Likelihood Probit Estimates

Regressand: Binary variable: MAND=1 (Subsidiary has R&D mandate);
MAND=0 (Subsidiary has no R&D mandate)

REGRESSOR	PARAMETER ESTIMATE (‘*T*’ STAT)
CONSTANT	–0.4152 (1.49)
MECH	–0.0317 (0.12)
ELEC	0.0007 (0.00)
R1	–0.5336 (2.53)*
R2	–0.0780 (0.26)
USDUM	0.1664 (0.68)
JAPDUM	0.6988 (2.06)*
STRAT	0.2235 (2.39)*
ACQ	0.1444 (0.65)
DIVERS	–0.4666 (1.60)
DIAGNOSTICS	
Log-likelihood	–114.9804
Restricted Log-Likelihood	–125.1335
Likelihood Ratio Test: $\chi^2(9)$ ‘p’ value	20.3063 0.0161
Iterations	5

* Estimate significant at the 5% level.
** Estimate significant at the 1% level.

Table 4

Estimating R&D intensity

OLS vs. IV estimates

REGRESSAND: RD (R&D/Sales ratio)

REGRESSOR	OLS ESTIMATES ('T' STAT)	IV ESTIMATES ('T' STAT)
CONSTANT	2.9394 (3.69)**	2.8725 (2.58)**
ELEC	0.3540 (0.91)	0.4150 (0.76)
MECH	0.3414 (0.77)	0.3925 (0.63)
RLOCRSK	–0.0005 (0.33)	–0.0032 (1.06)
R1	–0.2613 (0.77)	0.4761 (0.63)
R2	–0.5941 (1.17)	–0.4042 (0.56)
ABROR	–0.0438 (1.11)	–0.0702 (1.19)
FINRSK	–0.0662 (2.14)*	–0.0625 (1.44)
SALES	0.152×10^{-5} (2.75)**	0.114×10^{-5} (1.38)
DIVERS	–2.0153 (4.43)**	–1.4969 (1.97)*
ACQ	–1.1305 (3.50)**	–1.6328 (2.80)**
DT	–0.0887 (0.29)	–1.0198 (1.19)
USDUM	0.0566 (0.13)	0.1148 (0.19)
JAPDUM	–0.8765 (1.38)	–1.1738 (1.54)
STRAT	0.4741 (3.02)**	0.2307 (0.79)
EXTERNAL	0.0869 (0.55)	0.1429 (0.64)
MAND	0.5840 (1.54)	6.3637 (3.86)**
DIAGNOSTICS		
Adj. R^2	0.3402	0.2925
Log-likelihood	–495.0176	–520.2024
Restricted Log-likelihood	–550.1274	
LR Test: χ^2; (d.f.)	110.2196 (16)	59.85 (16)
SSE	1073.180	2093.700
n	225	

* Estimate significant at the 5% level.
** Estimate significant at the 1% level.

Table 5

Estimating R&D intensity
OLS vs. Treatment model

Regressand: RD (R&D/Sales ratio)

REGRESSOR	OLS	TREATMENT MODEL		
		ALL FIRMS	MAND=0	MAND=1
CONSTANT	2.939 (3.69)**	1.6998 (1.08)	1.2732 (0.40)	–60.677 (1.94)
ELEC	0.3540 (0.91)	0.3361 (0.86)	0.1254 (0.29)	0.5503 (0.59)
MECH	0.3414 (0.77)	0.2866 (0.64)	–0.1767 (0.35)	0.4333 (0.28)
RLOCRSK	–0.0005 (0.33)	–0.0005 (0.31)	0.7×10^{-4} (0.05)	–0.0027 (0.32)
R1	–0.2613 (0.77)	0.3116 (0.44)	0.6597 (0.52)	–24.58 (2.16)*
R2	–0.5941 (1.17)	–0.5031 (0.97)	0.1478 (0.25)	–4.945 (2.67)*
ABROR	–0.0438 (1.11)	–0.0424 (1.08)	–0.0625 (1.44)	13.076 (1.25)
FINRSK	–0.066 (2.14)*	–0.063 (2.02)*	–0.04 (2.99)**	–0.0607 (0.78)
SALES	0.152×10^{-5} (2.75)**	0.15×10^{-5} (2.71)**	0.21×10^{-5} (3.40)**	0.55×10^{-6} (0.44)
DIVERS	–2.01 (4.43)**	–1.54 (2.25)*	–1.589 (1.45)	–22.71 (2.28)*
ACQ	–1.13 (3.50)**	–1.50 (3.50)**	–1.53 (2.79)**	5.33 (1.79)
DT	–0.0887 (0.29)	–0.10 (0.33)	–0.0696 (0.22)	–0.2583 (0.28)
USDUM	0.0566 (0.13)	–0.2478 (0.53)	–0.6573 (1.14)	8.4592 (2.33)*
JAPDUM	–0.8765 (1.38)	–1.7528 (1.53)	–2.5155 (1.19)	29.972 (2.12)*
STRAT	0.474 (3.02)**	0.2229 (0.71)	–0.0056 (0.01)	10.066 (2.19)*
EXTERNAL	0.0869 (0.55)	0.1018 (0.64)	0.094 (0.56)	–0.909 (1.67)
MAND	0.5840 (1.54)	4.464 (3.65)**	-	-
λ	-	–2.275 (2.13)*	–3.138 (0.55)	59.963 (2.12)*
DIAGNOSTICS				
Adj. R^2	0.3402	0.3397	0.4031	0.2150
Log-likelihood	–495.0176	–494.5561	–361.2707	–116.8958
Restricted Log-likelihood	–550.1274		–413.5909	–133.2159
LR Test: χ^2; (d.f.)	110.2196 (16)	111.1426 (17)	104.6404 (16)	32.6402 (16)
SSE	1073.180	1068.790	697.962	225.927
Model Stability: F(17,191); ‘p’ value	-		1.7621 (0.035)	
n	225		170	55

Note: ‘t’ statistics in parentheses
* Estimate significant at the 5% level.
** Estimate significant at the 1% level.