Brunel Business School

Examining Multinational Corporations R&D Subsidiaries' Embeddedness in Multiple Networks of Knowledge

A Thesis submitted for the degree of Doctor of Philosophy

By

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Abstract

This research study elaborates on one of the most important features of the modern International Business (IB) area; the multinational R&D subsidiary. Taking into consideration the strategic importance and the particular role the R&D subsidiary plays, this study sheds light on the multiple forms of knowledge networks in which the R&D subsidiary is embedded. Accordingly, based on the two already known dichotomies of subsidiary knowledge networks (external home vs. external host and external host vs. internal) this thesis draws on the existing theory and empirical evidence and proposes a triangular view (i.e. external home, external host and internal) between the R&D subsidiary and its embeddedness within the surrounding knowledge networks.

Accordingly, based on three major theories of the management in the IB area, Social Network Theory (SNT), Resource Dependency Theory (RDT) and Agency Theory (AT), this study provides answers on a number of under researched questions. First, what are the determinants of each type of R&D subsidiary embeddedness in each of the three available knowledge networks? Second, considering the relative costs influencing R&D subsidiaries to rely more or less on one form of embeddedness compared to another, what sort of relationship exists (i.e. complementary or substitutive) between the aforementioned forms of R&D subsidiary embeddedness? Finally, considering the contextual- and HQ-specific factors that impact the overall functioning of the R&D subsidiary, what sort of effect do the multiple forms of R&D subsidiary embeddedness have on the latter's innovative performance?

This study adopts a quantitative approach and employs appropriate econometric methods in order to provide answers to the aforementioned research questions. Furthermore, data from three different sources are amalgamated. First, a unique survey questionnaire is utilised. This instrument was originally developed in the University of Reading and corresponds to both subsidiaries and the HQ. The sample covers Fortune 500 Multinational Enterprises (MNEs). Second, and in order to augment the information derived from the survey, supplementary information on patent characteristics is sourced from the United States Patent and Trademark Office (USPTO) database. Third, a range of aggregate-level (secondary) data enriches the existing dataset.

The findings reveal that each form of R&D subsidiary embeddedness is determined by a set of different predictors. Precisely, it is found that host location's macroeconomic uncertainty positively influences subsidiary's embeddedness in the home location's knowledge network. Being an R&D subsidiary and having an adaptation and support-oriented profile, as well as being highly centralised to the HQ, negatively influences the R&D subsidiary's embeddedness in the host location's knowledge network. On the other hand, having a more research intensive and internationally integrated R&D role positively influences the R&D subsidiary's embeddedness in the internal knowledge network of the MNE. The findings also indicate that a complementary relationship exists between external home and external host, as well as among external host and internal knowledge networks. On the contrary, a substitutive relationship is indicated between external home and internal networks under which the R&D subsidiary is embedded. Finally, as regards

the last research question the results indicate that only internal embeddedness has a positive and significant impact on innovative performance, while scientific and research endowment of the host locations is also found to positively influence the innovative output of the R&D subsidiary.

Implications for academics and practitioners (both managers and policy makers) are widely discussed and suggest that the three-dimensional view of embeddedness is useful in understanding and explaining the way MNEs' foreign R&D subsidiaries operate.

Declaration of Originality

No portion of the work referred to in the thesis has been submitted in support of an application for another degree or qualification of this or any other university or other institute of learning.

I declare that the thesis embodies the results of my own work. Following normal academic conventions, I have made due acknowledgement of the work of others.

Copyright in text of this thesis rests with the author. Copies (by any process) either in full, or of extracts, may be made only in accordance with instructions given by the author.

Chapters of this Thesis have been presented in form of academic papers in competitive sessions of the following conferences:

1) *The Academy of Management Conference*, Boston, 2012.
2) *The Academy of International Business Conference*, Washington DC, 2012.
3) *DRUID Conference*, Copenhagen, 2012.
4) *The Academy of International Business Conference, UK & Ireland Chapter*, Birmingham, 2013.
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Στην οικογένειά μου και στη Στέλα

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List of Abbreviations

AT	Agency Theory
CEPII	Institute for Research on the International Economy
CP	Chemicals and Petroleum
EC	Electronics
HBA	Home-Base Augmenting
HBE	Home-Base Exploiting
HLM	Hierarchical Linear Model
HQ	Headquarters
IB	International Business
ICC	Intra-Class Correlation
ICT	Information and Communication Technology
IILs	Internationally Integrated Labs
IPR	Intellectual Property Rights
IT	Information Technology
LILs	Locally Integrated Labs
LL	Log Likelihood
LR	Likelihood Ratio
MLE	Maximum Likelihood Estimation
MLM	Multilevel Model
MNE	Multinational Enterprise
NSI	National System of Innovation
OECD	Organisation for Economic Co-operation and Development
OLS	Ordinary Least Squares
PH	Pharmaceuticals
R&D	Research and Development
RBV	Resource-Based View
RDT	Resource Dependency Theory
RKT	Reverse Knowledge Transfer
RQ	Research Question
SLs	Support Labs
SNT	Social Network Theory
SURE	Seemingly Unrelated Regression Equation
UK	United Kingdom
US	United States
USPTO	United States Patent and Trademark Office
VIFs	Variance Inflation Factors
VPC	Variance Partitioning Coefficient
WDI	World Development Indicators

1. INTRODUCTION

1.1. Background of the research

This thesis sheds light on characteristics, roles, knowledge motives and innovative performance regarding Multinational Enterprises' (MNEs) foreign-based R&D subsidiaries. A particular focus is given to the mechanisms by which foreign-based R&D subsidiaries seek for new knowledge from the surrounding environment. Accordingly, a special interest is shown in the means by which such knowledge communication is achieved. This mechanism is usually referred in the academic literature as "subsidiary embeddedness" (Andersson and Forsgren, 1996, Andersson *et al*., 2002). Although subsidiary embeddedness is a notion that has repeatedly used in a variety of studies, this research study aims to focus on research-intensive subsidiaries (i.e. R&D subsidiaries), thus on MNE units which are entirely focused on technological and research activities. Although the notion of embeddedness is often interconnected to the notion of knowledge sourcing, in this case I consider the notion of embeddedness as more contiguous to the theme of this study (compared to the notion of knowledge sourcing). This is because this research is driven, not only by the subsidiary's available sources of knowledge, but also by the social and in many cases interpersonal relations, which are vital ingredients of the social network theory, and more specifically of the embeddedness notion (Granovetter, 1985).

There are two important aspects of subsidiary embeddedness that this study will examine in detail. First, the main focus will be given to the subsidiary which is one of the most critical parts of the MNE. As we know from the literature, the structure of the organizational context of the MNE is based on three main components. The Headquarters (HQ), the subsidiary and the external environment. The fact that nowadays MNEs establish and operate subsidiaries in almost every corner of the world gives an additional grade of importance to the role of subsidiaries. This is also depicted by the increasing research work that looks at roles, characteristics and impacts of foreign-based subsidiaries on other vital aspects, such as subsidiary performance (Birkinshaw *et al*., 2005; Delios and Beamish, 2001) and MNE competence development (Andersson *et al*., 2001; Birkinshaw *et al*., 1998). This

thesis will not focus on subsidiaries in general, but on those subsidiaries which are assigned a specific R&D role and accordingly carry out a certain amount of research work. This particular focus is mainly driven by the fact that R&D subsidiaries are surrounded by four key features; i) they are characterized as having a strategic role since they bear a great amount of responsibility for the whole MNE; ii) the relationship between the subsidiary and the HQ is even more important due to the amount and value of information / knowledge transferred from one to the other; iii) they are assigned a specific role (mandate) in terms of producing a specific amount of research work that in most occasions is vital for the whole MNE; iv) the environment under which they are embedded is of unique importance in terms of knowledge absorption, compared to other traditional types of subsidiaries which usually have a typical subsidiary-customer relationship.

Second, the next most important aim of this research is to examine the forms and characteristics of subsidiary embeddedness in all available knowledge networks. Subsidiary embeddedness can take the form of internal and external embeddedness. Indeed, the external embeddedness of an MNE R&D subsidiary in the host location of its operation 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. Furthermore, apart from the external (local) embeddedness, foreign-based subsidiaries are also surrounded by an equally important network of knowledge. This is the internal (intra-MNE) network (Foss and Pedersen, 2002; Yamin and Otto, 2004). Within this knowledge network subsidiaries are able to absorb and transfer knowledge to and from the HQ or other affiliate units of the MNE. The literature on these two types of subsidiary

embeddedness has been under continuous examination, especially during the last two decades.

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 the 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. Furthermore, the literature so far has not clearly indicated how each one of the three dimensions is perceived by the R&D subsidiaries. Although all these three dimensions are of vital importance for the MNE, there is no clear indication of what sort of relationship (complementary or substitutive) holds between them when the latter is applied in the MNE R&D subsidiary's environment. Finally, although the literature has been very informative on how the knowledge flows within the subsidiary's environment influence the level of its performance (Fang *et al.*, 2007; Lee and MacMillan, 2008; Mahnke *et al.*, 2005; Monteiro *et al.*, 2008; Tsai, 2002), or even the level of its innovativeness (Almeida and Phene, 2004; Phene and Almeida, 2008; Tsai, 2001, 2002; Tsai and Ghoshal, 1998), it has been focused on the knowledge flows, rather than on subsidiary embeddedness.

1.2. Research problem

As discussed before, the key research problem that motivates this study relates to the number of available knowledge networks the foreign-based R&D subsidiary is surrounded by. A wide review of the literature will suggest that the existing research studies in the research topic predominantly focus on the knowledge linkages and relationships of foreign-based subsidiaries in the host location of their operation.

Despite this single-dimensional view of embeddedness, more recent literature has acknowledged the existence of other potential and existent sources of knowledge. Accordingly, the modernised view of the foreign-based subsidiary's organisational context has divided the available knowledge networks into two streams; i) internal vs. external (Almeida and Phene, 2004; Ambos, 2005); and ii) external home vs. external host (Criscuolo, 2009; Le Bas and Sierra, 2002). As becomes apparent, both streams of research have been developed in terms of dichotomies. Although these dichotomies provide a more simplified view of the knowledge network and the relative relationships surrounding the subsidiary, it should be noted that these are not fully representative of what a foreign-based subsidiary challenges in terms knowledge networking.

This issue arises mainly because the aforementioned dichotomies show only the one side of the coin. Regarding the internal vs. external host dichotomy, the interaction of the subsidiary with other external sources of knowledge is not always assumed to be in the host location of the subsidiaries' operation, but also this can take place in the home location where the HQ has a rather important mediating role. In terms of the external home versus external host distinction, it is very usual that the interest after a certain point is transferred to the HQ, since the home country's linkages are also part of the HQ external linkages. This means that there is an unawareness regarding the internal link which actually makes these relationships possible. The aforementioned issues derive from the hypothesized dichotomization of knowledge networks and, in fact, show that there is still a missing link in this particular classification of knowledge networks.

1.3. Research questions

Based on the above limitations of the current literature, and focusing on the novel approach of 'multiple embeddedness' suggested by Meyer *et al*. (2011) this thesis proposes and then examines a set of key questions all related to the aspect of foreign-based R&D subsidiaries' embeddedness in multiple knowledge networks. Accordingly, in this study I develop the implications of the conjecture that an R&D subsidiary can draw upon the 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 aforementioned networks is a result of a strategic choice made by the HQ. Consequently, three questions arise:

I. First, what are the unique predictors (determinants) for each type of embeddedness (external home, external host, internal)?

II. Second, how can we conceive of the relationships between the three types of embeddedness - are they complementary or substitutive?

III. Third, how do the three types of embeddedness influence the overall innovative performance of the R&D subsidiary?

The answers to these questions are important in order to assess how the MNE exercises leverage or arbitrate 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.

1.4. Research framework and theoretical underpinnings

As is already mentioned, this study amalgamates the themes of international business and technology management. Although the existing research on this topic, and more specifically on MNE R&D subsidiary context, has been very informative during the last two decades, this study contributes to our understanding of how geographically dispersed R&D subsidiaries choose to establish ties with the available surrounding networks.

In order to better assess the problem of multiple embeddedness of foreign-based R&D subsidiaries I will first draw on the existing literature regarding the particular organizational context of the MNE, as well as the special role of R&D subsidiaries. It is of vital importance to understand how the first ever model introduced by Vernon (1966), which assumed that ownership-specific advantages were initially grown in the HQ of the MNE (i.e. in the home region of the MNE) and then transferred to the rest of the MNE network (i.e. foreign subsidiaries), has nowadays transformed into the transnational model (Bartlett and Ghoshal, 1999), where the subsidiary plays a

vital role in the overall competitive advantage of the MNE. In addition, by drawing attention to three key management theories (Agency theory, Resource dependency theory and Social network theory), all related to the HQ–subsidiary relationship and roles, this thesis aims to develop an appropriate theoretical ground for explaining each of the above three research questions. In addition, special attention is given to the existing typologies of R&D subsidiaries. Based on an extensive review of the literature I provide information on various aspects related to the types and roles of R&D subsidiaries and how these have excelled until recently. Finally, an extensive review of the literature on internal and external embeddedness and their impact on innovative performance shows the way for the proper development of the study's research hypotheses.

1.5. Data and methodology

In order to examine the three aforementioned research questions I have used three different data sources. More specifically, in this PhD thesis I combine data from three different sources.

First, I make use of an existing survey questionnaire relevant to the world's leading MNEs which operate R&D subsidiaries in foreign locations. The unique characteristic of this particular survey is that it consists of two parts (i.e. two distinct questionnaires). The first questionnaire relates to the parent company characteristics and roles and consequently is answered by the HQ of the MNE. Similarly, the second survey questionnaire was distributed to MNEs' foreign-based R&D subsidiaries and accordingly contains information regarding characteristics and perceptions arising from the MNE's largest and most important foreign-based R&D subsidiary.

Second, and in order to complement the relevant information that has already been gathered from the survey questionnaires, this study also utilises the United States Patent and Trademark Office (USPTO) database in order to match the existing

survey-based data with more objective and accurate measures. This is expected to make the study even more robust and reliable. Accordingly, patent counts, along with other relevant information retrieved from each filed patent was collected and accordingly enhanced the explanatory power of the study. This information mainly facilitates the estimation of innovative performance of each examined foreign-based R&D subsidiary, as well as the associated factors sourced from it (i.e. supplementary measures for R&D subsidiary's technological embeddedness in the aforementioned three networks of knowledge).

Finally, taking into consideration that this PhD thesis is based on a cross-section data and in order to capture as much of the unobserved heterogeneity as possible, I also make use of a wide range of aggregate-level (secondary) data. These data are highly related to my initial conjectures and the relative hypotheses and controls. These data have an impact on all the three research questions that have been analysed earlier on.

Since the current study elaborates on the determinants of a subsidiary's multiple embeddedness, it is automatically assumed that the econometric model should take into consideration the joint determination of the levels of embeddedness, that is, a form of simultaneous structure with potentially correlated errors. Accordingly, a Seemingly Unrelated Regression Equation (SURE) model was chosen, since it is the most efficient one, as it handles effectively the aforementioned aspect of simultaneity (Zellner, 1962).

Second, in order to examine the relationships between the three different types of embeddedness, it was decided to proceed with two research methods. First, I estimate the correlation of residuals (based on the previously developed model), which in turn illustrates the relationship among the three examined networks (complementary or substitutive relationship between the three types of subsidiary embeddedness). The same estimation method is used by Arora and Gambardella (1990) in order to examine the complementarity of knowledge of firms in biotechnology. Second, and since the previous method is restricted to assess possible

complementarity and not substitutability, I also adopt the production function approach as in the study of Belderbos *et al*. (2006).

Finally, taking into account the multilevel (nested) formation of the subsidiary with its affiliated network (HQ and host environment) it is apparent that a cross-classified multilevel model (MLM) is the most efficient estimation technique for assessing the innovative performance of R&D subsidiaries (Hox, 2002), since the latter embodies multiple R&D units which are clustered under different, higher levels, such as the host location and the HQ, at the same time.

1.6. Structure of the thesis

The thesis is structured as follows:

Chapter two draws on the existing literature of the organisational context of the MNE. Specifically, it commences with a review of the literature regarding the three main components of the MNE's organisational context (i.e. HQ, subsidiary, local environment), while it focuses on the reciprocal linkages of the subsidiary with the HQ and the external (local) environment. It continues by elaborating on the three main management theories (AT, RDT, SNT), that have been identified as having an immense impact on the three research questions. Finally, the chapter concludes with an extensive review of the existing literature on R&D subsidiary typology (roles and characteristics), while special attention is given to the R&D subsidiary's importance by exploring what is different for subsidiaries acting as R&D units compared to those subsidiaries which do not adopt this specific role.

Chapter three starts with an introductory section which elaborates on what has changed in the landscape of international R&D during the last two decades and how this change has impacted the management of R&D from an IB perspective. After that, the chapter continues with an extensive review of the literature which draws on the embeddedness notion, based on several theoretical lenses (i.e. economic

sociology, economic geography, and technology management). What follows is the development of two distinct frameworks in relation to the main forms of subsidiary embeddedness; i) coordination of R&D and the internal embeddedness of the R&D subsidiary and ii) subsidiary autonomy and local embeddedness. The development of these two frameworks shows that the modernised view of the MNE's R&D subsidiary has evolved in that there is a particular desirability and need for 'multiple (triple) embeddedness'. Finally, the chapter concludes by presenting a comprehensive review of the gaps in our knowledge on subsidiary embeddedness literature, while extensive discussions are made on the determinants of subsidiary non-technological embeddedness, technological embeddedness, as well as the determinants of (technological) embeddedness upon subsidiary innovative (and market) performance.

The aim of **Chapter four** is twofold. First, based on the proposed research questions and the literature review that has been presented and discussed in chapters two and three, it proposes a conceptual model which links the research gaps discussed earlier. Second, drawing on the theoretical underpinnings of this study and focusing on each research question, a section focusing on the thesis' research hypotheses is developed. A total of twelve research hypotheses are presented in this chapter.

Chapter five presents with analytical rigour the methodological considerations of this study. First, it starts with a general view of the existing research approaches and research paradigms in this area of studies. It continues by presenting the research context of the current study and how the author arrived at that context. The chapter concludes with a comprehensive analysis of the econometric methods under which the current study's hypotheses have been assessed.

Chapter six presents the data used in order to assess the already developed hypotheses. A detailed description of all three sources of information is presented (i.e. subsidiary and HQ questionnaires, patent data, and aggregate-level data). It also incorporates an additional section which elaborates on the importance of the

'Reading survey' until the present. Finally, it concludes by analysing 'dataset-related issues', such as non-response bias and common method bias.

Chapters seven, eight and nine present the findings drawn from the assessment of the data presented in chapter six on the already designed econometric models. The first section of each chapter provides an analytical description of the measures and variables used. The second section elaborates on the descriptive statistics, while the third section presents the empirical analysis (regressions and relative tests) that corresponds to each research question.

Chapter ten concludes by presenting the discussion regarding the analysis of the findings. Furthermore, it points out implications for both academics and practitioners in the fields of international business and beyond. Finally, possible limitations and caveats are acknowledged and accordingly presented, while directions for future research are suggested.

2. THE ORGANISATIONAL CONTEXT OF THE MNE AND THE SPECIAL CASE OF R&D SUBSIDIARIES

2.1. Introduction

A simple but well-perceived definition of the MNE is the following: 'A corporation that is registered in more than one country or that has operations in more than one country' (Pitelis and Sugden, 2000, p. 72). Although this is a seemingly simple definition, a careful look at the meaning of it proves that the MNE is a complex kind of firm. It can be reasonably argued that this complexity is an outcome of two causes. First, because the MNE operates not as a traditional organisation, but as one operating in multiple geographic locations where ongoing progression and evolution is the only answer to dynamic changes. The second and most important reason is the multidimensional structure of the MNE. Due to its operation in different geographic locations MNEs have excelled at creating a unique organizational structure which combines reciprocal relationships between HQ, subsidiaries and external actors – all located in diverse geographical and business environments. The above two reasons have made the MNE a well-studied phenomenon in the IB literature (and beyond) nowadays.

As was mentioned before, the MNE is a highly dynamic organisation which has the ability to evolve over time. This ability predominantly stems from its need to produce innovative products which will enhance its performance and subsequently will contribute to the competitive advantage of the MNE in the global market (Cantwell and Mudambi, 2005). As a result, nowadays MNEs seek multiple, diverse, and combinative knowledge sources, in foreign geographic locations, and not only in domestic ones (Kogut and Zander, 1992).

The aim of this chapter is twofold. First, is to highlight the unique organizational context of the MNE as we know it, as well as to review the theories and ideas that have been used to analyse its organizational structure. Second, special attention will be given to the special role of the R&D subsidiary within the MNE structure and how this role has evolved over time.

2.2. The key components of the MNEs' organisational context

2.2.1. The headquarters (HQ)

As was previously mentioned, the MNE is a complex and dynamic organization which is surrounded by multiple contexts, environments and entities. First and foremost, the most important unit of the MNE is the HQ, which actually acts as the 'heart' of its global operations. The HQ is given the role of the unit that carries the responsibility for all the activities of the organization (Chandler, 1962), while the vital and most important characteristic is its ability to act as a hierarchical coordinator in order to facilitate the organization's tasks, i.e. achievement of goals accompanied by continuous growth (Hungenberg, 1993). Although the literature has given a simple and descriptive definition of HQ, in reality different types of HQ exist and cooperate with each other in the MNE context (Birkinshaw *et al.*, 2006). These can be corporate HQ (Bouguet and Birkinshaw, 2008; Foss, 1997), divisional HQ (Benito *et al*., 2011; Dellestrand, 2011), functional HQ and regional HQ (Lasserre, 1996; Sullivan, 1992). Each type of HQ accommodates a specific corporate strategy and scope of the MNE. The corporate HQ – on which I will focus in this study - is actually the 'formal residence' of the MNE where the top management team is situated and is liable for the formal operations of the whole organization (Birkinshaw *et al*., 2006). On the other hand, all the other types of HQ have other administrative roles or are situated in close proximity to important host locations (especially in large but vulnerable markets, in terms of institutional and political stability) for strategic reasons.

The role of the HQ is multidimensional and involves a wide range of functions, which correspond to the 'differentiated fit' (Ghoshal and Nohria, 1989) and the 'shared values' principle (Nohria and Ghoshal, 1994). In terms of this study, where the internationalisation of MNEs' R&D activities is intended to be researched in depth, the focus will be on the corporate HQ – foreign-based subsidiary relationship and the relative development of adequate control mechanisms. First, as a part of the 'coordination mechanisms literature' between the HQ and the subsidiary (see Martinez and Jarillo, 1989), a rather important aspect that determines the operational freedom of the subsidiary, is the level of autonomy (decentralization) given to the

latter. Second, and especially regarding the functioning of the foreign-based subsidiary acting as R&D unit, the specific role that is mandated by the HQ to the latter as regards the density and type of its R&D operations is again of vital importance for the MNE and its overall performance (Nobel and Birkinshaw, 1998). Third, other aspects, such as the subsidiary's mode of entry in the foreign location, the selection of the geographic location and the subsidiary's market scope, are also of vital importance for the MNE and are vastly determined by the corporate HQ's strategic decision-making.

2.2.2. The subsidiary

It is common sense that the subsidiary acts as a vehicle in the internationalisation process of MNEs' activities. In order to better understand what a subsidiary is and what is achieved through its operations, a short definition of it will be provided. Numerically, and strictly speaking, a subsidiary is defined as a company/unit whose majority of stocks is controlled by another company, also known as 'parent' or 'holding company'. In terms of this study where the technical aspects of this definition are well-respected, an emphasis will be given to the operational, relational and geographical part of it. Accordingly, for the needs of this study, a subsidiary is defined to be 'any operational unit controlled by the MNE and situated outside the home country' (Birkinshaw, 1997, p. 207). The hidden notion behind this definition is that no single parent-subsidiary relationship is assumed, since subsidiaries are units characterized by the development of multiple linkages with other corporate affiliate units in both home and host locations. Furthermore, this relationship depicts well the multiple (home and host) local context of the MNE (Meyer *et al*., 2011). Of course, the width and depth of such a relationship depends on various factors which are of both internal and external nature.

One of the most important reasons for making the subsidiary a well-studied phenomenon of the IB literature nowadays is the fact that subsidiary roles, functions and characteristics have continuously changed over the last four decades. Indeed, several studies have given a holistic view or classification of the roles and characteristics of foreign subsidiaries (e.g. Ghoshal and Bartlett, 1986; White and

Poynter, 1984). The first theoretical model that tried to give a specific dimension to roles and characteristics of foreign subsidiaries was made by Vernon (1966) and later by Dunning (1981). Both scholars assumed that a one-sided relationship exists between HQ and foreign subsidiaries in the sense that ownership-specific advantages were initially grown in the HQ of the MNE (i.e. in the home region of the MNE) and then transferred to the rest of the MNE network (i.e. foreign subsidiaries). As a vital part of the ongoing evolution of the MNE, subsidiaries were also evolved over time (Birkinshaw and Hood, 1998). The model of Vernon (1966) which describes foreign subsidiaries as implementers of existing technology produced at corporate HQ was further elaborated by White and Poynter (1984). Drawing on strategies of foreign-owned subsidiaries in Canada the authors define Vernon's model as the 'Miniature Replica Business'. Their approach is very close to what Vernon had pointed out beforehand. That is, MNEs establish 'Miniature Replica' subsidiaries in foreign locations in order to produce and place into the market products and product lines that are strictly designed in the parent company. Hence, mini replicas have not only the role of product distributor, but also the role of producing (replicating) existing product lines in the local market. Such a strategy has unique advantages for the MNE since the products are tailor-made according to the market needs of each host location. Furthermore, other important problems are waived (e.g. import barriers, transportation/logistics costs and achievement of economies of scale).

Although the vast majority of the examined subsidiaries belong to the 'miniature replica' classification, the authors also provided a complete classification with other types of subsidiaries, based on the roles and characteristics surrounding them (e.g. marketing satellite, rationalised manufacturer, product specialist or strategic independent). What they suggested was that the role of the foreign-based subsidiary manager is extremely challenging due to the continuously changing environment and the interacting sources which are more compared to the domestically-based subsidiary. Their concluding remarks and suggestions can be perceived as prophetic since they stress that, 'It is increasingly apparent that many subsidiaries will have to adjust their strategies, their product, market and value added scope, in order to successfully deal with these changing circumstances' (meaning the decreased

protection of the host market, the globalisation of customer preferences and the appearance of new international competition).

Indeed, the work by White and Poynter (1984) was visionary as regards the changing nature of subsidiaries in view of the globalization trend which later on became even more dynamic. In the last two to three decades we have observed that foreign-based subsidiaries have developed capabilities which were totally contradictory to what Vernon (1966) was indicating almost half a century ago. Nowadays the MNE does not see the corporate HQ as the unique source of competitive advantage. Bartlett and Ghoshal's 'Transnational Corporation' (Bartlett and Ghoshal, 1999) is a representative example of how thinking has changed on this matter.

Table 2.1. Organizational characteristics of the Transnational

Organizational characteristics	The Transnational company
Configuration of assets and capabilities	Dispersed, interdependent and specialized
Role of overseas operations	Differentiated contributions by national units to integrated worldwide operations
Development and diffusion of knowledge	Knowledge developed jointly and shared worldwide

Adopted by Bartlett & Ghoshal (1999)

Table 2.1 provides information on the transnational model originally developed by Bartlett and Ghoshal (1999). Their approach was focused on three main pillars; the configuration of assets and capabilities; the role of overseas operations; and the development and diffusion of knowledge. First, transnational corporations have developed globally dispersed capabilities which are not based on centripetal, but on centrifugal forces (i.e. not only on capabilities developed at the corporate HQ level, but also at the foreign subsidiary level). Second, unlike the national contribution that the foreign subsidiary used to have (see for example miniature replicas), under the

transnational model the foreign subsidiary produces and contributes as an integrated unit of the MNE's global operations. Third, the innovative capabilities and knowledge produced in a certain unit belongs to the organisation's shared vision for joint (cooperative) innovation and knowledge sharing (see for example reverse knowledge transfer). It can rather be argued that the 'transnational model' effectively captures what has changed in the global operation of foreign-based subsidiaries during the last twenty years.

2.2.3. The external (local) environment

The third and final part of the MNE's contextual environment is the external one. The external environment of the MNE is also characterized by a multidimensional concept and refers to different local contexts. This means that the foreign-based subsidiary is a multi-embedded entity, since it is mutually embedded in the MNE (which operates close to the home location) and the local (host) network. Accordingly, the notion of dual embeddedness refers to the subsidiary's status, which is mostly based on different institutional pressures from both home and host context. As we already know, the MNE has the capability to tap its activities into several resources inside and outside of the HQ location. The vehicle for this resource acquisition is the subsidiary which is tapped into a certain foreign-based (host) location. Accordingly, and considering the specific strategic needs and scope of the subsidiary's operation, it is decided what sort of local resources will be acquired and in what degree these will be utilized. Consequently, several factors shape the level of the subsidiary's embeddedness in the host or home network, or both, of its operation. These factors are related to local scientific and market richness, the macroeconomic (institutional, political, governmental) regime, as well as the various types of distance (cultural and geographical) between the home and the host location.

What follows is a literature review of the aforementioned key factors shaping an MNE's decision to tap its activities into the resources of a specific host location.

2.2.3.1. Market potential

One of the most dominant factors shaping MNEs' decision to locate their activities in a foreign-based location is the strong presence of an advanced market accompanied by high growth potential. Recent empirical evidence shows that this corporate strategy is mainly achieved through the establishment of production facilities in close proximity to the research units (Ambos, 2005; Florida and Kenney, 1994). Accordingly, a wide range of research output has been developed incorporating data from different triad regions and provides evidence that the market size of a given country-region plays a critical role in attracting MNEs' research-intensive investments (Cantwell and Piscitello, 2002; Dunning, 1994; Kuemmerle, 1999a; Kuemmerle, 1999b; Kumar, 1996; Kumar, 2001; Miller, 1994; Odagiri and Yasuda, 1996; Shimizutani and Todo, 2008). Although each research study incorporates data from both diversified (in terms of nationality) MNEs (i.e. Japanese, US, European MNEs) and different investment locations (US, Europe, Japan, Emerging markets) the results are similar and support the view that market size plays an equally important role for all the MNEs regardless their nationality and location of R&D investment.

2.2.3.2. Scientific richness

Reviewing the literature on the drivers of MNEs' R&D internationalisation it becomes clear that one of the most crucial aspects that firms seem to pay attention to in their international expansion strategy is the presence of a strong and rich science base. The level of research excellence in a given country seems to play a huge role on attracting technology intensive investments. Empirical evidence from triad-based MNEs shows that their decision to locate their innovative activities in a foreign-based location is greatly influenced by the presence of local scientific (Cantwell and Piscitello, 2002; Florida, 1997; Granstrand, 1999; Kuemmerle, 1999a; Kumar, 1996; Moncada-Paterno-Castello *et al*., 2011) and education infrastructure (Cantwell and Piscitello, 2002; Ambos, 2005). Although the level of research excellence of a country is in common sense acknowledged as a factor positively associated with the degree of technology intensive investment, evidence shows that this has an even greater impact on HBA rather than on HBE activities of the MNEs (Ambos, 2005; Asakawa, 1996). The latter is related to the fact that MNEs which locate their R&D

activities in offshore locations purely for research, rather than market-oriented activities, will be more prone to seek experienced and technologically capable scientific personnel in order to enhance and empower the research capability of their unit.

2.2.3.3. Governmental support

Apart from traditional market, and research, orientated factors shaping the decision of MNEs regarding their international movement it is also observed that governments also play a significant role in attracting MNEs' investment attention. Technically speaking, governments are in a position to execute policy interventions and develop business regulations in a manner that make their countries more attractive for innovation-related investments. Precisely, this sort of governmental aid and intervention in public policy may be known as National System of Innovation (NSI). This intervention consists of a set of institutions that jointly, or individually, contribute to the development of the national technological system. The means and methods by which these policies should be implemented effectively is the most important factor not only for the attractiveness of globally competitive and innovative MNEs, but also for the endogenous growth and development of domestic firms, labour force and public institutions. Accordingly, governments act as coordinators and designers of this system bringing adequate policies and regulations to the table for attracting technology-intensive investments. Empirical evidence indicates that governmental aid and support enhances the ability of a country to attract greater amounts of MNEs' technology intensive investments (Hoekman *et al*, 2005; Lan and Young, 1996), via public expenditures on items such as R&D, tax incentives and improvement of the educational system or even by enforcing the country's intellectual property rights (IPR) protection regime (Kumar, 1996; Moncada-Paterno-Castello *et al*., 2011). Furthermore, it should be highlighted that not only host countries, but also home countries of investment should shape their NSI in a way that facilitates the offshoring of domestic MNEs' R&D activities (Dunning, 1994; Dunning and Lundan, 2009), since it is expected that they could contribute to the strategic orientation of the MNEs more effectively by facilitating their investment decision on seeking complementary rather than substitutive assets in the host location. The above evidence elucidates why governmental intervention

(from both home and host countries) is of vital importance for the international distribution of MNEs' R&D activities.

2.2.3.4. Technological agglomeration and knowledge spillovers

From empirical evidence that has come to the academic surface during the last two decades a very important driver of internationalisation of MNEs' R&D activities has eventually emerged. Although we knew from the past that companies locate their activities in close geographic proximity to their rivals, leading firms, universities or research institutions, we did not have a complete and accurate view of how this happens and what actually firms are looking for.

We now know that MNEs move from location to location and base their innovation-driven activities in foreign locations more than ever before in order to leverage precious knowledge spillovers arising from these particular scientific sources. It is widely known that firms tend to establish scientific clusters in locations of high technology accumulation, such as Silicon Valley. This motive is called 'technological agglomeration' and is defined as 'the geographic co-location of different scientific and technological fields' (Robinson and Mangematin, 2007, p. 871). The IB and innovation management literature has extensively been involved in technological collocation and knowledge spillovers research which arises from the geographic (and technological) agglomeration of MNEs' R&D units. Empirical evidence shows that MNEs locate their R&D activities in foreign-based locations for technological collocation reasons, which in reality are followed by specialised R&D knowledge (Chung and Alcacer, 2002; Moncada-Paterno-Castello *et al.*, 2011; Odagiri and Yasuda, 1996). Accordingly, location choice for MNEs can be a product of potential inter- and intra-industry spillovers (Cantwell and Piscitello, 2002; Cantwell and Piscitello, 2005), or even of industry-university collaboration (Cantwell and Piscitello, 2005; Granstrand, 1999).

2.2.3.5. Geographic and cultural proximity (distance)

It is already known from the IB literature and precisely from FDI, and trade- related studies that geographic and cultural distance are both considered as significant determinants of inward FDI in a specific location (Buckley *et al*., 2007; Terpstra and Yu, 1988). In case of the R&D-driven location choice we are aware that national cultures play a significant role in attracting R&D investments (Jones and Davis, 2000), since some nations have developed more innovation-friendly cultural environments than others. This nations' innovation-related culture is in line with the innovation philosophy of the MNEs that choose to base their R&D activities in a particular location. Empirical evidence from Ambos and Ambos (2011) reveals that German MNEs' offshore R&D activities are deterred by a high degree of cultural distance between the source (i.e. Germany) and the host country of R&D investment. Furthermore, since MNEs are characterized by a complex and multidimensional organizational scheme, the decision on where they will locate their R&D activities is predetermined by endogenous factors, such as the degree of decentralization and the coordination mechanisms they use. Accordingly, an MNE which is characterized by a more regional degree of decentralization and coordination of its R&D units will not decide to base its R&D activities in a distant foreign location, but will place it in close proximity to the HQ of the company. Empirical evidence from the automobile industry shows that coordination impediments, as well as travel time and costs, are associated with the disheartened development of automobile global R&D networks (Miller, 1994), while the same indications hold for other leading industries as well.

