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Subsidiary research and development, and the local environment

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Abstract

Multinational enterprises (MNEs) increasingly seek to optimise their global innovative capabilities by incorporating subsidiary-specific advantages in different countries. But how important are the different location advantages for subsidiary investments in research and development? This paper adds to our understanding of the effects of commonly cited location advantages by analysing the degree to which they actually influence the incidence and level of subsidiary R&D. We developed hypotheses from the existing literature on location advantages, multinational R&D, and innovation incentives, and tested them in relation to an empirical data set containing over 2000 responses from subsidiary managers in seven countries in Europe. Four aspects of the local business environment were investigated: competitive conditions, supply conditions, scientific institutions, and government support. We found that only the presence of scientific institutions has a consistent, positive effect on the incidence and level of subsidiary R&D. Government support has a positive effect on the incidence of subsidiary R&D, but not its level. However, highly competitive environments have a negative effect, at least in small countries.

Keywords: International R&D; Multinational enterprise; Subsidiary R&D; Location advantages

1. Introduction

Multinational enterprises (MNEs) are no longer content, as in earlier decades, to develop new products and processes at home and transfer these innovations to foreign subsidiaries to adapt to local market needs. They increasingly seek

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to optimise their global innovative capabilities by incorporating subsidiary-specific advantages in different countries, sometimes engaging in major research at the subsidiary level. The literature on multinational R&D discusses a range of putatively valuable location advantages (e.g. Boutellier, Gassmann, & Von Zedwitz, 1999; Conference Board Europe, 1995; Florida & Kenney, 1994; Frost, 2001; Håkanson, 1992; Kuemmerle, 1999; OECD, 1998; Patel & Vega, 1999; Pearce, 1997; Von Zedwitz & Gassmann, 2002). But most of this work is based on either patent data or sources from MNE headquarters, not the responses of subsidiary managers. There is also an extensive general literature on the effects of different aspects of the local business environment on R&D (e.g. Porter, 1990; Von Hippel, 1988)—but none, to our knowledge, analyse these effects from the perspective of the subsidiary manager.

This paper adds to the literature on international R&D by analysing which of the commonly cited location advantages affect the incidence and level of subsidiary R&D, based on the questionnaire responses of subsidiary managers. To this end, we generated hypotheses from the literature on location advantages, multinational R&D, and innovation incentives, and tested them with subsidiary level data. The results have implications both for understanding multinational R&D, and the effects of industrial policy.

In its reliance on subsidiary assessments, this paper contributes to the emerging literature that takes a "subsidiary view" of the MNE (e.g. Andersson, Forsgren, & Pedersen, 2001; Birkinshaw, 2000; Birkinshaw & Hood, 1998a). The study employs data of the "Centres of Excellence" database,[1] which was constructed specifically to investigate the nature of the MNE as a "multi-centre" firm (e.g. Holm & Pedersen, 2000; Moore, 2001). The survey on which this paper is based contains responses from subsidiary managers in seven European countries: the UK, Germany, Austria, Sweden, Norway, Finland, and Denmark. Our approach differs from parallel research with this database in its focus of analysis. While prior studies have sought to illuminate the affiliate's relationship with the parent MNE and with its local and global business partners from the affiliate's point of view, they paid little attention to the effects of the local environment. An important exception is the recent contribution by Frost, Birkinshaw, and Ensign (2002), who investigate the factors (including the local environment) governing the emergence of centers of excellence in MNEs in Canada.

The paper explores two interrelated research questions. Which of four commonly cited location advantages—market competitiveness, supply conditions, scientific institutions, and government support—are inducing R&D by subsidiaries?

[1] The main purpose of the "Centres of Excellence" (COE) database was to identify (and study) subsidiaries that have a strategic role that goes beyond their local activities, that function as a driving force for the further development within the MNE. In this paper, it should be emphasized, we focus not on whether particular subsidiaries represent "centres of excellence" per se, and which do not (this is the focus, for example, of Frost et al., 2002), but rather on identifying (and studying) those that perform R&D. Nor have we incorporated COE data from the Canadian MNE subsidiaries, to maintain our focus on the location effects of environmental conditions in Europe.

Moreover, which of these factors have a significant impact on the scale of the R&D investment?

Three interesting findings emerge from the empirical analysis. First, only the presence of scientific institutions has a consistent and positive effect on both the incidence and level of subsidiary R&D. Second, government support has in some cases a positive effect on the incidence of affiliate R&D—but not its scale. Third, highly competitive market environments have a negative effect on subsidiary R&D, at least in small countries. Taken together, these findings demonstrate that of greatest importance to stimulating subsidiary R&D are institutional conditions, especially proximity to top quality scientific institutions. Thus we suggest that more attention be paid to the assessments of subsidiary managers of the strengths of the local environment in planning R&D investment decisions and strategies at the subsidiary level. Understanding how activation of local-environment potentials can generate dispersed individualised capacities in MNE development is a central role in the value of R&D subsidiaries.

The arguments in this paper are structured as follows. We start with a brief review of the relevant literature. The next section develops the hypotheses used to test the effects of different location advantages on subsidiary R&D. We then present the empirical data, and the design of the empirical study. The results of the empirical study are set forth, followed by a discussion of the impact of mode of subsidiary establishment and the size of the host country market on subsidiary R&D. In conclusion, we outline some of the implications of the analysis.

2. Theoretical background

The literature on multinational R&D has made considerable progress in delineating the nature of MNE motivations to internationalise R&D, and the importance and effect of different types of location advantages. Earlier studies emphasised cost factors and the subsidiary's ability to adapt new products developed centrally to local market needs (Lall, 1979; Mansfield, Teece, & Romeo, 1979; Ronstadt, 1978; Teece, 1976). More recent work has underlined the importance of location advantages for knowledge acquisition, learning and competence development (Almeida, 1996; Boutellier et al., 1999; Conference Board Europe, 1995; De Meyer, 1992, 1993; Dunning, 1998; Frost, 2001; Kuemmerle, 1999; Patel & Vega, 1999; Pearce, 1997).

