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Subsidiary Embeddedness is a Strategic Choice: Complementarity and the factors associated with different types of embeddedness

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Abstract:
We conjecture that the Research and Development (R&D) subsidiary of a Multinational Enterprise (MNE) can be potentially embedded in three different networks viz. the science base of the home country, the science base of the host country, and/or the internal knowledge network of sister subsidiaries and parent MNE. We explore the type of relationship (complementary or substitutive) that exists between the three networks. Further, we develop a set of hypotheses about the factors that are associated with each form of embeddedness. We test these conjectures on data obtained from internationally located MNE R&D subsidiaries. We find that the three types of embeddedness are complementary to each other and the factors associated with each kind of subsidiary embeddedness are different.

Keywords: Multiple embeddedness; Multinational enterprises; R&D subsidiaries; complementarity; Subsidiary Roles; Seemingly unrelated regression

Jel codes: F23; L14; O32

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1. Introduction

The external embeddedness of the R&D subsidiaries of MNEs in their host economies is seen as an important element of the knowledge management strategy of the MNE by a large and emerging literature on international business (Cantwell, 2009). The need for external linkages in the host country typically arises from one of three motives - because the subsidiary may want to tap into the science base of the host country (e.g. investments around famous universities) or into a cluster of suppliers of intermediate products (e.g. semi-conductor fabrication in Taiwan) or to tap into inter-firm peer networks that are concentrated in particular countries and geographies (e.g. Silicon Valley, Cambridge). An important insight of much recent work on embeddedness is to highlight that embeddedness is the prime mechanism by which country specific and location bound advantages are transformed into firm specific assets for the firm.

The external embeddedness of technology creating activities in a host economy (which may co-exist with considerable degrees of autonomy) is often counterpoised with a strong internal embeddedness of the subsidiary within the MNE's subsidiary network. The internal embeddedness serves to exchange technological knowledge and information from sister affiliates and parents to the subsidiary, while Lahiri (2010) shows such intra-MNE ties play an integrative role in fostering knowledge management within the MNE and improve the overall quality of geographically dispersed R&D.

This emphasis on the centrifugal (or spread) forces in R&D management is contested by the technology management literature which has long argued that centralisation of R&D activity at home locations (or centripetal forces) dominate in the geographical organisation of R&D and will tend to favour home based networks of knowledge more amenable to control and perhaps also more trusted by headquarters (HQ) (Patel, 2010; Patel and Pavitt, 1991; Verspagen and Schoenmakers, 2004). Criscuolo (2009) shows that the citations to patents from the MNE's home country remain very important and argues that embeddedness within the home country's national system of innovation (NSI) is as important as embeddedness within host environments and may be the source of a different type of spillover due to the internationalisation of R&D that is little studied - knowledge spillovers to the home economy rather than the host economy.

This view about home country embeddedness is also confirmed by several studies in the economic geography tradition (reviewed in Werker and Athreye, 2004) which have questioned whether regional advantages influence the innovative activity of firms by encouraging host embeddedness. While small firms appear to benefit greatly from specific regional advantages, large firms which depend on international, national and regional resources in order to carry out their technology creating activities are not always influenced by regional factors and features (Doloreux, 2004; Karlsson and Olsson, 1998). This set of results gives credence to the centripetal view where the organising abilities and technological advantages of the home country dominate the innovative performance of large firms.

The extant literature in international business and technology management on the embeddedness of R&D subsidiaries is inconclusive partly because studies in international management focus on external host and internal embeddedness relationships alone (Almeida and Phene, 2004; Blanc and Sierra, 1999; Lee et al., 2001; Song et al., 2011; Sumelius and Sarala, 2008; Yamin and Andersson, 2011), while those in the technology management tradition consider mainly the external home and external host embeddedness roles (Criscuolo, 2009; Criscuolo et al., 2005; Le Bas and Sierra, 2002). Methodologically, both approaches by neglecting one of the three dimensions of R&D subsidiary embeddedness offer at best a partial representation of the reality and so are potentially misleading.

In this paper we develop the implications of the conjecture that an R&D subsidiary can draw upon host and home country external network, as well as its internal knowledge context when searching for sources of technological knowledge and the extent to which it is embedded in the three networks is the result of a strategic choice made by the HQ. Consequently, two questions arise: First, how can we conceive of the relationships between the three networks - are they complementary or substitutive? Second, what are the unique predictors for each type of embeddedness? The answers to both questions are important in order to assess how the MNE exercises leverage or arbitrage in locating their R&D activities based on location specific characteristics of the home and host locations, as well as the knowledge resources available in other parts of the MNE's network of subsidiaries.

The remainder of the paper is organised in the following way: Section 2 develops a framework for thinking about the relationships between the three types of

embeddedness and draws upon the extant literature to derive propositions about the factors that might predict more of one type of embeddedness over the other. We test these conjectures using survey data on R&D subsidiaries located in 14 different international locations and these data are described more fully in Section 3. One implication of the conjecture that the MNE can use one or all networks is that the decision to embed itself in host, home or the internal network is a joint decision and should be modelled as such. Section 4 outlines the methodology employed in the paper. Sections 5 and 6 of the paper present and discuss our main findings respectively, and Section 7 concludes.

2. Literature review and hypotheses development

2.1. Notions of embeddedness and their application to the MNE

The idea of firm embeddedness originates in the literatures in economic sociology and economic geography and is associated with slightly different meanings in each case. In the economic sociology literature, Granovetter (1985) pioneered the view that economic relations between firms and their environment are mediated by social networks and relations between them. He also argued that the strength of these networks and relationships shaped information flows between those agents – in particular the counter intuitive idea that weak ties (infrequent interaction) were more important than strong ties (more frequent interaction) in several situations.

In the economic geography literature, the concept of embeddedness is crucial to the idea of 'the untraded competencies of a region' (Boschma and Martin, 2010; Maskell and Malmberg, 1999; Storper, 1997) that confer advantages to firms locating in those regions. Here embeddedness refers to factors embedded in a region, such as the social culture, the specific politics, the development of technology creating institutions with their linkages and other aspects of history and endowments which may confer more lasting competitive or technological advantage. Thus, unlike the sociology literature where embeddedness arises as a consequence of interpersonal social interactions the geography literature's view of embeddedness is more predicated on a proximity based view. Since technology is assumed to have a large tacit component which benefits from frequency of interaction and sharing of abstract concepts, the economic geography view of embeddedness has become important to discussions of technology transfer from the broader environment to the firm.

In the context of the MNE, two notions of embeddedness, internal and external, have been considered important. Internal embeddedness refers to the MNE subsidiary's position within the federated network of affiliate subsidiaries and the parent company and the frequency of its interaction with sister and parent units. Similarly, Andersson and Forsgren (1996) define the subsidiary's degree of external embeddedness as a measure of relevant direct and indirect relationships the subsidiary has developed with suppliers, customers etc., as well as by taking into consideration the aspects of the particular transactions with them echoing the ties' view of embeddedness emphasised in the sociology literature. Almeida and Phene (2004) who first emphasised the importance of this distinction for technology creating activities however, lean towards a more economic geography interpretation of proximity. They argued that an MNE firm's decision on what type of R&D unit will be established and where may be influenced by the level and density of network embeddedness between the unit, the parent company, the other affiliates and the external actors (firms and institutions) of the host location. The depth of embeddedness is usually measured by the frequency of interaction - a concept that comes from the sociological literature on ties.

2.2 The relationships between each type of embeddedness

As we noted in the introduction, MNEs' subsidiaries are actually situated in three interrelated networks viz. external home, external host and internal network. Although the innovative activities of the leading MNEs have followed a more globalised route throughout the years (Cantwell, 1995), it is also known that MNEs which internationalise their R&D activities usually locate them in technological fields where they are strong at home (Les Bas and Sierra, 2002; Patel and Vega, 1999). This fact underlies the common notion that innovative activities implemented in the home country confer huge competitive advantages for the MNE (Le Bas and Sierra, 2002). The host location where the R&D subsidiary is located can provide a network of resources and partners whose contribution (knowledge) is likely to complement the existing knowledge derived from the home location of the MNE. Empirical evidence for this proposition comes mainly from the study of patent citation data drawn from European and US MNEs (Criscuolo et al., 2005). Criscuolo (2009) argues that substituting home with host location's NSI carries significant negative drawback for

the whole MNE (e.g. knowledge spillovers to competitors in the host location). More recent work by D'Agostino and Santangelo (2012) shows that R&D subsidiaries of OECD-based firms with a pure adaptation profile (and operating in the top six emerging economies of the world) tend to complement host R&D with home region knowledge creation. Thus, we may expect that the two external networks - home and host - will have a complementary relationship and firms that are strongly embedded at home may also be strongly embedded in the host economy. Accordingly, we hypothesise that:

H1a: External network of the home country and external network of the host country under which foreign R&D subsidiaries are embedded will have a complementary relationship in the sense that more of one type of embeddedness will give rise to more of the other type of embeddedness.