2.2.4. The two main linkages for subsidiary importance

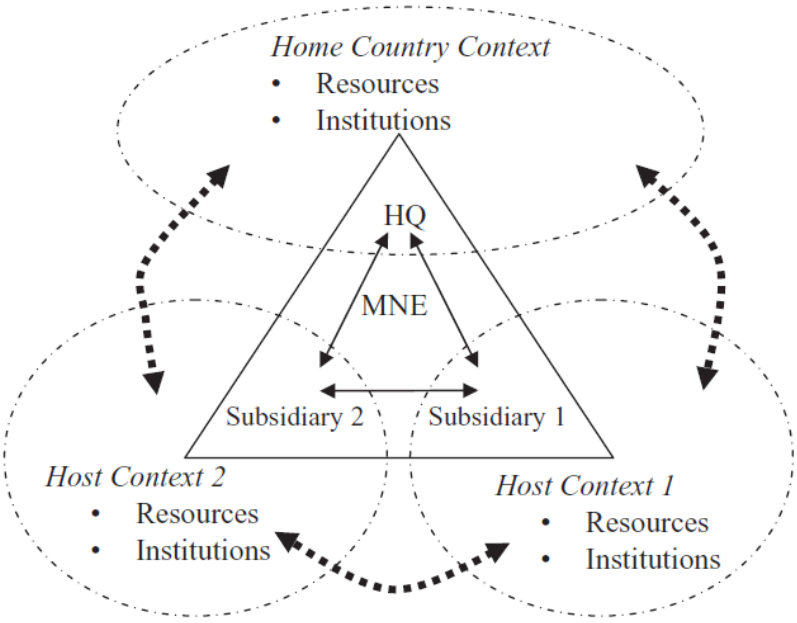
Research activities of the MNE are no longer perceived as of purely domestic scope, but on the contrary there is enough evidence to support the view that MNEs internationalize their R&D activities more than ever before. Accordingly, it would be wise to look more effectively and closely into the continuously evolving organizational context of the MNE, as far as the international R&D activities of the latter are concerned.

An MNE is composed of several parts. Although the HQ is actually considered to be the hub of the MNEs' operations, there are several other units which equally contribute to the overall knowledge generation of the MNE. These are the foreign-based subsidiaries, which are characterized by a research-intensive scope. Finally, of critical importance is the local endowment under which the subsidiaries operate, since the latter are in position to exploit the available resources in the local context and accordingly transform them to knowledge and competitive advantage for the MNE. Although the traditional MNE scheme focuses on three vital parts (HQ – subsidiary – local environment), the recent evolutionary theory in the IB research has augmented this three-tier scheme to a more complex organizational phenomenon. Meyer *et al*. (2011, p. 239) have developed an important theory that 'MNEs interact with multiple local contexts in which their headquarters and subsidiaries are embedded'. The argument of the aforementioned authors is based on the notion that the MNE is no longer perceived as a single-dimensional organization where the operation, strategy and decision-making are based on one monolithic context. On the contrary, multiple and complex network relationships are identified, where several actors inside and outside the MNE communicate at the same time (McCann and Mudambi, 2005).

Following the review of the literature and the general discussion on the evolution of the MNE's organizational context it is time to analyze the modernized view of the relationship between the subsidiary and the HQ. Figure 2.1 portrays how MNEs' multiple components and sources of knowledge communicate, as well as which factors surrounding each context are vital for the MNE's overall competitive advantage. The figure shows how critically important is the distinction of home (local environment of the HQ) and host (local environment of the foreign-based subsidiary) local context for the MNE. Furthermore, a triangular reciprocal relationship between the MNE's units is depicted showing that the transnational model surrounded by worldwide differentiated units with knowledge that has been developed jointly and shared worldwide is indeed the current model that better describes the organisational context of the MNE. In order to better understand the model described in Figure 2.1 I will divide its main theoretical implications into two

separate parts; i) the subsidiary reciprocal relationship with the HQ; and ii) the subsidiary reciprocal linkages with the local environment.

Figure 2.1. Multinational enterprises and local context



Adopted by Meyer *et al*. (2011)

2.2.4.1. Subsidiary reciprocal relationship with the HQ

The 'triangular' relationship describing the linkage between the MNE parts is portrayed in Figure 2.1. Vernon's model (Vernon, 1966) had a strict single-dimensional argumentation which was indeed the case for MNEs at that period of time (i.e. 1960s and 1970s). This argument is also reviewed in several studies (e.g. Birkinshaw and Hood, 1998; Ghoshal and Bartlett, 1986; Martinez and Jarillo, 1989; White and Poynter, 1984; etc.). However, the modernized view by Meyer *et al*. (2011), has adopted a more evolutionary approach which was also the case for the transnational corporation model (Bartlett and Ghoshal, 1999), the competence-creating subsidiary (Cantwell and Mudambi, 2005) and the centre of excellence (Andersson and Forsgren, 2000). Under this argument the foreign-based subsidiary has developed unique capabilities and knowledge that is of great importance in terms of creating competitive advantage for the whole MNE and not only for the subsidiary. Under this assumption the subsidiary works jointly, not only with the

MNE's HQ, but also with other vital parts of the organisation (i.e. other subsidiaries of the MNE). This phenomenon is also known as 'intra-firm knowledge flows' (Gupta and Govindarajan, 2000) while the means by which this sort of collaboration is achieved is usually referred to as 'internal embeddedness' (Meyer *et al*., 2011; Yamin and Andersson, 2011).

One of the most significant aspects of internal embeddedness is the bidirectional flow of knowledge. Bearing in mind that nowadays a subsidiary can produce knowledge which is of critical importance for the rest of the MNE we are led to the newly introduced phenomenon of 'reverse knowledge transfer' (i.e. the flow of knowledge in a direction opposite to the standard hierarchical HQ to subsidiary approach) which has been researched intensively during the last two decades (e.g. Ambos *et al*., 2006; Buckley *et al*., 2003; Frost and Zhou, 2005).

2.2.4.2. Subsidiary reciprocal linkages with the local environment

The above facts and figures show how the modern MNE transfers knowledge internally. Despite the importance of the internal network we also need to analyse an equally important source of knowledge for the subsidiary, which is the local (external) environment. On the contrary to what we knew from the past, the reciprocal linkages of the subsidiary with the local environment can also be developed in multiple geographic locations and not only in single ones. As it is shown in Figure 2.1 there is also a reciprocal bidirectional flow of information between the institutions and resources of each environment examined. We already know that subsidiaries engage in collaboration with external parties, such as firms, research institutions, public organizations, universities (i.e. inter-firm collaboration). What has been neglected by the literature, though, is that these forms of collaboration are not always located in the same geographic location with the subsidiary under examination, but also in other locations where affiliate units operate. The study by Meyer *et al*. (2011) has brought to attention this contemporary view, while the authors call this sort of reciprocal linkage with the local environment external (or local) embeddedness.

2.3. Key theories studying HQ and subsidiary organisational behaviour in the MNE context

2.3.1. Agency Theory (AT)

One of the most dominant and multi-applied theories in economics and management science streams is the AT. AT is sourced from the economics literature. Its aim is to highlight the difficulties arising in conditions of asymmetric information. Precisely, Jensen and Meckling (1976) define AT as the theory which describes the relationship between two conflicting parties, those of the principal and the agent. To put it in simple terms, AT depicts an on-going and ever-present relationship, in which two parties are involved, i.e. a principal who assigns a sort of work to an agent, who in turn is responsible for executing the assigned work. According to Eisenhardt (1989), under this form of relationship, AT is interested in providing answers on two main issues that may arise. First, it is the agency problem that may occur and is vastly related with the conflict among the two parties, which is an outcome of different desires and goals, as well as with the difficulty of the principal to observe whether the agent has performed properly or not on the assigned task. Second, it is the problem of risk sharing (moral hazard), which is an outcome of different risk attitudes between the two parties, and accordingly the employment of different actions by each party, due to attitude differentiation.

AT and especially the principal - agent perspective has been successfully employed in several areas of management science, and particularly in corporate governance. From the MNE point of view, O'Donnell (2000) argues that AT is one of the most dominant and most frequently used theories which have been successfully applied in IB studies in order to explain the particular organisational relationships in the MNE network. Translating the principal – agent perspective into the HQ – subsidiary context, it can be easily understood how this sort of contradictory relationship between these two parties can be framed in the relationship between HQ managers and subsidiary managers (Scharfstein and Stein, 2000). Indeed, this hierarchical relationship between HQ and subsidiary depicts well the aforementioned arguments

of AT (Mudambi and Pedersen, 2007). Precisely, as concerns the conflict between the two parties in regards to both desires and goals, it can be easily interpreted why such a relationship may hold under the HQ – subsidiary perspective. The main issue behind this conflict is the level of control and monitoring mandated by the HQ on the subsidiary. Indeed, the HQ requires and dictates a tight control of the subsidiary's operations, while the subsidiary always seeks for more operational freedom.

This sort of conflicting interest between these two parties is pictured as one of the most significant agency problems in the HQ–subsidiary relationship (Chang and Taylor, 1999). Second, the problem of risk sharing is also well depicted by the HQ–subsidiary relationship. Especially in the case of R&D subsidiaries, where innovative products are designed, developed and produced, risk sharing is a factor which the HQ takes enormously into consideration, since it aims to minimise any exposure to third parties. The latter may occur mainly due to weak IPR protection regimes, increased distance, and employees' lay-offs or turnover, since the monitoring/control becomes less efficient under these circumstances. Accordingly, it can be rather argued that AT fits well with the HQ–subsidiary relationship. Consequently, the effect of this relationship on the subsidiary's forms of embeddedness, as well as on its innovative performance is expected to be partially explained by AT.

From an IB perspective there are several studies that have employed AT as a learning theory in order to examine phenomena of coordination and asymmetric information between HQ and subsidiaries. Roth and O'Donnell (1996) draw on AT in order to answer the question whether the compensation strategy of foreign subsidiaries is influenced by the agency problem. Using several proxies, such as the cultural distance of the subsidiary from the HQ market, the level of centralisation, as well as the subsidiary's higher management commitment to the HQ, they found a positive association between the incentive structure lined up to the agency state and the subsidiary effectiveness. Another research study developed by Kim *et al*. (2005) also draws on AT in order to study the impact of agency problems in the HQ-subsidiary relationship. Their proposition is that the corporate governance of foreign-based subsidiaries should be designed according to the diverse levels of agency problems, which are also related to the differentiated strategic roles that have been given to the subsidiaries. Finally, a study by Bjorkman *et al*. (2004) examining the

effect of organizational mechanisms on inter-unit knowledge transfer employs AT and shows that MNEs can indeed positively influence the level of inter-unit knowledge flows by indicating the objectives of the subsidiary, as well as by employing coordination (socialisation) mechanisms.

2.3.2. Resource Dependency Theory (RDT)

RDT stems back to the late 1970s and more precisely in the literature related to organisational interdependence (Pfeffer, 1972; Pfeffer and Salancik, 1978). RDT assumes that organisations are not self-sufficient units, but interdependent ones, whose survival is contingent upon their environment and other organisations (Pugh and Hickson, 2007). Accordingly, in order to survive and compete they need to have access to valuable resources such us capital, human resources, technology and information. From the examined literature it becomes clear that two important characteristics have influenced the evolution of this particular theory. First, the maximisation of organisations' power (Pfeffer, 1972), and second the extent to which external resources (contingencies) influence the overall behaviour of the organisation (Pfeffer and Salancik, 1978). Simply put, organisations aim to maximise their strength by reducing the power of their competitors, mainly by increasing their own competitive advantage (power) over others. In order to gain a certain level of power which in turn will give a lower level of dependence to other sources, organisations aim to control vital resources for their power maximisation (Ulrich and Barney, 1984).

The MNE is an environment in which both power and control of external resources play a dominant role for the organisation's competitive advantage. Unlike AT where the subsidiary's decision rights are assumed to be 'loaned' by HQ, in RDT the subsidiary is assumed to 'own' its decision rights (Mudambi and Pedersen, 2007). In reality, the concept of differentiated networks that nowadays has been given to the 'modern' MNE, where various units operate in different countries characterised by various operational utilities, as well as the trend of HBA mandate that characterises an increasing body of MNEs nowadays, means that the foreign-based subsidiary may have developed the necessary skills and self-capacity, in a sense that its resources can possibly be of vital importance for the HQ and the rest of the MNE network. As

Mudambi and Pedersen (2007) argue, the MNE as a dispersed firm owns subsidiaries in various geographic locations which acquire valuable and non-substitutable resources. In simple words, RDT can explain why subsidiaries controlling such vital resources for the day-to-day operation of the MNE will be able to exercise a strong influence on corporate decision-making. In the same vein Ghoshal and Nohria (1989, p. 324) argue that 'Resource dependency is the key determinant of the structure of internal exchange relationships within complex organizations'.

From the subsidiary embeddedness perspective, RDT can be a helpful theoretical tool in order to set the arguments on how a subsidiary's external or internal resources are considered in terms of their effect on the subsidiary's innovative performance, as well as on what sort of relationships characterize the examined forms of subsidiary embeddedness.

Several empirical studies related to the subsidiary–HQ relationship (Forsgren, 1989), as well as the subsidiary embeddedness perspective (e.g. Ambos and Schlegelmilch 2007; Andersson and Forsgren, 1996) have incorporated RDT as the key theoretical foundation of their research arguments. Precisely, Andersson *et al*. (2001a) employ RDT in order to conjecture and consequently show that the association between a subsidiary's technological embeddedness and its organizational performance relies upon the MNE's dependence on the examined subsidiary. Similarly, Luo (2003) draws on RDT in order to explain the significance of internal (intra-MNE) linkages in weakening exposure and dependence to external resources in emerging markets, hence buffering possible threats that usually emanate from there.

2.3.3. Social Network Theory (SNT)

SNT is traced back in the 19th and 20th centuries when, for first time, the term 'economic sociology' was introduced and later on developed by the very well-known economic sociologists of that period. Precisely, Jevons (1879) and later on Weber (1978) were the first to pinpoint the importance of social interaction in respect to modern economics (i.e. capitalist modernity). In the very new economic era and specifically in the later years of the 20th century, the 'economic sociology' stream was evolved and apparently partly replaced by the 'new economic sociology' stream

and the pioneering work of Mark Granovetter (1985) on economic action and social structure. What Granovetter emphasised through his work was the concept of embeddedness, under which economic relations among individuals, organisations and firms occur under existing social relations (Granovetter, 1985).

Apart from the social interaction perspective, the notion of embeddedness has also a direct effect on firm performance, since the latter can be positively influenced by the social interaction with actors belonging in the firm's environment (Uzzi, 1996). These sorts of relationships are usually based on cooperative actions and establishment of trustful characteristics, which can facilitate even more the learning process and knowledge dissemination from the one side of the firm to the other (Uzzi and Lancaster, 2003). Indeed, both formal and informal interactions among actors and firms can positively affect the level of innovation, since both firms and individuals start building their social interaction around trust (Granovetter, 1992). In reality, this phenomenon can be explained by the fact that under the social network perspective firms are able to use valuable resources and assets, such as innovative goods, services, and funds, whose access was previously quite limited.

From an MNE perspective, the modernised concept of social networking, and especially the concept of embeddedness, have both played a very important role in explaining various intra-, inter-, and extra-organisational aspects. As was discussed in the previous section it was found in an extensive review of the literature that embeddedness has been well adapted as a measure of MNE network relationships, where the interaction of MNEs' subsidiaries with the external and internal environment has been captured and analysed. Indeed, taking into consideration that the MNE network, and especially subsidiaries, are more likely to interact with other firms, embeddedness can facilitate the knowledge transfer and reciprocal activity among two different parties. Furthermore, the multifaceted role and positioning of the subsidiary has progressed the SNT (from an MNE perspective), in a sense that embeddedness is now considered to be a multidimensional social networking form, and not a single-dimensional one.

Precisely, the form of embeddedness that has been extensively examined is the external (host) or local embeddedness (Andersson, Bjorkman and Forsgren, 2005;

Hakanson and Nobel, 2001; Nell and Andersson, 2012; Perri *et al*., 2012, Santangelo, 2012). The evolution of the embeddedness concept has motivated other studies to construct relative measures and accordingly examine other forms, such as relational business and technical embeddedness (Andersson *et al*., 2002), inter- and intra-organizational network relationships (Gammelgaard *et al*., 2012), and embeddedness overlap in the subsidiary's local network (Nell *et al*., 2011).

2.3.4. Are these theories ideal in order to frame the HQ – subsidiary relationship?

From the above facts and figures it becomes apparent that all the three theories examined (i.e. AT, RDT and SNT) are employed in several empirical and non-empirical IB studies in order to support the arguments concerning HQ-subsidiary relationships and the general implications of the MNE organizational context. Indeed, the dynamic and continuously evolving nature of the MNE needs to be explained by equally dynamic theories. Generally it can be argued that the examined IB studies reviewed in this section have proved that the relationships between HQ and subsidiary (AT, RDT), as well as the linkages between the subsidiaries with external actors (SNT), are well captured. This is also captured by the impact of these studies on the evolution of the HQ-subsidiary relationship.

2.4. The special case of R&D subsidiaries: Roles and characteristics

2.4.1. How is the R&D subsidiary different from other subsidiaries?

While we have already analysed the organizational context of the MNE, and the key theories surrounding it, we still need to explain what makes the R&D subsidiary a totally different feature in the IB literature, as well as what distinguishes it from all the other types of subsidiary. While some of the studies that brought to attention the specialized case of foreign-based subsidiaries introduced some elements related to the unit's innovativeness, research capability, and resource dependency, these were, in most of the instances referred to, the subsidiary as a general case, where all the operations are perceived as equal (e.g. Ghoshal and Bartlett, 1986; Poynter and White, 1984). It was only in the late 1980s that several studies appeared to emphasize the special case of R&D units (i.e. R&D subsidiaries) and tried to explain

why this particular type of subsidiary requires special attention from the IB scholars. In this section I will focus on the factors associated with the distinctiveness of R&D subsidiaries compared to the traditional view of subsidiaries.

The strategic role of R&D subsidiaries

Presumably the most significant factor that changed the view of the IB community towards the differentiation between traditional subsidiaries and R&D subsidiaries is the strategic role that the latter play in the MNE organizational context. The first study to highlight this distinctiveness was the work by Birkinshaw and Hood (1998). The authors noticed a particular evolution on two particular facets; (i) enhancement/depletion of capabilities in the subsidiary; and (ii) explicit change in the subsidiary's charter. The first aspect relates to the development of subsidiary's capabilities in attracting resources and generating products which can be vital not only for the subsidiary itself, but also for the whole MNE. The second aspect has to do with the change in the elements of the business under which the subsidiary plays a vital part and is considered to have a great amount of responsibility for the MNE. Those two strategic characteristics have been fundamental in evolving R&D subsidiaries as a distinctive part of the MNE.

The important role of HQ control

Although centralization and control mechanisms are vital for the whole MNE, as well as for all the existing types of subsidiaries, there is a special attention being given to the level of control that each R&D subsidiary experiences. Due to the research intensity of R&D subsidiaries there is an increasing fear of visibility of information to third parties (Zhao, 2006). This fear is further augmented by the fact that a possible leakage of existing innovations/information can have a devastatingly detrimental effect on the whole MNE and consequently on the competitive advantage of it. The fact that R&D subsidiaries are based in overseas locations implies that there is an increasing risk of exposure to possible lack of control from the HQ. Furthermore, each country where the MNE operates is surrounded by a unique NSI context which means that also the IPR protection regime will vary from

country to country. Accordingly, MNEs choose to establish control mechanisms (through coordination, socialization, etc.) in order to oversee the working process that is implemented in the R&D subsidiary. As a result, in most of the cases, the R&D subsidiary is being left with a limited amount of autonomy which has a negative impact on the MNEs' innovative performance (Bartlett and Ghoshal, 1989). On the other hand, providing an unlimited amount of autonomy to the R&D subsidiary can cause information leakage to third parties. This is a double-edge sword for the MNE, while this relationship can be framed under the AT context.

The special role of R&D mandate

It is already known from the literature that each R&D subsidiary is determined to a certain degree by the R&D mandate. This subsidiary-related characteristic is set by the HQ according to the needs, scope and strategic decision-making of the MNE. As was mentioned before, during the late 1980s several scholars attempted to classify and formalize the specific types of international R&D activities of MNEs. Although the IB scholars are aware of two distinct types of R&D activities - those targeting more research oriented practices and those with a more market (adaptation) oriented profile – a great number of research works have been formulated around these two dissimilar categories (e.g. see the works of Ambos, 2005; Cantwell and Mudambi, 2005; Chiesa, 1996; Dunning and Narula, 1995; Le Bas and Sierra, 2002; Von Zedwitz and Gassmann, 2002). Undeniably, these two forms of R&D activities are largely related to the particular focus of each MNE, i.e. research or market orientation. On the other hand, it should be noticed that these two types are also in close relationship with a very well-known aspect of traditional economic theory. This aspect has to deal with the demand and supply factors (or push and pull factors) of an economy (sourcing either from home or host location) – an aspect also related to the location's richness of endowment and, consequently, the embeddedness of the R&D subsidiary in the science base.

The important role of the location's endowment richness

What becomes clear from the aforementioned distinctiveness of R&D subsidiaries' typologies is that MNEs move toward two streams of internationalisation of their innovative activities and these streams are largely related to their decision to tap into the resources of a specific location in order to either exploit (mainly through reaping the market's growth potential) the specific location, or to explore the country's specific advantages and endowment richness (principally through seeking for agglomeration practices through basing their units in close proximity to other innovative industries, competitors or universities) (Shimizutani and Todo, 2008). This is also associated with the Country Specific Advantages (CSAs) sourcing from the location the subsidiary has tapped into. Precisely, MNEs can possibly base their R&D activities in a host location in order to leverage the high market demand for a specific product, whose technology is developed in the home region (closely controlled by the HQ). Accordingly, market or adaptation orientated facilities can be developed by focusing on distributing the product in the market (Hakanson and Nobel, 1993a). On the other hand, we know that MNEs seeking to enhance their international innovative competitiveness will tap their R&D activities in locations where the supply of scientific and technological excellence will be of exceptional quality and quantity (Gerybadze and Reger, 1999; Kuemmerle, 1999a).

2.4.2. Literature review on R&D subsidiary typology

Despite the fact that R&D internationalisation has attracted an immense amount of interest only during the last two decades, several research studies have been conducted in relation to the synthesis of a formal 'R&D subsidiaries typology/archetype'. Accordingly, in this subsection the most dominant and impactful studies that have developed a comprehensive synthesis regarding 'R&D subsidiaries typology/archetype' will be reviewed.

Bartlett and Ghoshal (1986) are among the first who proposed a typology of subsidiaries in IB. They focus on particular strengths and capabilities of these subsidiaries, as well as they express the view that MNEs should exert more

confidence on subsidiaries' role. More specifically, they argue that 'International subsidiaries should not just be pipelines to move products. Their own strengths can help build competitive advantage' (1986, p. 89). Accordingly, they categorize subsidiaries by four different levels. First, is the Strategic Leader, an expert national subsidiary located strategically in an advanced central market. Second, is the Contributor, a subsidiary with strong competence, mainly located in a small and insignificant market. Third, is the Implementer. In this category we find subsidiaries which are deliverers of the products, having as their major mission the generation of funds in order for the company to keep expanding. The last category is the Black Hole. This category's subsidiaries are established in very important global markets targeting, as a rule, the maintenance of the company's market position in the global map. The most vital role of this subsidiary is to exploit information in regard to technological advances and market trends of competitors by giving feedback to headquarters.

In their more recent study, Bartlett and Ghoshal (1999) propose and explain four different approaches to how MNEs tend to manage their operations on a global basis. First, the Multinational Strategy is an approach which is based on national differentiation as a tool for achieving low cost and high revenue efficiency, while subsidiaries opt to differentiate their products according to the given national diversities and industry characteristics. Accordingly, these firms tend to establish R&D subsidiaries in foreign countries in order to adapt their products according to the domestic circumstances. This strategic pattern was traditionally followed by European companies. Second, the International Strategy is a relatively differentiated approach compared to the Multinational Strategy. In this process MNEs focus on both creation and exploitation of innovation globally, targeted, as a rule, on creating a characteristically competitive position in foreign markets. In reality, their internationalisation strategy involves the creation of new products and processes in the home base and the transfer of them to the less developed foreign markets. This tactic was primarily followed by US MNEs. Third, the Global Strategy is a pattern which is based on the high centralization of the global-scale operations of the MNE. This approach results in more efficient cost advantages, as well as in the enhancement of the quality position of the products. This strategy has been of

massive use to high technology Japanese companies. Finally, a new approach which is hugely adopted by MNEs nowadays is the Transnational Strategy. The main idea behind this strategic approach is the assumption that companies can develop their innovations in different areas of the world, and not only at home. MNEs establish subsidiaries and develop products in various geographical areas where the required resources are available. The term "excentralization" rather than "decentralization" is used in order to better describe this new motive. Following this strategy the company is dispersed, both interdependently and in terms of subsidiary specialization.

From another point of view, Kuemmerle (1997) proposes another sort of typology relevant to the internationalization strategy of R&D. He distinguishes two different types of laboratory site. First, the Home-Base Augmenting (HBA) laboratory site, which has as a main purpose of establishing the absorption of knowledge from the local community and scientific resources, the creation of new knowledge, and finally the production of new technology by transferring it back to the MNE's central R&D site. Second, the Home-Base Exploiting (HBE) laboratory site aims to transfer the existing knowledge and technology from the home laboratory of the MNE to the foreign laboratory in order to adjust its products more efficiently according to the local market's needs.

Hood and Young (1982) and Pearce (1989) proposed three different types for MNEs' foreign R&D labs. The first type of R&D is that conducted in *Support Laboratories (SLs)*, whose main role is to adapt existing products and processes to local conditions. The second type is the *Locally Integrated Laboratories (LILs)* whose role 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. Finally, a third type of R&D laboratory is identified, the so-called *Internationally Interdependent Laboratories (IILs)*. This R&D laboratory 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 products and process patterns. Thus, it can be argued that *SLs* and *LILs* are oriented toward adaptation and improvement of existing

products and distribution of them in the host market (having an equal interpretation of the *Local adaptor* and *International adaptor* proposed by Nobel and Birkinshaw (1998)), while *IILs* (equivalent to *Global creator*) are more independent research units where novel research is conducted.

Håkanson and Nobel (1993) through their research study on foreign R&D of Swedish MNEs propose five different motives that force MNEs to operate R&D units in a foreign location. Their research reveals that MNEs tend to operate R&D laboratories abroad in the case of political factors (environment, domestic regulations), market proximity (product adaptation takes place according to the local needs and scope), exploitation of local R&D resources, and having a supporting role for local production. There is also a fifth category proposed in the study which consists of a combination of these four motives. Accordingly, the typology is structured as follows. Politically motivated units, Market oriented units, Research R&D units, Production support units and Multi-motive units.

Finally, Nobel and Birkinshaw (1998) used five prior studies (Ghoshal, 1986; Håkanson and Nobel, 1993; Kuemmerle, 1996; Pearce, 1989; Ronstadt, 1977) – the majority of which were analytically presented in this subsection - in order to synthesize a new typology of the unit's R&D role. They are driven to the assumption that there are 3 different typologies of R&D units (Local adaptor, International adaptor and International creator). First, Local adaptor has the role of the local disseminator of innovations which are produced in the home country, while there is limited or no development authorization for this particular subsidiary. Second, International adaptor has a more creative and more autonomous role in relation to the local adaptor's role. It has the ability to enhance or even produce innovative products for other units of the MNE. Finally, International creator is a more innovative and autonomous version of international adaptor. In this unit, R&D can be developed in the first stage having the form of basic or applied research, rather than adaptation and enhancement of an existing product. This type of subsidiary uses local scientific resources and links with various other R&D entities of the host environment in order to produce cutting edge technology for the whole MNE.

Apart from the above typologies, several other studies have recently focused their attention on recent trends and motives of international R&D activities of organizations (e.g. Gassmann and von Zedtwitz, 1999; Gerybadze and Reger, 1999). Apparently, the purpose of this research is first to identify and capture the classical typologies of R&D internationalization, as these have been formed during the last two decades, and second to adapt a specific international R&D subsidiary typology according to the research needs of this study. Subsequently, it is realized that all the above typologies have a close interconnection in terms of how they have been developed, as well as in relation to the types of R&D subsidiaries that each one presents. In fact, although these studies differ - in terms of giving slightly different titles to each type of R&D laboratory - it is suggested that 'there is a surprising consistency in the proposed types' (Nobel and Birkinshaw, 1998, p. 481).

In sum, the literature suggests that one of the most well-examined and extensively discussed topics on internationalization of MNEs' R&D activities is the particular role and mandate that is assigned to foreign-based R&D units. In line with this review of literature on R&D subsidiary typology, Nobel and Birkinshaw (1998) identified the most influential studies that have developed comprehensive typologies of R&D units (Table 2.2 portrays the most dominant works on R&D typologies).

Table 2.2. Typologies of R&D unit roles (Adopted from Nobel & Birkinshaw, 1998)

Pearce (1989)	**Support laboratory**	**Locally integrated laboratory**	**Internationally interdependent laboratory**	
Ronstadt (1977)	Technology transfer unit	Indigenous technology unit Adaptive R&D	Global technology unit	Corporate technology unit
Ghoshal (1986)	Implementer subsidiary	Contributor subsidiary	Innovator subsidiary	
Håkanson and Nobel (1993)	Technical support unit	Adaptive R&D unit	Generic R&D unit	Research unit
Kuemmerle (1996)	Home base exploiting unit		Home base augmenting unit	
Nobel and Birkinshaw (1998)	Local adaptor	International adaptor	Global creator	

Note: Pearce (1989) also acknowledges the work of Cordell (1973) as a major contributor to his typology. Ghoshal's typology refers to the subsidiary as a whole, and not just the R&D unit.

3. MANAGEMENT OF INTERNATIONAL R&D AND THE INNOVATIVE PERFORMANCE OF SUBSIDIARIES

3.1. The changing landscape of international R&D during the last two decades

As was already explained in the previous chapter, the notion of R&D subsidiary and the concept of R&D internationalisation have been academically elaborated during the last 20 to 25 years. Vernon (1966) and later on Hymer (1972) highlighted the importance of MNEs' home locations and that all the technological advances and firms' international competitiveness are exclusively produced in close proximity to the HQ of the MNE, rather than in foreign-based subsidiaries. This approach was initially explored and accordingly revised by Cantwell (1995) who, through his research work on historical patent data obtained from the USPTO, empirically proved that MNEs have shown signs of R&D internationalisation more than ever before, while the geographical locations of these activities have been widely extended. On the other hand, it should be stressed that during the early years of empirical research in that direction the findings showed that although the global dispersion of R&D activities had started to take place more intensively, the heart of technological activities was still centered on the HQ or in close proximity to the MNEs' home location (Cantwell, 1995; Miller, 1994; Patel, 1995; Patel and Pavitt, 1991).

Undeniably, the location of international R&D investment is the major aspect that has changed radically since the early years of MNEs R&D internationalization. While the first studies exploring the motives of MNEs R&D internationalization were strictly focused on the Triad region (North America, Western Europe and Japan) (e.g. Casson and Singh, 1993; Patel and Pavitt, 1991; Pearce and Singh, 1992), some of the most well-known studies of more recent years (e.g. Kuemmerle, 1999a; Von Zedtwitz and Gassmann, 2002) have shown that major MNEs now invest technologically in new geographic areas and particularly in emerging markets.

This trend is well reflected by the early 2000s article of *The Economist* titled 'Innovative India'. According to the article, in 2003 Intel's Indian subsidiary filed 63 patents while 1,500 IT professionals were employed in this subsidiary. Another article (The Economist, 2010) titled 'The world turned upside down' makes known that:

'Companies in the Fortune 500 list have 98 R&D facilities in China and 63 in India. Some have more than one. General Electric's health-care arm has spent more than $50m in the past few years to build a vast R&D centre in India's Bangalore, its biggest anywhere in the world. Cisco is splashing out more than $1 billion on a second global headquarters—Cisco East—in Bangalore, now nearing completion. Microsoft's R&D centre in Beijing is its largest outside its American headquarters in Redmond. Knowledge-intensive companies such as IT specialists and consultancies have hugely stepped up the number of people they employ in developing countries. For example, a quarter of Accenture's workforce is in India'.

These facts show that the geography of innovation has changed to a great degree compared to what we used to know almost 20 years ago. It is critical to highlight that the study conducted by Pearce and Singh (1992) also surveyed the Fortune 500 list of MNEs and during that time there was limited indication of formal R&D operations in the emerging world. Indeed, the number of primary locations of R&D has increased from 13-14 in early 1990s to 17-18 in early 2010s. The factors of this geographic expansion are well known in the academic literature but are also elaborated in the aforementioned article of *The Economist*. The first factor amalgamates two fundamental characteristics of the labour force (i.e. relatively cheap and highly educated and skilled scientific personnel) which are predominantly associated with technology exploiting R&D. The second factor relates to the economic growth of the emerging world (BRICS) which in fact attracted a great number of MNEs which showed potential for market augmentation, as well as for exploration of new ideas in new geographic locations.

Since each of these two factors is of unique importance for the MNE nowadays, it is also equally important to discuss the means by which the MNE is able to manage the international operations of its R&D activities. The foreign-based R&D subsidiary relies on a set of coordination mechanisms which are set and ruled by the HQ of the MNE. Especially for subsidiaries which have a technology exploiting R&D focus, coordination mechanisms are crucial for the achievement of integration among different units within an organization. This sort of interaction relates to the internal process of knowledge communication between the subsidiary and other units of the MNE. On the other hand, R&D subsidiaries can also be characterized by a more research intensive profile, which is related to the exploration of new ideas in order to renew the competitive advantages of the MNE. In that case subsidiaries are characterized by a greater level of autonomy and consequently a higher level of interaction with the local (i.e. external) environment. During the most recent years the means by which this sort of interaction between the subsidiary and the internal and local network is achieved is also known as subsidiary embeddedness. In the following sections of this chapter I will proceed to an extensive analysis of the aforementioned notions, additionally I will review the literature in order to analyse the existing gaps on subsidiary embeddedness.

3.2. Embeddedness: a form of knowledge interaction between entities

3.2.1. The notion of network embeddedness

The idea of firm embeddedness originates in economic sociology (see Polanyi, 1957; Granovetter, 1985) and economic geography (see Grabher, 1993) literatures and is associated with slightly different meanings in each case. What follows is a systematic analysis of the literature in regard to the embeddedness notion. Precisely a particular focus will be given on how this concept was originated, how it has evolved, and finally what is the particular interest of this research study regarding the embeddedness notion and its relationship to the MNE subsidiary within the economic geography and technology management literature.