Numerous studies have demonstrated that nations differ in their ability to attract international R&D (Cantwell, 1989; Patel & Pavitt, 1995; Porter & Sölvell, 1998). MNEs often seek to establish R&D activities close to "local clusters" of excellence, comprising groups of dynamic, interrelated firms and specialised scientific institutions that attract like-minded, technologically advanced competitors and potential business partners. Research on "national systems of innovation" (Lundvall, 1988; Nelson, 1993) has shown how specific nations and regions may emerge as especially advantageous for innovation.

Based on this work, four specific location advantages may be identified as of special importance to international R&D: (1) local competitive conditions, (2) local

supply conditions, (3) access to scientific institutions, and (4) host government support. These will be further elaborated in the presentation of the hypotheses in the next section.

The focus of most analyses of multinational R&D, as cited above, has been on MNE incentives to internationalise R&D and MNE assessments of location-specific advantages, rather than subsidiary evaluations as to how, and in what ways, the local business climate affects R&D. Yet the empirically observed impact of environmental factors may differ, depending on whether they are evaluated by managers from headquarters or the affiliate. The initial location decision is taken at headquarters, based on the MNE's general understanding of the relevant country-specific factors. Yet the subsidiary manager, embedded in the local environment (particularly in the case of acquired subsidiaries), may well have a clearer understanding of the strength and value of these advantages in practice.

Nor does related work on international competitive advantage provide more specific insights in this regard. Porter's (1990) research, for example, does not explicitly consider the importance of cluster development on foreign-owned subsidiaries, nor the different location advantages as experienced by the R&D subsidiary per se. Nor does he differentiate between firms as regards ownership, arguing that the local environment affects firm development regardless of whether the firm is domestic or an MNE subsidiary. Similarly, while we know a great deal about how different types of incentives and market characteristics are conducive to R&D (Robson, 1993; Von Hippel, 1988), these insights have not been applied in relation to the issues raised here.

There is a large literature on the different kinds of R&D performed by subsidiaries, and R&D subsidiary roles (Chiesa & Manzini, 1996; Davis, 2000; Mansfield et al., 1979; Papanastassiou, 1999; Pearce, 1997, 1999; Pedersen & Valentin, 1996; Ronstadt, 1978; Taggart, 1997; Von Zedtwitz & Gassmann, 2002). Some subsidiaries transfer technology developed centrally (or elsewhere in the MNE) to the host country, often adapting it to local market needs. Others engage in their own R&D. Some may be designated as "product mandate" subsidiaries, some become part of a larger innovative effort across different parts of the MNE. But the above studies have been concerned with the role of the affiliate (and the level of subsidiary R&D) within the context of the MNE, not its role in the local environment as experienced by the subsidiary manager.

An important emerging literature takes a "subsidiary view" of the MNE (Birkinshaw & Hood, 1998a,b; Frost et al., 2002; Holm & Pedersen, 2000; Moore, 2001). Considerable progress has been made in understanding the subsidiary manager's role, and how subsidiaries often take the initiative to carry out local activities not mandated by headquarters (Birkinshaw, 2000). The range of subsidiary activities is based on a mutual understanding between headquarters and the subsidiary regarding the subsidiary's responsibilities. But the actual investment in developing resources and capabilities is subject to initiatives made at the subsidiary level. Management takes into account not only firm-specific and environmental factors also considered at the corporate level, but also its own understanding of

local opportunities. Yet these studies have not been concerned—except on a general level—with the special problems and opportunities afforded by subsidiary R&D.

The question then arises: how do given location advantages affect the propensity of the affiliate to engage in R&D—when the subsidiary managers themselves are asked? No analyses, to our knowledge, have sought to answer this question.

3. Hypotheses

In this section, we develop four hypotheses concerning the relationship between location advantages and subsidiary R&D, derived from the literature on location advantages, multinational R&D, and innovation incentives more generally.

In defining subsidiary propensity to engage in R&D, two aspects are important. The first relates to the *incidence* of subsidiary R&D. The subsidiaries in our sample carried out a variety of activities, including logistics, marketing, production, development and research. We analyse the degree to which the different location factors affect whether or not the affiliate, specifically, conducts research and development (the nature of the dependent variable is defined more precisely below). As we will argue, the weight of the literature suggests that the stronger the local institution or resource, the greater the incidence of subsidiary R&D.

Second, in evaluating the effects of the local environment on subsidiary R&D, it is also important to look at the *level* of the innovative activities carried out. This captures the widely varying scale of subsidiary R&D from small development units that adapt products to local markets, to decentralised corporate R&D units providing major technologies to be applied throughout the MNE. Our study thus analyses the degree to which specific location factors are conducive to a relatively high level of subsidiary R&D. There is no literature that focuses specifically on this question to guide us in making predictions. Ex ante, however, and after reviewing the pertinent studies, we can find no theoretical reasons to expect a divergence between the determinants of the incidence of R&D in subsidiaries, and its level. Thus we would expect, as in the previous paragraph, that the stronger the local institution or resources, the greater the level of subsidiary R&D.

3.1. Local competitive conditions

In the literature on the economics of innovation, the effects of competition on innovation have been extensively studied. The basic economic logic behind the patent system, for example, is to provide firms with the incentive to invest in R&D by giving them temporary monopoly rights in their inventions. Without patent protection, imitators would quickly erode the innovator's profits by selling the good at a lower price that would not have to cover the original costs and risks of R&D (e.g. Besen & Raskind, 1991). More generally, a monopolist might be able to utilize larger economies of scale and access to low-cost internal finance.

In recent years, however, analysts have argued that competition actually enhances innovation (Baker, 2001). This new emphasis can be seen in both the theoretical literature on industrial organisation (e.g. Boone, 2000) and empirical studies

(e.g. Merges & Nelson, 1994; Roberts, 1999). Because innovation is a cumulative process, inventions are continuously refined and improved over time. Strong competitive environments may benefit innovation by pressuring firms to out-compete rivals by achieving cost efficiencies, or to come first on the market with a new product or process. Recent work on the strategic use of patents also indicates that patents are used not only to create monopoly positions, but for a range of other purposes, such as negotiating tools in cross-licensing agreements, or as signals of value or territorial intent (e.g. Cohen, Nelson, & Walsh, 2000).