The relationship between internal and external network embeddedness on the other hand appears to be a bit more ambiguous. Evidence from domestic (non-internationalised) enterprises shows that internal and external resources form a complementary relationship that enhances the firm's absorptive capacity as regards the external knowledge acquisition (Hervas-Oliver and Albors-Garrigos, 2009). Blanc and Sierra (1999) argue that since an MNE R&D subsidiary, apart from adapting itself to the host location under which it operates, also aims to benefit from possible knowledge spillovers arising from its internal network, its internal corporate embeddedness and external embeddedness may act as substitutes or complements. Similarly, Gammelgaard and Pedersen (2010) conducting a survey on external and internal knowledge sourcing of subsidiaries find a non-linear relationship between the two. More specifically, the relationship between the two is complementary but is transformed to a substitutive one when the subsidiary's resource constraints become predictable and binding. These resource constraints in turn lead the R&D subsidiary to a more tied relationship with only one of the two networks. Yamin and Andersson (2011) investigating the role of internal embeddedness on subsidiary's importance within the MNE indicate that when internal embeddedness is made to interact with external embeddedness, external embeddedness no longer has a positive explanatory role in explaining the subsidiary's importance suggesting again that the

relationship between internal embeddedness and external host embeddedness is likely to be substitutive.

We follow Gammelgaard and Pedersen, (2010) and think that managerial resource constraints might determine the relationship between the three networks. The internal embeddedness of the subsidiary is a choice variable for the parent firm, which in turn will also decide how the subsidiary utilises the home country networks. This control exercised by the parent suggests that internal and external home networks may be complements and the position in both is fully controlled by the parent. Activities that increase external host location embeddedness are however controlled by the subsidiary and this may involve trade-offs about how highly the subsidiary can be integrated in the internal network of the MNE due to the large coordination costs that may arise from two managements (parent and subsidiary) having to synchronise their selection of actors and activities. Accordingly, we suggest the following hypotheses:

H1b: External network of the home country and internal network under which foreign R&D subsidiaries are embedded will have a complementary relationship and is probably fully controlled by the HQ.

H1c: External network of the host country and internal network under which foreign R&D subsidiaries are embedded will have a substitutive relationship in the sense that more of one type of embeddedness will result in less of the other type of embeddedness.

Figure 1: Multiple embeddedness of the R&D subsidiary and interrelationships.

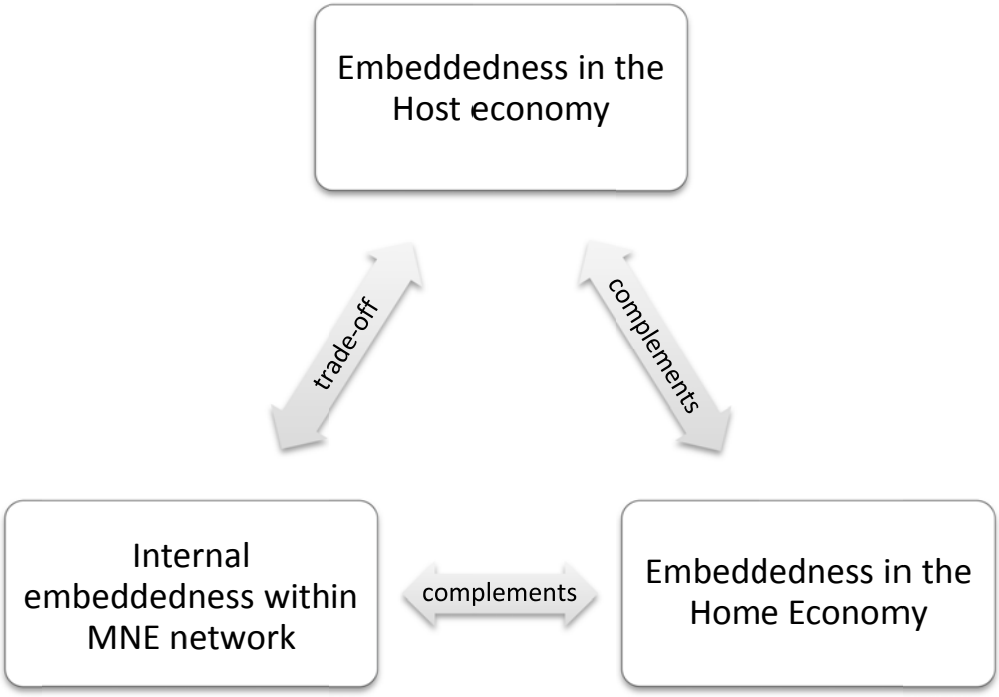


Figure 1 above portrays the hypothesised relationship among the three examined types of embeddedness (External Home – External Host – Internal).

An important distinction is that of R&D subsidiaries whose technological activities are home-base augmenting (HBA) and those whose technological activities are home-base exploiting (HBE) (Cantwell and Mudambi, 2005; Kuemmerle, 1997)[1]. Studies have shown that the two types of R&D subsidiary tend to behave differently vis-à-vis their external linkages. HBA labs develop strong ties with research institutions and universities, while HBE subsidiaries increase the degree of liaison with customers and local production units (Ambos, 2005). To the extent that the resourcing of HBA subsidiaries is often directly managed by the HQ, and their contact with the host economy is highly selective (often restricted to universities and scientists), we may expect H1c to be irrelevant as the sort of resource constraints that underlie the trade-off relationship do not apply in the case of HBA activities.

[1] A large number of studies on the internationalization of R&D have focused on defining, explaining and producing R&D typologies (or archetypes) in order to further explain recent trends, host location characteristics and managerial implications on why, where and how MNEs' R&D activities go international (Gassmann and von Zedwitz, 1999; Håkanson and Nobel, 1993; Le Bas and Sierra, 2002; Nobel and Birkinshaw, 1998; von Zedwitz and Gassmann, 2002). We focus on the simplest of these typologies viz. HBE and HBA activities.

2.3. Influences on each type of embeddedness

2.3.1. The R&D Mandate

Hood and Young (1982) and Pearce (1994) in the late 80s and early 90s, categorised three different mandates for MNEs' foreign R&D labs. The first type of R&D is that conducted in Support Laboratories (SLs), whose main mandate is to adapt existing products and processes to local conditions. The second type is the Locally Integrated Laboratories (LILs) whose mandate is to closely coordinate with various other functions of the subsidiary's local environment in order to develop or enhance products according to local needs and scope. They identified a third type of R&D lab, the Internationally Interdependent Laboratories (IILs), which has no systematic connection with the MNE's production units, since it is mandated to work with other interdependent networks from all over the globe targeting new scientific effort in order to create new product and process patterns. Thus, SLs and LILs are oriented toward adaptation and improvement of existing products and distribution of them in the host market, while IILs are more independent research units where novel research is conducted. In addition, Andersson et al. (2002) show that there is a complementary relationship between the (host) external network of the affiliate (in terms of technical embeddedness) and its R&D specific role (as a source of knowledge for other sister units), while Andersson (2003) shows that external technical embeddedness is positively related to a subsidiary specific role within the MNE[2], which means that the level of technical embeddedness with the host environment is positively affected by the specific role (either R&D- or purchasing-driven) that has been assigned to the laboratory by its HQ. Thus, there is a strong suggestion in these studies that the external (host) network orientation of the R&D subsidiary is associated with the mandate of R&D subsidiaries.

On the other hand, the technology management and economic geography literatures emphasise that the home country embeddedness of firms is important for their most significant innovations. Thus, Gertler et al. (2000), based on Canadian data from the Ontario region, show that indigenous firms were more likely to perform innovative activities locally and were more embedded in the local economy than their multinational counterparts, as they exhibited higher R&D intensity, had a larger

[2] Both these studies are based on data for Swedish MNEs which are much more internationalized in their R&D activities due to the relative smallness of the country (Patel, 2010).

proportion of scientific, technical and managerial employees, adopted innovative inter-firm practices more extensively, and were more likely to source innovative ideas from local customers. The multinational establishments, in contrast, tended to exhibit lower R&D intensity, were more reliant on their in-house marketing units, and continued to rely on their parent companies (internal network) as a primary source for innovative ideas. The finding of the dependence of MNE subsidiaries on their parent for innovation and their lower R&D intensity is also echoed by studies on knowledge spillovers (Driffield and Love, 2007; Veugelers and Cassiman, 2004). Williams and Nones (2009) distinguish the embeddedness behaviour of basic research units and service subsidiaries and show that basic research units are more embedded in the internal network of the MNE and more isolated from their external (host) network, while service subsidiaries are more prone to extend their communication with local customers (i.e. external host network).

New basic research activity, even if sourced from overseas labs, will probably be kept very close to the existing home networks which generated significant innovations for the firm in its early growth. Criscuolo (2009) argues that in order for the MNE to harvest maximum gains from the R&D activity that takes place abroad, there should be no doubt that the MNE's R&D function is well-tied into the parent country's network. IILs laboratories are endorsed by the HQ and carry greater research responsibilities than the two other types of R&D units. It is likely that the original research mandate of IIL will make it more closely tied to the home external network because the tacit knowledge and people-specific elements of new technological research and strategic considerations will make the firm sensitive to potential leakages of technology as well.