3.2.1.1. Embeddedness: a notion with deep sociological roots

The concept of embeddedness as we know it nowadays has deep sociological and anthropological roots. The need of economic sociologists and economic anthropologists to extend classical (traditional) economic thought and accordingly to give a more cultural and social dimension to it resulted in the birth of the idea of embeddedness. Polanyi (1957) is considered to be the father of this idea, since he was the first to emphasize the way economies and economic relations are embedded in cultures and societies. His work is mainly known for the incorporation of the notion of *substantivism* (Polanyi and MacIver, 1957), which is the embryonic concept of the idea of embeddedness. The key idea behind the origin of *substantivism* is that in non-capitalist, socialistic economies, business activities are not just a function of market exchange, but a reciprocal (mutual) interpersonal activity between actors which is based on the redistribution of goods. The key notion behind this idea is that the economic activity and the resulting transaction of a good is not as simple as economic theory used to consider at that period of time, but it should be valued as a more complex procedure, under which various sociological and anthropological aspects related to culture, politics, values and religion play an important role.

Based on the idea of *substantivism* and adapting it to a more economic sociology stream of research under which firms and industries have a vastly important role regarding the day to day economic transactions in the market society, Granovetter (1985) pioneered the view that economic relations between firms and their environment are mediated by social networks and relations between them. Although this view is considered to have a more neo-liberal approach compared to the existing socialistic view of Polanyi, Granovetter's work was the first to incorporate the importance of interpersonal relationships in the modern industrialised era. What Granovetter (1985) and Uzzi (1996, 1997) later on argued is that the strength of networks and relationships shaped information flows between agents – in particular the counter intuitive idea that weak ties (infrequent interaction) were more important than strong ties (more frequent interaction) in several situations. The sociological dimension of embeddedness is still perceived as the origin of interpersonal and inter-firm relationships in the modern industrialised era, while numerous studies have adopted this particular theoretical underpinning in their research work in order to

better capture the business relationships, as well as the determinants and outcomes of them.

3.2.1.2. Embeddedness in economic geography: The role of spatial proximity

A complementary, rather than differentiated dimension has been given to embeddedness by economic geographers. Martin (1994) argues that apart from its social interaction effect, embeddedness, as a form of economic action is also spatially related. For economic geographers the term embeddedness is strongly related to the words "region", "territory", "spatial" and "milieu". Grabher (1993) was among the first to talk about "spatial lock-in" when he referred to value creation of firms and their proximity-based network, while Harrison (1992) emphasised the role of embeddedness in regional level when co-location of firms in specific regions can create a local network of economic relations among them. Hess (2004) unravelled the multiple dimensions and typologies of the embeddedness notion by prioritising three key aspects of it. (i) Who is embedded, (ii) in what is it embedded, and (iii) in what geographical scale is it embedded. While on the one hand modernised economic sociologists (such as Granovetter) refer to economic behaviours between individuals and firms under social relationships surrounded by no particular geographical scale, on the other hand economic geographers tend to use the term embeddedness in order to picture firms (and not individuals) which are embedded in networks and institutional settings under a certain local or regional geographical scale.

To put it simply, 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. In that case, embeddedness refers to factors embedded in a region, territory, or cluster, 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 economic sociology literature where embeddedness arises as a consequence of interpersonal social interactions the

economic geography literature's view of embeddedness is more predicated on a proximity-based view (regional, spatial, local, etc.).

3.2.1.3. Embeddedness under the MNE context: The international R&D perspective

The MNE is a rather interesting case in terms of how embeddedness is perceived and applied within the former's environment. This specific interest is mostly related to the fact that both the economic sociology and the economic geography streams are of vital importance for the interpretation of embeddedness in the MNE context. Precisely, this can be further explained by the fact that an MNE is an organisation which operates in multiple geographic locations and countries, where both firm and individual characteristics are of crucial importance for the overall competitive advantage of the MNE. This characteristic can be particularly appealing to the case of foreign-based R&D subsidiaries, which are units operating in offshore locations, communicating with multiple internal (headquarters and affiliated units) and external environments (firms, universities, research centres located in both home and host locations) at the same time (Phene and Almeida, 2008).

On the one hand, 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. On the other hand, a rather complementary view of embeddedness has been developed which lies within the MNE knowledge network, and particularly in the network of relationships among the subsidiary and its affiliated network of knowledge sourcing (i.e. internal and external knowledge network). Hence, although the social relationships under which both firms and individuals are engaged may correspond to the economic sociology stream, the multiple location perspective, which best describes the foreign-based R&D subsidiary, exhibits why economic geography's conception of embeddedness also matters.

Accordingly, and taking into account the sociological (i.e. the interrelationship effect) and geographical (the location effect) perspective of embeddedness, the aim of this study is to shed light on the frequency of interaction of MNEs' R&D subsidiaries with both internal and external knowledge sources (i.e. forms of embeddedness). The sociological perspective that sources from the frequency of interaction between units and individuals who belong to these units make the distinction between the notions of (technological) embeddedness and knowledge sourcing even more reasonable. Accordingly, although these two notions seem to be similar, the sociological perspective that accompanies the theme of this research, leads this study towards the adoption of the embeddedness concept.

3.3. Coordination of R&D and its relationship to internal embeddedness of the R&D subsidiary

As was discussed in the first section of this chapter, coordination mechanisms are clearly a necessary part of organizational integration in the MNE environment, while they are also a vital part of technology exploiting R&D. Although knowledge is nowadays transferred through many different pipelines and methods, organizations have now developed the necessary coordination mechanisms which are followed by the organization's human resources. These mechanisms are even more important for R&D units which repeatedly generate knowledge and transfer information in many different geographic locations. In order to protect this information from possible threats and knowledge spillovers to third parties, MNEs usually follow the practice of adopting a set of coordination mechanisms which will be used in order to transfer safely and efficiently all the required information within the organization.

In order to give a better illustration of how coordination theory is perceived, I will define it as 'a body of principles about how the activities of separate actors can be coordinated' (Malone, 1988, p. 6). These actors can take the form of organizations, individuals, groups of people, computers and technological equipment. Inside an organization and particularly looking at the R&D process of an MNE, coordination is achieved through the participation, communication and integration of almost all the above bodies. There is no hesitation that coordination is crucially important for

the organization, that is, control and interaction of two or more different entities. In fact, the most fundamental aspect of coordination is the mechanisms with which it is achieved. Coordination mechanisms can be divided to formal (structural) and informal (subtle) mechanisms (Barnard, 1968; Martinez and Jarillo, 1989). According to Martinez and Jarillo (1989, p. 490) 'a mechanism of coordination is any administrative tool for achieving integration among different units within an organization'. This means that organizations use certain formal and informal mechanisms in order to coordinate, control and organize the work of interacting internal and external bodies.

The starting point of coordination mechanisms typology was given by Bernard (1968) who explicitly divided the coordination function into two different types, formal and informal. Respectively, a more advanced and detailed framework on the same topic was proposed by several other authors during the 1970s and 1980s. Galbraith (1973) and Edström and Galbraith (1977) studying the complexity of organizations suggest that apart from a formal bureaucratic procedure which is followed by organizations, other important aspects such as lateral controls (socialization, personal communication) and hierarchy (centralization - decentralization) should no more be considered as alternatives, but as complements to the existing complex coordination of the organization. Similarly, Ouchi (1979, 1980) contributes by emphasizing the need for designing a new organizational model which constitutes organizational control mechanisms. These mechanisms will be able to solve any problems which are faced by people who have partly different objectives in the organization. These are the market, clan and bureaucratic mechanisms. Baliga and Jaeger (1984) in their attempt to discover possible control and delegation controversies that are of concern for the management teams of MNEs, conceptualize a proper model which comprises of three interrelated mechanisms. These are bureaucratic control, cultural control and centralization. As they conclude, it is of vital importance that managers in MNEs are able to distinguish the type of control and the delegation level which are more suitable for the needs of their organization, especially when subsidiaries are involved in the coordination process.

As was previously mentioned, a more extensive and distinctive theoretical approach to the coordination mechanisms specification was given by Martinez and Jarillo (1989) who make an explicit review of the existing literature until the late 1990s. As they conclude, apart from the two theoretically developed streams of coordination (structural and formal mechanisms), a third stream, this one of subtler (informal) mechanisms, seems to be highly appreciated by both scholars and managers as a new trend of coordination among MNEs. This new stream of coordination mechanisms is the result of 'general changes experienced by international competition and the accompanying changes in MNEs' strategies' (Martinez and Jarillo, 1989:508). As is depicted in the following table (i.e. Table 3.1), the authors divide the mechanisms of coordination into two groups, structural and formal mechanisms, and more informal and subtle mechanisms.

Table 3.1. List of the Most Common Mechanisms of coordination

	Structural and formal mechanisms
1	Departmentalization or grouping of organizational units, shaping the formal structure.
2	Centralization or decentralization of decision making through the hierarchy of formal authority.
3	Formalization and standardization: written policies, rules, job descriptions, and standard procedures, through instruments such as manuals, drafts, etc.
4	Planning: strategic planning, budgeting, functional plans, scheduling, etc.
5	Output and behavior control: financial performance, technical reports, sales and marketing data, etc., and direct supervision.
	Other mechanisms, more informal and subtle
6	Lateral or cross-departmental relations: direct managerial contact, temporary or permanent teams, task forces, committees, integrators, and integrative departments.
7	Informal communication: personal contacts among managers, management trips, meetings, conferences, transfer of managers, etc.
8	Socialization: building an organizational culture of known and shared strategic objectives and values by training, transfer of managers, career path management, measurement and reward systems, etc.

Adopted by Martinez and Jarillo (1989, p. 491)

During the last two decades there has been a huge amount of academic interest in the coordination and communication mechanisms of the MNEs' R&D units. The authors have, based on the previously mentioned theories of coordination mechanisms which have explicitly developed during the 1970s and 1980s, found a new stream of

academic and managerial interest. Apart from the R&D typology, authors adapted and improved the coordination mechanisms scheme in a way that it should be tailored to the needs of HQ and subsidiaries of the R&D laboratory of the MNE. Again, the streams are divided to two different paths, those of formal and informal coordination mechanisms, although the divergences of the typologies which are analysed from the authors are not very different. Many of them though (Nobel and Birkinshaw, 1998; Reger, 1999; Persaud *et al*, 2002; Kim *et al*, 2003; Manolopoulos *et al*, 2011) focus their research interest on communication systems and bilateral communications (internal and external) among R&D centers. This communication is usually an informal procedure which is mainly achieved through socialization and people-based integration techniques. The importance of communication is characteristic and is portrayed through the following words '…the people-based mode seems even more effective for global integration' (Kim *et al*, 2003, p. 331).

Although this research study does not intend to employ all the existing forms of coordination, a comprehensive review of the literature as regards the most important typologies of mechanisms of coordination will be presented. Accordingly, the typology of this research work is closely related, firstly to the work of Nobel and Birkinshaw (1998), and secondly to the typology developed by Persaud *et al*. (2002). The analysis is based on both formal and informal coordination mechanisms. This conclusion guides us to the selection of the following coordination mechanisms; Centralization (Autonomy), Formalization (Planning), Socialization, inter- and intra-communication mechanisms, as well as extra-communication mechanisms.

Formalization (Planning) mechanisms

MNEs follow a formal coordination structure to operate the functional division of their units. This formalized mechanism of control and coordination of the units is frequently referred to in the literature as "planning" (Thompson, 1967; Reger, 1997) or "standardization" (Thompson, 1967; Martinez and Jarillo, 1989). According to Persaud *et al*. (2002, p. 61) with the term "formalization" we refer to 'decision-making based on formal systems, established rules, and prescribed procedures'. The application of formalization mechanisms by the upper management team of the

MNE aims to incorporate a formal and controlled context of operation in order to elaborate a more manageable system with which parent and subsidiary units will communicate and operate under a clear and systematic plan. Certainly, such a system functions with a highly formalized structure and is mainly controlled by bureaucratic procedures. These bureaucratic aspects (standardized work procedures, strict rules, protocols and policies) in many cases dishearten the work of the personnel, especially where R&D activities are taking place (Gates and Egelhoff, 1986). On the other hand, formalized procedures and standardization are unavoidable when specific methods and hierarchical practices have to be followed, especially when a precise output or product has to emerge from the production process. In sum, it can be supported that the existence of formalization mechanisms is interpreted as the situation of presence of systematic coordination and consultation from the HQ to the foreign-based subsidiary.

Socialization Mechanisms

According to Bartlett and Ghoshal (2000, p. 515) socialization is a process by which the management team creates 'a broad culture and set of relationships that provide an appropriate organizational context for delegated decisions'. The importance of socialization mechanisms for an organization, and especially for MNEs which operate foreign subsidiaries is unambiguous. Baliga and Jaeger (1984) were among the first who studied the control systems developed by MNEs. In their study, they emphasize the critical importance of cultural control inside the organization. According to them, cultural control is disseminated through 'an inferred organizational code, an organizational game which is an important guide to behavior in addition to whatever explicit rules do exist' (Baliga and Jaeger, 1984, p. 27). Hence, it is not only about sharing knowledge and information that makes socialization between people and units important, it is also about the 'creation of common and shared understandings of goals, values and practices to influence both how subsidiary labs perceive their interests and how they act' (Persaud *et al*, 2002, p. 61). A more recent definition and explanation of the term socialization is given by Mendez (2003) who suggests that socialization refers to the frequency of contacts between the different units through long-term job rotation and short-term visits. Likewise, and from a knowledge-sharing point of view, it is understandable that the

more the units of an MNE use, transfer and share common ideas and targets in the long term, the more likely it is that the units and the people who belong to them will exchange valuable resources and complementary knowledge (Björkman *et al*, 2004). By acting in this way, MNEs manage to enhance their units' absorptive capacity, as well as to increase the volume of knowledge diffusion among their R&D subsidiaries. Commonly, Manolopoulos *et al*. (2011) in their recent research work incorporate a common set of beliefs, such as corporate culture and shared language in order to evaluate the degree of social coordination mechanisms in the context of international R&D. Apart from the same goals, visions, culture, language and strategies that are being set by the management team of the MNE, socialization among the units and members can be achieved through bilateral visits of R&D personnel among units, and training programs (Nobel and Birkinshaw, 1998; Björkman *et al*, 2004). We already know that inter-team and intra-team cooperation has been found to be beneficial for knowledge creation by subsidiaries (Mudambi *et al*, 2007), while it has been proved that corporate socialization mechanisms enhance the transfer of knowledge from subsidiaries to other units of the MNE (Björkman *et al*, 2004).

Communication mechanisms

Apart from the aforesaid analysed mechanisms (i.e. centralization, formalization and socialization), another form of coordination mechanism, the communication mechanisms, has been found to play an important role. Communication is achieved with the participation of two entities, the sender and the receiver, while the whole process is achieved through channels and related mechanisms, such as electronic media, intranet, emails and face to face meetings. In the existing literature, communication is divided into subparts. Persaud *et al*. (2002) recognize two typologies of communication, those of vertical flow of information (communication among HQ and subsidiaries) and the horizontal flow of information (communication between subsidiaries). A further type of communication is proposed by Nobel and Birkinshaw (1998) who refer to external communication. The latter type of communication is based on the communication between the unit of the MNE and the external environment (such as universities, customers, suppliers and research centers). In various research studies, communication is not interpreted separately

from socialization, and the term "people-based coordination" or "integration" is used (Kim *et al*, 2003; Manolopoulos *et al*, 2011). The main theme of this typology is based on the assumption that firms use people in order to make coordination and control in the foreign units of the MNE possible. A recent study by Mudambi *et al*. (2007) researches the impact of intra- and inter-teamwork on knowledge generation by foreign R&D subsidiaries. The results stress the substantial value of both types of teamwork to both knowledge creation and innovative performance.

3.4. R&D subsidiary autonomy and local (external) embeddedness

A vital part of coordination mechanisms that has a huge impact on the role and performance of the R&D subsidiary is the degree of autonomy granted to the latter. Generally speaking, the coordination of the units of the MNE, the decision-making authority and the operational function of a unit (subsidiary) are very much related to the degree of autonomy that each unit receives. In order to better understand the notion and exact meaning of the term 'autonomy', I will provide some information on its characteristics based on the review of the literature.

It is widely known that the degree of autonomy, as well as the process under which the autonomy of each unit is decided, is largely set by the HQ of the MNE. According to O'Donnell (2000, p. 528) a subsidiary's autonomy can be defined as 'the degree to which the foreign subsidiary of the MNE has strategic and operational decision-making authority'. As Persaud *et al*. (2002) suggest, autonomy is the 'obverse of centralization where decision-making is centralized'. While in many cases, the "degree of autonomy" is considered to be the same as "centralization – decentralization", these two terms are close in meaning but not identical. According to Gupta and Govindarajan (1991, p. 785) the term "decentralization" is explicated as 'the extent of decision-making authority that is delegated to the general manager of a subsidiary by corporate superiors'. In this study the terms "autonomy" and "decentralization" will refer to the operational independence of the subsidiary and accordingly these terms will be used synonymously.

Autonomy is known to be positively related to a subsidiary's local (external) embeddedness (Andersson and Forsgren, 1996) and negatively associated with internal embeddedness (Birkinshaw and Morrison, 1995). This phenomenon (i.e. positive relationship between subsidiary autonomy and external embeddedness) is related to the fact that subsidiaries which enjoy a greater level of autonomy are more prone to engage in collaboration with external actors (eg. other firms, research institutions, public organizations or universities), in order to further explore new ideas leading to the strategic renewal of the MNE's competitive advantage. This type of subsidiary will also have a more research-intensive role since they are less integrated in the internal network of the MNE and more incorporated in the external environment under which they operate.

Subsidiaries which enjoy high levels of autonomy and a research exploration role will also produce innovations and new knowledge which is of immense importance for the competitive advantage of the MNE. As a result, the whole MNE (HQ and sister units) becomes resource dependent on a subsidiary which produces this sort of competitive advantage. In that case autonomy generates the phenomenon of reverse knowledge transfer (RKT). Accordingly, employees who are located in foreign-based subsidiaries integrate with the internal network of the MNE transferring their knowledge to other affiliate units or even the HQ itself. The latter case is in reverse to the hierarchical relationship we already knew from the AT and the aforementioned coordination mechanisms, since a bottom-up relationship is now produced.

3.5. Subsidiary desirability for multiple (triple) embeddedness

From the previously analysed section it becomes apparent that subsidiaries rely on two distinct sources of knowledge at the same time; the external (local) network of knowledge which they tap into for new forms of collaboration; and the internal network of knowledge which is used as the channel of coordination and knowledge transfer from unit to unit. This is also known as the case of 'multiple embeddedness' (Meyer *et al.*, 2011). The multiple embeddedness perspective has elaborated two equally important features for the MNE. First, the MNE should be able to organize

its foreign-based subsidiaries in a way that they will be effective in exploiting the differences and similarities of the multiple host locations. Second, the subsidiary should be able to efficiently balance internal embeddedness with external (local) embeddedness.

Although the notion of multiple embeddedness clearly separates the networks into external and internal ones, the modernized view of the MNE at the subsidiary level is more complicated. This complexity comes about because subsidiaries engage in collaboration with external sources of knowledge in more than one location. A comprehensive analysis of the existing empirical literature reveals that nowadays, foreign-based subsidiaries have the power and ability to simultaneously tap into a selection of different networks. Precisely, several studies have focused on external (local) and internal relationships and the factors associated with them (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 other studies have concentrated on the distinction between external environment to external home (location of the parent company) and external host (i.e. location under which the foreign-based subsidiary operates) (Criscuolo, 2009; Criscuolo *et al.*, 2005; Le Bas and Sierra, 2002). A more generalized view of this knowledge network (embeddedness) distinction leads to a three-way interaction between the subsidiary and the available forms of knowledge networks. Accordingly, foreign-based subsidiaries are embedded in three (and not in two) different environments at the same time; the MNE internal environment and the subsidiary external environment (host and home environment). As was mentioned in the beginning of this section this type of simultaneous engagement is frequently referred by the academic community as the "notion of dual or multiple embeddedness" (Figueiredo, 2011; Meyer *et al*., 2011; Narula and Dunning, 2010; Tavares and Young, 2005). In our case where there are considered to be three networks of knowledge, we will also use the term 'triple embeddedness'.

Although this choice between forms of (simultaneous) embeddedness may be perceived as a strong advantage for the MNE subsidiary (mainly due to the fact that

they are able to simultaneously trade-off and/or complement knowledge and resources), at the same time this can be viewed as a double-edged sword, since along with the business opportunities, several operational challenges arise for the MNE (Meyer *et al*., 2011). The aforementioned distinction between three different forms of subsidiary embeddedness (internal, external home and external host) leads to the assumption that MNE subsidiaries are forced into strengthening or weakening their ties with these three forms of embeddedness according to both MNE internal (such as the strategic role and decision-making authority given to the subsidiary) and external characteristics (such as environmental uncertainty and endowment richness), as well as to use their choice between these forms differently in order to enhance the innovative performance, and therefore competitive advantage, of the R&D subsidiary. The following section will review the existing literature on this topic.

3.6. Subsidiary embeddedness and the international management of R&D – gaps in our knowledge

The literature on embeddedness from the MNE subsidiary's perspective is not yet very extensive. In fact, there has been a very limited amount of research compared to other aspects of MNE subsidiary internationalisation (e.g. knowledge transfer, determinants of location choice, mode of entry and HQ-subsidiary relationship). This section aims firstly to identify and secondly to analyze the extant literature on MNE subsidiary multiple forms of embeddedness.

There are several reasons for proceeding to such a comprehensive analysis of the literature. First, and according to the author's best knowledge, there is no previous extensive review of the literature published on this important and specialized topic of international business. Second, although we are already aware of the multiple/dual embeddedness notion and its related aspects (Figueiredo, 2011; Meyer *et al*., 2011; Narula and Dunning, 2010; Tavares and Young, 2005), we still struggle to understand how this theoretical underpinning has evolved over time and in what degree this could be progressed further. Third, considering that embeddedness can have a dual role in explaining several aspects of international business (i.e. acting

either as explanatory or dependent variable), a comprehensive review of the literature can provide valuable answers on how researchers have treated embeddedness up to this point, and what still remains unexplained. Finally, such an comprehensive literature review can be a useful instrument for further identifying the gaps for future research in this particular area, and accordingly it can facilitate this study by showing the way for a more proper and valuable setting of the conceptual framework.

The complete literature review resulted in 57 studies. Detailed information relevant to the research strategy followed; bibliographic methods were applied and other relevant information can be found in the Appendix of Chapter 3. After careful consideration and taking into account the aim of this research, the relevant articles that have been identified among the existing literature have been divided to three categories. This classification is based on the type of research question each reviewed article has answered. Accordingly, the first category includes studies which – although they do research on subsidiary embeddedness - do not focus on the technical/technological part of embeddedness, but rather on other aspects of it (e.g. relational embeddedness, political embeddedness or institutional embeddedness). This category is not of great interest here and it will not be analysed in depth compared to the other two categories. The second category is related to research studies which elaborate on determinants of technical/technological embeddedness. This form of relationship is of great interest for our literature review since it examines the factors shaping the degree of embeddedness in the case of technology - related aspects of R&D subsidiaries. The final category includes research works on the determinants of subsidiary embeddedness upon subsidiary performance. Although our study is concerned with the aspect of innovative performance, there are also articles that have shown a particular research interest in other forms of performance (e.g. market performance and organizational performance).

Regardless of the findings of this literature review, what should be highlighted is that two forms of embeddedness were known and researched in the pre-1996 period, when subsidiary embeddedness was first brought to the IB attention. The first form

is called ‘relational embeddedness’ and refers to the quality and depth of a single dyadic tie. Gulati (1998: 296) argues that ‘relational embeddedness stresses the role of direct cohesive ties as a mechanism for gaining fine-grained information’. This definition can be interpreted in the MNE context as ‘the extent to which subsidiaries establish individual, direct relationships with customers, suppliers, competitors etc.’ (Andersson *et al*., 2002, p. 981). On the other hand, ‘structural embeddedness’ can be defined as ‘the extent to which a dyad’s mutual contacts are connected to one another (Granovetter, 1992, p. 35). In that sense, organizations are not connected solely with each other, but they also have relationships with third-level actors. Accordingly, structural embeddedness is a more complicated measure compared to relational embeddedness, since it measures the number of participants who interact, the likelihood of future interaction among them, as well as the probability that the same participants are going to talk about these interactions (Granovetter, 1992).

In general terms, a very interesting result from the analysis of the literature, which in a large degree confirms the notion of dual or multiple embeddedness, is the fact that a great amount of the reported studies simultaneously incorporate the notion of internal and external embeddedness (e.g. Ambos, 2005; Chiao and Ying, 2012; Collinson and Wang, 2012; Dellestrand, 2011; Figueiredo, 2011; Marin and Bell, 2010). Although some of these studies do not use the terms ‘internal embeddedness’ and ‘external embeddedness’, but relative terms, such as ‘intra-corporate’ and ‘local embeddedness’, ‘internal and external network range and strength’, the central idea remains the same and confirms that the notion of dual/multiple embeddedness is well perceived and implemented research-wise by a great range of the academic community. Furthermore, a remarkable piece of information derived from the literature is that very few empirical studies have focused on the examination of the external embeddedness of the foreign-based subsidiary’s home location. Particularly, Criscuolo (2009) analyzing patent citation data sheds light on this underdeveloped form of embeddedness. Two other studies, namely those of Pinkse and Kolk (2012) and Rizopoulos and Sergakis (2010) focused on the institutional embeddedness in the home location, but their studies are mainly based on conceptual work. Interestingly, external host or relational (local) embeddedness, albeit a well-researched form of subsidiary embeddedness, still dominates the attention of

researchers in a great range of studies (e.g. Ambos and Schlegelmilch, 2007; Andersson *et al*., 2005; Andersson *et al*., 2007; Barner-Rasmussen, 2003; Li *et al*., 2007; Newburry, 2001; Spencer, 2008, etc.), even after the post-2005 period.

3.6.1. Discussions of non-technological embeddedness

In terms of the subsidiary embeddedness, the literature review indicated that the majority of studies use the notion of relational embeddedness in order to measure and describe the interaction among subsidiaries with either internal or external actors (e.g. Andersson *et al*., 2002; Dellestrand, 2011, Dhanaraj *et al*., 2004; Moran, 2005; Nell and Andersson, 2012; Santangelo, 2012)., There are about 35 studies (these are reported in Table A1 in the Appendix of Chapter 3) that are found to incorporate different forms of subsidiary embeddedness. Although the traditional distinction between relational and structural embeddedness is well perceived by a wide range of the academic and non-academic world nowadays, the aforementioned literature review of subsidiary embeddedness identified several other sub-forms of (mainly relational) embeddedness. There are studies which have employed a more conceptual methodological model, use the term 'institutional embeddedness' (e.g. Pinkse and Kolk, 2012; Rizopoulos and Sergakis, 2010) or 'political embeddedness' (e.g. Sun *et al*., 2010) in order to describe the extent of governmental involvement and political support, which in general terms represents the non-market forces around the MNE context. Other sub-forms of embeddedness include the terms 'over-embeddedness' (Nell *et al*., 2011), 'service embeddedness' (Jack *et al*., 2008), 'strategic', 'capability' and 'operational embeddedness' (Garcia-Pont *et al*., 2011), 'systemic knowledge embeddedness (Hong and Nguyen, 2009). Also, other studies use terms relevant to local or external embeddedness, such as "regional embeddedness" (Kramer *et al*., 2011).

3.6.2. Discussions of the determinants of (technological) embeddedness

One of the most dominant sub-forms of subsidiary embeddedness is the technical (e.g. Andersson, 2003; Andersson and Forsgren, 2003; Hong and Nguyen, 2009) or technological embeddedness (e.g. Jindra *et al*., 2009). According to Andersson *et al*. (2002, p. 982) the notion of technical embeddedness refers to 'interdependencies

between firms in terms of their product and production development processes' and reflects that 'a high degree of technical embeddedness means that the two organizations are highly interdependent in terms of their technological activities'. Jindra *et al*. (2009) have defined and measured technological embeddedness as the importance of either internal or external sources of the subsidiary in terms of patents, licenses and R&D. This form of embeddedness is particularly important since it captures the idea of technology-related relationship/interaction between the central part of the production of innovation (i.e. R&D subsidiary) and all the other possible actors that can be perceived as the knowledge source or moderating parts of this relationship.

As can be seen in Table 3.2 the studies that have elaborated on the idea of technical or technological embeddedness are very few. While there are some studies that incorporate the notion of dual (i.e. internal and external) technological embeddedness (e.g. Jindra *et al*, 2009) or home embeddedness (e.g. Criscuolo, 2009), the vast majority of the examined studies (7 out of 8) do not examine the determinants of embeddedness, but they use embeddedness as an explanatory factor for other important aspects (such as mandate, performance, reverse technology transfer, MNE competence development). There is only one study that investigates the impact of subsidiary relational embeddedness on subsidiary technical embeddedness where a positive relationship is observed (Andersson *et al*., 2002).

Subsidiary (technological) embeddedness is widely perceived as a significantly positive determinant of subsidiary's market performance (Andersson *et al*., 2001) and MNE's competence development (Andersson *et al*., 2002). This fact has made us consider that we should better understand what makes subsidiaries rely more on one form of embeddedness compared to another. The particular choice of an R&D subsidiary to develop stronger or weaker ties with one or more available forms of embeddedness (i.e. internal, external host and external home) is possibly determined by various factors. The literature, although it has highlighted the beneficial impact of embeddedness on performance of both the subsidiary and the MNE, still lacks empirical documentation regarding this sort of relationship (i.e. the determinants of

subsidiary's - triple/multiple - embeddedness). Furthermore, although there is an clear distinction in technological embeddedness between internal and external in the study by Jindra *et al*. (2009), we are still unable to foresee and explain this duality in terms of the subsidiary's local embeddedness (i.e. the choice between home and host). Since subsidiaries use the HQs' technological advantage in order to access the home market's sources of technological knowledge, such a distinction between external home, external host and internal embeddedness may well explain the antecedents of the R&D subsidiary's choice of a particular knowledge source over another.

Table 3.2. Literature review on studies researching on various forms of subsidiary technical/technological embeddedness

A/A	Study	Sample	Host country	Home country	Form of embeddedness	Dep.	Ind.	Researching effect on / from		
1	Andersson (2003)	97 subsidiaries	Sweden	Mainly Europe	**External technical (host)**		x	MNE capability development		Role of subsidiary
2	Andersson & Forsgren (2000)	98 subsidiaries	Sweden	Mainly Europe	**External technical (host)**		x	Subsidiary importance		Subsidiary influence
3	Andersson, Forsgren & Pedersen (2001)	98 subsidiaries	Sweden	Mainly Europe	**Technology embeddedness**		x	Market performance		Organisational performance
4	Andersson, Forsgren & Holm (2001)	97 subsidiaries	Sweden	Mainly Europe	**External technical embeddedness**		x	Market performance		MNE competence development
5	Andersson, Forsgren & Holm (2002)	97 subsidiaries	Sweden	Mainly Europe	Relational business embeddedness & **Relational technical embeddedness**	x	x	Relational technical embeddedness	Market performance	MNE Competence development
6	Criscuolo (2009)	4751 citations	USA	Europe	**External (home) country embeddedness**		x	Reverse technology transfer		
7	Hong & Nguyen (2009)	4 subsidiaries	China	Japan	**Technical, systemic and strategic knowledge embeddedness**		x	Knowledge transfer mechanisms		
8	Jindra *et al*. (2009)	458 subsidiaries	5 Eastern European countries		**Internal & external technological embeddedness**		x	Extent and intensity of vertical linkages with domestic firms.		

3.6.3. Discussions of the determinants of (technological) embeddedness upon subsidiary innovative performance (and beyond)

Innovative performance has been increasingly viewed as one of the most critical aspects of the MNE. Interestingly, during the last three decades, there has been a growing number of studies dedicated to the IB field showing a particular interest in exploring and explaining the factors which shape the level of innovative performance and/or knowledge generation of MNEs' foreign R&D subsidiaries (Almeida and Phene, 2004; Belderbos, 2001; Ghoshal and Bartlett, 1988; Lahiri, 2010; Mudambi and Navarra, 2004; Mudambi, Mudambi, and Navarra, 2007; Phene and Almeida, 2008). It is known that the MNE's decision to base its R&D operations in geographically dispersed locations may differ from time to time, while according to Kuemmerle (1997), this strategic decision is largely related to the type/role of R&D subsidiary that will operate in the host location of interest. The MNE-related theory indicates that in case an MNE decides to locate in a foreign (host) location and consequently establish an R&D subsidiary, it is required that a precise internationalisation strategy should be followed, under which the main responsibilities and research orientation of the R&D subsidiary, as well as the context of its organizational structure (i.e. level of (de)centralization and network liaison with other units/actors) will be defined. At the subsidiary level several endogenous and exogenous actors interact in order to disseminate knowledge and create new forms of innovation, which in turn will be transformed into a sort of competitive advantage for the subsidiary, as well as for the whole MNE. Accordingly, there are two important characteristics which are vital for the enhancement of the subsidiary's innovative performance. First, the competence creating feature that is assumed to lead the subsidiary to improve its innovative capacity (Cantwell and Mudambi, 2005), and second the ability to source knowledge and resources from different environments at the same time (i.e. achieving combinative capability), leading to the 'multiple embeddedness' phenomenon (Meyer *et al*., 2011).

Table 3.3. Literature review on studies researching on impact of subsidiary embeddedness on innovative performance/knowledge generation.

A/A	Study	Sample	Host country	Home country	Form of embeddedness	Dep.	Ind.	Researching effect on / from			
1	Andersson, Bjorkman & Forsgren (2005)	158 subsidiaries	Finland & China	Western-owned	Local embeddedness	x	x	Use of expatriates	Emphasis on knowledge development	Yearly profit	**Knowledge creation**
2	Egelhoff (2010)	Conceptual paper			Embeddedness of subsidiaries within local environments		x	**Level of new innovations generated at the subsidiary level**			
3	Figueiredo (2011)	7 subsidiaries	Brazil		Dual embeddedness (i.e. intra-corporate and local embeddedness)		x	**Innovative performance**			
4	Hakanson & Nobel (2001)	110 R&D subsidiaries	International	Sweden	External (host) embeddedness	x	x	Cultural distance	Subsidiary technological capacity	Age - time	**Innovativeness**
5	Lam (2003)	4 subsidiaries	UK	USA & Japan	External (host) embeddedness		x	**Organizational learning and innovation within MNEs**			
6	Marin & Bell (2010)	333 subsidiaries	Argentina		Corporate integration (internal embeddedness) and local integration (external embeddedness)		x	**High levels of local innovative activity**			

Table continued on next page

A/A	Study	Sample	Host country	Home country	Form of embeddedness	Dep.	Ind.	Researching effect on / from		
7	Moran (2005)	120 subsidiaries	International		Structural and relational embeddedness (direct ties, indirect ties, closeness & relational trust)		x	Managerial sales	**Innovative performance**	
8	Mu *et al*. (2007)	234 subsidiaries	USA	International	External (host) embeddedness		x	**Localised innovation by the subsidiary**		Knowledge outflow from the subsidiary
9	Santangelo (2012)	20 subsidiaries	Italy	Triads	External embeddedness (relational ties with domestic actors)		x	Rival vs. non-rival subsidiaries	**Knowledge production**	Competence-creating vs. non-competence-creating motivation

The literature review (see Table 3.3) of studies amalgamating the notions of embeddedness and innovative performance revealed that there are several research works which have elaborated on the effect of embeddedness on innovative performance and relative aspects (such as knowledge creation, innovativeness, knowledge production). Although the forms of embeddedness which are reported to have an impact on performance are not taken from a purely technology – related point of view, the results confirm the positive relationship between external (host) embeddedness and innovative performance (e.g. Mu *et al*., 2007; Santangelo, 2012), while similar results are reported regarding the impact of internal embeddedness on innovative performance (e.g. Marin and Bell, 2010). Finally, a particular study (Figueiredo, 2011) has confirmed the positive impact of simultaneous (dual) embeddedness (internal and external) on innovative performance. While it is obvious that several studies have incorporated the notion of embeddedness or dual embeddedness and tested their impact on the subsidiary's innovative output there are still some hidden aspects that have not been framed in these particular research works. This lack of evidence is mainly due to the fact that very few studies examining this relationship have at the same time considered contextual and HQ – specific factors. As a result such a neglected approach may lead to an over attribution of embeddedness or other location factors while ignoring the crucial role of both parent (HQ) and subsidiary management and their particular roles.