One of the most salient empirical findings of Porter's (1990) study of the competitive advantage of nations (and the reasons why some firms, in some nations, innovate more than others) was the association between vigorous domestic rivalry and the creation and persistence of competitive advantage in an industry. Such rivalry impelled local firms to improve and grow, creating pressures "to innovate in ways that *upgrade* the competitive advantage of a nation's firms." (p. 120, his emphasis). Erstwhile competitors can also become partners in international technology collaborations such as equity exchanges, joint ventures or cross-licensing agreements.

A great strength of the R&D subsidiary in this regard derives from its dual position in two 'knowledge communities', i.e. the MNE, and the local environment (e.g. Frost, 2001; Frost et al., 2002). As part of the MNE, the R&D subsidiary is arguably—ceteris paribus—more insulated against the potentially negative effects of competition mentioned earlier than a smaller, independent local innovator. The affiliate could also draw on expertise elsewhere in the MNE to confront rival firms, use patents strategically, and so forth.

Finally, studies of multinational R&D (e.g. De Meyer, 1992; Florida & Kenney, 1994; Gerybadze & Reger, 1999) have shown that the opportunity to try out new products with sophisticated lead customers in the local environment can help the affiliate to identify and solve problems at an early enough stage in the development process to facilitate product reshaping (or even shelving). Such contacts also enhance subsidiary learning about customer needs and the ability to monitor the latest developments in the field. On balance, then, we will postulate that:

H1. Subsidiaries in more demanding competitive environments will have a greater propensity to engage in R&D.

3.2. Local supply conditions

Frequently, successful ideas for new products originate outside the firm that engages in the actual development work (Pavitt, 1984), making the innovation process highly interactive. Von Hippel (1988) has documented the key role of suppliers in developing functionally useful innovations. Face-to-face communication appears particularly valuable for exchanging tacit knowledge, or when the knowledge exchange involves direct observation of products or production processes in use (Porter & Sölvell, 1998). MNEs have developed global technological procurement systems, which can selectively draw on superior supplies of production materials in particular locations. Increased interdependence of supply chains requires not only

closer co-ordination of production processes, but also joint product development. Both tendencies require the exchange of technological know-how and R&D, which is greatly facilitated if the pertinent R&D units are based in physical proximity.

Siting R&D facilities abroad also enables multinationals to take advantage of the skills, knowledge and contacts of local suppliers, both to ease the adaptation of products developed centrally to domestic needs, and also to enhance learning. The effective integration of high-quality production and simultaneous engineering provides substantial advantages in terms of time, quality, flexibility and cost (Gerybadze & Reger, 1999). The quality of the local supplier network is arguably especially critical for advanced, complex products requiring close linkages between the R&D laboratory and its key suppliers.

Similarly, Porter (1990) maintains that close, ongoing relationships with internationally competitive suppliers are integral to creating and sustaining competitive advantage. This not only facilitates access to the most cost-effective inputs and ongoing co-ordination, but also promotes the process of innovation and upgradation. By exchanging R&D and joint problem solving, firms can develop faster, more efficient solutions, accelerating the pace of innovation both within the co-operating firms and in the local business environment generally. This leads to the following hypothesis:

H2. Subsidiaries in environments with superior supply conditions will have a greater propensity to engage in R&D.

3.3. Proximity to local scientific institutions

In the literature, one of the main benefits from internationalising R&D is proximity to the local technological infrastructure. By conducting R&D abroad, firms can hire personnel with specialised product skills, but who are unwilling to leave their home country (Terpstra, 1977). By placing research activities abroad, multinationals can take advantage of the availability of engineers and technicians closely tied into the development process, at least partly mitigating the need for costly in-house training. This benefit might be of special importance to MNEs headquartered in small countries, to the extent that there are shortages of supply of needed scientific or technical staff on the home market (Håkanson & Zander, 1988) in the required area of specialisation.

Due to the relative openness of university environments, advanced knowledge is often readily diffused into the local environment. Corporate specialists tend to be attracted to areas where other specialists are located, enabling them to tap into informal scientific networks. Partnerships with local scientists and engineers can enhance competence building and lead to the development of new and better products (Taggart, 1989). According to a study by the French Ministry of Research (Madeuf, 1992) of 30 firms under foreign control, over half emphasised three main benefits of locating R&D in France: the country's scientific and technological tradition; the availability of skilled researchers; and the science and technology infrastructure.

The French oil and chemical MNE, Elf Aquitaine, has worked with university and public research laboratories since the 1970s. The company has received hundreds of university scientists on sabbatical leave in its laboratories, and sent its own scientists out to universities in North America, Europe, and Japan. During the 1980s, Elf Aquitaine set up foreign R&D offices in the US, Germany, the UK, Brazil, and Japan. Their purpose was to gather R&D information relevant to the company, initiate co-operative projects with local academic or industrial research organisations, and acquire technologies of interest (Boudelle & Jablon, 1993). Similarly, Hewlett Packard found it advantageous to site R&D facilities near the universities of Edinburgh and Stuttgart, which were world leaders in research in certain products of interest to the company (Terpstra, 1977).

Gerybadze and Reger (1999) found that research intensive companies in fields like genetic engineering and advanced solid-state physics emphasised the importance of access to unique resources and leading research results and talents in particular areas with strong international reputations. Evidence suggests that firms located near university research centers that pioneered patents were more likely to patent subsequently in a related field (e.g. Anand & Kogut, 1997). University laboratories can also act as incubators for new businesses, as professors and/or their students leave to start new companies, creating 'science clusters' such as in Cambridge, UK (Economist, 2001; Lawson, 1999).

One of Porter's (1990) most prominent findings was the frequency with which internationally leading national industries were associated with nearby specialised research institutions or university departments. Government laboratory research and government sponsored university research was also important. The most effective method of promoting industrial R&D was apparently the partial funding of specialised research institutions associated with industrial clusters, and the partial subsidisation of research contracts between research institutions and firms (especially small firms), along with general support of the universities. This leads to the hypothesis:

H3. Subsidiaries in environments with strong scientific institutions will have a greater propensity to engage in R&D.