On the other hand R&D labs with a more adaptive character (SLs and/or LILs) will tend to be more embedded within the host environment's external network, because the region specific information needed for adaptation is likely to be more readily available there. SLs are more likely to be embedded in the host location's environment basically for market seeking purposes.

The main responsibility of LILs is to develop new products for particular areas of the international market, as well as to promote existing products and processes in new - regional or even global - geographic areas (Pearce, 1999). For simplicity we may think of their mandate as involving product differentiation in addition to simple

adaptation. Such labs have to be multi-embedded entities because while their market seeking activities rely on the host location, their research draws upon and adds to the MNEs stock of knowledge and products. This latter role is best accomplished by being embedded in the internal or within MNE networks (Manolopoulos et al., 2011).

Thus, the literature on research mandates suggests a link between mandate, type of R&D lab and the nature of embeddedness. Based on our review we hypothesise that:

H2a: Foreign R&D subsidiaries acting as IILs will be embedded in the home (parent) country's external network.
H2b: Foreign R&D subsidiaries acting as SLs and LILs will be embedded in the host location's external network.
H2c: Foreign R&D subsidiaries acting as LILs will also be well-embedded in the internal network.

2.3.2. Environmental uncertainty

Two aspects of the macro environment may be important in determining where an R&D subsidiary will embed itself - this is the IPR regime and the stability of the business environment.

The public good nature of technological knowledge implies that knowledge spillovers, information leakage, macroeconomic instability and weak Intellectual Property Rights (IPR) protection can impose substantial costs for MNE R&D in foreign locations. A strong IPR protection regime has been found to be a positive determinant of technology investment attractiveness and thus determines whether R&D facilities will be established at all (Kumar, 1996; Narula and Guimón, 2010; Saggi, 2002).

Blomstrom and Kokko (2003) argue that knowledge dissemination usually takes place through staff inter-firm mobility and frequent liaisons between the lab and its external network – the very factors that are associated with deepening host embeddedness. Zhao (2006) conjectures that MNEs which face such problems will tend to practice careful task portioning in order to avoid any losses due to technological spillovers – and demonstrates this to be true in the case of emerging economies where IPR protection is weak. This suggests greater internal

embeddedness through collaborative links with parent and sister affiliates. This is not without debate. Using case studies of Indian R&D units, Kumar and Puranam (2012) argue that firms may develop adequate internal managerial techniques in order to raise awareness of IP and thus tackle any knowledge spillover and R&D leakage problems. Accordingly, we expect that R&D units facing potential R&D leakage challenges will tend to further strengthen their ties with their internal network, while those ties will be more embedded in the host location if the potential for R&D outflow is to a certain extent limited.

Furthermore, host locations surrounded by high macroeconomic instability will force R&D subsidiaries to extend their ties with the home (parent) network of the MNE. The literature shows that economic uncertainty in host locations of investment acts as a detrimental factor on the total investment rate regarding the development of new foreign subsidiaries (Fisch, 2008; Fisch, 2011). Accordingly, we expect that already established subsidiaries in host locations surrounded by high levels of macroeconomic uncertainty will be more likely to establish stronger ties with their home environment. Hence, we conjecture that:

H3a: R&D subsidiaries operating in a host environment with high macroeconomic instability will be embedded in the home (parent) country's external network.
H3b: R&D subsidiaries operating in an environment which has a strong IPR protection regime will be embedded in the host country's external network.
H3c: R&D subsidiaries surrounded by a weak IPR protection regime will be embedded in the MNE's internal network.

2.3.3. Subsidiary autonomy

Prior literature in international business has explicitly researched the particular role of subsidiary autonomy and its impact on economic development and firm performance (de Jong and van Vo, 2010; Edwards et al., 2002; Johnston and Menguc, 2007; Slangen and Hennart, 2008), but these studies are not always based on a study of R&D labs.

The degree of autonomy with which each R&D subsidiary operates is a decision conventionally set by the HQ of the MNE. Allowing subsidiaries independence may decrease some kinds of coordination costs especially in mature technologies and

also be a more efficient way of searching for local partners for technology creation. On the other hand, Patel and Pavitt (1991) provide a number of reasons why MNEs will tend to control their technological activities at home, rather than giving substantial degree of autonomy to their foreign-based R&D subsidiaries. The tacit knowledge nature of innovation process, the threat of commercial uncertainties surrounding a weak - in terms of intellectual property protection - R&D unit, and the promptness that decision-making should be done, are some of the reasons why MNEs prefer to control very tightly their R&D subsidiaries. Andersson and Forsgren (1996) identify a positive relationship between the degree of external (host) embeddedness and the level of autonomy allowed to the subsidiary by the HQ. On the other hand, a negative association between internal embeddedness and the degree of subsidiaries' autonomy has been observed in other studies - a finding also supported by Birkinshaw and Morrison (1995). Accordingly, based on the existing literature we conjecture our hypotheses as follows:

H4a: R&D subsidiaries acting as more autonomous (i.e. decentralised) units will be embedded in the host location's external network.
H4b: Foreign R&D subsidiaries acting as less autonomous (i.e. centralised) units will be embedded in the MNE's internal network.

2.3.4. Science and Technology endowments of the host location

Many of the hypotheses developed above assume that the costs of doing R&D are common to all locations since they are derived on the assumption that the transaction costs of undertaking dispersed technological activities stem from the tacitness and appropriability of knowledge. These costs must be evaluated against the location specific advantages of the host country stemming from the local endowment of national resources and institutions.

Among location-specific endowments, the attraction of accumulated stocks of technological knowledge in the host location and large scientific labour pools for technology based investments are stressed in a large number of studies (Cantwell and Mudambi, 2000; Cantwell and Piscitello, 2002; Dachs and Pyka, 2010; Demirbag and Glaister, 2010; Groh and von Liechtenstein, 2009; Lewin, et al., 2009; Narula and Guimón, 2010; Sachwald, 2008; Saggi, 2002; Varsakelis, 2001; Varsakelis,

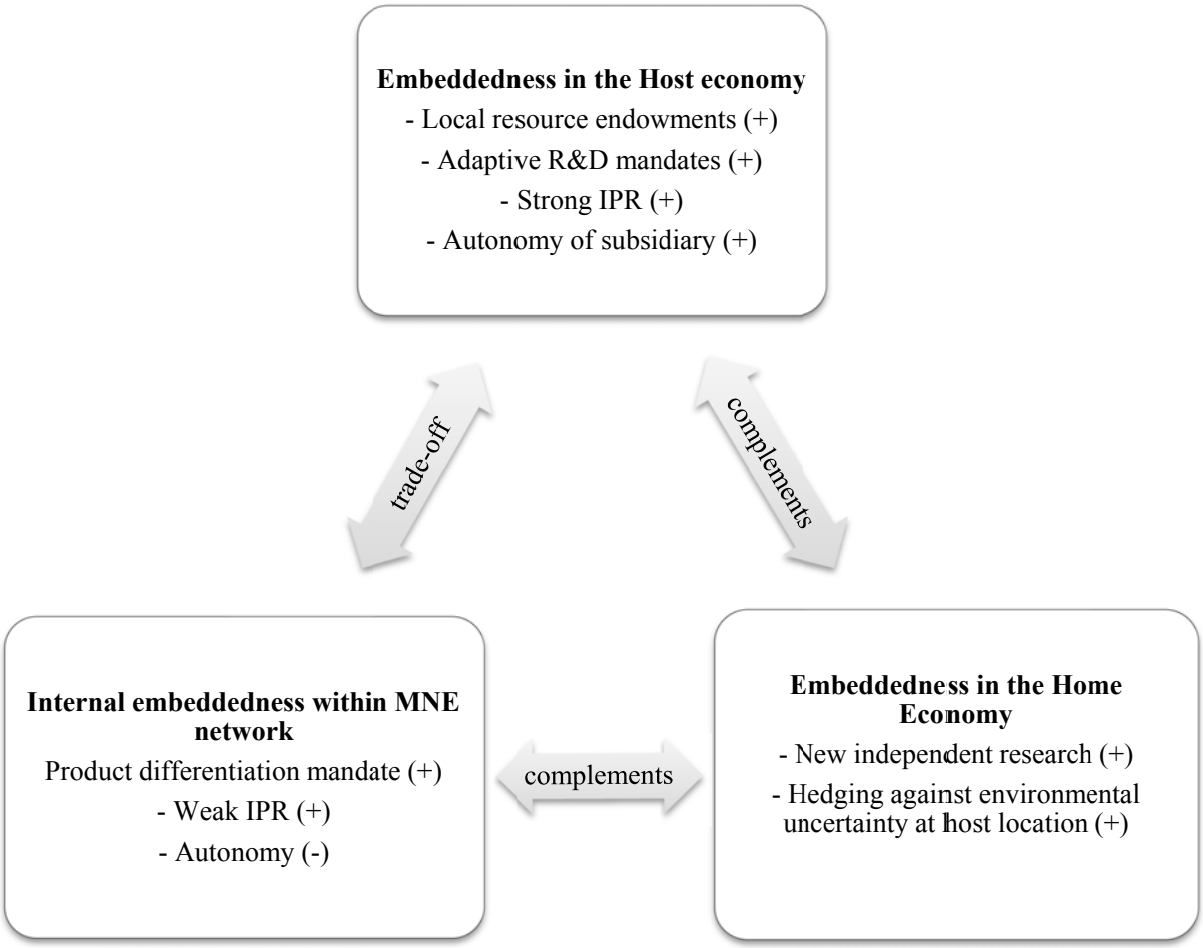
2006). In general it is argued that locations that display technological excellence, qualified labour pools and business friendly institutions, form a strong NSI which MNE R&D investments will want to tap into. For the same reason, MNE R&D labs will also tend to establish strong network ties with the external host environment in order to benefit from the location specific advantage.
Hence, we hypothesise that:

H5: R&D subsidiaries operating in host locations with strong technological endowments will be embedded in the host country's external network.