Table 3.4 presents the remaining studies drawn from the literature review. These have examined the impact of embeddedness on other forms of performance (mainly market performance). What can be observed is a tendency to examine the effect of external technical embeddedness on a subsidiary's market performance (this corresponds to three research studies developed by Andersson *et al*. the results of which are drawn from the same dataset). Furthermore, there are two recent studies which refer to the notion of dual embeddedness (Gammelgaard *et al*., 2012; Hallin *et al*., 2011) and examine its impact on subsidiary performance. Along with the previous analysis of the determinants of innovative performance these studies face the same issue of neglecting or inadequately examining relative contextual and HQ – specific factors.

Table 3.4. Literature review on studies researching on impact of subsidiary embeddedness on other forms of performance

A/A	Study	Sample	Host country	Home country	Form of embeddedness	Dep.	Ind.	Researching effect on / from		
1	Andersson, Forsgren & Pedersen (2001)	98 subsidiaries	Sweden	Mainly Europe	Technology embeddedness		x	**Market performance**		**Organisational performance**
2	Andersson, Forsgren & Holm (2001)	97 subsidiaries	Sweden	Mainly Europe	External technical embeddedness		x	**Market performance**		MNE competence development
3	Andersson, Forsgren & Holm (2002)	97 subsidiaries	Sweden	Mainly Europe	Relational business embeddedness & Relational technical embeddedness	x	x	Relational technical embeddedness	**Market performance**	MNE Competence development
4	Echols & Tsai (2005)	80 venture capital firms	USA		Network embeddedness		x	**Firm performance**		
5	Gammelgaard *et al*. (2012)	350 subsidiaries	UK, Germany & Denmark		Increases in inter- and intra-organizational network relationships	x	x	**Subsidiary performance**	Intra- & inter-organizational network relationships	
6	Hallin *et al*. (2011)	376 subsidiaries	Sweden	International	External (host) embeddedness and internal (corporate) embeddedness		x	**Received innovation's contribution to subsidiary business performance**		
7	London & Hart (2004)	4 MNEs	Active in EMs		Social embeddedness (integration with the local environment)		x	**Success**		

3.7. Summarizing the main findings drawn from the analysis of the literature

Summing up, it can be concluded that the analysis of the literature revealed that there is a research gap in specific relationships and forms of embeddedness which currently exists. Subsidiary (technological) embeddedness and its related forms (i.e. internal, external home and host) are an under-researched topic in the existing literature, since very limited empirical work has been done in order to explain the factors shaping the preference towards the one form of embeddedness against the other. Furthermore, the examination of the impact of subsidiary embeddedness on innovative performance has been made while neglecting crucial parameters, such as contextual and HQ – specific factors. Beyond that, the information acquired from the data used in previous empirical studies has given a taste regarding what a representative sample is and how this could help the current study in terms of structuring the dataset. Additionally, by gathering information on the research methodology that each previous study has adopted has shown the way to identify possible gaps from a research methodology perspective that should be taken into account in the current study. The latter methodological aspects will be analysed in depth under the following sections.

4. A GENERAL FRAMEWORK FOR EVALUATING R&D SUBSIDIARY EMBEDDEDNESS AND ITS INFLUENCE ON INNOVATIVE PERFORMANCE

4.1. The conceptual model

As was mentioned in the previous chapter the existing research studies in the examined research topic predominantly focus on the knowledge linkages and relationships of subsidiaries in the host location of their operation. Despite this single-dimensional view of embeddedness the literature has acknowledged the existence of other sources of knowledge which are of equal importance for the MNE's knowledge network. Accordingly the existence of empirical studies that have elaborated on the phenomenon of dual embeddedness highlights the importance of simultaneous relationships of the subsidiary with more than one type of knowledge network. For example, Almeida and Phene (2004) and Ambos (2005) argue that foreign-based subsidiaries are simultaneously embedded in two distinct knowledge networks; (i) the MNE internal network and (ii) the external network of the host country. Likewise, Criscuolo (2009) and Le Bas and Sierra (2002) propose a different distinction of possible knowledge networks and show that subsidiaries are simultaneously embedded in (i) the host external and (ii) the home (parent) external knowledge networks. As becomes apparent, both streams of research have developed in terms of dichotomies (external host vs. internal, external host vs. external home).

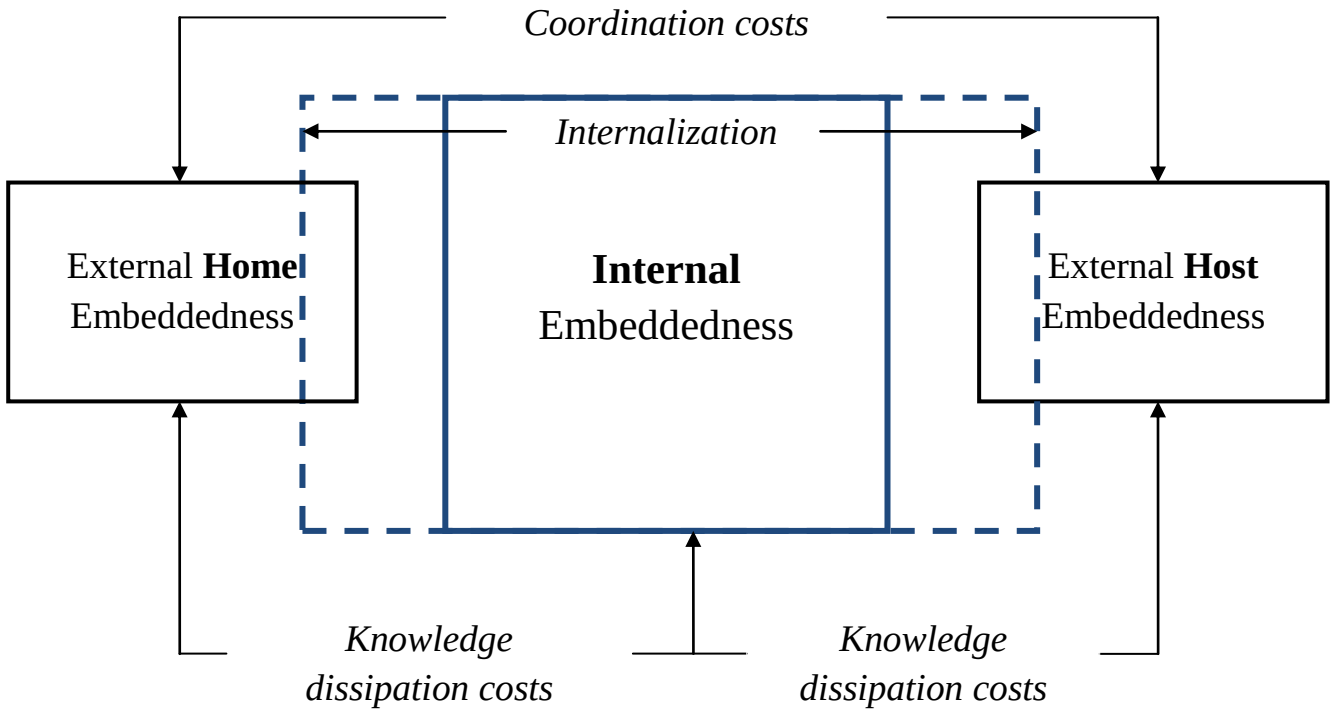
Although these dichotomies provide a more simplified view of the knowledge network and the relevant relationships surrounding the subsidiary, it should be stressed that these are neither clear nor representative of what a subsidiary encounters in terms of its day-to-day operations. As regards the internal vs. external host dichotomy the interaction of the subsidiary with other external sources of knowledge is not always assumed to be in the host location of the subsidiaries' operation, but also this can take place in the home location where the HQ has a mediating role. As regards the external home vs. external host distinction it is very usual that the focus is moved to the HQ and it is assumed that the host country's links of the parent is nevertheless part of the parent's external links thus disregarding

the internal link which makes these relationships possible. These issues arising from the particular dichotomization of knowledge networks show that there is still something missing from this particular classification.

Following the extensive review of the literature and based on the aforementioned arguments I propose that (from the point of view of a foreign-based R&D subsidiary) the knowledge for the capability development of a subsidiary can be potentially and simultaneously sourced from three different knowledge networks. These are the host country sources of technology and knowledge, the home country sources of technology and knowledge (under which the HQ's influence and control are critical in terms of how and in what density such a relationship will exist), and the MNE internal network (HQ and affiliate units). As is expected, the establishment and maintenance of relationships (ties) with each of these three networks is not always without cost. Accordingly, it can be assumed that there are both benefits and costs that arise from each type of subsidiary embeddedness. This type of cost is apparent when subsidiaries are simultaneously sourcing knowledge from two external sources.

Figure 4.1 portrays the three possible knowledge networks and the relative costs the subsidiary suffers on each occasion. The MNE traditionally seeks to internalize knowledge from external sources in order to augment its competitiveness which mainly arises from innovative activities. What is also portrayed in this schema is that the MNE maintains links either with the host external or the home external environment. Accordingly, these links are expected to suffer from knowledge dissipation costs. These costs are related to possible information leakage and knowledge spillovers to third parties and competitors. On the other hand, if the subsidiary chooses to maintain or even expand (i.e. internalise) its operations and information sharing it is likely that it will suffer from significant coordination costs. These costs will be the result of HQ's endeavour to organize reciprocal activities and technology transfer from HQ to subsidiary, as well as to avoid duplicative R&D activity.

Figure 4.1. Coordination and knowledge dissipation costs between the examined forms of subsidiary embeddedness.



Using this framework this study aims to expand the existing specification of possible knowledge sources (i.e. subsidiary embeddedness) and relate them to the modern view of the foreign-based R&D subsidiary and its activities. The new framework and the classification into three distinct categories will help us realise the true costs hidden behind the choice of a specific type of embeddedness (knowledge network) over the other, as well as providing information on which factors are hidden behind this particular subsidiaries' choice. This information is of critical importance for both the MNE and the subsidiary due to the strategic value of the R&D unit and its relationship to the firm's overall competitive advantage.

In this research study I develop a general framework under which the three types of R&D subsidiary embeddedness are interrelated and determined by common factors. First, and predominantly influenced by both AT and RDT, the first research question aims to examine which factors force subsidiaries to develop either stronger or weaker ties with the aforementioned networks, taking into account the subsidiary's simultaneous embeddedness in all three aforementioned networks. Figure 4.2 explicitly shows which MNE- and location-related factors are examined in order to identify how these are associated with the subsidiary's preference for one form of embeddedness against the other. Additionally, MNE and location-related control variables are added to the conceptual model in order to control for traditionally impactful characteristics on subsidiary embeddedness.

The second research question is mainly driven by the fact that the extant research has tended to overestimate the complementarity of different knowledge sources because it has not fully accounted for the costs involved in collaboration. Based on the argument that subsidiary managers and the HQ - as informed agents (based on AT) - aim to assess whether the benefits derived from accessing two knowledge sources at the same time will be outweighed by the costs of undertaking such collaborations. Accordingly I intend to examine whether a complementary relationship or a substitutive one holds between the combined sources of knowledge. The latter assumption's outcome will depend on whether there is a net benefit or cost arising

from the engagement with the two sources of knowledge at the same time. Figure 4.3 portrays the hypothesized relationship among the three examined types of embeddedness (External Home – External Host – Internal).

Third, the final part of this study aims to provide more explicit information on how subsidiary, HQ and contextual effects influence the overall innovative performance at the subsidiary level. Again, influenced by all the previously mentioned theories (AT, RDT, SNT), this model amalgamates data from multiple sources and multilevel concepts (see Figure 4.4) in order to identify how each of the aforementioned factors is related to a subsidiary's innovative performance. The contribution of this part is twofold. First, a conceptual approach examining the impact of all the three forms of embeddedness on innovative performance is adopted. Second, a more suitable methodological approach is employed according to the needs of the research question (see Chapter 5 for more information).

Figure 4.2. 1st research question: Determinants of different forms of embeddedness

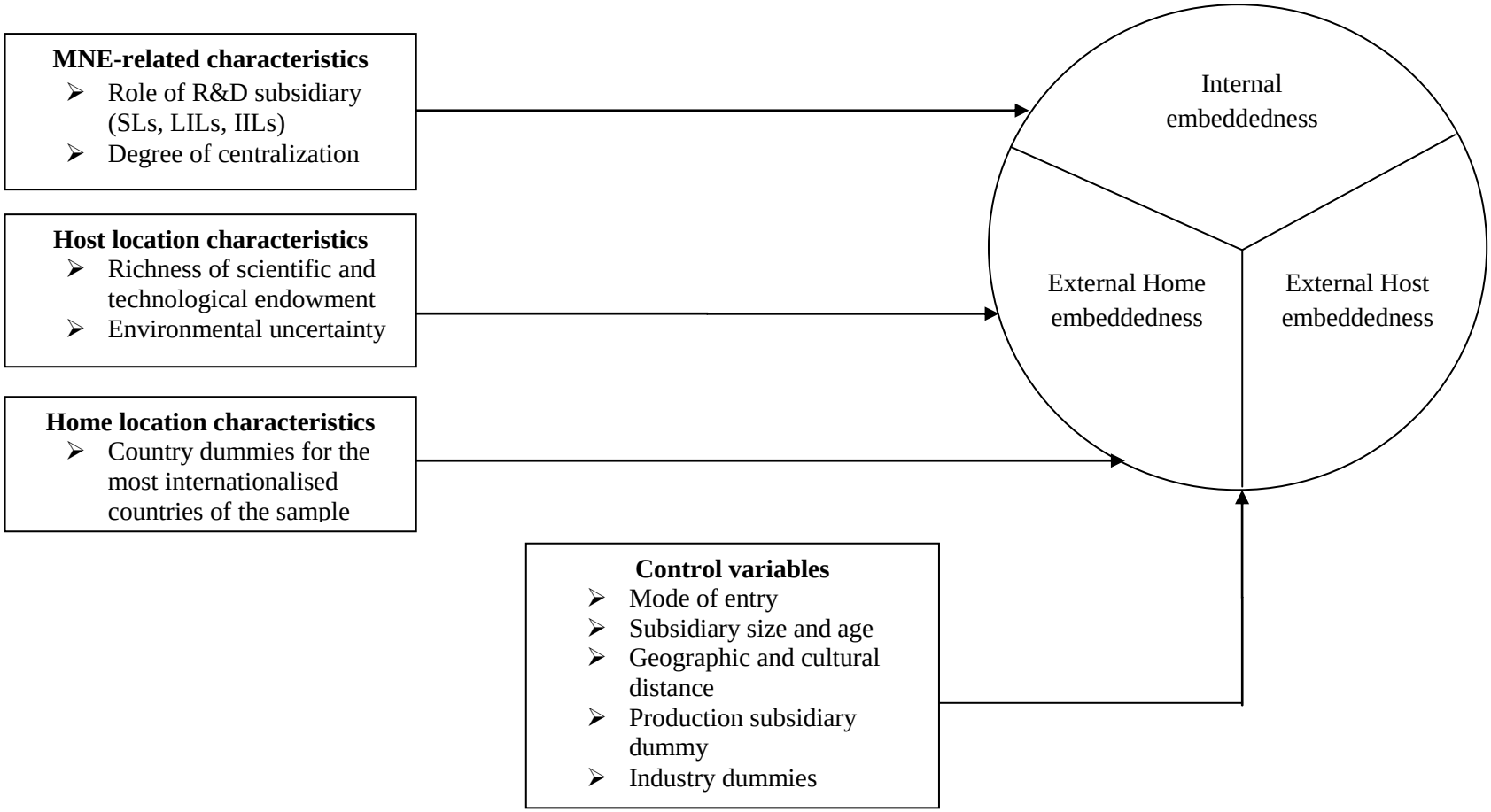


Figure 4.3. 2nd research question: Relationships among different forms of embeddedness

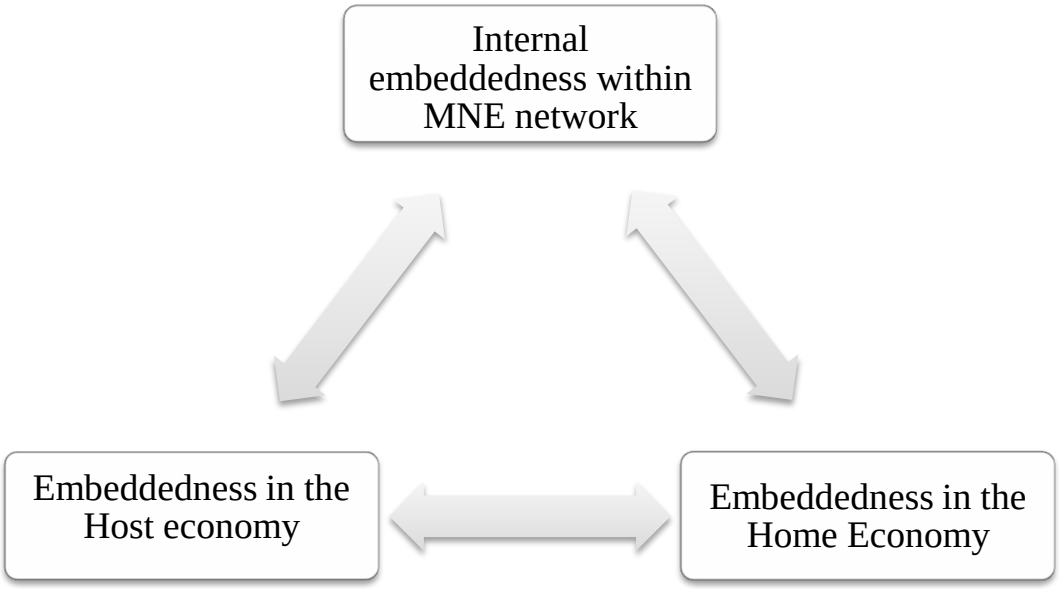
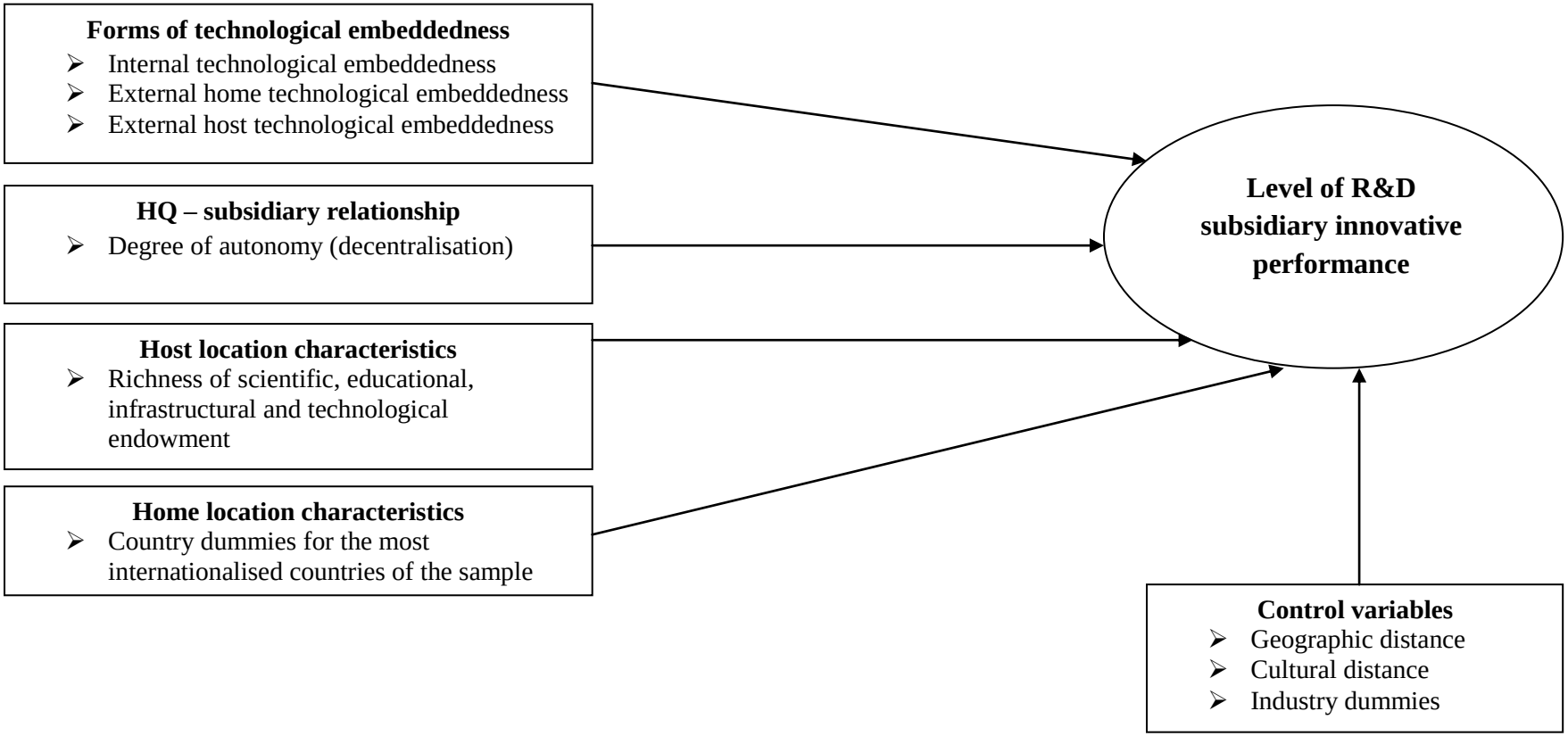


Figure 4.4. 3rd research question: The multiple determinants of R&D subsidiary innovative performance



4.2. Hypothesis development

4.2.1. Factors associated with different forms of embeddedness

4.2.1.1. The roles of R&D subsidiaries

One of the most well-examined and extensively discussed topics on internationalization of MNEs' R&D activities is the particular role and mandate that is assigned to foreign-based R&D units. Taking into consideration the core management theories that have been analysed in the previous two chapters, the strong consistency in the R&D typology, as well as the diversity of existing empirical studies which have used one of these established typologies, I aim to explain how the specific role of a R&D subsidiary can influence the degree of its embeddedness in multiple networks.

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 other studies show that external technical embeddedness is positively related to a subsidiary specific role within the MNE (Andersson, 2003; Andersson *et al*., 2001; Andersson and Forsgren, 2000), 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. Although the aforementioned empirical studies do not provide any sort of information regarding the impact of the specific type of R&D lab on the level of its embeddedness in the external network, there is a general view that the external (host) network orientation of the R&D subsidiary is associated with the role of R&D subsidiaries.

Even though there is no particular empirical evidence on the type of R&D lab's impact on each degree of examined form of embeddedness, there are empirical studies which have focused on examining the impact of R&D types on other relative aspects. Ambos and Schlegelmilch (2007) focused on the impact of the mandate of R&D units on the three distinct forms of management control. They found that both *International creators* and *International adaptors* are positively associated with

centralization, which means that compared to *Local adaptors*, these units are strongly tied to the internal MNE network. Similarly, Nobel and Birkinshaw (1998), using the same R&D typology and searching on communication and control patterns of different types of foreign-based R&D subsidiaries, showed that *Local adaptors* and *International adaptors* (equivalent to SLs and LILs respectively) are more likely to communicate with the internal corporate network, while *Global creators* (equivalent to IILs) are likely to have established strong communication channels with both external and internal networks. Recent empirical work from Manolopoulos *et al*. (2011a) researching on R&D subsidiaries based in Greece, identified a strong positive relationship between IILs and subsidiary scientists' cross-border visits, a result which indicates that R&D labs operating as *IILs* are more likely to seek knowledge in multiple locations. On another study based on the same dataset, Manolopoulos *et al*. (2011b) showed that R&D personnel employed in *SLs* were likely to undertake assignment for the MNE's parent laboratory, rather than for another independent R&D facility of the host location, while at the same time *IILs*' R&D personnel were more likely to be directed to carry out research work for another host country's independent research facility. Indeed, R&D employees in *IILs* act more independently compared to employees who belong to the other two types of R&D labs, and consequently they are not very closely embedded in the MNE network (Pearce and Papanastassiou, 1997).

While *IILs* seem to be equally embedded in the host country's external network, there is an argument which says 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 (Criscuolo, 2009). *IILs* are endorsed by the HQ and carry greater research responsibilities than the two other types of R&D unit. It is likely that the original research mandate of *IILs* will make it equally 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.

Summarizing the aforementioned literature review, it is suggested that R&D labs with a locally adaptive character (i.e. *SLs*) will tend to be more embedded within the

internal and home environment's external network, mainly because this type of unit is closely monitored by the HQ and is given very limited operational freedom. *SLs* adhere to the MNE's direction and concentrate on implementing the production development without focusing on the establishment of ties with the local external environment. On the contrary, 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 (equivalent to *International adaptors*). The aforementioned literature suggests that 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 MNE's stock of knowledge and products. The latter role is best accomplished by being embedded in the internal or within MNE networks (Manolopoulos *et al*., 2011a). Finally, R&D units with a more international and innovative theme (i.e. *IILs*) are expected to be well-embedded with all the three forms of subsidiary embeddedness. This type of R&D lab is closely embedded in the external network in order to establish strong relationships with both home and local scientific environment. On the other hand, it has been shown that there is also a need for the subsidiary to be sufficiently tied to the internal MNE network, mainly because of possible knowledge spillovers arising from volatile host environments and this is an aspect that the MNE is not willing to compromise on.

Further to the above facts and figures which relate to the analysis of the relative literature review, the key management theories (i.e. AT, RDT, and SNT) that I analysed in the previous parts of this Thesis, do equally drive the conjectures of my hypotheses. Specifically, the AT has shown that SLs are assumed to have restricted ability to generate original knowledge based on their own capabilities, since the HQ do not give extensive power to this type of subsidiary, either for decision-making authority, or for even simpler procedures that affect the day-to-day operations of the unit. Accordingly, restricted decision-making authority can diminish possible agency problems that arise, while at the same time push SLs subsidiaries to be more closely connected to the internal and the home country network, and less related to the host location. On the other hand, the other two types of subsidiaries (i.e. LILs and IILs) are given a greater level of decision-making authority, since their aim is to produce

original research and also contribute to the MNE's overall knowledge generation. These subsidiaries are routinely given greater flexibility, while after a certain point (where the subsidiary has a dominant role for the organisation's competitive advantage) their resources are such that signal that the subsidiary 'owns' its decision rights (Mudambi and Pedersen, 2007). In such a case, these subsidiaries (LILs and IILS) are in position to 'negotiate' their dependency more easily and effectively compared to their counterparts (SLs). As a result, these types of subsidiary (i.e. LILs and IILS) will be more closely connected to the host network of knowledge, compared to SLs, while they will also retain significant communication with the internal and (in some occasions) home network for either fundamental or ordinary reasons.

Accordingly, based on the aforementioned review, I propose the following hypotheses:

H1a: Foreign R&D subsidiaries acting as SLs are a positive predictor of both home country and internal embeddedness and a negative predictor of host country embeddedness.

H1b: Foreign R&D subsidiaries acting as LILs are a stronger predictor of both host country and internal embeddedness than home country embeddedness.

H1c: Foreign R&D subsidiaries acting as IILs are a positive predictor of all forms of embeddedness.

4.2.1.2. Centralization

Prior literature of 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 studying R&D subsidiaries. The literature suggests that each type of R&D subsidiary is managed through a different form of control (Nobel and Birkinshaw, 1998). From the already known modes of control I use that of *centralization*, since it

efficiently captures the level of decision-making power that holds a subsidiary's operating authority at the HQ level. Consequently, I draw my conjecture on the subsidiary's centralization characteristics in order to measure the impact of HQ decision-making power on the subsidiary's distinct levels of embeddedness.

The degree of centralization under 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 may 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 a substantial degree of autonomy to their foreign-based R&D subsidiaries. The tacit nature of knowledge in the innovation process, the threat of commercial uncertainties surrounding a weak - in terms of intellectual property protection - R&D unit, and the need for decision-making to be done promptly, are some of the reasons why MNEs prefer to control very tightly, and accordingly centralize the decision-making power of 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 its HQ. Likewise, Jindra *et al*. (2009) show that the more autonomous (less centralized) the R&D subsidiary is the more dense its vertical linkages will be. 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).

Focusing on the major management theories of this Thesis, it can be reasonably argued that a high degree of centralization does not favor establishment of ties with the external (host) network of knowledge. First, the AT shows that the HQ – subsidiary relationship leads to conflicting interest and the problem of risk sharing between the two units. HQ will normally require strict supervision in order to minimize possible risks associated with exposure of knowledge to third parties. In that case the autonomy of the subsidiary will be very restricted, and as such the interaction of the latter with external local resources will be constrained to a limited level. Second, the SNT assumes that economic relations between individuals and firms are vital in order for trust and adaptation to be gained. In case where autonomy

is limited, the interrelationships will also be restricted and although the length of a relationship may be strong, the depth will be weak, resulting in limited establishment of ties with the external host network, and presumably strong establishment with the internal and home network, where the level of autonomy is mandated by the HQ of the MNE.

Accordingly, based on the existing literature I propose my hypothesis as follows:

> *H2: Foreign R&D subsidiaries acting as more centralized (less autonomous) units are a positive predictor of both home country and internal embeddedness, and a negative predictor of host country embeddedness.*

4.2.1.3. 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 from the assumption that the transaction costs of undertaking dispersed technological activities stem from the tacitness 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. As a result, it is deduced that an abundance of scientific institutions in the host location is positively related to the incidence and the level of R&D produced by the subsidiary (Davis and Meyer, 2004). For the same reason, foreign-based R&D subsidiaries will also tend to establish stronger network ties with the external host environment (compared to the external home environment) in order to benefit from the location specific

advantages. At the same time, a possible scientific and technological abundance in the host location may be detrimental to the strength of ties of the R&D subsidiary with the MNE's internal network, since a possible substitutive effect may be generated, under which the R&D unit will be able to replace a large part of the internally generated stock of knowledge with an equivalent amount of it, which is more easily obtainable in the host location. This is also explained through the RDT argument, since subsidiaries surrounded by rich scientific endowments will have more easy access to knowledge that possibly complement or substitute the existing knowledge of the MNE. In that case, while the subsidiary establishes strong ties with various external actors, the MNE becomes resource-dependent on the subsidiary's own capabilities and knowledge that has emerged through possible collaboration with the external environment's various actors. Accordingly, when the available knowledge which exists in the host location is such that possibly exceeds the level of knowledge available in the internal network then subsidiaries are pushed towards establishment of stronger ties with the host rather than with the internal knowledge network.

Accordingly, based on the above literature review I propose my hypothesis as follows:

H3: Foreign R&D subsidiaries surrounded by rich host country characteristics are a stronger predictor of host country embeddedness than home country embeddedness and a negative predictor of internal embeddedness.

4.2.1.4. Environmental uncertainty

Two aspects of the macro environment may be important in determining where an R&D subsidiary will embed itself - this is (i) the Intellectual Property Rights (IPR) regime and (ii) the stability of the economic environment. The public nature of technological knowledge implies that knowledge spillovers, information leakage, macroeconomic instability and weak 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 apportioning 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 care over IPR suggests greater internal embeddedness through collaborative links with parent and sister affiliates but 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 intellectual property and thus tackle any knowledge spillover and R&D leakage problems. Accordingly, I 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 country and internal network of the MNE. The literature shows that economic uncertainty in host locations of investment acts as a detrimental factor to the total investment rate regarding the development of new foreign subsidiaries (Fisch, 2008; Fisch, 2011). Accordingly, I 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 (both parent location and MNE network).

Additionally, volatile macroeconomic and institutional environments are likely to generate conflicting interest between the two involved parties (i.e. subsidiary – HQ) and this is also pictured as one of the most significant agency problems in the HQ – subsidiary relationship (Chang and Taylor, 1999). This problem especially relates to the issue of risk sharing. Due to the valuable and innovative products that are generated in the R&D subsidiary, there is always the increasing risk of knowledge spillovers to third parties. These spillovers are likely to occur through possible employees' lay-offs, while a very important factor that makes this issue even more

alarming for the MNE is the weak IPR protection regimes in the host locations. In such a case, the MNE orders stronger centralization at the subsidiary level, in order to avoid any detrimental effects due to possible knowledge spillovers. Such a process automatically enables greater control from the HQ, hence more frequent communication and establishment of stronger ties with the internal network, and in many occasions with the home external network (since the latter is also better monitored from the HQ). On the other hand, due to the aforementioned reasons, the density of embeddedness with the host location is expected to be limited.

Consequently, based on the aforementioned analysis of the literature I propose my hypothesis as follows:

> *H4: Foreign R&D subsidiaries operating in volatile macroeconomic and institutional environments are a positive predictor of home country and internal embeddedness and a negative predictor of host country embeddedness.*

4.2.2. The relationship between the three forms of embeddedness

4.2.2.1. The relationship between the two forms of external embeddedness

As was 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 over the years (Cantwell, 1995), it is also known that MNEs which internationalize 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). Likewise, Criscuolo (2009) argues that substituting home with host location's NSI carries significant negative drawbacks for the whole MNE (e.g. knowledge spillovers to competitors in

the host location). More recently, D'Agostino and Santangelo (2012) showed 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. From an AT perspective, I expect that a substitutive relationship is not a very likely event to occur. This is attributed to the fact that the HQ will increasingly demand greater decision-making authority and control at the subsidiary level in order to avoid possible detrimental effects related to knowledge spillovers. As a result, the HQ will possibly adhere to giving only restricted autonomy to the subsidiary. Hence, it is likely that the subsidiary will complement rather than substitute various resources and processes that are available on both environments (home and host).

Thus, I 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, I hypothesize that:

> *H5: The external knowledge network of the home country and the external knowledge network of the host country in which foreign R&D subsidiaries are embedded will form a complementary relationship.*

4.2.2.2. The relationship between external (home and host) and internal embeddedness

The relationship between internal and external network embeddedness on the other hand appears to be a bit more ambiguous. Foreign-based R&D subsidiaries are less likely to hold inimitable knowledge assets that cannot be replaced by a similar amount and quality of knowledge from the rest MNE internal network, or even from the external environment. This argument holds even more for subsidiaries which have limited years of operation in the host economy, and consequently it is less likely that they have already developed a high level of independence from the federated network. Gammelgaard and Pedersen (2010) confirm the latter notion. Through conducting a survey on external and internal knowledge sourcing of subsidiaries they find a non-linear relationship between the two. More specifically,

the relationship between those two forms of knowledge 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. Furthermore, even if the R&D unit has developed the necessary technological competencies, these are not always enough to support its overall operation independently of any sort of interaction with the external environment, since other valuable complementary assets are required (such as sales and distribution channels, production facilities).