3.4. Government support

The general literature on the effects of government support for R&D is, to a certain extent, contradictory. The economic rationale for public intervention to encourage private R&D is that due to failures in the markets for R&D, profit-maximising firms will underinvest in this. Many studies have found a positive correlation between public support for R&D and firm incentives to invest in R&D (e.g. Nadiri, 1993; Robson, 1993). Porter (1990), while generally skeptical of the value of government subsidies, feels they are justified in areas where externalities cause firms to underinvest, such as certain types of R&D that can boost productivity. On the other hand, extending government support to foreign-owned firms has been controversial in some quarters, given that benefits can be transferred abroad. Moreover, according to the OECD (1999), the research intensity of

foreign affiliates, generally speaking, is lower than that of national firms, except for a few countries like Ireland, Australia, and the United Kingdom.

Even so, the empirical evidence suggests that many countries have supported foreign subsidiary R&D. In the 1970s, for example, Canada offered financial rewards to National Cash Register to begin a new research program there, and helped IBM and Control Data to expand their Canadian R&D (Terpstra, 1977). In the 1990s, governments extended a range of incentives to multinationals considering setting up R&D operations (OECD, 1998). These include provisions to help MNEs cut the costs of developing new products and processes, such as subsidies to cover job training. Some foreign countries offer more public inducements to conduct R&D than the corporation's home country, reducing the cost of carrying out R&D abroad (Niosi, 1997)

The European Union has financed initiatives supporting product innovation in specific areas (such as environmentally friendly technology), broad technology programs such as ESPRIT and EUREKA, and various advisory services. Participation is open to all legal entities established in any of the countries formally associated with the program (along with specified non-member countries). The EU emphasises that its financial support for research and technology development is not a subsidy but a competitive award system, with awards given only to the best projects. A project can, directly or indirectly, involve thousands of researchers. The goal is to encourage collaborations that will continue to develop and evolve over the longer term (European Commission, 2002).

The benefits to governments in promoting high technological intensity include the creation of a demand for a more qualified labour force, higher wages, and in the long run, higher growth rates from value addition and employment. Supporting the R&D activities of foreign-owned subsidiaries, in particular, carries the advantage of attracting international capital, technology, and skills, potentially resulting in higher levels of innovation that could not be attained by domestic firms alone, along with learning curve advantages. In sum, the weight of the evidence suggests that:

H4. Subsidiaries in environments with high levels of government support will have a greater propensity to engage in R&D.

4. The empirical data

To test these hypotheses, this paper draws on data assembled via an international research project, "Centres of Excellence" (COE). Two thousand one hundred and nine responses were received from subsidiary managers in seven European countries: the UK, Germany, Austria, Denmark, Sweden, Norway and Finland.[2]

Co-operating researchers developed a set of "rules" to ensure that the individual country databases met certain minimum requirements. To be part of the common

[2] Scholars from participating countries met in 1996 and 1997 to devise a common questionnaire. Extensive reliability tests with both academics and business leaders were carried out to test the proposed questions. A revised questionnaire was adopted which has been sent out in all the participating countries.

project, the database for each country had to include at least 200 questionnaire responses. Substantial efforts had to be made to ensure that the sample was as representative and accurate as possible (for example, where questionnaire responses were left blank, the respondents were contacted by telephone and asked to complete the answers). On the other hand, a certain amount of flexibility was built into the data collection process to meet individual country conditions.[3]

The questionnaire covered different aspects of affiliate characteristics, activities, and competencies. The response rate varied from 20 to 55%. About three-fourths of the questionnaires were answered by subsidiary executive officers, the rest by financial managers, marketing managers or controllers (Holm & Pedersen, 2000). For the present analysis, we excluded all responses by subsidiaries whose parent is located in the same country (most of which are acquisitions). After eliminating these and observations with missing values, we obtained 1697 usable observations for the regression analysis.

In one of the questions (reproduced in Appendix A), respondents were asked to indicate which of selected types of activities the affiliate carried out, including (as separate items) basic or applied research, and development. This enables us to determine the incidence of subsidiary R&D. About a quarter of the respondents indicated that they performed research, and half indicated that they performed development.

As can be seen in Table 1, the percentage of R&D subsidiaries in the individual countries varies considerably. It is particularly high in the large countries, with 78% of affiliates in Germany conducting R&D, but only 48% in Norway. More affiliates originally established by an acquisition engage in R&D (68%) than Greenfield affiliates (40%). Almost all firms that carry out R&D engage also in development, while less than half of them engage in research. The pattern of research subsidiaries resembles that of R&D generally, with affiliates in large countries and those established by acquisition being more likely to be involved in research.[4] These differences across country and establishment mode will be controlled for in the empirical analysis.

In another question, respondents were asked to estimate the level of their investments (over the past 3 years) in the activity carried out on a Likert-type scale of 1 (very low) to 7 (very high). For subsidiaries that performed R&D, this enabled us to determine the scale of their R&D activities. In a third question, respondents evaluated specific aspects of the local business environment using a similar Likert-type scale. Based on subsidiary responses to these three questions, we were able to

[3] For example, the criterion for defining the initial population of multinational subsidiaries could differ somewhat. In Denmark, for example, questionnaires were sent to all foreign subsidiaries with more than 20 employees; in Norway, questionnaires were sent to all foreign subsidiaries with annual sales of at least 10 million Norwegian crowns in 1995. To take another example, the data were collected mainly in the fall of 1996 for some countries, and in the spring of 1997 for others.

[4] The low research score for Germany might be due to the fact that the German word *'Forschung'* has narrower meaning (relating only to scientific research) than the English word *'Research'*.

Table 1
Subsidiary R&D by host country and establishment mode

	All subsidiaries (*N*)	R&D subsidiaries (%)	Development subsidiaries (%)	Research subsidiaries (%)
UK	169	72	68	54
Germany	172	78	77	36
Subtotal large countries	341	75	74	45
Austria	256	50	49	34
Denmark	264	59	58	18
Norway	216	48	44	25
Sweden	410	52	50	18
Finland	210	52	47	32
Subtotal small countries	1356	51	49	20
Total	1697	56	54	25
Greenfield	737	40	38	18
Acquisitions	960	68	66	31
Total	1697	56	54	25

test for relationships between the nature of the affiliate's activity and its evaluation of key aspects of the local business environment.