2.3.5. Summary

Figure 2 summarises the factors we expect will be associated with each kind of embeddedness based on our survey of the different strands of literature. We expect that the extent of embeddedness in the host economy is predicted by R&D mandates that favour product adaptation and differentiation, strong IPR regimes, favourable technological endowment in the host location and with higher autonomy of the subsidiary. Embeddedness in home networks is predicted by mandates for independent and new scientific research as well as by business environment uncertainties at host locations. Lastly, high levels of internal embeddedness are predicted when R&D labs have a product differentiation mandate and face weak IPR regimes in the host economy. However, high levels of internal embeddedness are inversely related to the autonomy enjoyed by a R&D subsidiary.

Figure 2. Summary of hypotheses to be tested in the empirical analysis.



3. Data and variables

3.1. Survey Data used in the analysis

The data used in our analysis is drawn from a survey of 133 overseas subsidiary R&D centres undertaken in 1989. The survey included the MNE's largest international R&D unit whose role was to support local marketing and/or engineering activities, or to be capable of advanced research by contributing in a globally integrated research program. The detailed nature of questions asked in this survey and the coverage of home, host and internal networks, make it an ideal source of data on which to test our conjectures. Although our study's dataset may seem dated, it is not very much older than the data used in several of the studies we cite in our literature review. For example the studies by Un and Cuervo-Cazurra (2008) and Nell and Andersson (2012) use data from the period 1991-1994; while Mudambi et al. (2007) use the most recent data which were collected in 1995. This should not be

surprising considering that the extreme political sensitivity of MNE R&D investments abroad has been a severe barrier to the collection of more recent data.

The sampling frame of the survey consisted of the Fortune 500 list published in 1986 when only 405 of the 500 units had established R&D facilities abroad, and thus the feasible sample was automatically reduced to almost 405 industrial companies. A questionnaire was sent via mail to the existing population of foreign R&D units[3]. In total, 135 questionnaires were returned. Of these, two were considered as unusable[4] truncating our final sample to 133 observations – a response rate of almost 32.8 per cent.

In order to better describe the global distribution of R&D units we incorporate a cross-tabulation (Table 1) which presents the host countries in which MNEs operate R&D laboratories against their country of origin. Table 1 shows that European MNEs tend to operate overseas R&D laboratories mainly in the US, while there is evidence that US and UK firms prefer to allocate their R&D units in UK and US territories respectively.

--- Table 1 goes about here ---

The sample's distribution is quite representative of what we know about global research activity of MNEs in the late 1980s based on patent analysis. Patel and Pavitt (1991) identified that the US accounts for almost the half of the global R&D activity, with Japan and the UK follow. In our survey sample, R&D subsidiaries based in the US, the UK and Japan account for the 71.4 per cent of the total sample.

However, this may not be a major drawback. Dunning and Lundan (2007) estimate that the number of locations from which international R&D is drawn remains small despite the increased internationalisation of R&D and, based on patent data Patel (2010) also shows that the US and Europe continue to be the main locations for international R&D - these locations are very well covered in our data. Thus, while

[3] The first questionnaires were sent out in October 1988 and the last ones in June 1989, while the first completed questionnaire was received back in November 1988 and the last one in August 1989. The survey questionnaire is available from the authors upon request.

[4] By mistake these two R&D subsidiaries were perceived to operate away from their parent location. Apparently, when the questionnaires were received it was reported that these are domestic R&D units operating close to the HQ of the parent company. Hence, we excluded these two observations from our final sample.

many of the new R&D locations, such as Israel, Ireland, India and China, are not covered in this survey, we may still be picking up the most important R&D locations based on the volume of R&D conducted.

As regards the industry division of the sample, Table 2 reports that about 75 per cent of it consists of R&D subsidiaries in pharmaceuticals, electronics and chemicals and petroleum sectors – which are among the most internationalised sectors in R&D.

--- Table 2 goes about here ---

We supplemented the subsidiary specific information drawn from the survey questionnaire with host location specific characteristics which are drawn from well-known secondary data sources. Thus, the two proximity-related variables were taken from the CEPII (Institute for Research on the International Economy) database, while for the IPR index we use the Ginarte-Park Index for the time period 1960-1990. Also, the unemployment rate is obtained from the International Labour Organisation, while the inflation rate and GDP per capita are obtained from the WDI (World Bank) database.

3.2. Controlling for non-response bias

In order to control for possible non-response bias in our sample we proceed to two different methods. First, we compare the number of respondents (N = 133) to that of the original population (N = 405) for all the examined geographical locations. Looking at Table 3 we see that almost all the foreign locations where R&D subsidiaries operate are well represented in the returned questionnaires, except for Canada and France which are somehow underrepresented compared to our initial population.

--- Table 3 goes about here ---

Second, since some questionnaires were collected after respondents received a second notice (reminder), we test for a possible non-response bias that may negatively affect our sample's explanatory power. From a total of 133 questionnaires,

99 responses were collected in first round and 34 right after our reminder. To investigate the non-response bias we compared subsidiaries' age and size characteristics in the responses collected under first and second attempt (Armstrong and Overton, 1977). A t-test found no statistically significant difference ($p < 0.05$) between questionnaires received before and after the reminder.

3.3. Variables created

3.3.1. Constructing measures of external and internal network embeddedness

The embeddedness of a subsidiary is measured either through the density of its relationships with different actors (as in Ambos, 2005) or in terms of the subsidiary's dependence upon particular relationships in its external environment (as in Andersson and Forsgren, 2000). Based on the survey instrument used we constructed the following measures of embeddedness:

External Home: This variable is based on the answer to the question "Does any liaison exist between this R&D unit and the home country: i) research institutions; ii) universities; and iii) R&D labs of local and/or foreign companies?" The answers to this question have a categorical-likert operationalization, ranging from 1 (no contacts reported) to 3 (regular contacts reported). We assume the higher the frequency of contact the more embedded is the subsidiary in external home networks. We created the variable *External Home* based on the mean score of responses to the above three questions. The Cronbach's alpha value for this construct is 0.65.

External Host: The survey questionnaire also asks for the subsidiary's response to the following questions: "1) Does this R&D unit give contract jobs to the following institutions in this country: i) independent research labs; ii) universities; 2) Does any exchange program of scientists exist between this unit and other local research institutions/labs? 3) Are seminars relating to ongoing research in this unit held in collaboration with other local research units/institutions? 4) Are research findings of this unit published in journals? 5) Are local independent researchers one of the most likely sources of project ideas initiated in this unit?" The answers to all the above questions also have a categorical-likert formation, based on the frequency of interaction, and range from 1 (never) to 3 (regularly). Again we assume the higher the frequency of contact the more embedded is the subsidiary in external host networks. In constructing *External Host* we take the mean score of a subsidiary's

response over the above questions. The Cronbach's alpha value for this construct is 0.60.

Internal: Apart from the two previous forms of external embeddedness, the survey questionnaire also provides valuable information with regard to the degree of internal embeddedness of the R&D subsidiary. The questions used to construct this variable are as follows: "Are the parent or other sister R&D units involved in your projects in any of the following ways? i) systematic coordination of your projects into wider programmes ii) to bring about a major change in the direction of the project iii) to advise on the development of a project iv) technical assistance at the request of the R&D unit." The answers to these questions have a categorical-likert operationalization, ranging from 1 (never) to 3 (regularly). Accordingly, if the interaction with its affiliate and parent units is frequent it is implied that the subsidiary is highly embedded in the internal (MNE) environment. The mean score of the above four questions was calculated in order to construct this variable, whose Cronbach's alpha value is 0.73.