Although the relationship between external (home and host) and internal sources of knowledge is not clear to us yet, there is evidence to suggest that a complementary link among external and internal knowledge takes place. Studies conducted from a strategic alliance perspective (Kumar and Nti, 1998; Nielsen, 2005), as well as from a technology management point of view (Audretsch *et al.*, 1996; Cassiman and Veugelers, 2006; Foss and Pedersen, 2002; Papanastassiou, 1999; Veugelers, 1997) confirm the positive link between these two forms of knowledge sourcing. Likewise, evidence from domestic (non-internationalized) enterprises shows that internal and external resources form a complementary relationship that enhances the firm's absorptive capacity as regards external knowledge acquisition (Hervas-Oliver and Albors-Garrigos, 2009). From a different perspective, Lee *et al*. (2001) amalgamated two fundamental theories, the resource-based view (RBV) and social capital theory in their attempt to explain entrepreneurial wealth creation. The findings suggest that both form a complementary relationship, since the one (i.e. social capital) is valuable if and only if a firm is endowed with the other (i.e. internal capabilities). Taking into consideration that the firm's internal capabilities are closely related to internal knowledge sourcing, as well as that social capital is associated with the external knowledge acquisition, the latter findings provide useful information in my attempt to explain the relationship of the three forms of embeddedness.

My conjectures are based on the notion that external embeddedness of the foreign-based R&D subsidiary is divided to two distinct environments. These are the home and the host locations. Although there is no previous empirical indication of what relationship we should expect between the aforementioned forms of embeddedness, I conjecture that both forms of external embeddedness will be characterized by a

complementary relationship with the subsidiary's internal network. First, as concerns external host and internal embeddedness, I assume that R&D subsidiaries will not be able to entirely substitute the internal knowledge with an equivalent amount of knowledge that is available in the host economy, mainly because such a strategy is possibly associated with a high degree of exposure to third parties characterized by mutual interest. Even when the subsidiary is located in a well-protected - in terms of IPR protection regime – environment, knowledge spillovers are likely to occur, mainly because of the coexistence of highly competitive firms in the same cluster. This is also discussed in previous parts of this chapter, while this issue is also related to the RDT perspective and the aspect of risk sharing.

Furthermore, although knowledge may be highly internalized due to possible knowledge spillovers in weak IPR protection regimes (Kumar and Puranam, 2012; Zhao, 2006), the subsidiary will always need to make use of external channels and related facilities which are vital for its day to day operations. Second, regarding the relationship among home external and internal embeddedness, I speculate that such a relationship is more likely to evolve into a substitutive one. The literature so far has shown that foreign-based R&D subsidiaries are not very likely to become highly independent of their parent and affiliate units, unless they have developed technological competences which are inimitable and highly valuable to the rest of the MNE network (Mudambi and Pedersen, 2007). Along with that, the HQ is more likely to source knowledge from external actors who are located in the home country due to geographic proximity compared to the foreign-based subsidiary. Moreover, it is more possible that the HQ will detect inefficiencies of duplicate knowledge sourcing when this occurs in its area of operation rather than when the subsidiary sources knowledge from external actors who are based in the host country. Again, the RDT and AT perspective and more precisely the issue of risk sharing are applicable to the development of this conjecture. Since the HQ will not give a great level of autonomy at the subsidiary level, the decision-making authority will principally rely on the HQ. In that case, the HQ will be better able to control the subsidiary's relationships with both the internal and the home network since these two networks are (in a great degree) operated and established in the home location of the subsidiary. Accordingly, the resources from both networks are such that are well-controlled and overseen by the HQ. In such a case, a substitutive effect is more likely

to occur. Finally, considering that subsidiaries will always rely on the parent company (either for basic or less important needs) which is highly embedded in the home location's environment, and due to the coordination costs and inefficiency of sourcing knowledge from external home country actors when the HQ might already have developed the mechanisms to effortlessly source knowledge from external actors based in the home location, I conjecture that there will be a substitutive relationship between the internal and external home embeddedness of the subsidiary.

Accordingly, I formulate the following hypotheses:

H6: The external knowledge network of the host country and the internal knowledge network in which foreign R&D subsidiaries are embedded will form a complementary relationship.

H7: The external knowledge network of the home country and the internal knowledge network in which foreign R&D subsidiaries are embedded will form a substitutive relationship.

4.2.3. Examining the subsidiary's innovative performance in a multilevel context

4.2.3.1. First (Lower) Level Factors: Forms of Technological Embeddedness

4.2.3.1.1. Internal technological embeddedness

The extant literature has been very informative as regards the impact of inter-team and inter-unit collaboration on innovative performance and quality of generated knowledge. Subsidiaries, although operating in geographically dispersed environments where the knowledge transfer among the subsidiary and its HQ and affiliate units is impeded by the geographical distance (Ambos and Ambos, 2009) and relative transaction costs, are extensively embedded within its internal network. Indeed, the level of technological collaboration between geographically dispersed actors - within an organization - is perceived as a factor of fundamental importance for the overall functioning of a firm, while it has been empirically shown in the past that the centrality of an organizational unit's network position can act as a positive determinant of its innovation activity (Tsai, 2001).

From the intra-MNE collaboration and teamwork perspective, numerous research studies have produced findings which support the positive linkage between intra- and inter-unit collaboration and innovative performance and/or knowledge generation. As regards the innovative performance and quality of generated knowledge, the literature suggests that there is a positive influence of intra- and inter-unit activities of the subsidiary on its knowledge generation. Precisely, the amount of subsidiary's engagement in inter-unit resource exchange is positively related to the former's level of product innovation (Tsai and Ghoshal, 1998), while inter-team and inter-unit cooperation has been found to be a positive determinant of a subsidiary's knowledge generation (Mudambi *et al*., 2007) and knowledge specialization (Sumelius and Sarala, 2008) respectively. Furthermore, even when the MNE's R&D units are vastly geographically dispersed, it has been found that higher levels of intra-organizational linkages can have a more positive impact on a subsidiary's quality of generated knowledge (Lahiri, 2010). Even when the question is not related to the generated knowledge and innovative performance, but to the organizational performance of the subsidiary, the literature shows that knowledge inflows from a subsidiary's affiliate units have a positive influence on the subsidiary's overall business performance (Mahnke *et al*., 2005). From an AT perspective, I expect that since the HQ requires a tight control of the subsidiary's operations and decision-making authority, the majority of the innovations will be overseen and processed by the HQ of the MNE. Furthermore, I expect that the most significant innovations are indeed 'moderated' by the HQ and consequently are internalized, mainly in order to avoid any detrimental effects due to possible knowledge spillovers. Accordingly, I conjecture that R&D subsidiaries which are characterized by a high level of internal technological embeddedness - with their (federated) internal network (i.e. HQ and affiliate units) - will perform better in terms of innovation quantity and quality. Hence, I conjecture that:

> *Hypothesis 8: The higher the internal technological embeddedness of an R&D subsidiary, the greater the innovative performance at the subsidiary level.*

4.2.3.1.2. External technological embeddedness

The geographically dispersed business network, under which the foreign-based subsidiary operates, has led many scholars to an expansion of their research to the extra-MNE network (i.e. network of firms, universities, private and public research institutions, which are all related to the day-to-day operation of the geographically dispersed R&D subsidiary). This sort of relational interaction or collaboration with various actors of the host location is usually regarded as local (Andersson *et al*., 2005) or external embeddedness (Andersson *et al*., 2001a; Andersson *et al*., 2001b; Hallin and Holmstrom Lind, 2012; Sumelius and Sarala, 2008; Yamin and Otto, 2004), while other empirical studies have used the term 'knowledge linkages' (Almeida and Phene, 2004; Phene and Almeida, 2008). Although these two (i.e. local/external embeddedness and knowledge linkages) differ to some extent in terms of terminology and data operationalization, what is observed is the presence of common ground, which is the research on establishment of collaborative ties with the external network of the subsidiary.

As regards the impact of external embeddedness on a subsidiary's performance, the literature has been relatively informative in the past. The existing empirical work on relational embeddedness and ties indicates that a high degree of external technical embeddedness of a subsidiary has a direct and positive impact on its performance (Andersson *et al*., 2001a; Andersson *et al*., 2001b; Andersson *et al*., 2002). From the perspective of innovation and knowledge generation, there are two streams of research that have shed light on this relationship. From the 'knowledge linkages' point of view, there is evidence that subsidiaries which collaborate and establish knowledge linkages, either with host location's local firms (Almeida and Phene, 2004; Almeida and Phene, 2008) or with local universities (Asakawa *et al*., 2010) are found to perform better in terms of knowledge and research generation. Likewise, from the embeddedness perspective, the literature suggests that geographically dispersed R&D subsidiaries which are committed to a great level of external (or local) embeddedness with the surrounding (host location's) environment are more likely to perform better in terms of the subsidiary's knowledge generation (Andersson *et al*., 2005; Sumelius and Sarala, 2008), or even in terms of the MNEs' overall innovative performance (Yamin and Otto, 2004). Finally, based on the RDT point of view, I assume that subsidiaries characterized by innovative capabilities will

be more prone to entrench ties with the external environment, in order to further enhance their capabilities and performance. In such a case, the MNE becomes resource-dependent upon the subsidiary and is likely to allow greater flexibility and autonomy.

Accordingly, I conjecture that the degree of a subsidiary's external (home and host) technological embeddedness will have an immensely positive impact on the subsidiary's innovative performance.

> *Hypothesis 9a: The higher the external technological embeddedness of an R&D subsidiary at the host location, the greater the innovative performance at the subsidiary level.*

> *Hypothesis 9b: The higher the external technological embeddedness of an R&D subsidiary at the home location, the greater the innovative performance at the subsidiary level.*

4.2.3.2. Second (Higher) Level Factors

4.2.3.2.1. HQ's influential role: the impact of autonomy

The established IB theory shows that the MNE's R&D subsidiary operates neither as a single entity nor as an autonomous one. On the contrary, and considering the particular sensitivity that exists on aspects related to possible knowledge spillovers, the organizational structure of the subsidiary is predominantly determined by a hierarchical model, which is originally sourced from the parent company (HQ). More specifically, the level of autonomy of an R&D unit is to a great extent determined by the authorization provided by the HQ. The degree of decentralization that is given to the R&D subsidiary is related to the level of innovative performance of the latter. Subsidiaries enjoying a higher level of autonomy from their HQs are usually more prone to produce more competence-creating innovations than their counterparts surrounded by a strongly tied (de)centralization scheme. Previously, Bartlett and Ghoshal (1989) empirically confirmed the notion that subsidiaries' level of autonomy is related to enhancement of the MNEs' innovative performance. In the same manner, Persaud *et al*. (2002), researching R&D labs belonging to MNEs in

Triad nations, show that increased autonomy in terms of collaboration with external actors has a positive effect on the innovative proficiency of the R&D subsidiary.

Similarly, Boehe (2008), conducting a more recent empirical study on MNEs' subsidiaries based in Brazil, finds that more innovative units seem to enjoy greater autonomy than less innovative ones, while research from western MNEs' subsidiaries located in China and Finland suggest that the level of decision-making autonomy is related to the development of a subsidiary's specialized knowledge, in the sense that the more the autonomy that is given to the subsidiary, the greater the subsidiary's specialized knowledge that is generated (Sumelius and Sarala, 2008). Apparently, it can be shown that highly autonomous subsidiaries have the flexibility to establish ties with external actors, create synergies and interact with their peripheral environment (cluster) more regularly, a fact that enhances the creativity of the subsidiary and consequently the overall quality of generated knowledge. The main two theories that drive the main conjectures (i.e. AT and RDT) contradict each other. Precisely, while AT assumes that there is always a conflict of interest between HQ and subsidiary managers (the former seek for tight control and less autonomy, while the latter the opposite), the RDT shows that the more flexible and important the subsidiary becomes the more resource-dependant it evolves for the MNE.

Accordingly, given the fact that the degree of autonomy is dictated by the HQ to the subsidiary, as well as considering the possible resources that can act as positive influence for the subsidiary itself, I propose the following hypothesis.

> *Hypothesis 10: The higher the degree of decentralisation strategy that is mandated by the HQ to its foreign R&D subsidiaries, the greater the innovative performance at the subsidiary level.*

4.2.3.3. Host country characteristics

Apart from the HQ engagement in the R&D subsidiary's activities, another factor of critical importance is the host location's characteristics, and more precisely those characteristics which are related to the knowledge landscape of the host country. Traditional aspects deriving from the economic geography literature, such as the

degree of geographical and cultural proximity of the subsidiary to the HQ location, are valued as crucial determinants of innovative performance of the subsidiary. From the NSI perspective, even more influential for the subsidiary is the quality and effectiveness of the infrastructural and educational environment, including the level of the intellectual property rights (IPR) protection regime, the presence of a dynamic educational and scientific capacity, the existence of supportive mechanisms and infrastructure which can facilitate the wide operation of the subsidiary, and the richness of technological endowment which can add value and complement the existing knowledge of the R&D subsidiaries, especially when the latter operate as Home-Base Augmenting (HBA) units (Cantwell and Mudambi, 2005; Kuemmerle, 1997).

Although an increased level of internal and external embeddedness may lead to the broad improvement of subsidiaries' innovation, we should consider that apart from the innovator's landscape (i.e. the degree of technological embeddedness established either with internal and/or external actors), the subsidiary should be equally tapped into a secure, knowledge-intensive and resourceful framework, under which the establishment of ties with the surrounded network can be effectively managed. The MNE-related literature suggests that host locations characterized by munificence of rich scientific and technological endowments have a positive impact on the generation of new knowledge by the R&D subsidiaries (Almeida and Phene, 2004; Mudambi *et al*., 2007). Although the current study draws on the MNE's subsidiary literature and more precisely on the latter's association with knowledge generation and innovative performance, we should stress that the positive role of the domestic stock of knowledge and the existence of capable resources in science and technology and their impact on innovation generation is highlighted in a great number of studies on the technology-intensive FDI literature as well (Cantwell and Mudambi, 2000; Cantwell and Piscitello, 2002; Demirbag and Glaister, 2010; Lewin *et al*., 2009; Narula and Guimón, 2010; Sachwald, 2008). Consequently, I conjecture that the level of infrastructural, scientific and technological richness of the host location under which the subsidiary is tapped into will have a positive impact on the subsidiary's innovative performance, considering that the knowledge landscape of the surrounding environment (i.e. host location) is of equal importance for the sufficient supply of resources and knowledge to the R&D unit. Accordingly, and

taking into account the structure of subsidiary's network, I propose the following hypotheses.

Hypothesis 11: The higher the capacity of the host location's infrastructural and educational environment, the greater the innovative performance at the subsidiary level.

Hypothesis 12: The denser the scientific and technological richness of the host location's environment, the greater the innovative performance at the subsidiary level.

4.3. Summary

This chapter presented and analysed the conceptual models which were developed according to the needs and research scope of this study. Furthermore, an analysis of each theory that has influenced the development of these conceptual models has been made. Additionally, a number of hypotheses corresponding each time to a specific research question (or stage of research) were developed, after having evaluated the existing empirical literature. The next stage of this study aims to introduce the methodological concept that has been adopted in this research work, focusing on how each research method fits with each research question examined, as well as with the data that will be used. Extensive analysis of the multiple data sources that will be used in this study, as well as analysis of the construction of variables will be made.

5. IMPLICATIONS OF THE THEORETICAL FRAMEWORK FOR SETTING UP THE EMPIRICAL METHODOLOGY

5.1. Introduction

Having analysed and positioned the arguments and hypotheses related to the three research questions, the most effective research methodology will be identified. Accordingly, in this chapter I aim to analyze and discuss the research methodology designed for the examination of all the anticipated research questions. What follows is a general view and analysis of the already known research paradigms and the two scientifically acknowledged types of research argumentation. After that, I aim to explain what makes the adopted methodologies ideal for the assessment of the aforementioned research questions, as well as for the examination of the notion of 'multiple embeddedness'. Drawing on the particular type of each research question, as well as the theoretical background of it, I will draw the research context, research methodology and estimation techniques (econometric techniques) of this study.

5.2. Research approaches

Before I proceed to any sort of analysis of the data, research methodology, or estimation techniques it is of vital importance to highlight the research approach of this research study, as well as to make known the reasons why a specific research paradigm (philosophy) is employed. According to Collis and Hussey (2003) research paradigm is the exact philosophical structure that directs the implementation of a scientific research study. In order for the researcher to be able to design and implement the most appropriate research methodology - in terms of data gathering, analysis and interpretation of results – a competent level of knowledge as concerns the existing research paradigms should exist.

According to literature, two research paradigms (philosophical approaches) are widely known nowadays, the positivist paradigm and the interpretive (or phenomenological) paradigm (Saunders *et al*., 2011). The positivist paradigm traditionally takes a quantitative approach, since its main aim is to objectively answer the research question, which has initially been set by the researcher. On the

other hand, the phenomenological paradigm is a research approach which is contradictory to positivism, since its aim is to qualitatively and subjectively measure and interpret human behavior and particular attitudes. As there is a distinction in the selection and use of each research paradigm, an equal distinction is observed as regards the argumentation of the research hypotheses. This argumentation is based on two different methods of reasoning, the inductive and the deductive. Both are based on philosophical grounds and their assumptions have driven scientific evolution over time. Overton (1990) provides a simple but very illuminating definition for both types of argumentation. In deductive reasoning the inference process progress from the general to the specific, while in inductive reasoning the process follows the reverse direction, which is from the specific to general. In terms of a traditional research study which involves a research question, a theory and hypothesis testing, the deductive reasoning builds on the existing theoretical foundations in order to derive the appropriate hypothesis, which will later on be tested, and accordingly confirmed or rejected. On the other hand, in deductive reasoning, the researcher first observes a phenomenon, she afterwards looks for specific patterns, formulates the hypothesis and finally ends up by drawing conclusions, building, or even extending theories.

5.3. Research context of the current study

The context of this research is primarily driven by two different factors. First, after a comprehensive review of the existing empirical literature it was found that the current trend in research of the examined area (i.e. subsidiary embeddedness) employs a quantitative deductive approach. As can be derived from the previously analysed literature on subsidiary embeddedness, the vast majority of empirical studies (i.e. 50 out of 57 studies) have adopted a quantitative approach in order to test their hypotheses, indicating that a quantitative analysis is the most preferred method for examining such research questions. Second and most importantly, the adopted methodology should reflect the theoretical underpinnings and hypotheses that have been developed in the three previous chapters. The fact that the key aspects of this research study are the interrelation of three forms of embeddedness, as well as the multilevel contexts under which foreign-based R&D subsidiaries operate, gives the impression that a more advanced and appropriate estimation method should be

adopted. Accordingly, the aim of this chapter is twofold. First, the employment of the most effective research technique according to each type of research question. Second, the development of a research methodology that is consistent with the theoretical framework of this study.

5.4. Econometric design

5.4.1. The determinants of multiple embeddedness of R&D subsidiaries

As was repeatedly stated earlier on, subsidiaries are simultaneously embedded in multiple networks. Although this joint determination is perceived as fundamental in order to explain various unexplained aspects related to subsidiaries' network position and organizational structure, I should equally control for the possibility of simultaneous existence of linkages between the parent and the subsidiary. We know from the literature that both the parent and the subsidiary may share the same local actors. Such a relationship is known as 'embeddedness overlap' (Birkinshaw *et al*., 2001; Nell and Andersson, 2012; Nell *et al*., 2011).

Since this study did not take into consideration the possibility of embeddedness overlap when the survey took place (i.e. there was no question asking whether subsidiary and parent share the same local resources or not), possible employment of a simple Ordinary Least Squares (OLS) regression in order to observe the impact of each explanatory variable on each form of embeddedness may be criticized. The principal focus of my 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). Accordingly the estimation technique that will be employed should be such that it will take into account the aforementioned issue.

On this occasion, 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 the 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, I can write them in the form of a Seemingly Unrelated Regression Estimation (SURE), such as given by the system of equations below:

$$
\begin{aligned}
E_i^P &= \alpha + \beta_1 M_i + \beta_2 A_i + \beta_3 E_i + \beta_4 U_i + \beta_5 C_i + \varepsilon_i \\
E_i^H &= \gamma + \delta_1 M_i + \delta_2 A_i + \delta_3 E_i + \delta_4 U_i + \delta_5 C_i + \zeta_i \\
I_i &= \lambda + \mu_1 M_i + \mu_2 A_i + \mu_3 E_i + \mu_4 U_i + \mu_5 C_i + \eta_i
\end{aligned}
\qquad (5.1)
$$

Where, *M* is a vector with the roles of R&D subsidiaries (SLs, LILs and IILs), *A* denotes the centralisation of R&D subsidiaries, *E* denotes the host location's endowment richness, and *U* denotes the level of host location's environmental (macroeconomic and institutional) uncertainty. The vector *C* includes a number of control variables (Greenfield, LnYears, LnSize, LnGeographic distance, Cultural distance, CP, EC, PH, US, and UK), which are considered to have an impact on each of the three types of R&D subsidiary embeddedness.

SURE is defined as the most appropriate system for estimating the parameters of my model. This is mainly because 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 (Zellner, 1962, 1963) - which is not the case in this study, since there is the issue of 'embeddedness overlap' (Nell *et al*, 2011). To validate my choice of method I estimate each of the three equations above by OLS. Next, I estimate the residuals deriving from each independent equation and assess the correlation between them. As expected, the highly correlated coefficient values validate the use of the SURE methodology.

5.4.2. Exploring complementarity and substitutability between the different forms of embeddedness

According to Carree *et al*. (2011, p. 263), 'there are two econometric approaches used to test for complementarity: the "adoption" or "correlation" approach and the "production function" approach'. The first is applied by testing conditional correlations of the produced residuals based on (restricted form) regressions. This

sort of technique was first introduced by Arora and Gambardella (1990) who tested the strategies, which are related to external linkages of large firms in the biotechnology sector and accordingly showed that if any two strategies are complementary then the estimated correlations of their residuals are positively correlated. Despite the fact that this technique can be seen as a rather effective measure of complementarity between two strategies, the main issue behind its validity is that the correlated residuals may be a product of various measurement errors or omitted variables. The second approach (i.e. production function approach) refers to a combination of practices (strategies) which are estimated using cross-term interactions (among practices) and a production function in order to test how possible interactions may affect the performance of the aforementioned production function. Although such a technique has been successfully implemented for two practices (i.e. D'Agostino and Santangelo, 2012), the incorporation of more than two practices makes the estimation more sophisticated and problematic (Carree *et al*., 2011). Following the study by Cassiman and Veugelers (2006) who tested complementarity in the innovation strategy, this work also intends to test complementarity by adopting both research methods (i.e. correlation and production function approach).

5.4.2.1. Estimation Method 1 (Correlation approach)

First, I adopt the methodology originally developed by Arora and Gambardella (1990). I test my conjectures based on the notion that if the subsidiary's forms of embeddedness are complementary, then the covariance among any two of these three practices is positive. Consequently, in order to assess the relationships between the three different types of embeddedness I first estimate each of the three equations (one for each dependent variable, i.e. External Home, External Host and Internal) by Ordinary Least Squares (OLS). In each equation I use a set of subsidiary-, country- and industry-level variables that are expected to have an impact on each of the three types of embeddedness. The three independent equations are as follows:

$E_i^P = \gamma + \delta X_i + \zeta_i$ (5.2)

$E_i^H = \eta + \theta X_i + \kappa_i$ (5.3)

$I_i = \lambda + \mu X_i + \xi_i$ (5.4)

Where $\zeta \sim (0, \sigma_\zeta^2)$, $\kappa \sim (0, \sigma_\kappa^2)$, $\xi \sim (0, \sigma_\xi^2)$, E_i^P, E_i^H, and I_i are the three types of embeddedness and X is a vector of subsidiary-, country- and industry-level variables that are expected to have an impact on the three aforementioned types of embeddedness. The next step involves the estimation of the residuals which are derived from each independent equation, while the final step involves the assessment of the correlation between the residuals. The correlation of the residuals derived from each independent equation will determine whether the formed relationships among the three different types of embeddedness are complementary or not.

An important limitation of this method is that it can only test the complementarity of practices and not substitutability because the error terms can be contaminated by other unobservable effects. Accordingly, and since the one out of the three hypothesis assumes substitutability, I further need to employ the production function approach. A further drawback of this estimation method is that the three forms of embeddedness are simultaneously (jointly) determined (as it was also discussed before). Hence the correlation approach may produce biased estimates due to this issue and accordingly the estimated residuals may be of inefficient quality.

5.4.2.2. Estimation Method 2 (Production function approach)

This method is based on the common understanding of complementarity in production economics, which is that two inputs are complementary if more of one input increases the marginal productivity of the second input (Milgrom and Roberts, 1990). The technique was further developed by Athey and Stern (1998), and more recently by Belderbos *et al*. (2006) and Carree *et al*. (2011). In the case of this study where the output of subsidiary embeddedness corresponds to innovative performance (i.e. innovation output) produced within the R&D subsidiary, I assume that the subsidiary maximizes its innovative performance f (**x**), with respect to the vector of all possible combinations of three forms of embeddedness, **x** = (External Home,

External Host, Internal). Before proceeding to the estimation method I first have to transform the subsidiary embeddedness variables into dichotomous variables so as to conform to the assumptions of the production function models[1]. Then and in order to test the hypothesized complementarity / substitutability I first need to proceed to multiple inequality restrictions based on the supermodularity theory (Milgrom and Roberts 1990, 1995).

Milgrom and Roberts (1990) give the following definition for complementarity:

Assuming that we have an objective function *f (.)* of which the value is influenced by the practices x_i (i =1 . . . n) then:

Practices $x1$ *and* $x2$ *are considered complementary in the function f if and only if f* $(x_1+1, x_2+1, x_3, \ldots, x_n) + f(x_1, x_2, x_3, \ldots, x_n) \geq f(x_1+1, x_2, x_3, \ldots, x_n) + f(x_1, x_2 + 1, x_3, \ldots, x_n)$ *with the inequality holding strictly for at least one value of* $(x_1, \ldots, x_n)$.

Similarly, the definition for substitutability (or subadditivity) is equal to the aforementioned definition with the difference that the inequality is now reversed.

Considering the above definition, as well as the nature and aim of this study (which is to evaluate how the value of innovation is determined by three practices), the estimation function *f* can be expressed as follows:

$$f(x_1 + x_2 + x_3) = \sum_{r=0}^{1} \sum_{s=0}^{1} \sum_{t=0}^{1} \beta_{rst} K_{(x_1,\ x_2,\ x_3)=(r,s,t)} \qquad (5.5)$$

Where x_1, x_2 and x_3 are the three unique embeddedness practices (external home, external host and internal), coefficient β indicates the performance impact of adopting a cooperation practice among the three possible forms of embeddedness, while indicator function K indicates all exclusive combinations of subsidiary embeddedness practices.

[1] The complementarity / substitutability test requests the cross-derivative to be non-negative for all possible cross-term interactions of practices (Carree *et al.*, 2011). In our data, this was the case only when we used a dichotomous transformation (see Chapter 8 for more details about this transformation).

For simplicity reasons, the estimation function (5.5) can be rewritten in a form of possible combinations of all the three practices. Accordingly, this is expressed in the typical binary order as follows:

D = {(0, 0, 0), (0, 0, 1), (0, 1, 0), (1, 0, 0), (1, 1, 0), (1, 0, 1), (0, 1, 1), (1, 1, 1)} (5.6)

The upper set D consists of all the possible combinations corresponding to the examined three practices. Consequently, I define $x = (x_1 + x_2 + x_3)$ as a set of three forms of subsidiary embeddedness, where two forms of embeddedness x_1 and x_2 are complementary if the following two inequalities hold, with at least one of the inequalities holding strictly:

$$f(1,1,0) - f(1,0,0) - f(0,1,0) + f(0,0,0) \geq 0 \quad (5.7a\text{-}1)$$

$$f(1,1,1) - f(1,0,1) - f(0,1,1) + f(0,0,1) \geq 0 \quad (5.7a\text{-}2)$$

The definition of substitutability is exactly the same as the (5.7a-1) and (5.7a-2) with the difference that a 'larger' inequality sign is replaced by a 'smaller' one. Equally, by following the same procedure I expect that the same conditions of complementarity hold regarding practices x_1 and x_3 - (5.7b-1) and (5.7b-2) - and x_2 and x_3 - (5.7c-1) and (5.7c-2).

$$f(1,0,1) - f(1,0,0) - f(0,0,1) + f(0,0,0) \geq 0 \qquad (5.7b\text{-}1)$$

$$f(1,1,1) - f(0,1,1) - f(1,1,0) + f(0,1,0) \geq 0 \qquad (5.7b\text{-}2)$$

$$f(0,1,1) - f(0,1,0) - f(0,0,1) + f(0,0,0) \geq 0 \qquad (5.7c\text{-}1)$$

$$f(1,1,1) - f(1,0,1) - f(1,1,0) + f(1,0,0) \geq 0 \qquad (5.7c\text{-}2)$$

The aforementioned six constraints can be rewritten as follows:

$$\beta_{110} + \beta_{000} - \beta_{100} - \beta_{010} \geq 0 \qquad (5.8a\text{-}1)$$

$$\beta_{111} + \beta_{001} - \beta_{101} - \beta_{011} \geq 0 \qquad (5.8a\text{-}2)$$

$$\beta_{101} + \beta_{000} - \beta_{100} - \beta_{001} \geq 0 \qquad (5.8b\text{-}1)$$

$$\beta_{111} + \beta_{010} - \beta_{011} - \beta_{110} \geq 0 \qquad (5.8b\text{-}2)$$

$$\beta_{011} + \beta_{000} - \beta_{010} - \beta_{001} \geq 0 \qquad (5.8c\text{-}1)$$

$$\beta_{111} + \beta_{100} - \beta_{101} - \beta_{110} \geq 0 \qquad (5.8c\text{-}2)$$

Regarding the aforesaid constraints I follow Belderbos *et al*. (2006) and normalize *f* (0, 0, 0) or β_{000} to zero. This means that in the projected empirical model (i.e. the technology production function) I estimate a constant term (β_{000}) which equals zero and 7 dummy variables (β_{100}, β_{010}, β_{001}, β_{110}, β_{101}, β_{011}, β_{111}) for all the exclusive combinations of subsidiary embeddedness.

Accordingly, the complete technology production function of this study can be written as follows:

$$Ln(Patents_i + 1) = a + \sum_{r=0}^{1} \sum_{s=0}^{1} \sum_{t=0}^{1} \beta_{rst} I_{(x_1,\ x_2,\ x_3)=(r,s,t)} + \beta Z_i + \varepsilon_i \qquad (5.9)$$

Where $\varepsilon \sim (0, \sigma_\varepsilon^2)$, *Ln* (*Patents*$_i$ + 1) is the subsidiary's production of innovation measured as the total number of patent counts issued to the R&D subsidiary within a 5-year window by the year this survey was conducted, *Z* is a vector of subsidiary-, country- and industry-level variables that are expected to have an impact on subsidiary's innovative performance, and ε an error term.

In order to test whether a presence of complementarity or substitutability is observed for the exclusive combinations of subsidiary embeddedness practices it is vital to estimate three different versions of the aforementioned model using maximum-

likelihood estimation (MLE); an unconstrained model and two models with imposed inequality constraints (i.e. one with greater than or equal restrictions and another with less than or equal restrictions). The inequality restrictions correspond to the six conditions expressed above (5.8a-1 to 5.8c-2). In order to test for or against complementarity I proceed to a likelihood-ratio (LR) test between the unconstrained and the constrained versions.

Although the 'production function approach' is a well-respected estimation method it should be noted that there are several limitations characterizing it. The fact that there is need to estimate regressions based on inequality constraints gives an additional grade of difficulty in this method, since only a few econometric software programmes are able to execute such complex models. Furthermore, the LR test uses critical values characterized by a large inconclusive region under which I am not always able to reject or fail to reject the null hypothesis. For that reason Carree *et al*. (2011) developed a more simplified testing procedure involving simple linear regressions. This test uses the significance of the coefficients reported from the linear regression and a standard t-test in order to derive whether a condition of complementarity or substitutability holds. Unfortunately in my case this method is not an optimal choice for two main reasons. First, its fit is vastly related to practices characterized by noticeable impact on performance (Carree *et al*., 2011). Second, the sample size is not adequate in order to proceed to such a test (According to Carree *et al*. (2011) a representative size is more than 1000 observations).

5.4.3. Factors shaping R&D subsidiaries' innovative performance in a multiple embeddedness context

5.4.3.1. MLM in IB Studies

Hierarchical and multilevel models are predominantly used in the social and life sciences, while experimental studies also make substantial use of this particular statistical approach. Interestingly, the MLM has increasingly attracted the interest of social scientists, while management and international business scholars have started embracing this new research method more than ever before. Evidence shows that the

MLM is now considered to be the most effective research method for analyzing multiple phenomena and behaviours across different levels (Hox, 2002). This particular assumption is also depicted in the recent special issue of The Academy of Management Journal (edited by Hitt *et al*., 2007), and the guest editorial in the Journal of International Business Studies (Peterson *et al*., 2012).

In the case of this study, where the theme of international business meets that of innovation, it is observed that very limited research work on MLM has been implemented until the recent past. According to the recent review study by Erkan Ozkaya *et al*. (2012), which assesses the hierarchical linear modeling (HLM) in management and related area studies, it is observed that only 42 out of the 146 HLM studies (approximately 29%), which were published within the period 1997-2010, were IB-focused. The aforementioned authors highlight the fact that the great majority of these research studies (almost 86%) was published in the post-2004 period, which, despite the limited number of published works is an indication of how authors in the IB area perceive the importance of MLM techniques. Despite the rising interest and focus of management scholars on various MLM techniques, the up-to-date research on the IB and innovation area is still in a very embryonic phase.