5. Design of the empirical study

Our empirical tests measure the impact of four environmental factors on the establishment and scale of subsidiary R&D. We employ a two-step estimation procedure to reflect the nature of the decision process. In the first step, we estimate the probability of a subsidiary engaging in research and development, using a Logit regression model. In the second step, we estimate the level of the R&D endeavor for those subsidiaries actually engaging in it. We used an OLS regression model of the level of R&D investment among those who are involved in R&D.

The dependent variable in the first analysis is constructed from two items of 'research' and 'development' as follows:

$$\text{R\&D-incidence} = \text{Max}\ (\text{Research-incidence},\ \text{Development-incidence})$$
$$\text{R\&D-level} = \text{Research-level} + \text{Development-level}$$

R&D-incidence is a binary variable, constructed from two binary variables. R&D-level is an ordinal variable, constructed from two Likert-scale items (Cronbach's alpha: 0.76). The independent variables have been constructed based on respondents' answers to the question which asked them to evaluate different aspects of their local business environment: ''level of competition'', ''existence of scientific institutions'', ''government support''. Our measure of supply conditions is an aggregate of two items (Cronbach's alpha: 0.72) ''availability of supply material'', and ''quality of suppliers''.

Table 2
Basic statistics: mean and standard deviation

	All subsidiaries	R&D subsidiaries	Subsidiaries without R&D
Market competitiveness	5.68 (1.21)	5.64 (1.25)	5.72 (1.16)
Supply conditions	4.78 (1.20)	4.82 (1.17)	4.72 (1.24)
Scientific institutions	3.07 (1.66)	3.27 (1.64)	2.71 (1.61)
Government support	2.52 (1.50)	2.69 (1.52)	2.32 (1.44)
Size (employment)	428 (1461)	633 (1891)	170 (449)
Establishment form (1)	0.57 (0.50)	0.68 (0.46)	0.42 (0.49)
Internal sales (%)	2.51 (1.76)	2.87 (1.83)	2.06 (1.57)
Non-Euro parent (2)	0.29 (0.45)	0.26 (0.44)	0.32 (0.47)

Notes: The figures for the four location variables are based on subsidiary evaluations of the given advantages on a Likert scale from 1 (lowest importance) to 7 (highest).
The other variables are based on responses to the pertinent questions, including two dummy variables: (1) Greenfield, 0; acquisition, 1; and (2) European parent, 0; non-European parent, 1.

While not the focus of the present research, corporate structure and strategy are pertinent for subsidiary strategies. We capture the variation of parent firms and subsidiary roles with the following firm-specific control variables:

1. Dummies for the host countries. We chose the largest economy, Germany, as a base case.
2. Size of the affiliate, measured by its employment.
3. Integration of the affiliate with the parent, measured by the percentage of sales internal to the MNE. This variable captures parent firm strategy with respect to the affiliate.
4. Origin of the parent, a dummy taking 1 for non-European firms and 0 for European ones.
5. Form of establishment, a dummy taking 1 for acquisition and 0 for Greenfield projects.

Basic statistics and correlations for the variables are shown in Tables 2 and 3, respectively. In the correlation matrix, only one entry reaches above the common benchmark of 0.3, the interaction between scientific institutes and government support (0.31). This moderate correlation does not affect the substance of our results (see footnote 6 later). Among control variables there are interactions between form of establishment and source countries. The coefficients of these control variables thus have to be interpreted with caution, yet as they are not focus of this research, this need not concern us further.

6. Results of the empirical study

Table 4 reports the results of the two-step estimation for the incidence and level of R & D in Eqs. (1) and (2). Overall the equations are statistically significant with

Table 3
Correlations

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	R&D incidence	1															
2	R&D level	–	1														
3	Market competitiveness	−0.03	0.02	1													
4	Supply conditions	0.05	−0.03	0.24	1												
5	Scientific institutions	0.20	0.23	0.15	0.20	1											
6	Government support	0.12	0.03	0.00	0.12	0.31	1										
7	Denmark	0.03	−0.06	−0.05	0.06	0.11	0.14	1									
8	Britain	0.11	0.17	0.06	−0.12	−0.05	−0.06	−0.14	1								
9	Finland	−0.03	−0.00	−0.00	0.04	−0.01	0.14	−0.16	−0.13	1							
10	Norway	−0.06	−0.02	−0.07	−0.10	−0.07	−0.14	−0.16	−0.13	−0.14	1						
11	Austria	−0.11	−0.06	0.06	0.08	0.04	−0.04	−0.18	−0.14	−0.15	−0.16	1					
12	Sweden	−0.05	−0.04	−0.09	−0.11	−0.16	−0.02	−0.24	−0.19	−0.21	−0.22	−0.24	1				
13	Size (employment)	0.16	0.15	0.10	0.07	0.14	0.08	−0.05	0.16	−0.06	−0.08	−0.06	−0.08	1			
14	Internal sales	0.23	0.14	−0.01	0.08	0.15	0.10	0.05	−0.01	−0.07	−0.13	0.04	−0.04	0.10	1		
15	Non-Euro	−0.06	0.03	0.05	0.05	0.07	−0.00	−0.02	−0.01	−0.06	−0.05	0.06	−0.00	0.07	0.04	1	
16	Form	0.27	0.01	−0.05	0.01	0.06	0.07	0.13	−0.00	−0.03	−0.06	−0.15	0.04	0.07	0.08	−0.37	1

Note: Correlations with Level of R&D refer to 946 observations, all others to the full sample used in the analysis with 1697 observations.