3.3.2. Explanatory variables

The type of R&D Lab

The survey questionnaire allowed us to create a variable that could measure the type of R&D lab, according to the mandate allocated by the parent company. Thus, following the R&D subsidiary classification introduced by Hood and Young (1982) and Pearce (1994), each unit was asked to classify its activities into the following categories:

Support Laboratories (SLs): Is the lab's role to assist production and marketing facilities in the host country and to make effective use of the parent's existing technology?

Locally Integrated Laboratories (LILs): Does the lab's role, though predominantly oriented to the local market and/or production conditions, involve more fundamental development activity than SLs?

Internationally Integrated Laboratories (IILs): Does the lab play a role in an integrated R&D program coordinated by the (parent) or other major laboratory?

Responses to the above three questions form a categorical–likert operationalization with the relative responses being: not this type of laboratory (1), partially this type of laboratory (2) and predominantly this type of laboratory (3).

Environmental Uncertainty

IPR protection regime: This variable is constructed by the Intellectual Property Rights Protection Index (for years 1960-1990). The original scores of the IPR Protection Index (Park, 2008) range from 1 (weakest) to 5 (strongest).

Macroeconomic instability: The measurement of this particular scale variable is calculated by aggregating the level of unemployment (as a percentage of total labour force) and inflation, GDP deflator (annual percentage) in the host country. A range of research studies (Clausing and Dorobantu, 2005; Golden, 1993), especially in the field of economics, have used this sort of index in order to capture the misery level of the macroeconomic environment. In fact, an increasing level of this index indicates a more volatile macroeconomic climate for the country.

Autonomy

In order to measure the degree of R&D subsidiary's decentralization we use the following survey-based question. "Do this and other units of the parent company interact?" The possible answers to the above question have categorical-likert formation and range from 1 (very often) to 3 (never). Hence it is implied that the less the interaction with other units of the MNE the more autonomous the R&D subsidiary is.

Local endowment

In order to measure the degree of influence of the host's scientific and technological endowments of a particular location we use four questions from the survey. The questions ask the respondents the following: "Which conditions or circumstances do you consider have most influenced recent decisions with regard to the development of this unit? i) a distinctive local scientific, educational or technological tradition conducive to certain types of research project ii) presence of a helpful local scientific environment and adequate technical infrastructure iii) availability of research professionals iv) favourable wage rates for the research professionals." The answers to this question have a categorical-likert operationalization, ranging from 1 (irrelevant to decisions) to 3 (a major factor

contributing to the decisions). The variable is calculated by taking the mean of the upper four questions, while the value of this construct's Cronbach's alpha is 0.72.

3.3.3. Control variables

We also use a number of control variables in the analysis based on variables found to be important in other studies. The size and growth of the host economy markets play a key role for MNEs which seek to adapt their products according to the needs of the host environment. Large domestic markets are more likely to attract larger amounts of R&D investments of the HBE sort (Cantwell and Piscitello, 2002; Dachs and Pyka, 2010; Kumar, 1996; Kumar, 2001). Also, we use *GDP per capita a*s an index of market potential (Fagerberg, 1987).

Gassler and Nones (2008) show that location-specific factors, such as the geographic and cultural proximity between the parent and the host country also influence the costs of R&D. Sharing a common language and being physically close are likely to be associated with similar norms in public science and an easier adaptability of the local workforce to the corporate culture of the MNE. Accordingly, we include:

Geographical Distance: This variable is calculated by taking the natural logarithm of geographical distance between the lab's parent country and its host location. The distances are calculated following the great circle formula, which uses latitudes and longitudes of the most important city (in terms of population) or of its official capital.

Cultural Proximity: This is a dummy variable taking the value 1 if a language is spoken by at least nine per cent of the population in both countries and value 0 otherwise.

As noted earlier the distinction between being a technology augmenting or technology exploiting subsidiary might be an important factor strengthening or weakening certain relationships. Technology exploiting subsidiaries are more likely to be based close to production plants. We created *Production subsidiary*, a dummy variable taking the value 1 if the firm reported that it is an R&D facility which is associated with a production subsidiary. We include this variable to better capture technology exploitation/augmentation, as suggested by Cantwell and Mudambi (2005).

LnYears: A survey-based scale variable measured by the natural logarithm of years of the R&D unit's operation in the host location. Ln(Year of survey-Year of R&D facility's incorporation).

LnSize: Again, a survey-based scale variable estimated by the natural logarithm of the R&D unit's employment at the most recent year of the R&D unit's operation.

Industry dummies: In order to control for possible industry effects on the degree of R&D subsidiaries' network embeddedness we incorporate industrial sector dummies. Accordingly, four industry dummies are constructed, while each one corresponds to a unique industrial division (Chemicals and Petroleum, Electronics, Pharmaceuticals and Miscellaneous industries).

Country dummies: We also make use of two country dummies for two of the most internationalised countries (in terms of R&D activities) of our sample (US and UK).

Table 4 describes the variables created, provides information about their source, as well as it presents basic descriptive statistics for each of the variables.

--- Table 4 goes about here ---

4. Econometric design

4.1. Modeling the multiple embeddedness of R&D subsidiaries

The principal focus of our arguments is that subsidiary embeddedness in any host location to exploit new technological opportunities is jointly determined with the other forms of embeddedness, i.e. within the MNE network for better coherence of R&D and within the external networks in the home location of the HQ to permit better overall control. This is the case even if the factors influencing technological coherence, technological opportunity and the control of technological activities may be quite different. Furthermore we have argued that managerial traction requires that there are complementary relationships between levels of external embeddedness (host and home) but that internal and external host embeddedness may be substitutive as the coordination costs of host location management constantly keeping the other affiliates informed may be quite high.

The statistical implication of such a joint determination of the levels of embeddedness is a simultaneous structure where errors across the equations are

allowed to be correlated. Accordingly, if our dependent variables *External Home* (E_i^P), *External Host* (E_i^H) and *Internal* (I_i) are measures of the external (in the host and parent country) and internal network embeddedness respectively, we can write them in the form of a Seemingly Unrelated Regression Estimation (SURE) such as given by the system of equations below:

$$E_i^P = \alpha + \beta_1 IILs_i + \beta_2 Macro\_instability_i + \beta_3 C_i + \varepsilon_i$$

$$E_i^H = \gamma + \delta_1 SLs_i + \delta_2 LILs_i + \delta_3 IPR_i + \delta_4 Autonomy_i + \delta_5 Endowment_i + \delta_6 C_i + \zeta_i$$

$$I_i = \lambda + \mu_1 LILs_i + \mu_2 IPR_i + \mu_3 Autonomy_i + \mu_4 C_i + \eta_i$$

where the vector (*C*) includes the control variables (Ln_Years, Ln_Size, Production_subsidiary, CP, EC. PH, US, UK, Ln_Geo_distance, Cultural_proximity, and Ln_GDPPC) while the explanatory variables correspond closely to our conjectures on the factors that are associated with each type of embeddedness based on the literature review. These are of four types: variables that measure the mandate to the R&D unit (SLs, LILs and IILs), the level of environmental (macroeconomic and institutional) uncertainty of the host location, host location's endowment richness and the degree of autonomy (decentralisation) of the R&D subsidiaries.

SURE is defined as the most appropriate system for estimating the parameters of our model since it allows Cov (ε_i,ζ_i), Cov (ε_i,η_i) and Cov (ζ_i,η_i) to be non-zero and in this way it improves on the OLS estimates of each equation separately which would be appropriate if each type of embeddedness was determined independently of the other. The SURE method is also different from a simultaneous equation system since it enables us to include different sets of regressors, for E_i^P, E_i^H and I_i (Zellner, 1962). The literature review in Section 2 strongly suggests that the factors associated with each type of embeddedness are slightly different.

To validate our choice of method and also to assess the relationships between the three different types of embeddedness we estimate each of the three equations above by OLS and report them in the appendix to the paper. Next, we estimate the residuals deriving from each independent equation and assess the correlation between them. This validates the use of the SURE methodology, but since the residuals reflect the statistical properties of the dependent variables the correlation of residuals also serves as a check on Hypotheses 1a-c which relate to the

complementary or substitutive relationship between the three types of subsidiary embeddedness

4.2. Multicollinearity

Survey data are prone to multicollinearity between the variables and the constructed factors (reported in Table 4). Multicollinearity is initially identifiable through the correlation matrix, where variables can be highly, but imperfectly, correlated (Greene, 2003). If such a case holds, and although the regression analysis is processed normally, it is almost certain that severe statistical problems will come up and our model will turn out to be of inefficient quality. The correlation matrix (Table 5) indicates that possible presence of multicollinearity may hold among *GDP per capita* and *Macroeconomic instability* (ρ = -0.85). In order to further assess whether multicollinearity is an issue, we estimated the variance inflation factors (VIFs) for each coefficient in each examined model(s).

--- Table 5 goes about here ---

The VIFs scores (Table 5) in all the examined equations reported values no greater than the 'rule of thumb' of 10 (Hair *et al*., 1998). Thus, multicollinearity is not an issue in any of the estimations.