5.4.3.2. MLM as Assessment Tool for MNE-Subsidiary Relationship

As it was previously mentioned, although there is an emerging interest in MLM from the IB scholars, the extant literature is still very limited. From the IB-innovation perspective, Lederman (2010) was among the first to assess his research questions by adopting an advanced multilevel technique. Precisely, he researched the multilevel determinants of product innovations by incumbent firms nested under three different levels (countries, firms, sectors). Even though the existing research output is very informative on MNE-subsidiary relationships and subsidiary environments, and despite the fact that MLM fits flawlessly with the multilevel formation of the related research questions, very limited (e.g. Arregle *et al*., 2009; Hillman and Wan, 2005; Spencer and Gomez, 2011) to nonexistent research work exists in this field of studies. Subsidiaries operate in a multilevel context so their nature and their performance is contingent upon various internal and external factors. The recent study by Peterson *et al*. (2012, p. 455) highlights the aforementioned notion by

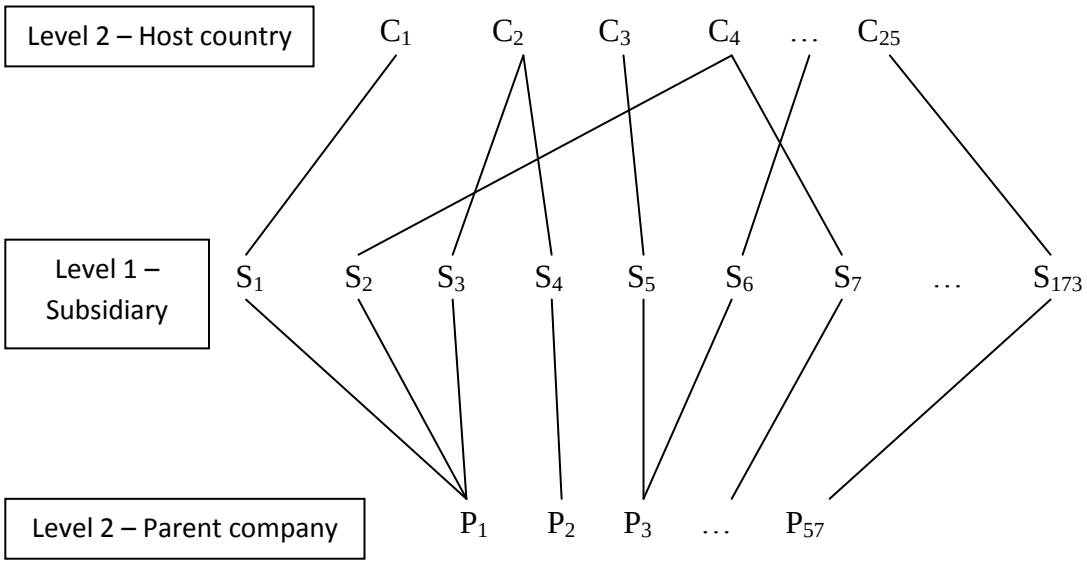
concluding that ‘MLM not only perfectly fits the multilevel structure of these research questions; it also allows a better and more elaborated modeling, opening up new theoretical perspectives for quantitative studies on this topic. Accordingly, MLM should be used to study how higher-level nation or MNE variables, and lower-level subsidiary or team variables, and their interactions, explain lower-level decisions and outcomes’.

5.4.3.3. The Context

The basic notion behind the MLM is its hierarchical structure. When referring to hierarchy, I mean that multiple units are clustered under different levels (Goldstein, 1995). The researcher is able to identify the impact of both fixed and random effects on the examined dependent variable. In other words, when an experiment or a research study is conducted, the main interest is to observe in what way the presence or absence of a specific factor affects the outcome of the examined dependent variable. On such occasions, I am only interested in the fixed (exact categories) factors that appear in the study or experiment. On the other hand, when an analysis in a particular sample is conducted, there is always the possibility that the examined factor is not fixed, and thus not entirely replicable. In such a case, different categories are presented in the study, which represent a random sample from a larger population.

From the existing MLM theory it is known that not all the multilevel data are entirely hierarchical (Hox, 2002). Although the existing data deals with three different levels (subsidiary, HQ and host country), in reality, this study’s model is in a non-hierarchical formation, since the assumption that the structures of population that the above data have been drawn from are hierarchical is violated (Rasbash and Browne, 2008). Figure 5.1 portrays the cross-classified nature of the examined relationship more clearly.

Figure 5.1. Conceptual diagram for cross-classified structure



The only way to tackle the non-hierarchy is to implement a cross-classified MLM, where MNE's R&D subsidiaries are reported at level 1, while parent companies (HQ) and host (foreign) countries are cross-classified at level 2. Accordingly, the level 1 (subsidiary level) empty (intercept-only) model can be written as:

$$Y_{i(jk)} = \beta_{0(jk)} + e_{i(jk)} \quad (5.10)$$

where $Y_{i(jk)}$ is the innovative performance of R&D subsidiary i within the cross-classification of parent company j and host country k, while $\beta_{0(jk)}$ is the intercept (overall mean) and $e_{i(jk)}$ a residual error term. Since the aforementioned model is cross-classified, the subscription (jk) denotes that the parent company and host country identifiers are both considered to be at the same level.

Since intercept $\beta_{0(jk)}$ varies independently across both parent company j and host country k, it can be rewritten using the second level equation. Hence:

$$\beta_{0(jk)} = \gamma_{00} + u_{0j} + v_{0k} \quad (5.11)$$

where γ_{00} is the average outcome of the level 1 dependent variable, u_{0j} is the residual error term for the parent company *j* and v_{0k} is the residual error term for the host country *k*.

Therefore, substituting equation (5.11) for equation (5.10), the intercept-only (empty) model is structured as follows:

$$Y_{i(jk)} = \gamma_{00} + u_{0j} + v_{0k} + e_{i(jk)} \quad (5.12)$$

where innovative performance $Y_{i(jk)}$ is modeled with an overall intercept γ_{00}, a residual error term u_{0j} for parent company *j* and a residual error term v_{0k} for host country *k*. Finally an individual residual error term $e_{i(jk)}$ for R&D subsidiary *i* cross-classified within parent company *j* and host country *k* is included.

5.4.3.4. Variance Partitioning Coefficient (VPC)

Through the implementation of an MLM, the researcher is also able to measure the variance components which are attributed to each of the examined classifications of interest. As already known, the MLM explanatory variables are nested under a certain level (cluster). Each level has a totally different attitude with regard to how it explains the examined dependent variable. For instance, in the field of education it has been observed that the effect of schools accounts for almost 5-20% of the differences in the income of individuals (Goldstein *et al*., 2002). Another example is drawn from the study by Mani *et al*. (2007), who investigate the ownership structure of foreign direct investment by Japanese firms and find that heterogeneity of both firms and nations accounts for almost 35% on the mode of entry and 16% on the level of equity. Likewise, a recent study by Ohlsson *et al*. (2012) shows that individual differences in self-employment are attributed to country of birth for 8-10% and labour market areas for 12-14%.

Furthermore, the VPC, which is also known as intra-class correlation (ICC), acts as a validation test on whether a MLM is the most efficient research method - compared to OLS or traditional regression methods - in order to assess the relevant research questions. Erkan Ozkaya *et al*. (2012) indicate that only the 29% of the existing

multilevel studies in IB has reported VPC as a justification for employing MLM. VPC is estimated as follows:

$$VPC = \frac{\sigma^2_{u0j} + \sigma^2_{v0k}}{\sigma^2_{u0j} + \sigma^2_{v0k} + \sigma^2_{\varepsilon i(jk)}} \qquad (5.13)$$

where VPC is the proportion of the sum of the individual residual variation and accounts for the outcome that it is attributed to both parent company (σ^2_{u0j}) and host country characteristics (σ^2_{v0k}).

5.4.3.5. Model Specification

The upper measure (i.e. VPC) shows why Ordinary Least Squares (OLS) is often unsuitable for estimating models using multilevel data, since the latter assumes that this correlation (i.e. VPC) is equal to zero (Fielding and Goldstein, 2006). Furthermore, by estimating multilevel data with standard regression methods (such as OLS regression), we are frequently led to an underestimation of standard errors (Snijders and Bosker, 1999). Considering the above facts, as well as the hierarchical nature of the model, it is decided that a multilevel cross-classified model is the most appropriate for the examination of such a triangular relationship between the aforementioned actors (i.e. HQ, host country and R&D subsidiary). For the estimation of the model, I make use of the STATA software version 12, which, apart from estimating hierarchical linear models, also incorporates an extra option for estimating a cross-classified MLM. By conducting such an analysis, I am able to observe firm-, parent company- and country-level effects on innovative performance, while I can also observe the level of VPC accounted for in the examined cross-classified model.

The count nature (i.e. variable with non-negative integer values) of the examined dependent variable signals that the most efficient econometric technique for estimating such a model is the Poisson regression (Wooldridge, 2002). Although Poisson regression is an efficient method for estimating count data, in many cases the presence of overdispersion is observed. In this case, the most efficient method for estimating such a model is the negative binomial regression (Hausman et al., 1984),

since it has the ability to relax this assumption by including an overdispersion parameter. In this study, the dependent variable's variance was much greater than its mean, hence it is derived that the negative binomial model is more efficient than the Poisson model. However, there is an additional method that enables us to relax the assumption of overdispersion and execute efficiently such a model. This method enables the adoption of a linear model after the execution of a logarithmic transformation of the dependent variable. As a result, I decided that I should proceed with the latter method (i.e. the logarithmic transformation of the count variable).

Accordingly, by adding the explanatory and control variables in the intercept-only model (3), the final model is structured as follows:

$$\mathrm{Ln}(1+Y_{i(jk)}) = \gamma_{00} + \gamma_{01}F_{i(jk)} + \gamma_{02}P_j + \gamma_{03}H_k + \gamma_{04}C^F_{i(jk)} + \gamma_{05}C^H_k + u_{0j} + v_{0k} + e_{i(jk)} \quad (5.14)$$

where $\mathrm{Ln}(1+Y_{i(jk)})$ is the dependent variable measuring the innovative performance of R&D subsidiaries, $F_{i(jk)}$ is a vector of firm level variables (including the three aforementioned forms of technological embeddedness), P_j is a vector of parent company variables, H_k is a vector of host country characteristics, while $C^F_{i(jk)}$ and C^H_k are two vectors of firm level and host country level control variables respectively. Additionally, an overall intercept γ_{00}, a residual error term u_{0j} for parent company *j*, a residual error term v_{0k} for host country *k* and an individual residual error term $e_{i(jk)}$ for R&D subsidiary *i* cross-classified within parent company *j* and host country *k* are included.

5.5. Summary

This chapter presented the methodological approach and relative econometric techniques adopted for this study. In general terms, this study uses a positivist (quantitative) and deductive approach in order to examine the previously mentioned research questions. For the three research questions examined under this study there is an equivalent number of research techniques that should be applied for each research question. For each question there is at least one key word that leads to the adoption of the most efficient research technique. Regarding the first research question, the words 'simultaneously determined' and /or 'jointly determined' are

vital for choosing the most appropriate technique. Second, the words 'complementarity' and 'substitutability' also lead to a specific methodology which is especially designed for simultaneously determined research strategies. Finally, the words 'multilevel' and 'hierarchical' also show the way for the employment of the fittest empirical model. Table 5.1 summarises the information regarding the research methodology employed and the literature under which the research design is based on. There is also relevant information regarding which hypotheses are tested under each research question and technique. The next section will present the data that will be used in order to estimate the aforementioned econometric models, as well as it will elaborate on the data samples, sources and traditional issues faced in quantitative surveys (such as non-response bias and common-method bias).

Table 5.1. Data, methods and hypotheses corresponding to each examined research question

Examined research question (RQ)		**Test of hypotheses**	**Econometric technique**
RQ1	The determinants of multiple embeddedness of R&D subsidiaries	H1 – H4	- Seemingly Unrelated regression equations (SURE) (Zellner, 1962)
RQ2	Exploring complementarity and substitutability between the different forms of embeddedness	H5 – H7	- Correlation approach (Arora & Gambardella, 1990) - Production function approach (Belderbos *et al*., 2006)
RQ3	Factors shaping R&D subsidiaries' innovative performance under multiple embeddedness context	H8 – H12	- Cross-classified Multilevel model (MLM) (Hox, 2002)

6. DATA

6.1. Introduction

One of the main aims of this study is also to incorporate diverse and rich data sources. As it has already been mentioned the research topic of this study relates to firm-level phenomena, such as relationships between HQ and subsidiary, subsidiary and external environment, and other management-related aspects mostly associated to the top-bottom hierarchy in the HQ – subsidiary relationship (i.e. centralization, R&D mandate, etc.). As we are also aware, this sort of data are very unlikely to be found in financial or other firm-related databases which host primary data of various companies. Accordingly, the best way to assess the validity of my arguments is to use a survey questionnaire which can be also be enriched with aggregate-level data.

Specifically, in this study I amalgamate data from three different sources. First, I utilise an existing survey questionnaire of leading MNEs which operate R&D subsidiaries in foreign locations. This survey has two parts (questionnaires). The first part corresponds to the parent company and accordingly is answered by the HQ of the MNE, while the second part (survey questionnaire) was distributed to MNEs' foreign-based R&D subsidiaries. Second, and considering the fact that a great deal of data were gathered using survey-based methods, this study utilises the United States Patent and Trademark Office (USPTO) database in order to complement the survey-based data with more objective and accurate measures. Accordingly, patent counts, along with other relevant information retrieved from each filed patent was collected and consequently enhanced the explanatory power of this study in estimating the innovative performance of each examined R&D subsidiary and the associated factors sourced from it. Finally, taking into account the fact that this study is based on cross-section data, I make use of a wide range of aggregate-level (secondary) data, all related to the hypotheses and relative 'controls'. In the next section, information regarding samples, data, and related aspects is provided and explained in detail.

6.2. The survey questionnaire(s)

The primary data of this study are drawn from the University of Reading survey of the Internationalisation of R&D conducted in 1989 (described in Casson and Singh, 1993; Pearce and Singh, 1992). The sampling frame of the survey consisted of the Fortune 500 list published in 1986. A separate set of questionnaires was developed and sent to parents (HQ) and their largest R&D subsidiary. The questionnaires were sent via mail to the existing population[2], where the unit's CEO or R&D manager was responsible for providing answers to the survey's questions. The questions asked in each questionnaire are very similar and change only slightly for each occasion (this can also be observed in the questionnaires which are reported in Appendix 3). Unfortunately, the response rate was not symmetric for both HQ and subsidiaries resulting in different numbers of total responses for each examined group. Furthermore, the fact that many companies provided responses only for their subsidiaries or HQ (and not for both) made possible generation of paired responses (i.e. responses of matched HQ and subsidiaries on the same examined question) an unfeasible goal. Additionally, there is a much greater utilization of the subsidiary questionnaire compared to the HQ questionnaire, mainly because of the fact that this study is subsidiary-focused rather than HQ-focused. This means that the information derived from the subsidiary questionnaire includes more relevant information for the assessment of these hypotheses compared to the equivalent amount of information derived from the HQ questionnaire.

6.2.1. The subsidiary questionnaire

Although the Fortune 500 list contains information on 500 MNEs, for the subsidiaries' sampling frame only 405 of the 500 units had established R&D facilities abroad during that period of time. Accordingly, the feasible sample was automatically reduced to almost 405 industrial companies. In total, 135 questionnaires were returned. Of these, two were considered as unusable[3] truncating

[2] 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.

[3] 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, I excluded these two observations from my final sample.

my final sample to 133 observations – a response rate of almost 32.8 per cent. I am convinced that the responses given by the R&D subsidiaries' respondents effectively mirror the actual relationship between the units and their counterparts, since the most qualified person of the R&D unit was chosen to answer to the questionnaire, while the anonymity of both the company and the respondent were well ensured.

Unlike the most known existing empirical studies which have targeted more than one foreign R&D unit of the same MNE (Kuemmerle, 1999a; Nobel and Birkinshaw, 1998), this survey targeted the MNE's largest international R&D unit[4] (Casson and Singh, 1993; Pearce and Singh, 1992) 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. Although someone may argue that this particular selection strategy may exclude a number of MNE's R&D units which add and explain a lot to the total variation of the MNE's internationalization strategy, it can be equally supported that this selection process ensures that the examined foreign subsidiary truly operates as an R&D-focused unit and not as an arm's length subsidiary, whose role may not be related to the MNE's R&D activities at all.

In order to better describe the global distribution of R&D units I incorporate a cross-tabulation (Table 6.1) which presents the host countries in which MNEs operate R&D subsidiaries against their country of origin. Table 6.1 shows that European MNEs tend to operate overseas R&D subsidiaries 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. Furthermore, 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 half of the global R&D activity, with Japan and the UK following. In my survey sample, R&D subsidiaries based in the US, the UK and Japan account for the 71.4 per cent of the total sample. Furthermore, the survey captures foreign-based R&D subsidiaries located in fourteen countries in total.

[4] The identification of the largest foreign R&D subsidiary was made after consulting a number of the leading directories of R&D facilities and evaluating its size according to financial and employment characteristics.

Table 6.1. Cross-tabulation table between parent and host locations

Headquarters locations	Overseas locations where R&D subsidiaries operate														
	AU	**AT**	**BE**	**CA**	**CH**	**ES**	**FR**	**GE**	**IT**	**JP**	**NL**	**SE**	**UK**	**US**	**Total**
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 6.2. Industry composition of the subsidiary data

Industry	**Percentage**
Chemicals & Petroleum	37.0
Electronics	19.3
Pharmaceuticals	18.5
Miscellaneous	25.2

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 internationalization 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, while these locations are very well covered in the reported data. Thus, although many of the newly introduced R&D locations, such as Israel, Ireland,

India and China, are not covered in this survey, I 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 6.2 reports that about 75 per cent of it consists of R&D subsidiaries in the pharmaceuticals, electronics, and chemicals and petroleum sectors – which are among the most internationalized sectors in R&D.

6.2.2. The HQ questionnaire

As was mentioned in the previous section, the survey procedure is identical for both questionnaires, but for apparent reasons the response was slightly higher for the HQ compared to the subsidiaries. Specifically, the questionnaire was sent to MNE parent laboratories and a total of 163 responses were received. This is a satisfying percentage, considering the international theme of the survey and the related difficulties in gathering responses from different countries in that period of time. Parent laboratories were defined as 'either a corporate-level R&D unit (physically located at HQ, or distinguished as the corporate unit) or, with a diversified enterprise, as the main R&D facility of a major division (Casson *et al*., 1992).

The main utilization of this questionnaire is related to the first section of the survey. This asked the respondent to provide information regarding the countries where the MNE has established R&D unit(s). Accordingly, the most important information derived from this questionnaire is the identification of all the host locations in which the examined MNEs operate R&D subsidiaries. To put it simply, one of the main purposes of the above questionnaire was to identify the exact geographic locations where the MNEs had established R&D subsidiaries. Considering the difficulty of identifying the exact nature of an R&D subsidiary's operation by researching into aggregate or financial level databases, internet sites, etc., this survey is efficiently utilized by providing such valuable information on the exact number of subsidiaries and their particular location, which is further supplemented with patent and location specific data. Unfortunately, from the total of 163 responses, only 57 could be used in the analysis[5] (Table 6.3. portrays the cross-tabulation between HQ locations –

[5] The reason for this significant sample truncation is that either some MNEs reported no foreign locations of operation, or the data which they entered were incomplete or inaccurate (e.g. some

R&D subsidiaries locations). Apart from the first section of the questionnaire, there are also other sections containing valuable information. Despite the existence of additional sections and although the HQ questionnaire is of vital importance for the examination of the third research question of this study, the information derived from it relies on the first section of the questionnaire.

Table 6.3. Cross-tabulation HQ locations - R&D subsidiaries locations

		Parent Companies' locations											
	Country	**AT**	**BE**	**CH**	**DE**	**FI**	**FR**	**IT**	**JP**	**NL**	**UK**	**USA**	**Total**
Host locations of R&D subsidiaries	**AG**				1								1
	AT				3	1	1				1	1	7
	AU								2		2		4
	BE				1	1	1			1	2	5	11
	BR							2	1		2		5
	CA										3	3	6
	CH				1	1					1	1	4
	DE	1				1		1	2	1	8	8	22
	DK		1										1
	ES								1	1		2	4
	FR		1		1	1		2	1	1	4	9	20
	IN										1		1
	IT				2		1			2	2	3	10
	JP				2						3	8	13
	MX										1		1
	NL		1			1			1		1	3	7
	NO						1						1
	PH								1				1
	SE				1	2				1			4
	SG								2				2
	TH								1				1
	TW								1				1
	UK		1		1	1		1	2	1		14	21
	USA			1	1			2	4	2	13		23
	ZA				1						1		2
	Total (H)												**173**
	Total (P)	1	1	1	4	2	1	2	6	2	17	20	**57**

respondents preferred to report that they operate R&D units worldwide rather than to specify the exact host location of their operation).

Regarding the industry composition of this HQ sample, Table 6.4 reports that approximately 85 per cent of it consists of companies operating in pharmaceuticals, electronics, chemicals and petroleum, and automobile and machinery sectors.

Table 6.4. Industry composition of the HQ data

Industry	Percentage
Chemicals & Petroleum	22.5
Electronics	24.2
Pharmaceuticals	18.4
Automobile and Machinery	19.6
Miscellaneous	15.3

6.2.3. The importance of the 'Reading survey': what makes it special until nowadays

The survey dataset used in this research study is dated in the late 1980s when the information and accordingly the literature on R&D internationalization were still in an embryonic phase. This is further confirmed by the fact that some of the most leading surveys in the same topic were conducted a decade after this survey was first introduced (e.g. Håkanson and Nobel, 1993; Kuemmerle, 1997; Nobel and Birkinshaw, 1998; Von Zedtwitz and Gassmann, 2002). Although someone may argue that the validity and application of the information derived from this questionnaire is outdated, mainly because many years have passed since then, there are several reasons to believe that this survey's importance is still as significant as it was when it was initially developed. First, this survey was one of the very first to investigate the phenomenon of internationalisation of MNEs' R&D subsidiaries. Second, it was detailed-oriented and covered a great number of MNE issues, while it was rich and precise enough to develop separate questionnaires for HQ and subsidiaries. Third, this survey's information and potential impact are still quite unexplored, since only one journal paper and one edited book have been published (using this particular survey data) since then. Fourth, the difficulty in conducting such a rich survey combining double questionnaires and a satisfactory response rate from Fortune 500 industrial companies is quite difficult, even nowadays, where information and communication technology (ICT) has augmented and developed more than ever before. Finally, 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 my conjectures.

6.3. Patent and patent citation (USPTO) data

Knowing the exact names of the MNEs' R&D subsidiaries and the locations in which they have been established, I can identify relevant and timely patent data in order to construct the dependent variable (innovative performance). The United States Patent & Trademark Office (USPTO) is one of the most renowned patent databases, and numerous academic and corporate studies have relied on this particular data source. Through its search engine I am able to identify time-relevant multidimensional data regarding patent activity and knowledge generation for the examined subsidiaries. I am particularly interested in identifying the number of patents registered by the examined sample's firms in the selected foreign locations in order to measure their innovative performance. Moreover, the USPTO database provides additional data regarding inventor-specific characteristics (company, location), which can be used in order to identify the source of the produced knowledge (patent), as well as co-inventor information which gives the opportunity to capture the degree of a subsidiary's technological embeddedness with internal (HQ and affiliate units) and external (firms and universities) actors.

6.4. Country (aggregate) level data

Apart from the survey questionnaire and the USPTO data, I also supplemented the subsidiary specific information with host location specific characteristics which are drawn from well-known secondary data sources. Thus, the two proximity-related variables (geographic and cultural respectively) were taken from the CEPII (Institute for Research on the International Economy) database and 'The Hofstede Centre'. Additionally, for the IPR protection regime scores I use the Ginarte-Park Index for the time period 1960-1990. Furthermore, since this study includes various NSI-related factors in its arguments (either as hypotheses or as controls), as well as other location-related data, relevant aggregate-level data were gathered from one of the most well-known web sources (World Bank Database, WDI).

6.5. Non-response bias and common method bias

In order to control for possible non-response bias and common method bias in the subsidiary questionnaire sample I proceed by several different methods. First, I compare the number of respondents (N = 133) to that of the original population of R&D subsidiaries' sample (N = 405) for all the examined geographical locations. Indeed, 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 the initial population (see Table 6.5 for details). Second, since some questionnaires were collected after respondents received a second notice (reminder), I test for a possible non-response bias that may negatively affect the explanatory power of the sample. From a total of 133 questionnaires, 99 responses were collected in first round and 34 after reminder. To investigate the non-response bias I 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 subsidiary questionnaires received before and after the reminder.

Table 6.5. 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

Source: Pearce and Singh (1992)

The same procedure is followed for the HQ questionnaire. Accordingly, by performing a t-test on HQ size and age data, no statistically significant difference ($p < 0.05$) between the aforementioned two samples is found, hence no such issue exists. Consequently, from the total of 57 usable questionnaires, it was determined that 57 parent companies own and operate 173 foreign R&D subsidiaries which are clustered in 25 host countries (the cross-tabulation between HQ (home) locations and subsidiaries' (host) locations can be reached in Table 6.3).

As was mentioned before, Patel and Pavitt (1991), through their renowned research study of large firms and the production of the world's technology, identify that the US accounts for almost half of the global activity, while Japan and the UK follow. These numbers are well depicted in this research work, since American, British and Japanese MNEs are indeed well represented in this study, accounting for approximately 75% of the total responses. Apart from the issue of the parent countries' representation, there is also that of the host countries in which the 173 R&D subsidiaries in the sample are based. The study by Rugman and Verbeke (2004) reports that, almost 80% of large MNEs' sales takes place in their home triad region (Japan, Western Europe and North America). This percentage is well represented in this study's sample, since almost 87% of the examined overseas R&D subsidiaries are based in the triad region.

Finally, in order to test if a common method bias had inflated the relationships between the subsidiary questionnaire's variables used in the analysis, I proceeded to the Harman's single-factor test on the items which were included in the model (Podsakoff and Organ, 1986). The factor analysis extracted four factors with eigenvalues greater than 1, while the first one explains 21.12% of the total variance (eigenvalue = 4.37). The results did not provide evidence for the presence of a single emerging factor, neither do they confirm that the factor that has been produced accounted for the majority of the variance (> 50%), leading to the assumption that the data are reliable and that common method bias is not of major concern.

6.6. Summary

This chapter provided information regarding the source of data used in this research study. Furthermore, a detailed report on other issues traditionally related to survey questionnaires was presented (i.e. non-response bias and common method bias). In the next three chapters I will proceed to the empirical analysis of my research work based on the methodology described in the previous chapter, as well as on the data presented in this one. A detailed analysis of all the constructed variables and their operationalization will be developed in the following three chapters as well.

7. THE DETERMINANTS OF MULTIPLE EMBEDDEDNESS OF R&D SUBSIDIARIES

7.1. Introduction

This chapter provides information regarding the exact measures constructed and incorporated in the model. This model has previously introduced in chapter 5 and aims to empirically answer the first research question (i.e. *what are the determinants of different forms of embeddedness*). Accordingly, in the following sections of this chapter I will provide a thorough analysis of the measures used for the estimation of the relative model, descriptive statistics and correlations of the coefficients, as well as the regression analysis' results, all based on the data and methodology introduced in the previous two chapters (i.e. Chapter 5 and 6). For the development of the below measures two different data sources have been used (i.e. subsidiary questionnaire and macroeconomic data from World Bank database), while a SURE methodology is adopted, since it is indicated as the most appropriate econometric technique for the estimation of this model.

7.2. Measures

7.2.1. 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 (e.g. Ambos, 2005) or in terms of the subsidiary's dependence upon particular relationships in its external environment (e.g. Andersson and Forsgren, 2000). One of the most important aspects that characterise a unit's embeddedness is the mutual adaptation among it and its related actors. Adaptation is what is aimed to be achieved through a strong and long-term relationship between two actors/units. In this study, and since the subsidiary units are characterized by mutual interest (i.e. subsidiaries focusing solely on technological and research activities), which are presumably based on long-term relationships (due to the technological and scientific nature of this relationship), I consider that the concept of mutual adaptation routinely exists between the actors associated with these units. Thus, actors of the units, as well as actors of the interconnected units are mutually

adapted to the technological activities of the unit, whose aim is to generate/alter/enhance new products and produce innovations. For that reason, in front of the word 'embeddedness', it would be more accurate to use the word 'technological' in order to better stress the perspective of mutual interest between the involved actors. However, for simplicity reasons, I will keep on referring to this notion as 'subsidiary embeddedness'.

The questions are formed in a way that the respondents are asked to provide information on how frequent the subsidiary's interaction with internal and external counterparts is. The 3-point likert-type structure of the questions allows the respondent to evaluate the level of interaction from weak (1) to strong (3). Accordingly, a range of questions are answered regarding the degree of relationships either with external or internal counterparts of the R&D subsidiary. Based on the survey instrument used I 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). I assume the higher the frequency of contact the more embedded is the subsidiary in external home networks. I 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 I assume the higher the

frequency of contact the more embedded is the subsidiary in external host networks. In constructing *External Host* I 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.

7.2.2. Explanatory variables

The type of R&D Lab: The survey questionnaire used one of the most well-known R&D subsidiary typologies/archetypes in order to ask the respondents under which type they classify the operations of their R&D unit. Hence, I am able to create a variable that could measure the type of R&D lab, according to the mandate given by the parent company. Precisely, following the R&D subsidiary classification introduced by Pearce (1989), each unit was asked to classify its activities into the following three 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).

Centralization: In order to measure the degree of R&D subsidiary's centralization, I first need to evaluate the degree of autonomy each subsidiary enjoys. The most effective way to assess the impact of this measure is to construct a variable which draws on the degree of centralization of decision-making power of the R&D subsidiary. I adhere to the general rule which dictates the use of the average score of a multi-item scale for this measure, as this is also the case in other relative studies (Birkinshaw and Hood, 2000; Nell and Andersson, 2012). Precisely, I use four 3-point likert-type questions in order to construct my centralization variable. The items included decisions regarding (i) shift of projects to parent or other strategic labs, (ii) the level of interaction with them, (iii) the general decentralization strategy of the parent towards its foreign affiliate unit, and (iv) the growth dependence of the R&D lab. The value of Cronbach's alpha for this multi-item construct is 0.51[6].

Local endowment: In order to measure the degree of influence of the host's scientific and technological endowments of a particular location, I 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

[6] Although the reliability score for this construct does not reach a high level of efficiency, Nunnally *et al*. (1967) suggested that a score ranging between 0.50 - 0.60 is considered as acceptable reliability. Considering that the survey questionnaire does not provide any other sort of question in order to construct an even more efficient variable for centralisation, it was decided to proceed with this measure.

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 aforementioned four questions, while the value of this construct's Cronbach's alpha is 0.72.

Macroeconomic uncertainty: I measure macroeconomic uncertainty as a combination of institutional and macroeconomic factors which lead to increased volatility in the host location under which the R&D subsidiary operates. First, I make use of the *IPR protection regime* and its relative distance between the home and the host location of R&D operation. This variable is constructed drawing on the Intellectual Property Rights Protection Index (for years 1960-1990), while the original scores of the IPR Protection Index (Park, 2008) range from 1 (weakest) to 5 (strongest). The greater the distance between the host and the home location, the more volatile the institutional environment is considered to be. Second, in order to measure the level of macroeconomic instability I aggregate the level of unemployment (as a percentage of the total labour force) and inflation, GDP deflator (annual percentage) in the host country. Other empirical 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. The Cronbach's alpha for this multi-item construct is 0.70, while the extracted factor accounts for 68.35% of total variance.

7.2.3. Control variables

I also use a number of control variables in the analysis based on variables found to be important in other studies. Accordingly, I include:

Greenfield: Theory suggests that acquired units are likely to be more embedded in the host country but less embedded in the internal corporate network. I control for this relationship and accordingly I develop a variable which is in dummy formation

and takes the value “1” if the subsidiary originated as a fresh installation (i.e. Greenfield investment) and value “0” if the subsidiary originated as a form of acquisition or joint venture.

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.

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).

Gassler and Nones (2008) show that location-specific factors, such as the geographic and cultural distance 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, I incorporate the following variables:

Geographic Distance: Following Monteiro *et al*. (2008), this variable is calculated by taking the natural logarithm of geographic distance between the unit'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 Distance: In order to assess the degree of cultural distance between the home and the host location of the subsidiary I proceed to the estimation of the well-known index initially developed by Kogut and Singh (1988), which was later adopted by various scholars researching in the same area (e.g. Benito and Gripsrud, 1992; Phene and Almeida, 2008; Shane, 1995). In particular, the index draws on Hofstede’s renowned indices and ‘is formed from the deviation among each other of the four cultural dimensions (i.e. power distance, uncertainty avoidance, masculinity/femininity, and individualism). The deviations were corrected for differences in the variances of each dimension and then arithmetically averaged’ (1988, p. 422). The index is as follows:

$$CD_{ju} = \sum_{i=1}^{4} \{(I_{ij} - I_{iu})^2 / V_i\}/4$$

Where I_{ij} stands for the index for the *i*th cultural dimension and *j*th host country, V_i is the variance of the index of the *i*th dimension, *u* indicates the home country, and CD_{ju} is the cultural difference of the *j*th host country from the *u*th home country.

Industry dummies: In order to control for possible industry effects on the degree of R&D subsidiaries' network embeddedness I 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: I also make use of two country dummies for two of the most internationalized countries (in terms of R&D activities) of my sample (US and UK).

Table 7.1 provides information regarding the exact type of question used in the survey questionnaire in order to construct the key dependent and explanatory variables of this study.

Table 7.2 summarizes the variables created, provides information about their source, as well as it presents basic descriptive statistics for each of the variables.

Table 7.1. Questions used for the construction of variables

Variables	Questions used from the questionnaire in order to construct multi-item variables
External Home	"Does any liaison exist between this R&D unit and the home country: a) research institutions; b) universities; and c) 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).
Extenal Host	"i) Does this R&D unit give contract jobs to the following institutions in this country: a) independent research labs; b) universities; ii) Does any exchange program of scientists exist between this unit and other local research institutions/labs? iii) Are seminars relating to ongoing research in this unit held in collaboration with other local research units/institutions? iv) Are research findings of this unit published in journals? v) 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).
Internal	"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 programs 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 all the above questions also have a categorical-likert formation, based on the frequency of interaction, and range from 1 (never) to 3 (regularly).
Centralization	"i) Are promising projects shifted to parent or other strategic labs of the group around the world? ii) Does this and other R&D units of the parent company interact?" The answers to both questions range from 1 (never) to 3 (regularly). "iii) If the unit has grown in size over time has this been a) mostly as a result of its own success b) because of its own success and parent's encouragement c) mostly at the encouragement of the parent. iv) How do you perceive the strategy of the parent towards its various R&D units? a) Allowing substantial autonomy b) Allowing them to develop independent initiatives, but under close central scrutiny c) Incorporating their work into a carefully coordinated programme".
Local Endowment	"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) favorable wage rates for the research professionals". The answers to the above questions have a categorical-likert formation, based on the frequency of interaction, and range from 1 (never) to 3 (regularly).

Table 7.2. Data sources and descriptive statistics

Variable	Number of items used	Cronbach's alpha (α)	Source	Type	Mean	SD	Min	Max
Dependent Variables								
External Network Home	3	0.65	Survey	Scale	2.13	0.49	1	3
Extenal Network Host	6	0.60	Survey	Scale	1.79	0.33	1.16	2.66
Internal Network	4	0.71	Survey	Scale	2.13	0.45	1	3
Explanatory Variables								
SLs			Survey	Categorical (1-3)	1.77	0.75	1	3
LILs			Survey		2.05	0.74	1	3
IILs			Survey		2.11	0.88	1	3
Centralization	4	0.51	Survey	Scale	2.34	0.33	1.5	3
Local Endowment	4	0.72	Survey	Scale	1.73	0.54	1	3
Macroeconomic instability	3	0.70	WDI & W.G. Park (2008)	Scale	0	1	-1.23	3.01
Control Variables								
LnGeographic Distance			CEPII Database	Scale	8.55	0.80	5.83	9.74
Cultural Distance			Own calculations	Scale	2.14	2.51	0.09	9.70
Greenfield			Survey	Dummy	0.68	0.46	0	1
LnYears			Survey	Scale	2.95	0.93	0.69	4.82
LnSize			Survey	Scale	4.14	1.36	1.38	7.54

7.3. Descriptive statistics

Descriptive statistics in Table 7.2 show that, on average, the extent of home country embeddedness (μ_{Home} = 2.13) is higher than host country embeddedness (External Network μ_{Host} = 1.79) in the sample of R&D subsidiaries, though a slightly smaller number of subsidiaries seem to report the opposite. Interestingly, external home and internal embeddedness ($\mu_{Internal}$ = 2.13) have similar magnitudes. In sum, it seems that R&D subsidiaries tend to establish stronger ties with the home network of the MNE, as well as with the internal federated network, rather than with the host location in which they operate.