Table 4
The five hypotheses: incidence and intensity of subsidiary R&D

Regression model	Incidence Logit (1)	Level OLS (2)
Market competitiveness	−0.141 (0.047)****	−0.008 (0.087)
Supply conditions	0.031 (0.048)	−0.161 (0.086)*
Scientific institutions	0.180 (0.037)****	0.452 (0.061)****
Governmental support	0.074 (0.039)*	−0.076 (0.065)
Denmark	−0.529 (0.252)**	−0.081 (0.351)
Britain	0.233 (0.280)	1.746 (0.368)****
Finland	−0.423 (0.267)*	0.596 (0.385)
Norway	−0.352 (0.265)	0.316 (0.391)
Austria	−0.801 (0.250)****	−0.199 (0.369)
Sweden	−0.451 (0.243)*	−0.349 (0.334)
Size	0.001 (0.000)****	0.00015 (0.000)****
Internal sales	0.215 (0.034)****	0.232 (0.051)****
Non-European parent	−0.036 (0.133)	−0.111 (0.234)
Form	0.993 (0.121)****	0.070 (0.222)
Constant	−1.714 (0.477)****	3.956 (0.786)****
Model statistics		
N	1697 (946 ones)	946
Chi-square (d.f.)	351.4 (14)****	–
Correct predictions	70.70%	–
R^2	–	12.4
F statistic	–	9.43****

Levels of significance: * = 10%, ** = 5%, *** = 1%,**** = 0.5%.

chi-square of 351.4 for the Logit-part and an F-statistic of 9.34 for the OLS part.[5] These equations allow us to assess the hypotheses as regards the effects of the four environmental factors for the likelihood that subsidiaries engage in R&D, and for the level of subsidiary R&D. For all four coefficients, we predicted a positive effect.

As regards the incidence of subsidiary R&D, our expectation was confirmed with regard to three of the four location variables: supply conditions, scientific institutions, and government support. For both scientific institutions and government support, the effect was significant. But we found a significant negative effect with regard to market competitiveness. As regards the level of subsidiary R&D, we found the expected positive effect for only one location factor: scientific institutions (significant at 0.5%). The effects of competitive conditions, supply conditions, and government support were all negative (for supply conditions, the negative effect was significant at 10%).

[5] A low R^2 in Eq. (2) can be attributed to the ordinal nature of the dependent variable. One might expect the dependent variable to be, for example, Poisson distributed rather than normal as assumed by applying OLS procedures. Yet inspection of the dependent variable suggests that it is approximately normal distributed. We also tested the model with an Ordered Logit model and obtained substantially identical results with respect to signs and significance of the variables.

When the two kinds of effects are taken together, the following findings emerge.

- **Hypothesis 1.** To our surprise, a demanding market environment has a negative effect as regards both the incidence and level of subsidiary R&D, which is significant (0.5%) for the incidence of R&D. Thus in challenging competitive conditions, subsidiaries appear mainly focused on meeting the immediate demands of the marketplace.
- **Hypothesis 2.** With regard to supply conditions, we again find an unexpected negative effect, this time with regard to the level of R&D (significant at 10%). Thus, under high quality supply conditions, firms are not spending more on R&D.
- **Hypothesis 3.** Scientific institutions have a highly significant positive effect on both the incidence and the level of R&D, which provides very strong support for our hypothesis.
- **Hypothesis 4.** Government support may induce firms to engage in R&D (10% significance), but our results suggest that it does not have a positive effect on the level of R&D. This finding has implications for industrial policy. Government support may be important in encouraging some R&D, but not in stimulating high levels of investment in R&D.[6]

In interpreting these results, several factors should be highlighted. First, the negative results for Hypotheses 1 and 2 might be explained by differences in subsidiary roles, depending on whether the subsidiary is competence creating or competence exploiting (e.g. Cantwell & Janne, 1999; Frost, 2001). Another explanation might concern the degree to which the subsidiary's R&D involves standardised or highly innovative goods.

Moreover, if we compare the mean subsidiary ratings of the different environmental factors with the significance of their effects, one particularly intriguing contrast emerges. While the presence of scientific institutions is highly significant for both the incidence and level of subsidiary R&D, the mean rating given to this factor by all the subsidiaries sampled (see Table 2) is only 3.07, considerably lower than the mean ratings for both market competitiveness (5.68) and supply conditions (4.78). This implies that most environments offer few research institutions, yet those that do attract considerable R&D in the foreign-investment sector. Arguably, this carries an important implication for industrial policy: if local scientific institutions could be upgraded, and their work made accessible to R&D subsidiaries, this would have a highly positive effect on the subsidiary's propensity to engage in R&D.

Considerable significance was found in the control variables. Among the country dummies, all small countries have a negative coefficient that is sometimes signifi-

[6] The negative sign in the level-equations might be caused by the slight correlation of 'government support' with 'scientific institutions.' The results thus should be read as saying, after controlling for the presence of scientific institutions there is no positive effect of government support.

cant. This indicates, as would be expected, that affiliates in smaller countries are less likely to engage in R&D than those in Germany, the largest host economy in the sample, which we use as a base case. The level of R&D is significantly higher in the UK than in Germany. This might indicate that Germany is underperforming in terms of attracting *major* R&D operations. As expected, large affiliates are more likely to engage in R&D. Tightly integrated affiliates (with a high proportion of internal sales) also have a greater propensity to engage in R&D, as might be expected given that their results would generate greater value that the MNE as a whole can exploit. Yet we find no difference between affiliates of European and non-European parent firms. Subsidiaries established as acquisitions are more likely to engage in R&D, though they have not recently invested high levels of R&D. The path dependency of post-acquisition processes thus appears to sustain R&D operations, though not necessarily at a particularly high level.

7. Discussion

In seeking to further interpret these findings, we have divided the sample into two sets of sub-samples, in order to test for the possible effects of mode of establishment and host country size.

7.1. Mode of subsidiary establishment

The history of the affiliate, and its establishment mode in particular, manifestly impact on its activity. Acquisitions inherit resources such as R&D facilities and business relationships from the acquired firm, and tend to maintain them. In fact, an R&D capability can be the prime asset sought by the acquirer. Post-acquisition restructuring may fundamentally change the organisation and replace non-core assets while exploiting the core asset (Meyer & Estrin, 2001), such as the R&D unit. Greenfield investments, on the other hand, are typically integrated more closely with other MNE units. Hence, acquired affiliates and Greenfields may well be responsive in different degrees to the local environment in configuring their R&D activities. Acquisitions are more likely to interact with local economic environments. On the other hand, Greenfield projects may well be established to take advantage of specific public sector incentives or scientific institutions. We thus tested the aforementioned hypotheses for subsets for either mode of establishment.