4.3 Robustness of results across technology exploiting and technology augmenting R&D subsidiaries

An important finding in the literature is the significantly different size and organizational structure of technology augmenting and technology exploiting subsidiaries. Kuemmerle (1997) describes the different focus, size, organisational structure and external links of these two R&D lab archetypes. HBA labs are established in order to absorb scientific knowledge available in the host location, create new knowledge and later on transfer it to the main R&D unit (HQ) of the company. On the other hand, HBE labs are driven by the need to commercialise existing knowledge that is available in the central R&D unit (HQ) and accordingly transfer it to the MNE's foreign-based labs and from there to local production units.

Although our survey questionnaire does not include any sort of question relating to these two typologies, we do have a question asking whether the R&D facility is associated with a production subsidiary. According to Kuemmerle (1997) technology-exploiting R&D subsidiaries are usually linked to production subsidiaries of the MNE - we exploit this fact to separate out that subsample as technology exploiting subsidiary and report estimations for that group alone. Unfortunately, since 70% of the full sample reported that is associated with a production subsidiary we could not run an additional regression for the rest (possibly technology augmenting subsidiaries) due to insufficient number of observations for proceeding. However, we do compare estimations of the technology exploiting R&D labs with the results for all R&D subsidiaries and infer the likely relationships in the more thinly populated technology augmenting subsample.

5. Empirical findings

5.1. Descriptive statistics

Table 4 shows that, on average, the extent of home country embeddedness is higher than host country embeddedness in our sample of firms, though a slightly smaller number of firms seem to report the opposite. Interestingly, external home and internal embeddedness have similar magnitudes. The dominant R&D mandate in our sample seems to be SLs. As regards the level of autonomy and local endowment, the descriptive statistics indicate that the sample of subsidiaries does not enjoy a great level of autonomy, but local endowments are perceived to be high. This may simply reflect the state of affairs in the internationalisation of R&D in the late eighties when it is widely accepted that the transnational model or MNE organisation was less popular and many MNEs tended to be multi-domestic or global firms (Bartlett and Ghosal, 1989).

The control variables suggest that 68 per cent of the sample consisted of production subsidiaries, while the average age of a R&D subsidiary in the sample was 26.2 years and the average R&D employment size was 154.3 people. Our location characteristics are drawn from well-known secondary data sources but because we cover only 14 countries and not sub-regional units they exhibit limited variability.

5.2. Empirical results

Table 6 presents the correlation of residuals from the OLS estimations (reported in Appendix Table A1) and shows that the residuals of the OLS equations are correlated and as such the use of a SURE methodology is validated (Zellner, 1962). Further, Table 6 also tests Hypotheses 1a-c.

--- Table 6 goes about here ---

Table 6 indicates a complementary relationship between external home and external host embeddedness since the correlation coefficient is positive and statistically significant (ρ = 0.45, p < 10%). Hence H1a is supported by the results. Similarly, we find that a positive and significant correlation between the residuals of external home and internal embeddedness (ρ = 0.21, p < 10%) confirming a complementary relationship between these two forms of embeddedness. Finally, we find a positive but statistically insignificant relationship between the residuals of external host and internal embeddedness (ρ = 0.20). Hypothesis 1c of a substitutive relationship between these two types of embeddedness is not supported.

Table 7 reports the SURE model estimation. Firm, industry and country specific controls are incorporated in all equations. More specifically, natural logarithms of geographical distance between the host and the parent economies, a dummy variable indicating the cultural proximity among parent and host locations, natural logarithms of R&D unit's size and years of operation, industry and major country dummies, as well as a dummy variable indicating whether the R&D unit is also associated with a production subsidiary are included in the equations as control variables.

--- Table7 goes about here ---

Hypotheses 2a, 2b and 2c test the impact of specific R&D mandate on external network embeddedness of host and home country, as well as on internal MNE network. SLs and LILs are positively associated with higher external embeddedness

in the host location (β = 0.14, p < 1% and β = 0.09, p < 10% respectively)[5]. Furthermore, LILs also have a positive and significant impact on greater internal embeddedness in MNE network (β = 0.15, p < 5%). The results do not confirm our conjecture that IILs are positively associated with greater home country embeddedness. The estimates in regard to the relationship between foreign R&D mandate and network embeddedness support Hypotheses 2b and 2c, but not Hypothesis 2a.

Turning our attention to the group of variables indicating the economic environment of the host location, we find the coefficient on *macroeconomic instability* is positive but weakly significant in predicting embeddedness in the external network of the home country[6].

Looking at the strength of the IPR regime, our estimates indicate a negative and significant relationship between IPR protection regime and external host network (β = -0.16, p < 5%), while no statistically significant result is found in examining the relationship between IPR protection regime and the MNE's internal network. These findings contradict with our initial argument in Hypothesis 3b, but are consistent with arguments suggesting that firms tap into regional clusters in order to benefit from spillovers from other firms in the sector.

The SURE estimates support our conjectures regarding the relationship between subsidiary's autonomy and levels of host and internal embeddedness. We find that autonomy is significantly and positively associated with external network of the host country (β = 0.10, p < 10%) indicating that the more autonomous the R&D unit remains, the greater is the extent of activities with the external environment of the host country. Secondly, a negative and highly significant relationship with the internal MNE network is observed (β = -0.25, p < 1%) signalling that the level of decentralisation of the R&D unit is inversely related with the degree of embeddedness within the MNE network. Accordingly, both hypothesis 4a and 4b are supported.

There is also evidence to support the view that larger the scientific and technological endowment of the host country the more embedded the R&D unit will

[5] For simplicity reasons, we make use of the Greek letter 'β' in order to report all the estimated coefficients of the regression results, while 'p' denotes the level of significance.
[6] The variable is significant only at the 12% level.

be in the host country's external network. The coefficient of the variable *Endowment* is positive and highly significant ($\beta = 0.18$, $p < 1\%$) supporting Hypothesis 5.

Among the control factors, we found that geographical distance is a factor that poses hazards in terms of establishing ties with the home country's network, while the age (years of operation) of the R&D unit is a factor which positively and significantly influences the development of ties with the home country's external network. R&D units associated with other production subsidiaries are not likely to establish strong connection with the external networks of the home country and the larger the size of the R&D subsidiary is (in terms of the total number of people employed in the unit), the more it is embedded in the internal network of the MNE.

5.3. Robustness checks for production (HBE) subsidiaries

Tables 8 and 9 present the SURE estimation for the subsample of technology exploiting subsidiaries. Following the pattern of the previous section we report the correlation of residuals in Table 8 and the SURE estimations in Table 9.

--- Tables 8 and 9 go about here ---

The results presented in Tables 8 indicate that all three types of embeddedness form complementary relationships. Technology exploiting R&D subsidiaries are more likely to seek for additional assets in different networks in order to complement their existing resources and not for substituting them with others.

The SURE estimates for the subsample presented in Table 9 suggest that the embeddedness activities of technology exploiting firms are likely to be driven by a smaller group of factors. Unlike the full sample's SURE estimates, these results indicate that macroeconomic instability is a positive indicator of the R&D subsidiary's embeddedness within the external network in the home country, while the technological endowments of the country, being a LILs and the level of autonomy of the subsidiary are not factors related with a higher embeddedness in the host location.

5.4. Discussion

Embeddedness is now widely accepted as the mechanism by which an R&D subsidiary of an MNE can access technological resources inside and outside the firm. Our study aims to understand what sort of embeddedness will be used and when. This understanding is critical in evaluating how an MNE exercises leverage or arbitrage in locating its R&D activities based on location specific characteristics of the home and host locations, as well as the knowledge resources available in other parts of the MNE's network of subsidiaries.

Our results confirm our initial conjecture that external embeddedness in the home and host economies are largely complementary activities as are the external embeddedness in the home location and internal embeddedness of the R&D subsidiary. When we restricted our sample to only technology exploiting subsidiaries, we find that all three types of embeddedness bear a complementary relation to each other. This suggests that the HBA-HBE distinction drawn by Kuemmerle is also important in discussions of embeddedness. Further, our results suggest that host embeddedness and internal embeddedness are either not correlated or negatively correlated for subsidiaries whose activities are more HBA in nature, although this needs more careful examination beyond the scope of our survey data.

Our findings also provide evidence of the factors that are associated with the three types of embeddedness. Among the factors that are associated with different types of embeddedness we find a strong role for mandates in predicting levels of host embeddedness. SLs are more likely to be strongly embedded in the host economy as their links with the external actors of the host location allow them to better and more effectively distribute and position their products in foreign markets. We found this to be the case when we restricted our attention to the subsample of technology exploiting subsidiaries as well.

Furthermore, we also found that mandates of product differentiation (LILs) make the R&D units multi-embedded as they leverage two different, but very fruitful resource environments (viz. external host and internal) at the same time. This finding is in line with other literature, such as Manolopoulos et al. (2011) and Pearce (1994), but to our great surprise the role for LILs disappeared when we restricted our attention to the subsample of technology-exploiting labs. This suggests the multi-

embeddedness of the LILs mandate is somehow aligned with technology augmentation activities.