Regarding the type of R&D activities (i.e. R&D mandate) the descriptive statistics are quite clear on what sort of research foreign-based R&D subsidiaries tend to carry on. Precisely, the dominant R&D mandate in the sample is IILs (μ_{IILs} = 2.11), while the second research mandate laboratory is LILs (μ_{LILs} = 2.05). Finally, the least important category of R&D laboratory turns out to be the SLs (μ_{SLs} = 1.77). This outcome (i.e. that IILs type of lab is more frequently met compared to SLs and LILs) is possibly related to this study's research strategy to focus its target sample on the largest R&D subsidiary of each examined MNE.

As regards the level of centralization, the descriptive statistics indicate that the sample of subsidiaries experience a great level of control by their HQ ($\mu_{Centralisation}$ = 2.34). This may simply reflect the state of affairs in the internationalization of R&D in the late eighties when it was widely accepted that the transnational model or MNE organization was less popular and many MNEs tended to be multi-domestic or global firms (Bartlett and Ghosal, 1989).

As concerns the level of local (host location) endowment's richness it can be rather supported that its importance is not of great magnitude for the examined MNEs' R&D subsidiaries. The low average value of this variable ($\mu_{Local_Endowment}$ = 1.73) indicates that the richness of the host location's scientific resources does not have a

particular impact on the MNE's decision to base its activities in a particular foreign location.

Finally, the control variables suggest that 68 per cent of the sample entered in the host location as a greenfield expansion (compared to joint venture / acquisition), while the average age of an R&D subsidiary was 26.2 years and the average R&D employment size was 154.3 people. The location characteristics are drawn from well-known secondary data sources but, because I cover only 14 countries and not sub-regional units, they exhibit limited variability.

7.4. Regression analysis

Considering that survey data are prone to multicollinearity between the variables and the constructed factors I need to check for possible inflated factors. 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 the model will turn out to be of inefficient explanatory power. The correlation matrix (Table 7.3) indicates that possible presence of multicollinearity is not an issue. In order to further assess whether multicollinearity is an issue or not, I estimated the variance inflation factors (VIFs) for each coefficient in each examined model. The VIFs scores (Table 7.3) in all the examined equations reported values no greater than the 'rule of thumb' of 10 (Hair *et al*., 1998). Thus, multicollinearity is not a problem for the model.

Table 7.4 reports the SURE model estimation. Firm, industry and country specific controls are incorporated in all equations. More specifically, geographic (expressed in natural logarithm) and cultural distance between the host and the parent countries, natural logarithms of R&D unit's size and age, industry and major country dummies, and a dummy variable indicating whether the unit's mode of entry is greenfield investment or acquisition / joint venture are incorporated in the model. Models 1, 3,

and 5 include only the control variables, while models 2, 4, and 6 are the full models, after having incorporated the explanatory variables as well.

Hypotheses 1a, 1b and 1c test the impact of specific R&D roles on the external network embeddedness of host and home country, as well as on the internal MNE network. The results partially confirm Hypotheses 1a and 1c. SLs is negatively associated with host country's external network (β[7] = -0.15, p < 1%), but there is no significant indication regarding its impact on the other two examined dependent variables (i.e. external home and internal) in order to strengthen my hypothesis. IILs is found to have a significantly positive impact on the internal network (β = 0.25, p < 1%), but no particular effect on either form of external embeddedness. Finally, being a LILs subsidiary does not have any sort of effect on all the examined forms of embeddedness. The results partly support Hypotheses 1a and 1c, but not Hypothesis 1b.

As regards Hypothesis 2, the SURE estimates are again partially supportive of my conjecture regarding the relationship between a subsidiary's degree of centralization and the level of external and internal embeddedness. Precisely, it is found that centralization is significantly and negatively associated with the external network of the host country (β = -0.39, p < 1%) indicating that the more centralized the R&D unit is, the less is the extent of activities with the external environment of the host country. Regarding the first part of the hypothesis, the level of significance of the coefficients of centralization are well above the threshold of 10%, hence it is not feasible to derive more conclusive results.

Hypothesis 3 draws on the impact of the host location's endowment richness on the three forms of embeddedness. Again, the findings partially confirm the initial conjecture. The coefficient is strongly significant and positive (β = 0.21, p < 1%) as regards its impact on the host country's embeddedness, and significant and positive (β = 0.20, p < 10%) regarding its impact on the home country's embeddedness, while there is no significant indication as concerns its effect on internal embeddedness.

[7] For simplicity reasons, from now on I will make use of the Greek letter 'β' in order to report all the estimated coefficients of the regression results, while letter 'p' will denote the level of significance.

Table 7.3. 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
1	Home	1																		
2	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	Centralization	-0.04	-0.26	-0.45	-0.17	0.31	-0.36	1												
8	Endowment	0.18	0.41	0.33	-0.19	-0.22	0.30	-0.18	1											
9	Macro_uncertainty	0.25	0.04	0.14	-0.19	-0.13	0.15	-0.01	0.08	1										
10	Greenfield	0.01	0.09	0.10	-0.14	-0.17	0.20	-0.21	0.17	0.23	1									
11	ln_Size	0.18	0.35	0.21	-0.24	-0.39	0.33	-0.17	0.14	0.06	0.12	1								
12	ln_Years	0.18	-0.02	-0.22	-0.04	0.25	-0.05	0.36	-0.12	0.21	0.13	0.12	1							
13	ln_Geo_Dist	-0.30	-0.12	-0.13	0.08	0.11	-0.15	0.11	-0.13	-0.02	0.04	-0.02	0.11	1						
14	Cultural_Dist	-0.19	-0.01	-0.04	0.05	0.03	0.06	0.09	-0.12	-0.21	-0.13	-0.00	-0.21	-0.00	1					
15	US	0.19	-0.00	0.02	-0.09	-0.05	0.02	0.08	0.01	0.77	0.17	0.09	0.21	0.13	-0.25	1				
16	UK	-0.11	-0.09	-0.09	-0.01	0.14	-0.13	0.09	-0.05	-0.29	-0.09	-0.10	0.03	0.01	-0.19	-0.32	1			
17	CP	-0.25	0.06	0.13	0.18	-0.07	0.10	-0.16	0.01	-0.15	0.05	0.04	-0.13	0.12	0.14	-0.20	0.12	1		
18	EC	0.06	-0.06	-0.01	0.01	-0.09	0.01	-0.15	0.03	0.13	-0.01	-0.08	-0.07	-0.10	-0.05	0.18	-0.13	-0.36	1	
19	PH	0.18	0.14	0.03	-0.25	-0.23	0.23	0.05	0.18	0.13	-0.00	0.13	0.10	-0.05	-0.10	0.16	-0.03	-0.37	-0.22	1
	VIFs scores (Home)	-	-	-	1.46	2.21	3.16	2.14	1.36	2.56	1.49	1.56	1.65	1.33	1.39	2.65	1.55	2.33	2.06	2.30
	VIFs scores (Host)	-	-	-	1.50	3.63	3.32	2.24	1.47	3.09	1.47	1.85	1.69	1.49	1.45	3.11	1.88	2.27	1.95	2.52
	VIFs scores (Internal)	-	-	-	1.49	2.21	2.95	2.22	1.39	2.67	1.36	1.60	1.74	1.32	1.43	2.73	1.68	2.19	1.91	2.14

Coefficients with values greater than |0.14| are significant at the 10% level of significance.

Table 7.4. Seemingly Unrelated Regression Equations (SURE)

	External Network Home			External Network Host		Internal Network
SLs (H1a)		0.11 (0.07)		-0.15*** (0.05)		0.09 (0.06)
LILs (H1b)		0.10 (0.12)		-0.06 (0.08)		-0.01 (0.10)
IILs (H1c)		0.02 (0.09)		-0.02 (0.06)		0.25*** (0.08)
Centralization (H2)		-0.13 (0.20)		-0.39*** (0.14)		-0.07 (0.18)
Endowment (H3)		0.20* (0.11)		0.21*** (0.07)		0.06 (0.09)
Macro_uncertainty (H4)		0.13* (0.07)		0.08 (0.05)		0.05 (0.06)
Greenfield	-0.001 (0.103)	-0.25** (0.11)	0.14* (0.07)	-0.11 (0.08)	0.18** (0.09)	0.05 (0.10)
ln_Size	0.01 (0.03)	0.04 (0.04)	0.06** (0.02)	0.01 (0.03)	0.10*** (0.03)	0.05 (0.03)
ln_Years	0.11** (0.05)	0.13** (0.06)	-0.02 (0.04)	0.03 (0.04)	-0.11** (0.05)	-0.13** (0.05)
ln_Geo_Dist	-0.15** (0.06)	-0.08 (0.07)	-0.08* (0.04)	-0.0001 (0.01)	-0.05 (0.05)	0.06 (0.07)
Cultural_Dist	-0.01 (0.02)	-0.02 (0.02)	-0.01 (0.01)	-0.001 (0.01)	0.007 (0.01)	-0.02 (0.02)
US	-0.01 (0.11)	-0.18 (0.15)	0.02 (0.08)	0.004 (0.11)	-0.06 (0.10)	-0.09 (0.14)
UK	0.02 (0.16)	-0.01 (0.19)	0.09 (0.12)	0.31** (0.13)	-0.12 (0.14)	-0.07 (0.17)
CP	-0.12 (0.13)	-0.20 (0.14)	0.13 (0.10)	0.07 (0.09)	0.01 (0.12)	-0.12 (0.12)
EC	-0.08 (0.15)	-0.09 (0.16)	-0.07 (0.11)	-0.15 (0.11)	-0.06 (0.13)	-0.28* (0.14)
PH	0.04 (0.15)	0.03 (0.18)	0.09 (0.11)	-0.14 (0.12)	-0.06 (0.14)	-0.39** (0.16)
Constant	3.43*** (0.59)	2.47** (1.00)	2.21*** (0.45)	2.74*** (0.70)	2.50*** (0.54)	1.47* (0.89)
Chi2	30.58***	48.98***	21.06**	56.07***	28.90***	51.08***
R-squared	0.28	0.45	0.21	0.49	0.27	0.46

Levels of Significance: *** p < 1% ** p < 5% * p < 10% (S.E. in parentheses)

Finally, turning attention to the *Macroeconomic uncertainty* variable it is found that there is a significantly positive relationship between the explanatory variable and the level of the home country's embeddedness ($\beta = 0.13$, $p < 10\%$), but no significant effect on the other two dependent variables (i.e. external host and internal). Hence, I am only able to partially support the initial conjecture for Hypothesis 4 as well.

Among the control variables, it is shown that a greenfield mode of entry and a greater size of the unit both have a more positive impact on the internal network embeddedness compared to the host country's network embeddedness. Furthermore, it is found that the age of the unit is a positive predictor of external home embeddedness and a negative predictor of internal embeddedness, while geographic distance is negatively associated with external home embeddedness and external host embeddedness (in a smaller degree).

7.5. Summary

In this chapter, after exhaustively analysing and presenting the relative measures and variables, I presented the regression results which answered whether the conjectured hypotheses have been supported or not by the incorporated data. The results support or partly support my initial conjectures for most of the cases, while some interesting outcomes have also taken place. These will be analysed in depth in the discussion chapter where the findings will be amalgamated with the relative literature in order to better understand how each finding is connected to the theory and vice versa.

8. EXPLORING COMPLEMENTARITY AND SUBSTITUTABILITY BETWEEN THE DIFFERENT FORMS OF EMBEDDEDNESS

8.1. Introduction

Under the previous chapter I provided information regarding the measures used in the empirical analysis which aimed to provide answer to the first research question. Under this chapter, I also aim to present the relative variables which will be used in order to test the second research question, which is '*what are the relationships among different forms of embeddedness'.* While the majority of the measures are similar to those that have been used in the previous chapter, additional data sources, such as patent data from USPTO have now been incorporated, while some modifications have also applied to some measures in order to better fit with the empirical model. Due to the complexity of the research question, as well as the conflicting and complementary methodologies that are available in the literature, this research question will be answered following two different estimation techniques, as has also been indicated in Chapter 5. Following the same format with the previous chapter, the following section will provide a comprehensive analysis of the relative measures, followed by descriptive statistics and correlations of coefficients, and finally by the two aforementioned econometric methods which will test the complementary and substitutive relationship among the different forms of subsidiary embeddedness.

8.2. Measures

8.2.1. Dependent variables

Estimation Method 1: Multiple forms of embeddedness

Estimation method 1 requires the estimation of the correlation between each form of embeddedness. The aforementioned measures have already been introduced from the previous chapter (i.e. determinants of subsidiary's multiple forms of embeddedness).

Two of these were measures of external (home and host) embeddedness and one of internal embeddedness.

Estimation Method 2: Innovative performance

As discussed in the methodology chapter, estimation method 2 requires an output measure of inventiveness based on knowledge sourced internally or externally by firms. Patent data have been used as a proxy of firms' inventiveness in several studies (e.g. Almeida and Phene, 2004; Phene and Almeida, 2008; Sampson, 2007). Although innovative performance can been assessed in many ways such as by using financial data by adopting the ratio of R&D expenditures to total return on investment or sales, or by implementing survey questionnaires under which the innovativeness of the company was evaluated by the response of a general manager or CEO, patent count data is perceived as a more objective measure of true inventiveness of firms in new product and new technology generation (Griliches, 1990; Hagedoorn and Cloodt, 2003). More specifically, the measure of innovative performance I use is the total number of USPTO patents issued to the R&D subsidiary within a 5-year window from the time this survey was conducted. Since I am interested in the patent activity of R&D units located in multiple locations, I set up the search by using the assignee name (e.g. SIEMENS), the host invention location (e.g. USA), as well as the 5-year window in which I am interested. Since the survey was conducted in 1989, then the 5-year window corresponds to the period 01/01/1989 – 31/12/1993.

8.2.2. Explanatory variables

Explanatory variables for both estimation methods

The variables used as explanatory (independent) variables in this study are identical to the variables used for the previous chapter (i.e. determinants of subsidiary's multiple forms of embeddedness), since the information was derived from the same questionnaire. For that reason I will not explicitly describe each one of the explanatory variables. Instead, I will provide a review of them. Accordingly I have used the question asking each R&D subsidiary to classify its activities (using again a 3-point likert-type structure in our questions) into the following three categories:

Support Laboratories (SLs), Locally Integrated Laboratories (LILs), and Internationally Integrated Laboratories (IILs). Furthermore I use a variable for measuring the degree of R&D subsidiary's centralization to the HQ. For that reason I follow the literature (Birkinshaw and Hood, 2000; Nell and Andersson, 2012) and I use a multi-item scale for this measure. The final variable is named *Centralization* and its construct is based on four 3-point likert-type questions. The items included decisions regarding shift of projects to parent or other strategic labs and the level of interaction with them, the general decentralization strategy of the parent towards its foreign affiliate unit, and growth dependence of the R&D lab. Finally, I introduce a variable named *Local endowment* for measuring how the host location's endowment richness (i.e. local scientific and technological resources, scientific environment and technical infrastructure, availability of research professionals and favorable wage rates for research professionals) has influenced the decision of the MNE to tap the examined R&D subsidiary into the specific host location.

Estimation Method 2: Incorporation of Multiple forms of embeddedness as independent variables

For estimation method 2 the three forms of subsidiary embeddedness will be used as independent variables in order to assess the relationship of complementarity or substitutability among them based on their impact on subsidiary's innovative performance. Before I proceed to the regression analysis I should first adjust my data to the specific econometric method (see Methodology section for more information). Accordingly, I proceed to the transformation of the upper three scale variables to dichotomous ones[8]. Bearing in mind that the original scaling of these variables ranges from '1' (weak) to '3' (strong) I transformed all the variables with values lower than '2' to '0', and the variables with values equal or greater than '2' to '1'. Hence, the newly constructed variables take the value '1' when a rather frequent to strong relationship with other sources of knowledge exists. On the other hand they are valued with '0' when a quite infrequent to none sort of relationship with other sources of knowledge is observed.

[8] The transformation of these variables from scale to dichotomous ones was made after having extracted the already developed three factors (i.e. *External Home*, *External Host* and *Internal*).

Control variables

Similarly to the explanatory variables described above, the control variables are also identical to those used in the previous analysis. Accordingly, subsidiary's mode of entry (*Greenfield*), size (*LnSize*) and age (*LnYears*) were all obtained from the subsidiary survey questionnaire. I also incorporated several industry dummies whose information was also taken from the same questionnaire. Furthermore, I used traditional aggregate measures, such as *Geographic Distance* (Monteiro *et al*., 2008), and *Cultural Distance* (Kogut and Singh, 1988). Finally, I made use of two country dummies for two of the most internationalized countries (in terms of R&D activities) of our sample (US and UK). Table 8.1 summarizes the variables created, provides information about their source, as well as it presents basic descriptive statistics for each of the variables.

8.3. Descriptive statistics

As was repeatedly mentioned before, the first two research questions use the same dataset (subsidiary dataset). Accordingly, the majority of variables incorporated in the model(s) have already been analyzed in the previous chapter. Consequently, the descriptive statistics are already known from previous analysis (see Chapter 7). The only difference is related to the incorporation of patent count data for each examined R&D subsidiary, while there is also a transformation of the three forms of embeddedness due to methodological issues. Regarding the patent count data which are used as a proxy of R&D subsidiary's innovative performance the descriptive results indicate that the patents for the examined 5-year period range from 0 to 654 patents, with a mean score of 54.34 patents per subsidiary. For methodological reasons the upper count has been transformed to a natural logarithm with a mean score of 2.43 patents per subsidiary. As regards the three transformed forms of subsidiary embeddedness the descriptive statistics indicate quite different magnitudes in comparison to the previous estimation (i.e. the estimation that corresponds to categorical values of the three examined forms of embeddedness). Accordingly, External Home Embeddedness mean equals 0.44, while Internal Embeddedness mean equals 0.54. Finally as expected External Host Embeddedness mean is reported as the lowest one with a mean score of 0.30, as was also the case when the variables had a categorical formation.

Table 8.1. Variable operationalization, data sources and descriptive statistics

Variables		Number of items used	Cronbach's alpha (α)	Source	Type	Mean	SD	Min	Max
Ln(Patents+1)				USPTO	Scale	2.43	1.69	0.69	6.48
External Home	(Method 1)	3	0.65	Survey	Scale	2.13	0.49	1	3
	(Method 2)				Binomial	0.44	0.49	0	1
Extenal Host	(Method 1)	6	0.60	Survey	Scale	1.79	0.33	1	3
	(Method 2)				Binomial	0.30	0.46	0	1
Internal	(Method 1)	4	0.73	Survey	Scale	2.13	0.45	1	3
	(Method 2)				Binomial	0.54	0.50	0	1
Centralization		4	0.51	Survey	Scale	2.34	0.33	1.50	3
Endowment		4	0.72	Survey	Scale	1.73	0.54	1	3
Greenfield				Survey	Binomial	0.68	0.46	0	1
LnYears				Survey	Scale	2.95	0.93	0.69	4.82
LnSize				Survey	Scale	4.14	1.36	1.38	7.54
LnGeographical Distance				CEPII Database	Scale	8.55	0.80	5.83	9.74
Cultural Distance				Own calculations based on Kogut & Singh (1988)	Scale	2.14	2.51	0.09	9.70

Table 8.2. Pair-wise correlation and VIFs scores (Estimation Method 1).

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	Home	1																	
2	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	Centralization	-0.04	-0.26	-0.45	-0.17	0.31	-0.36	1											
8	Endowment	0.18	0.41	0.33	-0.19	-0.22	0.30	-0.18	1										
9	Greenfield	0.01	0.09	0.10	-0.14	-0.17	0.20	-0.21	0.17	1									
10	ln_Size	0.18	0.35	0.21	-0.24	-0.39	0.33	-0.17	0.14	0.12	1								
11	ln_Years	0.18	-0.02	-0.22	-0.04	0.25	-0.05	0.36	-0.12	0.13	0.12	1							
12	ln_Geo_Dist	-0.30	-0.12	-0.13	0.08	0.11	-0.15	0.11	-0.13	0.04	-0.02	0.11	1						
13	Cultural_Dist	-0.19	-0.01	-0.04	0.05	0.03	0.06	0.09	-0.12	-0.13	-0.00	-0.21	-0.00	1					
14	US	0.19	-0.00	0.02	-0.09	-0.05	0.02	0.08	0.01	0.17	0.09	0.21	0.13	-0.25	1				
15	UK	-0.11	-0.09	-0.09	-0.01	0.14	-0.13	0.09	-0.05	-0.09	-0.10	0.03	0.01	-0.19	-0.32	1			
16	CP	-0.25	0.06	0.13	0.18	-0.07	0.10	-0.16	0.01	0.05	0.04	-0.13	0.12	0.14	-0.20	0.12	1		
17	EC	0.06	-0.06	-0.01	0.01	-0.09	0.01	-0.15	0.03	-0.01	-0.08	-0.07	-0.10	-0.05	0.18	-0.13	-0.36	1	
18	PH	0.18	0.14	0.03	-0.25	-0.23	0.23	0.05	0.18	-0.00	0.13	0.10	-0.05	-0.10	0.16	-0.03	-0.37	-0.22	1
	VIFs scores (Home)	-	-	-	1.46	2.21	3.16	2.14	1.36	1.49	1.56	1.65	1.33	1.39	2.65	1.55	2.33	2.06	2.30
	VIFs scores (Host)	-	-	-	1.50	3.63	3.32	2.24	1.47	1.47	1.85	1.69	1.49	1.45	3.11	1.88	2.27	1.95	2.52
	VIFs scores (Internal)	-	-	-	1.49	2.21	2.95	2.22	1.39	1.36	1.60	1.74	1.32	1.43	2.73	1.68	2.19	1.91	2.14

Coefficients with values greater than |0.14| are significant at the 10% level of significance.

8.4. Analysis

8.4.1. Estimation Method 1 (Correlation approach)

Once again, and since survey data are prone to multicollinearity between the variables and the constructed factors, I proceed to the estimation of the variance inflation factors (VIFs) for each coefficient in each examined model(s). The produced VIFs scores for estimation method 1 (see Table 8.2) range from 1.33 to 3.63, hence according to the 'rule of thumb' of 10 (Hair *et al*., 1998), multicollinearity is not a problem for my model(s).

The OLS estimates which correspond to Equations (5.2), (5.3), and (5.4) are presented in Table 8.3. These provide evidence that the incorporated firm-, country-, and industry-specific characteristics explain a range of 34.2% to 42.4% of total variance in the three equations. As regards the correlation of residuals, Table 8.4 provides the estimates and the signs of the correlation coefficients among any two forms of subsidiary embeddedness. The results indicate that my initial conjectures are only partially confirmed.

Specifically, as regards the relationship between home external and host external embeddedness it is found that the correlation coefficient is positively correlated ($\rho_{HM,HS}$ = 0.44) and statistically significant (at the 1% level of significance). This result confirms my initial assumption that foreign-based R&D subsidiaries will be mutually embedded in both external host and external home knowledge networks and that these are complementary to one another. The other two correlated coefficients have a positive sign ($\rho_{HM,I}$ = 0.17 and $\rho_{HS,I}$ = 0.17 respectively), but are statistically insignificant. As has been stated in the methodology part, the 'correlation approach' suffers from a major drawback which is that it is unable to estimate possible presence of substitutability between two practices. Accordingly, the correlation of residuals between the three forms of embeddedness provides only a partial view of the possible relationship between the examined forms of embeddedness. Furthermore, the fact that the three forms of embeddedness are considered to be jointly determined may raise issues regarding the feasibility of this specific method, since under this assumption OLS is problematic, and consequently

the estimation of residuals may be misleading or inefficient. For that reason I will also extend my analysis to estimation method 2 (i.e. production function approach).

Table 8.3. OLS Regression estimates (for Estimation Method 1).

	External Home	**External Host**	**Internal**
SLs	0.075 (0.054)	-0.156** (0.051)	0.063 (0.057)
LILs	0.109 (0.089)	0.013 (0.083)	-0.079 (0.122)
IILs	0.116 (0.084)	0.034 (0.078)	0.223** (0.074)
Centralization	-0.177 (0.201)	-0.390*** (0.121)	0.050 (0.114)
Endowment	0.115 (0.180)	0.147** (0.053)	0.103 (0.093)
Greenfield	-0.240** (0.101)	-0.104 (0.105)	0.070 (0.124)
ln_Size	0.053 (0.054)	0.042 (0.043)	0.011 (0.039)
ln_Years	0.150* (0.073)	0.044 (0.055)	-0.088 (0.068)
ln_Geo_Distance	-0.054 (0.054)	-0.023 (0.076)	0.025 (0.064)
Cultural Distance	-0.032 (0.023)	-0.000 (0.013)	-0.019 (0.018)
US	-0.006 (0.093)	0.095 (0.178)	0.005 (0.076)
UK	-0.241 (0.224)	0.091 (0.085)	-0.097 (0.115)
CP	-0.219 (0.126)	0.060 (0.123)	-0.001 (0.143)
EC	-0.016 (0.114)	-0.158 (0.092)	-0.129 (0.177)
PH	0.052 (0.137)	-0.107 (0.176)	-0.337** (0.131)
Constant	1.950* (0.675)	2.593*** (0.606)	2.829*** (0.780)
R-squared	0.342	0.424	0.380

Levels of Significance: *** p < 1% ** p < 5% * p < 10% (Robust S.E. in parentheses). N = 133 observations.

Table 8.4. Tests for complementarity / substitutability between different forms of embeddedness.

	Estimation method 1 (correlation of residuals)
Home x Host	0.44***
Home x Internal	0.17
Host x Internal	0.17

Levels of Significance: *** p < 1% ** p < 5% * p < 10%

8.4.2. Estimation Method 2 (Production function approach)

As I repeatedly did before, I also do test for possible problems of multicollinearity for the production function approach model. Accordingly, I estimate the variance inflation factors (VIFs) for the production function approach as well. The produced VIFs scores are indicated well below the 'rule of thumb' of 10 (Hair *et al*., 1998). Precisely, the VIFs scores for the coefficients of the technology production function model range from 1.43 to 3.08. This fact indicates that multicollinearity does not seem to be a problem for our model. The pair-wise correlations and the VIFs scores can be accessed in Table 8.5.

Following the methodology (estimation function 5.6) Table 8.6 shows the rate of exclusive combinations of embeddedness practices. Each combination is represented by an exclusive dummy variable which takes the value '1' in case of the indicated combination and the value '0' otherwise. The distribution shows that the cooperation embeddedness practices follow a more single-dimensional pattern rather than a combinative one. In fact, intra-organizational cooperation practice (β_{001} = 28) is much preferred over the inter-organizational and extra-organizational ones (β_{100} = 19, β_{010} = 8). Regarding the combinative practices, again the exclusive combinations that involve cooperation with internal knowledge sources are the most dominant (β_{011} = 9, β_{101} = 16, β_{111} = 19), while exclusive combinations of external knowledge sources are obviously less frequent (β_{110} = 5).

Table 8.5. Pair-wise correlation and VIFs scores (Estimation Method 2).

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	Ln(Patents+1)	1																						
2	SLs	0.21	1																					
3	LILs	-0.08	0.12	1																				
4	IILs	-0.07	-0.30	-0.57	1																			
5	Centralization	-0.02	-0.21	0.39	-0.40	1																		
6	Endowment	-0.01	-0.17	-0.23	0.33	-0.18	1																	
7	Greenfield	-0.05	-0.04	-0.16	0.27	-0.28	0.21	1																
8	ln_Size	0.04	-0.13	-0.41	0.34	-0.26	0.15	0.12	1															
9	ln_Years	-0.28	-0.10	0.23	-0.10	0.37	-0.02	0.11	0.12	1														
10	ln_Geo_Distance	-0.06	0.09	0.14	-0.11	0.03	-0.08	0.08	0.07	0.08	1													
11	Cultural Distance	0.17	0.09	-0.03	0.07	-0.08	-0.10	-0.19	-0.14	-0.38	-0.02	1												
12	US	-0.18	-0.08	0.00	-0.06	0.16	-0.12	0.10	0.10	0.36	0.06	-0.16	1											
13	UK	-0.24	-0.04	0.21	0.02	0.13	-0.09	-0.04	-0.00	0.04	0.00	-0.15	-0.38	1										
14	CP	-0.01	0.23	0.03	0.04	-0.25	-0.00	0.11	0.02	-0.04	0.32	0.00	-0.14	0.20	1									
15	EC	0.13	0.01	-0.05	-0.06	-0.13	0.01	-0.01	-0.10	-0.16	-0.25	0.12	0.12	-0.19	-0.37	1								
16	PH	0.00	-0.25	-0.24	0.33	0.12	0.25	0.03	0.12	0.09	-0.08	-0.11	0.20	-0.11	-0.40	-0.22	1							
17	β100	-0.00	-0.06	0.16	0.03	0.15	-0.05	-0.07	-0.08	0.12	0.13	-0.02	0.04	-0.06	-0.16	0.13	0.20	1						
18	β010	-0.20	-0.13	0.09	0.04	0.05	0.00	-0.16	-0.08	0.12	-0.01	-0.01	-0.04	0.29	0.11	-0.09	0.07	-0.08	1					
19	β001	0.23	0.12	0.09	0.04	-0.03	-0.05	0.12	-0.20	-0.16	0.15	0.12	-0.11	-0.03	0.21	-0.23	-0.08	-0.21	-0.11	1				
20	β110	0.01	0.05	0.09	-0.27	0.11	-0.06	-0.00	-0.09	-0.08	0.03	0.04	-0.18	0.10	-0.17	-0.09	0.07	-0.08	-0.04	-0.11	1			
21	β101	0.09	-0.07	-0.22	0.08	-0.10	0.15	-0.05	0.05	-0.14	0.03	0.07	0.08	-0.11	0.22	0.02	-0.13	-0.11	-0.05	-0.14	-0.05	1		
22	β011	0.13	0.09	-0.05	0.07	-0.03	-0.09	0.10	-0.06	-0.08	-0.32	0.02	-0.03	0.04	-0.08	0.24	-0.10	-0.16	-0.08	-0.21	-0.08	-0.11	1	
23	β111	-0.37	-0.03	-0.25	0.19	-0.30	0.31	0.06	0.36	0.11	0.05	-0.22	-0.10	0.01	0.09	-0.20	0.05	-0.18	-0.09	-0.23	-0.09	-0.12	-0.18	1
	VIFs	-	1.53	2.31	3.08	2.57	1.64	1.57	1.64	1.98	1.43	1.44	1.99	1.79	2.44	2.31	2.51	2.00	1.6	2.55	1.52	1.93	1.83	2.71

Coefficients with values greater than |0.14| are significant at the 10% level of significance. N = 133 observations.

Table 8.6. Distribution of exclusive combinations between different knowledge sources

Cooperation type	**Code**	**Total**
No cooperation	β_{000}	29
External Home	β_{100}	19
External Host	β_{010}	8
Internal	β_{001}	28
External Home, External Host	β_{110}	5
External Host, Internal	β_{011}	9
External Home, Internal	β_{101}	16
External Home, External Host, Internal	β_{111}	19

Table 8.7 presents the results of Equation (5.9). Regarding the explanatory power of the model, it seems that the incorporated variables explain a rather significant amount of variance, since the R^2 has a value of 50.9%. The regression results in Table 8.7 seem to explain only a fraction of relationships regarding single or even combinative embeddedness practices. Actually, the only significant values are observed on the combinative practice among External Home, External Host and Internal embeddedness (β_{111} = -2.121, p < 5%). Regarding the other variables I find that innovative performance is enhanced if subsidiaries are larger R&D subsidiaries, while being a US or UK subsidiary does not seem to have a positive impact on the innovative performance of the unit.

Table 8.7. OLS Regression estimates

	Innovative performance
SLs	0.405 (0.310)
LILs	-0.081 (0.395)
IILs	-0.363 (0.382)
Centralization	0.738 (0.927)
Endowment	0.025 (0.490)
Greenfield	-0.121 (0.515)
ln_Size	0.473*** (0.174)
ln_Years	-0.155 (0.289)
ln_Geo_Distance	-0.130 (0.324)
Cultural Distance	-0.024 (0.093)
US	-1.610*** (0.543)
UK	-1.641** (0.703)
External Home (β_{100})	-0.270 (0.773)
External Host (β_{010})	-1.067 (1.193)
Internal (β_{001})	0.788 (0.744)
External Home, External Host (β_{110})	-0.531 (1.164)
External Home, Internal (β_{101})	0.414 (1.005)
External Host, Internal (β_{011})	0.371 (0.759)
External Home, External Host, Internal (β_{111})	-2.121** (0.835)
Industry dummies	Yes
Constant	0.712 (3.923)
R-squared	0.509

Levels of Significance: *** p < 1% ** p < 5% * p < 10% (Robust S.E. in parentheses). N = 133 observations.

Table 8.8. Tests for complementarity / substitutability between different forms of knowledge sourcing

	LR-test C (≥)	**LR test S (≤)**
Home and Host	11.99***	0
Home and Internal	3.34	7.89**
Host and Internal	15.95***	3.33

Levels of Significance: *** p < 1% ** p < 5% * p < 10%

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As concerns the complementarity test results (Table 8.8) which correspond to the imposed inequality constraints (5.8a-1 – 5.8c-2) these are in favour of supporting the conjecture of complementarity between the two out of the three pairs of knowledge sourcing practices, while the assumption of substitutability (subadditivity) is in favour of the third pair. Specifically, the LR test turned out to confirm the argument of complementarity for the pairs of embeddedness practices of (i) External Home, External Host and (ii) External Host, Internal. On the other hand, the third pair (External Home, Internal) of embeddedness practices is indicated as substitutive one, since the relative LR-test turned out to be significant between the unrestricted and restricted (assuming substitutability) models. Accordingly, the results from estimation method 2 support my initial conjectures since they prove to be in line with Hypotheses 5 – 7.

8.5. Summary

This chapter presented the variables used in the empirical analysis regarding the answer to the second research question of this thesis. After taking into consideration the two alternative research methods (i.e. Estimation Method 1 and 2), as well as after proceeding to the appropriate incorporation of additional data and modification of existing ones, the econometric results turned out to be in favor of my initial conjectures, thus confirming Hypotheses 5 -7. The theoretical and managerial impact of these findings will be discussed in detail in the discussion chapter (Chapter 10), under which all possible implications for both research and practice will be presented and extensively reviewed.

9. FACTORS SHAPING R&D SUBSIDIARIES' INNOVATIVE PERFORMANCE UNDER MULTIPLE EMBEDDEDNESS CONTEXT

9.1. Introduction

This chapter's aim is to empirically assess the conjectured hypotheses (i.e. Hypotheses 8-12) related to the third research question of this thesis (i.e. *what are the multiple determinants of R&D subsidiary innovative performance*). As opposed to the previous two research questions, and as has also been discussed in Chapter 6, this chapter incorporates data from even more diverse data sources, utilising a HQ questionnaire, patent data from USPTO, and macroeconomic data from the World Bank database. What follows is an analytic presentation of the measures, the descriptive statistics deriving from those measures, and finally the empirical examination of the relative research question, based on the adoption of a cross-classified MLM, whose validity and relevance have been extensively analysed in Chapter 5.