Our results (Table 5) largely confirm the overall results described above. Few effects can clearly be attributed to the mode of establishment. The importance of scientific institutions is strongly confirmed in every equation. The surprising effect of the level of competition is still negative here, but significant only for acquisitions. Interestingly, public support for R&D appears effective only in inducing R&D in Greenfield operations, but it appears ineffective both in the case of acquisitions, and to encourage more intensive R&D investment.

Table 5
Differences by R&D subsidiary mode of establishment: Greenfield and acquisitions

Regression model	Greenfield		Acquisition	
	Incidence	Level	Incidence	Level
	Logit (3)	OLS (4)	Logit (5)	OLS (6)
Market competitiveness	−0.107 (0.074)	−0.051 (0.144)	−0.138 (0.063)**	−0.059 (0.094)
Supply conditions	−0.061 (0.071)	−0.169 (0.146)	0.097 (0.066)	−0.110 (0.104)
Scientific institutions	0.174 (0.052)****	0.570 (0.103)****	0.190 (0.053)****	0.401 (0.077)****
Governmental support	0.134 (0.058)**	−0.011 (0.113)	0.023 (0.054)	−0.118 (0.080)
Denmark	−0.584 (0.407)	−0.547 (0.742)	−0.569 (0.332)*	−0.017 (0.408)
Britain	0.570 (0.416)	1.617 (0.630)**	−0.075 (0.378)	1.700 (0.461)****
Finland	−0.555 (0.405)	0.649 (0.744)	−0.365 (0.363)	0.424 (0.457)
Norway	−0.200 (0.394)	−0.468 (0.692)	−0.534 (0.363)	0.551 (0.490)
Austria	−0.870 (0.364)**	−0.417 (0.639)	−0.697 (0.357)*	−0.201 (0.469)
Sweden	−0.680 (0.372)*	−0.126 (0.655)	−0.355 (0.327)	0.375 (0.398)
Size	0.001 (0.000)****	0.0001 (0.000)	0.001 (0.000)****	0.0002 (0.000)****
Internal sales	0.133 (0.049)***	−0.004 (0.089)	0.307 (0.051)****	0.351 (0.064)****
Non-Euro parent	0.244 (0.169)	−0.273 (0.347)	−0.491 (0.217)**	0.016 (0.326)
Form	–	–	–	–
Constant	−0.535 (0.641)	4.895 (1.215)****	−0.098 (0.585)	4.124 (0.827)****
Model statistics				
N	737 (298 ones)	298	960 (648 ones)	648
Chi-square (d.f.)	120.9 (13)****	–	130.9 (13)****	–
Correct predictions	69.50%	–	72.60%	–
R^2	–	16	–	13.2
F statistic	–	4.17****	–	7.39****

Levels of significance: * = 10%, ** = 5%, *** = 1%,**** = 0.5%.

7.2. Market size

Five countries in our sample are fairly small. This might, for example, help to explain why demanding market environments have a negative effect on subsidiary R&D in the overall results, and/or why government support does not have the predicted positive effect on the level of subsidiary R&D. Table 6 reports the results for sub-samples of large countries (Germany and the UK) and small countries (Austria, Denmark, Finland, Netherlands, and Sweden).

Again, the importance of scientific institutions is underlined by the data, though the significance of their positive effect on the incidence of subsidiary R&D in large countries is only 10%.

Our presumption that the negative effect of market competitiveness is somehow related to the fact that many host countries are small is confirmed. The incidence of R&D is negatively affected, significant at the 5% level. The negative effect of supply conditions on the scale of subsidiary R&D is significant only for small countries, which contrasts with a positive effect of supply conditions on the incidence of R&D for large countries. Finally, the positive effect of government

Table 6
Differences by host country

Regression model	Large country		Small country	
	Incidence	Level	Incidence	Level
	Logit (7)	OLS (8)	Logit (9)	OLS (10)
Market competitiveness	0.029 (0.120)	0.138 (0.198)	−0.173 (0.052)****	−0.125 (0.083)
Supply conditions	0.210 (0.119)*	−0.004 (0.196)	−0.007 (0.053)	−0.167 (0.092)*
Scientific institutions	0.153 (0.087)*	0.371 (0.132)****	0.174 (0.041)****	0.469 (0.070)****
Governmental support	0.061 (0.108)	−0.033 (0.158)	0.077 (0.043)*	−0.084 (0.070)
Denmark	–	–	−0.082 (0.181)	−0.420 (0.288)
Britain	0.249 (0.311)	1.685 (0.470)****	–	–
Finland	–	–	−0.089 (0.192)	0.300 (0.321)
Norway	–	–	−0.162 (0.188)	−0.014 (0.329)
Austria	–	–	−0.360 (0.187)*	−0.547 (0.322)
Sweden	–	–	–	–
Size	0.000 (0.000)*	0.00011 (0.000)*	0.001 (0.000)****	0.0004 (0.000)**
Internal sales	0.033 (0.076)	−0.088 (0.115)	0.241 (0.039)****	0.272 (0.057)****
Non-Euro parent	0.057 (0.306)	0.096 (0.464)	−0.063 (0.149)	−0.189 (0.271)
Form	0.601 (0.287)**	−0.039 (0.452)	1.009 (0.136)****	0.023 (0.255)
Constant	−2.147 (1.106)*	3.350 (1.792)**	−1.997 (0.438)****	4.927 (0.757)****
Model statistics				
N	341 (256 ones)	256	1356 (690 ones)	690
Chi-square (d.f.)	25.1 (9)****	–	287.9 (12)****	–
Correct predictions	76.80%	–	69.80%	–
R^2	–	9.2	–	12.5
F statistic	–	2.77***	–	8.06****

Levels of significance: *= 10%, **= 5%, ***= 1%,**** = 0.5%.

support on the incidence of subsidiary R&D is significant only for small countries, but not for large countries (possibly due to the small sample size).