We found no evidence that a strong IPR protection regime promotes higher levels of embeddedness in the host location. Rather weak IPR regimes are associated with higher levels of embeddedness in the host external network. This result holds even when we restrict our attention to technology exploiting subsidiaries alone. Evidence from existing literature in industrial organisation and on knowledge spillovers and cooperation in R&D shows that firms located in an environment with knowledge spillovers are likely to establish cooperative ties with the host environment (Cassiman and Veugelers, 2002; D'Aspremont and Jacquemin, 1988). Strong IPR regimes may prevent such spillovers from being exploited rapidly and without litigation. Consequently the level of embeddedness in such host environments may be low.

The instability of the macroeconomic environment is not associated with deeper ties with external networks in the home country for the entire sample, but this is an important consideration for R&D labs that are technology exploiting.

Another robust result of our empirical analysis is that decentralisation of the R&D unit from the rest of the MNE network has a negative impact on the degree of internal embeddedness (Andersson and Forsgren, 1996; Birkinshaw and Morrison, 1995). This is the case even when we separate the sample into technology exploiting units alone. However, in the sample that includes technology augmenting subsidiaries there is evidence that relative autonomy of the R&D lab and rich scientific and technological endowments of a location are associated with greater host embeddedness.

6. Summary and implications

The advantages of an MNE are closely tied to the different locations from where the multinational operates and its ability to leverage the benefits of location into a firm specific competence which is unique and inimitable. The mechanism by which firms draw on regional and own advantage is through embeddedness. The novel feature of our paper is the comprehensive consideration of all three forms of embeddedness that a subsidiary could be engaged in and a consideration of the key factors that may be associated with higher or lower levels of each kind of embeddedness.

We argue and show that embeddedness is a choice variable for the MNE's R&D subsidiary, and the factors associated with each form of embeddedness are clearly not the same. An interesting result in our study is that the research- or market-orientation of the R&D subsidiary (i.e. exploitation-augmentation) seems to act as a crucial parameter that conditions the relationship between each type of embeddedness, as well as the factors associated with them. What makes our conclusions rather strong is that we are able to discern these relationships using data for a period when it was thought MNE innovative activities were highly centralised.

Our conclusions are of course limited by the nature of our data in two ways. First, they are dated to the early nineties and it is possible that some of the relationships we have observed have atrophied or been overtaken by technology. This is particularly the case for internal embeddedness which may now be rendered easier due to the use of information technology and better knowledge management practices within the firm. A second limitation is that our data are cross sectional rather than panel and so we cannot control very well for the heterogeneous abilities of parent-subsidiary pairs or for the evolution of embeddedness over time.

Nevertheless, given the rising interest in the geographic distribution of R&D and company strategies to realise greater value from such investments, these limitations also provide a menu of future research possibilities and we hope the framework and methodology proposed here will prove useful to those enquiries.

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TABLES

Table 1. Cross-tabulation table between parent and host locations.

		Overseas locations where R&D subsidiaries operate														
		AU	**AT**	**BE**	**CA**	**CH**	**ES**	**FR**	**GE**	**IT**	**JP**	**NL**	**SE**	**UK**	**US**	**Total**
Headquarters locations	**CA**				N/A									3	1	4
	CH	1	1			N/A			2		1		1	1	10	17
	FR							N/A						1	5	6
	GE		1						N/A					1	17	19
	IT									N/A				1	1	2
	JP					1					N/A				5	6
	NL											N/A		2	3	5
	SE												N/A		3	3
	UK	1							2		1			N/A	15	19
	US	4		4	3	2	2	1	6	3		1		26	N/A	52
	Total	6	2	4	3	3	2	1	10	3	2	1	1	35	60	133
	Average age	39	22	23	17	31	25	15	46	32	2	35	27	28	25	26.2
	Average size	123	443	477	55	136	39	130	96	103	52	13	171	203	121	154.3

Table 2. Industry composition of the survey data

Industry	**Frequency**	**Percentage**
Chemicals & Petroleum	50	37.0
Electronics	26	19.3
Pharmaceuticals	25	18.5
Miscellaneous	34	25.2

Table 3. Distribution of the initial population and the final sample.

Country / Region	Population of foreign R&D subsidiaries (N = 405)		Final sample of foreign R&D subsidiaries (N = 133)	
	Percentage	Population Number	Percentage	Population Number
Australia	3.21%	13	4.51%	6
Canada	6.67%	27	2.26%	3
Other European countries (Austria, Belgium, Spain)	4.44%	18	6.02%	8
France	4.20%	17	0.75%	1
Germany	5.93%	24	7.52%	10
Italy	1.98%	8	2.26%	3
Japan	0.74%	3	1.50%	2
Netherlands	0.49%	2	0.75%	1
Sweden	0.49%	2	0.75%	1
Switzerland	2.96%	12	2.26%	3
UK	15.06%	61	26.32%	35
USA	49.38%	200	45.11%	60
Rest of world	4.44%	18	0.00%	0

Table 4. Data sources and descriptive statistics

Variable	Number of items used	Cronbach's alpha (α)	Source	Type	N	Mean	SD	Min	Max
Dependent Variables									
External Home	3	0.65	Survey	Scale	125	2.13	0.49	1	3
Extenal Host	6	0.60	Survey	Scale	113	1.79	0.33	1.16	2.66
Internal	4	0.73	Survey	Scale	129	2.13	0.45	1	3
Explanatory Variables									
SLs			Survey	Categorical (1-3)	121	2.22	0.75	1	3
LILs			Survey		119	1.94	0.74	1	3
IILs			Survey		124	1.88	0.88	1	3
IPR Host			W.G. Park (2008)	Scale	14	3.57	0.55	2.35	4.14
Macroeconomic instability			International Labour Organization & WDI	Scale	14	0.11	0.03	0.04	0.23
Autonomy			Survey	Categorical (1-3)	128	1.27	0.49	1	3
Local Endowment	4	0.72	Survey	Scale	123	1.73	0.54	1	3
Control Variables									
LnYears			Survey	Scale	114	2.95	0.93	0.69	4.82
LnSize			Survey	Scale	109	4.14	1.36	1.38	7.54
Production Subsidiary			Survey	Dummy	127	0.68	0.46	0	1
LnGeographical Distance			CEPII Database	Scale	14	8.55	0.80	5.83	9.74
Cultural Proximity			CEPII Database	Dummy	14	0.42	0.49	0	1
LnGDP per capita			WDI (World Bank)	Scale	14	9.84	0.19	9.24	10.24

Table 5. Pair-wise correlation and VIFs scores

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	External_home	1																				
2	External_host	0.33	1																			
3	Internal	0.21	0.27	1																		
4	SLs	0.08	0.32	0.01	1																	
5	LILs	0.00	0.21	0.24	0.18	1																
6	IILs	-0.08	-0.26	-0.43	-0.29	-0.42	1															
7	IPR_protection	-0.24	-0.09	-0.15	-0.14	-0.11	0.22	1														
8	Endowment	0.18	0.41	0.33	0.19	0.22	-0.30	-0.13	1													
9	Autonomy	-0.25	-0.13	-0.40	0.00	-0.05	0.25	0.28	-0.32	1												
10	Ln_Years	0.18	-0.02	-0.22	0.04	-0.25	0.05	-0.17	-0.12	0.07	1											
11	Ln_Size	0.18	0.35	0.21	0.24	0.39	-0.33	-0.09	0.14	-0.18	0.12	1										
12	Ln_Geo_distance	-0.30	-0.12	-0.13	-0.08	-0.11	0.15	0.16	-0.13	0.17	0.11	-0.02	1									
13	Cultural_proximity	0.31	0.00	-0.02	0.23	0.01	0.01	-0.31	0.07	-0.15	0.22	0.03	-0.08	1								
14	CP	-0.25	0.06	0.13	-0.18	0.07	-0.11	0.10	0.01	0.00	-0.13	0.04	0.12	-0.20	1							
15	EC	0.06	-0.06	-0.01	-0.01	0.09	-0.01	-0.11	0.03	-0.05	-0.07	-0.08	-0.10	0.06	-0.36	1						
16	PH	0.18	0.14	0.03	0.25	0.23	-0.23	-0.11	0.18	-0.11	0.10	0.13	-0.05	-0.02	-0.37	-0.22	1					
17	US	0.19	-0.00	0.02	0.09	0.05	-0.02	-0.65	0.00	-0.19	0.21	0.09	0.13	0.33	-0.20	0.18	0.16	1				
18	UK	-0.11	-0.09	-0.09	0.01	-0.14	0.13	0.23	-0.05	0.04	0.03	-0.10	0.00	0.34	0.12	-0.13	-0.03	-0.32	1			
19	Production_subsidiary	-0.23	-0.17	-0.14	-0.12	-0.15	0.31	0.07	-0.22	0.19	0.13	-0.27	0.09	-0.16	0.02	-0.06	-0.12	-0.00	0.08	1		
20	Ln_GDPPC	-0.25	-0.07	-0.12	-0.23	-0.14	0.16	0.64	-0.06	0.20	-0.17	-0.10	0.21	-0.33	0.17	-0.13	-0.18	-0.64	0.26	0.11	1	
21	Macro_Instability	0.21	0.03	-0.13	0.20	0.13	-0.14	-0.55	0.06	-0.17	0.17	0.03	-0.02	0.31	-0.13	0.09	0.12	0.58	-0.25	-0.10	-0.85	1
	VIFs (1)	-	-	-	-	-	1.63	-	-	-	1.34	1.36	1.29	2.16	2.21	1.76	2.05	2.16	1.73	1.41	6.08	5.30
	VIFs (2)	-	-	-	1.44	2.03	-	2.55	1.48	1.34	1.63	1.70	1.39	2.59	2.43	1.92	2.69	3.05	2.29	1.39	2.05	-
	VIFs (3)	-	-	-	-	1.71	-	1.90	-	1.19	1.44	1.49	1.30	2.14	2.14	1.78	2.01	2.61	1.95	1.37	2.03	-

Coefficients with values over 0.15 and under -0.15 are significant at the 10% level of significance.

Table 6. Correlation of residuals (Testing H1a-c)

		1	2	3
1	External home	1		
2	External host	0.45*	1	
3	Internal	0.21*	0.20	1

* p < 10%

Table 7. Seemingly Unrelated Regression Equations (SURE)

	Regressors	External Home	External Host	Internal
Hypotheses				
H2	SLs		0.14*** (0.04)	
	LILs		0.09* (0.05)	0.15** (0.07)
	IILs	0.06 (0.06)		
H3	IPR_protection_regime		-0.16** (0.07)	-0.06 (0.11)
	Macro_Instability	3.89 (2.49)		
H4	Autonomy		0.10* (0.06)	-0.25*** (0.09)
H5	Endowment		0.18*** (0.06)	
Control variables				
Firm level	Ln_Years	0.14** (0.05)	0.01 (0.04)	-0.07 (0.05)
	Ln_Size	0.04 (0.03)	0.03 (0.02)	0.06* (0.03)
	Production_subsidiary	-0.34*** (0.11)	-0.05 (0.07)	-0.09 (0.10)
Industry level	CP	-0.05 (0.13)	0.15 (0.09)	-0.02 (0.12)
	EC	0.01 (0.15)	-0.08 (0.10)	-0.15 (0.14)
	PH	0.18 (0.16)	-0.11 (0.12)	-0.22 (0.15)
Country level	US	-0.08 (0.12)	-0.06 (0.10)	-0.12 (0.13)
	UK	-0.16 (0.19)	0.21 (0.13)	-0.04 (0.18)
	Ln_Geo_distance	-0.17*** (0.06)	0.02 (0.04)	0.02 (0.06)
	Cultural_proximity	0.14 (0.13)	0.04 (0.09)	-0.07 (0.12)
	Ln_GDPPC	0.74 (0.48)	-0.09 (0.20)	0.02 (0.26)
	Constant	-4.52 (4.98)	1.97 (1.94)	2.27 (2.49)
	Parameters	13	16	14
	Chi2	52.41***	66.51***	46.44***
	R-squared	0.44	0.47	0.41

*** p < 1% ** p < 5% * p < 10% (S.E. in parentheses)

Table 8. Correlation of residuals (Testing H1a-c) for production subsidiaries

		1	2	3
1	External home	1		
2	External host	0.45*	1	
3	Internal	0.28*	0.37*	1

* p < 10%

Table 9. Seemingly Unrelated Regression Equations (SURE) for production subsidiaries

	Regressors	External Home	External Host	Internal
Hypotheses				
H2	SLs		0.17*** (0.04)	
	LILs		0.07 (0.07)	0.13 (0.10)
	IILs	0.09 (0.08)		
H3	IPR_protection_regime		-0.16* (0.09)	-0.06 (0.14)
	Macro_Instability	7.25** (3.64)		
H4	Autonomy		-0.02 (0.08)	-0.40*** (0.11)
H5	Endowment		0.02 (0.07)	
Control variables				
Firm level	Ln_Years	0.11 (0.09)	0.08 (0.05)	-0.01 (0.07)
	Ln_Size	0.01 (0.05)	0.03 (0.03)	0.02 (0.04)
Industry level	CP	-0.13 (0.17)	0.22** (0.11)	-0.02 (0.15)
	EC	0.08 (0.21)	0.02 (0.13)	-0.26 (0.18)
	PH	0.25 (0.25)	0.06 (0.17)	-0.15 (0.22)
Country level	US	0.25 (0.22)	0.10 (0.15)	0.00 (0.21)
	UK	-0.08 (0.25)	0.25* (0.15)	0.08 (0.20)
	Ln_Geo_distance	-0.14 (0.10)	-0.07 (0.06)	0.04 (0.08)
	Cultural_proximity	-0.04 (0.19)	-0.13 (0.12)	-0.16 (0.16)
	Ln_GDPPC	1.52* (0.81)	0.26 (0.26)	0.12 (0.35)
	Constant	-13.24 (8.31)	-0.62 (2.54)	1.12 (3.35)
	Parameters	12	15	13
	Chi2	24.83**	44.01***	33.28***
	R-squared	0.36	0.44	0.43

*** p < 1% ** p < 5% * p < 10% (S.E. in parentheses)

APPENDIX

Table A1. OLS regression with adjusted S.E. for 14 clusters in Host country

		External Home	External Host	Internal
Hypotheses				
H2	SLs		0.12* (0.06)	
	LILs		0.06 (0.05)	0.16* (0.08)
	IILs	0.12** (0.04)		
H3	IPR_protection_regime		-0.19* (0.10)	-0.05 (0.05)
	Macro_Instability	4.96* (2.36)		
H4	Autonomy		0.09 (0.08)	-0.32*** (0.06)
H5	Endowment		0.22*** (0.04)	
Control variables				
Firm level	Ln_Years	0.10* (0.05)	-0.00 (0.03)	-0.01 (0.04)
	Ln_Size	0.02 (0.02)	0.04 (0.02)	0.03 (0.03)
	Production_subsidiary	-0.31** (0.13)	-0.06 (0.11)	-0.12 (0.08)
Industry	CP	0.01 (0.13)	0.10 (0.13)	0.10 (0.07)
Level	EC	-0.00 (0.13)	-0.09 (0.08)	0.01 (0.07)
	PH	0.27* (0.13)	-0.13 (0.19)	-0.13 (0.12)
Country	US	-0.08 (0.11)	-0.07 (0.14)	-0.08 (0.08)
Level	UK	-0.11 (0.19)	0.14 (0.12)	-0.04 (0.09)
	Ln_Geo_distance	-0.18** (0.06)	0.03 (0.03)	-0.00 (0.03)
	Cultural_proximity	0.13 (0.11)	0.01 (0.11)	-0.08 (0.08)
	Ln_GDPPC	0.92* (0.44)	-0.13 (0.23)	0.10 (0.12)
	Constant	-6.32 (4.11)	2.42 (2.09)	-1.53 (1.24)
	R-squared	0.37	0.45	0.37

*** p < 1% ** p < 5% * p < 10% (Robust S.E. in parentheses)

Table A2. OLS regression with adjusted S.E. for 14 clusters in Host country (for production subsidiaries)

		External Home	External Host	Internal
Hypotheses				
H2	SLs		0.14 (0.08)	
	LILs		0.05 (0.08)	0.17** (0.06)
	IILs	0.17* (0.08)		
H3	IPR_protection_regime		-0.19* (0.08)	0.03 (0.08)
	Macro_Instability	6.51 (4.48)		
H4	Autonomy		-0.06 (0.15)	-0.50*** (0.11)
H5	Endowment		0.03 (0.05)	
Control variables				
Firm level	Ln_Years	0.05 (0.10)	0.07 (0.04)	0.03 (0.03)
	Ln_Size	0.02 (0.03)	0.04 (0.04)	0.01 (0.04)
Industry	CP	-0.07 (0.14)	0.15 (0.17)	0.12 (0.07)
Level	EC	-0.04 (0.12)	0.02 (0.06)	-0.04 (0.08)
	PH	0.30 (0.40)	0.05 (0.18)	-0.13 (0.23)
Country	US	0.23 (0.35)	0.09 (0.28)	0.24 (0.24)
Level	UK	-0.00 (0.19)	0.17 (0.19)	0.08 (0.14)
	Ln_Geo_distance	-0.18 (0.16)	-0.05 (0.09)	-0.02 (0.07)
	Cultural_proximity	0.09 (0.17)	-0.18 (0.17)	-0.18 (0.16)
	Ln_GDPPC	1.31 (1.27)	0.23 (0.47)	0.47 (0.34)
	Constant	-10.76 (11.90)	-0.21 (4.49)	-2.30 (3.10)
	R-squared	0.33	0.43	0.41

*** p < 1% ** p < 5% * p < 10% (Robust S.E. in parentheses)