8. Conclusions

In conclusion, three findings in particular stand out:

1. Porterian effects of market and supply conditions on capability development via R&D could not be confirmed in this study. In fact, we found a negative effect of a strong local environment in small countries: competitive market environments had a significant, negative effect on the incidence of subsidiary R&D, and superior supply conditions had a negative effect on the level of subsidiary R&D. In consequence, small countries cannot like large countries rely on the strength of the endowment of market and supply conditions, but have to rely on other means to attract R&D affiliates. Prior research having focussed on large countries may have overstated these effects.

2. Local scientific institutions have a strong effect on both the incidence and level of subsidiary R&D. This we found highly significant in all variations of our analysis. This result underlines the importance of local institutions in formulating strategies in foreign countries (Oliver, 1997; Meyer, 2001).
3. Public support for R&D appears effective only for the incidence of subsidiary R&D, in particular with respect to Greenfield projects, and inducing subsidiary R&D in small countries. But it does not encourage affiliates to engage in extensive R&D. The subsidiaries appear to do just as much as necessary to qualify for support, but with limited amounts of resources committed to R&D. Support offered to other types of affiliates appears ineffective. The underlying cause may be twofold. Governments may provide support with the specific aim of attracting Greenfield investors; or MNEs may opportunistically take advantage of available subsidies and set up Greenfield projects with low levels of R&D activities. The policy implication is that governments should consider coupling the amount of support available for R&D to some quantitative measure of R&D activity.

As all research, this study has its limitations. For one thing, we did not pose the same set of questions to sources at headquarters and the subsidiary. Thus while our findings reflect the views of subsidiary managers, we cannot make specific inferences as regards differences between the headquarters perspective, and the subsidiary perspective, for these particular respondents. This issue could profitably be addressed in future research. Moreover, many of our empirical measures are based on single items, and the dependent and independent variables are based on responses from the same person, which may lead to common method biases. Future studies may take these issues into account in the questionnaire design stage.

In terms of generalization, the analysis is limited to the effects of location advantages on affiliates in Europe. Our results may, to a certain extent, reflect aspects of the local environment which are specifically European, and thus of limited applicability to non-European countries. It should also be emphasised that since the same EU research and development policies apply to all affiliates, it is not possible, in this paper, to make more general inferences about the effectiveness of EU policies.

Further research may address the two surprising findings of the study. The failure to establish a link between local market and supply conditions and R&D requires new theoretical as well as empirical studies. The latter may employ more differentiated measures of the business environment based on both survey and archival data. The negative effect of market competitiveness for small countries in particular, suggesting a dichotomy of subsidiary roles in these countries, merits special attention. Additional research is also called for to analyse the effectiveness of public sector research support programs with respect to their uptake by foreign affiliates. Are these affiliates free riding, or are they really contributing substantive research (and possible spillovers) to the local business community? More generally, conclusions (2) and (3) urge empirical researchers of any aspect of entry or affiliate strategy to incorporate institutional variables in their analysis.

This research, moreover, calls for a reassessment of the suitability of the Porter (1990) framework for the analysis of industries with strong MNE involvement. Along similar lines, scholars have criticised Porter (1990) for not adequately taking into the account the realities of the modern multinational enterprise. Both Dunning (1993) and Rugman and Verbeke (1993) have argued that it is not enough to analyse the competitive advantage of the MNE solely in terms of its home country diamond. Our findings indicate that more research is needed to determine which is the relevant market for R&D subsidiaries: the immediate host country market, or the larger (regional or even global) market. The earlier-mentioned studies of multinational R&D (e.g. De Meyer, 1992; Florida & Kenney, 1994; Gerybadze & Reger, 1999), which emphasise the importance of trying out new products with sophisticated lead customers in the local environment (see Section 3.1), also note the wider importance of these lead customers, to the degree that the innovation will be subject to similar customer demands in other markets around the world. Our result of important differences between small and large host countries point to interesting avenues to deepen this line of research.

Here, and more generally, much depends on the subsidiary's role. Many affiliate conducts R&D locally but aim to exploit the fruits of this R&D internationally, such that the relevant competitive market may have to be defined more broadly. Similarly, a ''stand-alone'' pre-competitive laboratory unit will clearly be influenced differently by the local environment than the fully integrated R&D–production–marketing unit. Thus an important extension of this research, when trying to assess the effects of particular location advantages, would involve categorising R&D subsidiaries according to the roles of the affiliate within the MNE.

Managerial implications arise with respect to the role of subsidiary managers. As has been emphasised, this study, in contrast to most other work on the MNE, has been based on the views of subsidiary managers as regards what matters (and does not matter) to subsidiary R&D in the local environment. To the degree that our results differ from the expectations outlined in the hypotheses, it does seem that subsidiary managers possess key insights into the characteristics of the local environment that have not sufficiently been picked up by existing studies. To encourage higher levels of subsidiary R&D, greater efforts might be taken at other levels in the MNE to understand the assessments of local subsidiary managers as regards their placement in, and interactions with, the local environment.

Two specific implications for MNE management might be advanced. First, to the degree that multinational enterprises seek to optimise subsidiary R&D, more attention should be paid to the quality of local scientific institutions (and less to market and supply conditions) in making the initial location decision, and in allocation decisions regarding resources for R&D. Second, subsidiary managers, particularly in small countries, should be encouraged to establish and nurture as close contacts as possible with local scientific institutions.

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Appendix A. Selected questions from the questionnaire

Question 14: Which of the following activities are undertaken by the subsidiary? (please tick all that apply): "Research (basic or applied)", "Development", "Production of goods or services", "Logistics/Distribution", "Marketing & Sales", "Purchasing", and "Human resource management".

Question 21: How would you describe the level of investments in the following activities in the subsidiary for the past 3 years? Scale from 1 (very limited) to 7 (very large), with the same items as question 14.

Question 28: Please evaluate the business environment in (the host country) on the following dimensions. Scale from 1 (very low/bad) to 7 (very high): "Availability of business professionals", "Availability of supply material", "Quality of suppliers," "Demanding customers", "Level of competition", "Government support", "Favourable legal environment", and "Existence of scientific institutions."

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