9.2. Measures

9.2.1. Using patent data at the subsidiary level

As I also mentioned before, it is widely accepted that there is no specific method in order to assess innovative performance. Despite that fact, patent data has been considerably used as a proxy for firms' inventiveness. Although innovative performance has been measured with a variety of techniques in the past (i.e. financial data through the ratio of R&D expenditures to total return on investment or sales, survey questionnaires under which the innovativeness of the company was captured by the response of a line or general manager), patent count data is commonly conceived as one of the most efficient proxies that facilitate researchers' work, since the latter are in a position to compare and evaluate the performance of firms as regards new product and new technology generation (Hagedoorn and Cloodt, 2003). At the same time a more unbiased view of a firm's level of inventiveness is

achieved, since patent data act as an external indicator of technological novelty (Griliches, 1990).

Although patent data is extensively used by researchers during the last three decades, two main limitations apply which make us perceive it as an imperfect measure of innovative activity. It is known that inventions are divided to those which are patented and those which are not. This aspect mainly applies due to strategic issues which arise (Griliches, 1990), or even due to the fact that a patent is a form of codified (explicit) knowledge, while many firms prefer to keep some of their inventions in a tacit form. Accordingly, possible omission bias is a well reflected problem for using patent data as an instrument of innovative performance. Despite the aforementioned limitations, the extended literature and empirical use of patent data allow us to apply this sort of indicator in order to assess a subsidiary's innovative performance.

9.2.2. Dependent variable: Innovative performance

Patent counts are traditionally used as a proxy of innovative performance. As was also highlighted in the previous chapter, patent count data is perceived as one of the most objective measures of true inventiveness of firms in new product and new technology generation (Griliches, 1990; Hagedoorn and Cloodt, 2003). Accordingly, this study makes use of patent count data (i.e. quantity of innovation) in order to assess the innovative performance that is generated in the examined R&D subsidiaries.

Innovative performance: This measure is estimated by examining the total number of patents applied for by the R&D subsidiary within a 5-year window. As has been already mentioned, I make use of the USPTO database in order to collect this information, since its search engine provides a great range of search options in order to observe the patent information with increased accuracy. More precisely, since I am interested in the patent activity of R&D units located in multiple locations, I set up the search by using the assignee name (e.g. VOLVO), the host invention location (e.g. Germany), as well as the 5-year window in which I am interested. The total number of patents for this specific time frame is the measure for the quantity of

innovation each R&D subsidiary has generated. This sort of measure has been used as a dependent variable (i.e. measuring innovative performance) by other studies in the recent past (Almeida and Phene, 2004; Phene and Almeida, 2008; Sampson, 2007).

9.2.3. Independent variables

Lower level variables

Subsidiary embeddedness has been extensively researched in the wide IB-area. In terms of variable specification, Andersson and Forsgren (2000, p. 338) assess the subsidiary's embeddedness according to the unit's 'closeness of relationships, in terms of how the counterparts' activities are mutually adapted'. According to their viewpoint, adaptation is a very effective measure in order to assess the interdependence of both parties on a mutual project. Taking it a step further, technology or technical embeddedness is viewed through the same lenses (i.e. closeness of relationships and mutual adaptation of activities), with the difference that this relationship is strictly related to the product and production development (Andersson, Forsgren, and Pedersen, 2001; Andersson *et al*., 2002). As it can be perceived by the aforementioned definitions, the frequency of interaction between two actors (units) is used as a measure of the unit's embeddedness.

In this study, the degree of technological embeddedness is measured according to the frequency of co-authorship between the subsidiary's actors and other counterparts (either internal or external). Co-authorship has been widely used as a measure in previous studies in order to assess the degree of cooperation and knowledge flows between two units. "Cooperation" is a term for which numerous and multidimensional definitions have been given in the past. In reality, it is very difficult for anyone to give an explicit definition and characterisation (Katz and Martin 1997). A traditional measure of cooperation is co-authorship, which was first introduced by Smith (1958) and further investigated by various other researchers (Glänzel and Schubert, 2005; Melin and Persson, 1996; Subramanyam, 1983). What they all suggest is that such a proxy can be used as an efficient estimator of the level of cooperation between researchers. In terms of this research study, collaboration can take the form of patent co-authorship. Indeed, in many recent studies researchers

make use of patent co-authorship data in order to identify the degree of cooperation between scientists. More precisely, Mudambi *et al*. (2007) use patent co-authorship data in order to identify the effect of intra-teamwork on the knowledge generation of the R&D subsidiary. Likewise, Lahiri (2010) uses patent co-authorship as a measure of intra-organizational linkage between the scientists of the firm, who are located in different countries. Furthermore, Yamin and Otto (2004) incorporate the same sort of data (co-authorship of patents) in order to evaluate the degree of joint research and collaborative knowledge-sharing among inventors from different institutions. From the above, it is obvious that patent co-authorship has been integrated as a rather efficient and realistic measure of intra-, inter- and extra-organizational research collaboration. In this study patent co-authorship is used as a proxy of technological embeddedness in order to assess the impact of the latter on the unit's level of innovative performance.

Internal technological embeddedness: Innovation in R&D subsidiaries occurs either independently of any form of cooperation, or in association with their HQ and affiliate units' involvement. In order to examine such a relationship, I make use of the existing patent information. More precisely, I examine whether the patent which is assigned to the R&D subsidiary I am interested in has reported its HQ (parent company) or affiliate (sister) R&D subsidiary as co-inventor. This measure is created by dividing the sum of the patents in which such a relationship (HQ or affiliate R&D units as co-assignee) is reported by the total number of patents assigned to the R&D subsidiary for the 5-year period of interest. The proportion of this division is the measure of internal technological embeddedness.

External (Home and Host) technological embeddedness: Knowledge, apart from the fact that it can be assimilated by either inter- or intra-firm sources, can also be derived from various extra-firm activities. Many R&D units develop ties with external institutions (firms, independent research labs, universities, public research institutions, etc.) in order to draw on the existing or potential knowledge of external actors. These specific variables measure the degree of external (home and host) firms' involvement in the R&D subsidiary's innovation process. In particular, I estimate this measure by identifying whether the patent's co-assignee name is an external firm, institute or university located in (a) Host or (b) Home location. As for

the synthesis of the two previous variables, I divide the sum of the patents in which a subsidiary – external (either home or host) co-invention relationship is observed by the total number of patents which are registered by the R&D subsidiary for the 5 year period examined. The proportion of this division is the measure of external technological embeddedness in the home and host location.

HQ (parent) level variables

HQ decentralization strategy: As opposed to the majority of the existing research studies which have employed this sort of measure in their analyses by questioning the line or general manager of the subsidiary whether or not the latter is tightly or loosely centralized to the HQ of the MNE, this study incorporates this measure from the source of this strategy, which is the HQ. Even though each subsidiary is unique in terms of being characterized by a distinct degree of decentralization, compared to the rest of the MNE network, this study asks the HQ to assess the corporate decentralization (i.e. autonomy) strategy regarding the operation of the MNE's geographically dispersed subsidiaries. Accordingly, this survey-based question asks the respondent parent company (HQ) whether its foreign R&D subsidiaries are closely or autonomously associated with the HQ. Precisely, the question asks 'what proportion of foreign R&D units do you consider to be autonomous from the parent R&D unit?' The answers are given in the form of a percentage scale, ranging from 0-100%. To achieve a higher normality in terms of distribution, the answers are transformed to a 0-10 scale.

Country level variables

In order to evaluate the impact of the host location's characteristics on the subsidiary's innovative performance I selected a range of macro level indicators which are all associated with NSI, infrastructure, technology and education characteristics. Due to the dated nature of the survey, and hence, the time span under which the research is drawn, the availability of relevant data was restricted. From a range of data, I focused on those which had been used in other studies in the recent past, as well as on indicators that can determine the level of innovative performance, according to the existing literature. Most of the data are taken from the World Bank database (WDI). These are the total number of carrier departures; the total amount of energy production; the proportion of students who are in tertiary education; the

proportion of exports which are related to high-technology products; the number of patent applications made by residents of the host location and the number of publications in scientific and technical journals. Finally, I incorporate the strength of Intellectual Property Rights (IPR) protection regime (Park, 2008). A detailed analysis of variables' definitions and sources can be found in Table 9.1. As it was expected, some of these variables are highly correlated with each other; hence it is not appropriate to include all of them in the regression analysis at once, due to multicollinearity issues. According to Basilevsky (2009), a simple and effective solution is to proceed to factor analysis. This statistical technique will generate a small number of factors under which the aforementioned set of variables will be instrumented without losing much of their explanatory power and original identity.

Table 9.1. Sources and sort definition of variables used in factor analysis

Variable	Definition	Source
IPR protection index	This variable is taken 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).	W.G. Park (2008)
Carrier departures	Registered carrier departures worldwide are domestic takeoffs and takeoffs abroad of air carriers registered in the country.	WDI (World Bank indicators)
Energy production	Energy production refers to forms of primary energy - petroleum (crude oil, natural gas liquids, and oil from nonconventional sources), natural gas, solid fuels (coal, lignite, and other derived fuels), and combustible renewables and waste - and primary electricity, all converted into oil equivalents.	
Tertiary education	Gross enrolment ratio. Total enrollment in tertiary education (ISCED 5 and 6), regardless of age, expressed as a percentage of the total population of the five-year age group following on from secondary school leaving.	
High technology exports	High-technology exports are products with high R&D intensity, such as in aerospace, computers, pharmaceuticals, scientific instruments, and electrical machinery.	
Patent applications (made by residents of the host location)	Patent applications are worldwide patent applications filed through the Patent Cooperation Treaty procedure or with a national patent office for exclusive rights for an invention. A patent provides protection for the invention to the owner of the patent for a limited period, generally 20 years.	
Scientific Publications	Scientific and technical journal articles refer to the number of scientific and engineering articles published in the following fields: physics, biology, chemistry, mathematics, clinical medicine, biomedical research, engineering and technology, and earth and space sciences.	

Similar studies researching the factors determining the level of innovation have used the same technique (i.e. factor analysis) in order to avoid potential problems of multicollinearity (Mudambi and Navarra, 2004; Srholec, 2010). The performed factor analysis revealed that only two dimensions with eigenvalue greater than one are retained. Both factors account for 84.51% of total variance, which is a very efficient number. Table 9.2 presents the rotated factor loadings and the relative correlations in detail.

Table 9.2. Principal component factors

	Factor 1	Factor 2
	Infrastructural & educational environment	Scientific & technological richness
IPR protection index	0.787	0.084
Carrier departures	0.955	0.146
Energy production	0.964	0.099
Tertiary education	0.844	-0.064
High technology exports	0.704	0.554
Patent applications	0.056	0.961
Scientific Publications	0.957	0.219

Note: In total two factors with eigenvalue greater than 1 were retained, while both factors account for the 84.51% of the total variance (Rotation orthogonal varimax (Kaiser off)).

9.2.4. Control variables

Geographic Distance: The existing literature provides evidence that network position and geographic distance between the parent and the host country have an immensely positive impact on the performance of the geographically dispersed R&D subsidiary (Tsai, 2001). Indeed, we already know that MNEs prefer to locate their R&D activities in close proximity to their corporate HQ. This strategy is principally made in order to better control the affiliate's activities. Following Monteiro *et al*. (2008), this variable is operationalized by taking the natural logarithm of

geographical distance between the R&D subsidiary'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 the country's official capital. The data was gathered from the 'Institute for Research on the International Economy' (CEPII).

Cultural Distance: Institutional characteristics, cultural values and ethics are strongly related to subsidiary performance. Apart from being strong location indicators for the MNE, these characteristics can also be proved to be prominent indicators of innovative performance. In order to assess the level of cultural distance between the home and the host location of the subsidiary I proceed to the estimation of the index developed by Kogut and Singh (1988). The index draws on Hofstede's renowned indices and is formed based on the deviation among each other of the four (already known and previously presented) cultural dimensions.

Home country dummies: I also make use of two country dummies for two of the most internationalized countries (in terms of R&D activities) of my sample (US and UK).

Industry controls: I make use of industrial sector dummies in order to better control for specific industry effects on innovative performance. Five industry dummies are constructed, each one corresponding to a unique industrial division (Chemicals and Petroleum, Electronics, Motors and Mechanical Products, Pharmaceuticals and Miscellaneous). The complete list with this study's variable definitions and data sources can be accessed in Table 9.3.

Table 9.3. Sources and definition of variables

Variable	Definition	Source
LnPatents	Natural logarithm of the total number of patents applied for by the R&D subsidiary within a 5-year window.	USPTO
Internal tech. embeddedness	The proportion of patents which have reported its HQ (parent company) or sister R&D subsidiaries as co-inventors.	USPTO
External Home tech. Embeddedness	The proportion of patents which have reported other firms, research institutions or universities, based in the home (near to HQ) location, as co-inventors.	USPTO
External Host tech. embeddedness	The proportion of patents which have reported other firms, research institutions or universities, based in the host (near to foreign subsidiary) location, as co-inventors.	USPTO
HQ decentralization strategy	The proportion of foreign R&D units which are autonomous from the parent R&D unit.	Survey
Infrastructural & educational environment	This variable is a product of a factor analysis on several variables related to the host location's infrastructural, institutional and educational background.	WDI & Park (2008)
Scientific & technological richness	This variable is a product of a factor analysis on several variables related to the host location's technological and scientific background.	WDI
Ln_Geographic Proximity	The natural logarithm of geographical distance (expressed in kilometers) between the R&D subsidiary'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 the country's official capital.	Institute for Research on the International Economy (CEPII)
Cultural Proximity	Own calculations based on the index developed by Kogut and Singh (1988), which draws on Hofstede's indices. It is based on the deviation among each other of the four cultural dimensions (i.e. power distance, uncertainty avoidance, masculinity / femininity, and individualism).	Kogut & Singh (1988) using data from The Hofstede Centre
Home country dummies	Country dummies for the sample's most internationalised countries (i.e. US & UK).	Survey
Chemicals & Petroleum Electronics Automobile & Machinery Pharmaceuticals	These industry dummy variables are constructed based on the industrial sector that is assigned by the HQ to each of the reported R&D subsidiaries. Five industry dummies are extracted (Chemicals and Petroleum, Electronics, Motors and Mechanical Products, Pharmaceuticals and Miscellaneous), while the last one acts as reference category and includes all the miscellaneous industrial sectors.	Survey

9.3. Descriptive statistics

As was mentioned in the previous section, the analysis of the multiple determinants of R&D subsidiary innovative performance is based on the evaluation of one dependent variable, the innovative performance at the subsidiary level. The descriptive statistics indicate that the values of patent counts for the examined period range from 0 to 83 patents with a mean of 6.63. Furthermore, the means of patents reported in Table 9.4 are not the actual mean values but their natural logarithms. Regarding the key independent variables, the descriptive statistics show that R&D subsidiaries tend to establish cooperation ties with external resources of the host location three times more frequently compared to internal (MNE) actors and twice as frequently compared to external actors located in the home location[9]. Finally, the HQ decentralization strategy mean value (1.43) indicates that subsidiaries act as highly centralized units, rather than as autonomous ones. The industry division of the sample shows that the firms are quite equally distributed in terms of their industrial classification, while the sample represents some of the most highly technological fields of the global industry (almost 85%). This mainly consists of Pharmaceuticals (19.6%), Electronics (24.2%), Chemicals & Petroleum (22.5%), and automobile and machinery (18.4%) firms.

9.4. Regression analysis

Once more, before I proceed to the cross-classified MLM regression I first have to assess whether a possible presence of multicollinearity may hinder the efficiency of my model's estimates (Hair *et al*., 1998). The correlation matrix (Table 9.4) indicates the possible presence of multicollinearity, since the correlation coefficient between External home technological embeddedness and External host technological embeddedness equals $\rho = 0.816$. In order to further test whether such an indication is problematic for my analysis I further proceed to the estimation of the VIFs scores. The reported estimates of the VIFs indicate that there is no significant multicollinearity since the VIFs scores are well below the threshold of '10' (the

[9] This result contradicts the subsidiary questionnaire's descriptive statistics on subsidiary embeddedness, where both home and internal embeddedness were valued as more dense/frequent compared to the host embeddedness measure.

Table 9.4. Correlation table, descriptive statistics and VIFs scores.

		Mean	S.D.	1	2	3	4	5	6	7	8	9	10	11	12	13
1	LnPatents	0.921	1.309	1												
2	Internal tech. embeddedness	0.020	0.119	0.159	1											
3	External home tech. embeddedness	0.032	0.129	0.028	0.212	1										
4	External host tech. embeddedness	0.063	0.227	0.047	0.220	0.816	1									
5	HQ decentralization strategy	1.430	2.736	-0.081	-0.088	-0.013	0.035	1								
6	Infrastructural & educational environment	0	1	0.212	0.122	0.015	-0.016	-0.003	1							
7	Scientific & technological richness	0	1	0.041	-0.069	0.076	0.082	-0.071	0.000	1						
8	LnGeographical Proximity	8.056	1.203	-0.061	-0.055	0.076	0.161	-0.014	0.124	0.366	1					
9	Cultural Proximity	1.993	1.730	-0.152	0.055	0.029	-0.021	0.069	-0.312	0.305	0.139	1				
10	Chemicals & Petroleum	0.225	0.419	-0.037	0.091	0.087	0.100	-0.242	0.007	0.056	-0.088	0.142	1			
11	Electronics	0.242	0.430	0.112	-0.093	-0.081	-0.098	0.083	-0.166	-0.093	-0.077	0.032	-0.305	1		
12	Automobile & Machinery	0.184	0.389	0.032	-0.080	-0.109	-0.121	-0.034	0.068	0.013	0.036	-0.013	-0.257	-0.269	1	
13	Pharmaceuticals	0.196	0.398	-0.049	0.078	0.127	0.091	-0.128	-0.068	0.080	0.061	-0.047	-0.266	-0.280	-0.235	1
	VIFs scores	-	-	-	1.16	3.13	3.29	1.30	1.27	1.31	1.29	1.39	2.40	2.19	2.06	2.17

Notes: Coefficients with values greater than |0.139| are significant at the 10% level of significance.

highest observed score is 3.29). Accordingly, it can be assumed that multicollinearity is not an issue in this case.

Another issue that should be stressed is whether MLM is the most proper method in order to analyze the proposed research questions. As it was suggested by Erkan Ozkaya *et al*. (2012), only a small proportion of existing multilevel studies provide the VPC scores as justification for employing a MLM. In case of this study, the VPC estimates confirm my decision to assess the impact of multiple (cross-classified) factors using a MLM. Since the VPC scores do not approach 0, then the use of a cross-classified MLM, and consequently the 'grouping' by HQ and host locations seems to be the most proper method of analysis. Apart from the VPC estimates which show that the model explains almost perfectly the unobserved variation of the level 2 variables, there is also evidence from the deviance (-2LL) statistic suggesting that the final model (full model) is greatly preferable to all the previous models. In particular, a significant difference (ΔDeviance = 61.720) among the deviances of empty and full model is observed. Furthermore, the Wald statistic provides strong evidence for the explanatory power of the full models, since it is observed that the inclusion of higher level factors results in an increasing level of the Wald statistic.

Table 9.5 presents the MLM regression results for the determinants of R&D subsidiaries' innovative performance. Regarding the MLM regression results there is enough evidence to support Hypothesis 8. The higher the R&D subsidiary's internal technological embeddedness the greater the quantity of innovation produced in it. It comes clear that R&D subsidiaries rely heavily on technological ties and scientific collaboration with their HQ and affiliate units in order to become more innovative. On the other hand, the results were unsupportive of both Hypotheses 9a and 9b. The coefficients of the aforementioned variables in both models are found to be insignificant.

As regards hypothesis 10, the HQ decentralization strategy variable is insignificant in all models, indicating that there is not enough evidence to support these hypotheses. The existing theory is relatively informative as concerns the subsidiary's level of autonomy and its impact on the subsidiary's innovative performance, but in

this study it seems that I have neither enough information nor appropriate empirical evidence to confirm my initial conjecture. In regard to the host location's impact on subsidiary's innovative performance the findings are partially supportive of my initial conjectures. Precisely, I find strong support for Hypothesis 11, since the infrastructural and educational environment coefficient in the last two models is positive and highly significant ($p < 1\%$). The results are in line with the existing theory (NSI and FDI theory) and confirm my argument on how important is the host country's infrastructure, institutions and educational background for the subsidiary's innovative performance. Finally, after examining the last of the hypotheses I do not find enough evidence to support it. Specifically, Hypothesis 12 is found to be insignificant. This result indicates that the scientific and technological richness of the host location does not seem to have a particular impact on the subsidiary's innovative performance. Finally, the controls do not seem to have any strong effect on the subsidiary's innovation generation, while traditionally significant effects such as geographic and cultural distance, do not have any sort of significant impact on subsidiary's innovative performance as well.

9.5. Summary

This chapter empirically examined the third and final research question of this thesis. Following an accurate technique that fits well with the contextual aspects of the examined relationship, as well as through incorporating a wide range of variables from diverse data sources, this chapter aimed to answer the conjectured hypotheses. Although the findings do not support some of the examined hypotheses, the results are such that enrich our knowledge on the aforementioned relationship, both from a theoretical and practical perspective. The implications from the above findings will be discussed in depth in the next chapter, under which the results from this chapter, along with the results from the previous two chapters will be amalgamated with the relative theory.

Table 9.5. Cross-classified MLM regression results

Dependent variable: LnPatents	**Empty model**	**Empty model (+ Level 1)**	**Empty model (+ Level 1 & 2a)**	**Empty model (+ Level 1, 2a & 2b)**	**Full model (+ Level 1, 2a, 2b & controls)**
Intercept (γ_{00})	0.904*** (0.119)	0.862*** (0.122)	0.903*** (0.135)	0.967*** (0.139)	1.772** (0.904)
Fixed effects					
Internal tech. Embeddedness		1.806** (0.822)	1.761** (0.824)	1.510* (0.828)	1.618* (0.841)
External home tech. embeddedness		0.170 (1.259)	0.145 (1.260)	-0.061 (1.242)	-0.387 (1.276)
External host tech. embeddedness		-0.014 (0.729)	0.006 (0.729)	-0.032 (0.723)	0.294 (0.748)
HQ decentralization strategy			-0.031 (0.045)	-0.039 (0.046)	-0.028 (0.045)
Infrastructural & educational environment				0.267*** (0.098)	0.302*** (0.116)
Scientific & technological richness				0.068 (0.096)	0.160 (0.110)
LnGeographical Proximity					-0.148 (0.101)
Cultural Proximity					-0.051 (0.072)
Chemicals & Petroleum					0.105 (0.404)
Electronics					0.787* (0.411)
Automobile & Machinery					0.432 (0.426)
Pharmaceuticals					0.271 (0.418)
US					0.207 (0.307)
UK					0.262 (0.320)
Random effects					
Parent company Variation (u_{0j})	0.272	0.291	0.282	0.292	0.151
Host country Variation (v_{0k})	1.248	1.195	1.208	1.166	1.023
R&D Subsidiary Variation $e_{i(jk)}$	0.181	0.174	0.163	0.160	0.337
VPC	98.03%	97.78%	98.33%	98.29%	90.43%
Model fit statistics					
Wald Chi2	-	5.37	5.85	13.35**	21.77*
-2LL (Deviance)	577.508	572.254	571.800	521.944	515.018
ΔDeviance	-	5.254	0.454	49.856	6.926
AIC	585.508	586.255	587.800	541.945	551.019
BIC	598.121	608.328	613.027	572.634	606.260
Chi2 (LR test vs. Linear regression)	5.74*	6.54**	6.17**	6.44**	1.83

Notes: ***p<0.01, **p<0.05, *p<0.10 (Standard errors in parentheses). N = 173 R&D subsidiaries (level 1) cross-classified under 57 parent companies (level 2a) and 25 host countries (level 2b).

10. DISCUSSION AND CONCLUSIONS

10.1. Introduction

An important part of the recent internationalisation theory is based on the fact that an MNE's competitive advantage is to a great degree associated with knowledge creation, which has been brought about by innovative performance. In view of the fact that MNEs are now considered to be more internationalised than ever before, as well as considering that knowledge creation is no longer perceived to be exclusively an internal process, but rather a practice characterised by combinative (joint) forms of embeddedness, this study aimed to shed light on a set of key research questions which have immense research and practical implications for the society nowadays. By focusing on the MNE context and more precisely on foreign-based R&D subsidiaries of leading MNEs and by taking into consideration all the possible forms (both internal and external) of knowledge sourcing (embeddedness) this study examined three important research questions.

- What are the unique predictors for each type of embeddedness?
- How can we conceive of the relationships between the three forms of embeddedness - are they complementary or substitutive?
- How the multilevel structure of the subsidiary and different forms of multiple embeddedness influence the innovative performance of the R&D subsidiary?

Embeddedness is now widely accepted as the mechanism by which an R&D subsidiary of an MNE can access distinct forms of knowledge inside (intra-MNE) and outside (locally) the firm. Accordingly, this study has set as one of the most fundamental objectives the understanding of what form of embeddedness will be used, when this will be used and what results this may have for the overall innovative performance of the R&D subsidiary. The answer to this research question is critical in evaluating how an MNE exercises leverage or arbitrage in locating its R&D activities, based on location specific characteristics of both home and host locations, as well as considering the knowledge resources available in other parts of the MNE's network of subsidiaries. Second, considering the existence of multiple

forms of embeddedness this study has questioned whether MNEs' R&D subsidiaries use the one form over the other and if so why such a practice occurs. Simply put, this study questioned, and accordingly answered, whether there is a complementary or a substitutive relationship among the three possible forms of embeddedness. Finally, following a traditional and well-studied IB theme (that of the determinants of R&D subsidiary's innovative performance) this paper has attempted to examine the triangular relationship between the R&D subsidiary, the HQ and the host location, and their overall impact on the former's innovative performance by applying a multilevel methodology on each examined classification.

Accordingly, the aim of this chapter is first to discuss in depth the results of the econometric analysis which are reported in the previous three sections, and second to bring to attention how these findings can possibly generate theoretical (academic), managerial, and policy implications. Finally, limitations and directions for future research are presented at the end of this chapter.

10.2. Discussion of findings

Regarding the first research question the econometric evidence provides some interesting results for the factors that are associated with the three forms of embeddedness. Among the factors that are associated with different forms of embeddedness I find a strong role for types of R&D subsidiaries in predicting levels of host and internal embeddedness. SLs subsidiary is more likely to not be embedded in the host economy. This finding is in line with the initial argument which supported that the SLs subsidiary is likely to have very limited exposure to the host location's environment, mainly due to the fact that its operation is closely and strictly monitored by the HQ (Pearce, 1999). This result is further explained by the fact that the SLs subsidiary's operation is oriented towards adaptation of the MNE's existing technology according to local needs and scope. Hence, very limited to non-existent adhocracy, creativity and interaction with the scientific endowment of the host location is expected from the personnel of this type of R&D subsidiary. Furthermore, it is also found that IILs subsidiary is strongly embedded within the internal MNE network. This finding is in line with the cited literature, such as Ambos and Schlegelmilch (2007) and Nobel and Birkinshaw (1998), suggesting that, although

globally creative subsidiaries usually seek knowledge from new sources which are predominantly available in the external environment (Manolopoulos *et al*., 2011a), they also seem to be tightly embedded in the MNE network. A possible interpretation of this result is that IILs subsidiaries seek to develop synergies with other affiliate units taking advantage of a shared corporate culture and technological background, as well as the limited exposure to hazardous - in terms of knowledge spillovers - peer groups.

Another robust finding of the empirical analysis is that centralization of the R&D unit has a negative impact on the degree of external host embeddedness, a result which is in line with Andersson and Forsgren (1996) and Jindra *et al*. (2009). This result is not surprising at all. Highly centralized R&D units are likely to be vastly dependent upon the HQ decision-making authority, leading to the assumption that very limited operational freedom is achieved at the subsidiary level. As a result, R&D subsidiaries are characterized by a very restricted level of interaction with the external environment of the host location.

As regards the rest of the findings, the result of scientific endowment's richness and its impact on both forms of external embeddedness is in line with the initial conjectures. Abundance of scientific excellence force R&D subsidiaries to increased interaction with their host location's counterparts, while such abundance does not necessarily lead subsidiaries to end their synergistic behaviour with the home location's actors. A possible interpretation of this finding is that R&D subsidiaries located in environments surrounded by rich scientific and technological regimes will seek to complement the knowledge available at home, rather than to substitute it. Finally, it is found that there is a positive impact of the host location's environmental uncertainty on the subsidiary's embeddedness in the home location. Taking into consideration the magnitude of both macroeconomic and institutional environment the result indicates how important it is for this type of subsidiary to operate in a non-volatile environment. Both macroeconomic stability and IPR protection regime are factors of fundamental importance for the day-to-day functioning of the R&D unit.

The next most important finding of this study is related to the examination of the relationship between the three possible forms of embeddedness. Accordingly, by

adopting two well-known research methods for testing complementarity, it is primarily assessed and accordingly shown that the combinative knowledge sourcing strategies adopted by foreign-based R&D subsidiaries produce not only complementary results, but also substitutive ones. Precisely, it is found that a complementary relationship exists between external home and external host embeddedness, as well as among external host and internal embeddedness. On the other hand, a substitutive relationship is observed between external home and internal embeddedness.

The finding of complementarity between external home and external host embeddedness is in line with the study of D'Agostino and Santangelo (2012) who found that foreign-based R&D labs which are located in Emerging Markets and are characterized by an 'adaptation' profile tend to complement home R&D (as far as knowledge creation is concerned). This finding can be partially explained by the fact that MNEs which aim to substitute home with host location's NSI will struggle with significant difficulties which are detrimental for the whole MNE (Criscuolo, 2009). MNEs are by nature closely tied to their home location (in fact, this is also shown by the mean score of External Home embeddedness which is much greater than this of the External host embeddedness), having developed relationships based on trust and mutual respect with the external actors. Accordingly, and considering the high cost and time needed for developing the same degree of trust with the external actors of the host location, as well as the vast amount of risk accompanying a possible trade-off of home knowledge with that of the host knowledge network, MNEs are possibly forced to complement the knowledge available in the home location, rather than substituting it. Such a practice adds value to the existing knowledge acquired by the subsidiary, since the latter has the capacity of opting for the type and scale of knowledge that will be sourced from the one knowledge network (e.g. host location) that possibly is not offered in the other knowledge network (e.g. home location).

As regards the examination of the other two pairs of embeddedness the findings are in line with the initial conjectures. Although the existing literature has previously examined the relationship between internal and external knowledge (e.g. Cassiman and Veugelers, 2006; Gammelgaard and Pedersen, 2010; Papanastassiou, 1999; Veugelers, 1997), this assessment was merely based on a single form of external

knowledge network, and not on the two forms that this particular study has brought to attention. The reported (production function approach) estimations confirmed the argument of complementarity between internal and external host embeddedness. This finding can be framed within the RDT and its application to the MNE. Precisely, the literature has shown that foreign-based R&D subsidiaries are not very likely to become highly independent of their parent and affiliate units, unless they have developed technological competences which are inimitable and highly valuable to the rest of the MNE network (Mudambi and Pedersen, 2007). Taking into consideration that the vast majority of subsidiaries will tend to rely on the HQ either for basic or less significant needs, this finding explains to a great degree the reason why a trade-off between internal and external host embeddedness is not a case for foreign-based R&D subsidiaries.

On the other hand, as regards the relationship between external home and internal embeddedness the findings indicate that a substitutive relationship exists among the two aforementioned forms. This result is in line with the conjectured hypothesis which assumed that a trade-off is likely to exist between those two forms of embeddedness, mainly due to two major issues. First, high coordination costs may arise from such a strategic combination of knowledge sources, since the subsidiary will have to maintain a relationship with a knowledge network which is in distinct geographic proximity compared to the location under which the former is based. These costs are possibly increased even more considering that the subsidiary will have to maintain a strong relationship with the intra-MNE knowledge network. Second, the fact that foreign-based subsidiaries tend to establish and maintain ties with the home location's knowledge network may produce duplicative effects. Accordingly, the knowledge sourced from the home location is possibly duplicated since both the HQ and the foreign-based subsidiary maintain an augmented network of relationships which is hard and complex to manage while it leads to increased coordination costs since after a certain point the MNE has to make sure that the information absorbed by both units is unique and equally distributed. This argument is also framed under the over-embeddedness notion (e.g. Nell and Andersson, 2012; Uzzi, 1997) where after a certain point the cost of maintaining strong business relationships with external actors is such that causes a decrease in valuation of strongly embedded relationships. In this case, where both HQ and foreign-based

subsidiaries share the same external knowledge sources and are possibly affected by such a phenomenon, we are lead to the assumption that home external and internal embeddedness are quite normally characterized by a substitutive relationship.

Finally, this study aimed to answer an important question with deep practical and methodological roots about the multilevel determinants of an R&D subsidiary's innovative performance. Although the examined topic is considered to be a well-studied theme nowadays, there are still some hidden aspects that this study has aimed to bring to attention. Even though the aforementioned relationship is associated with three interrelated parameters, each one corresponding to a different level of classification, the majority of the existing studies have neither considered nor identified the multilevel nature of this relationship. This paper adopts a more sophisticated methodological approach, which is in line with the multiple embeddedness context under which the subsidiary operates.

The multilevel regression estimates provide evidence for supporting the view that R&D subsidiaries' innovative performance is greatly influenced by the extension of ties and technological synergies within the MNE network, while external embeddedness (both home and host) does not seem to be associated with innovation generation at the subsidiary level. On the other hand, subsidiaries are able to enhance their innovative performance by exercising leverage on the host location's infrastructural, institutional and educational environment. Accordingly, one of the most significant findings of this study is the distinct impact characterizing each of the examined forms of technological embeddedness on a subsidiary's innovative performance. Although all three variables measure and indicate technological and scientific synergies, as well as the establishment of ties among different units and their actors, the findings provide evidence that external embeddedness (i.e. establishment of scientific relations with other firms, institutions and universities) has no particular effect on the improvement of a subsidiary's innovation. Enhanced innovative performance is solely achieved through the MNE and its federated network (affiliate R&D units and HQ).

Furthermore, although external technological embeddedness does not provide any sort of impact on a subsidiary's innovative performance, there is strong evidence indicating that the subsidiary is able to leverage the host location's infrastructural and educational resources in order to create a subsidiary specific competence, which will boost its innovative performance. MNE's R&D subsidiaries are surrounded by competent and resourceful infrastructural and educational endowments, but it seems that they do not engage in scientific and technological synergies with them in order to enhance their innovative output. Instead, they prefer to exercise a sort of leverage on these resources, possibly through acquiring knowledge that is publicly available, or through recruiting and contracting local scientific personnel of high quality. A well-endowed infrastructure and institutional environment acts as a facilitator of a subsidiary's performance, since it is able to generate and disseminate its knowledge securely because it is surrounded by a strong institutional regime, while the host country's infrastructure is of great importance for the subsidiary's day-to-day operations.

As regards the decentralization strategy of the MNE, the results indicate that a decentralization strategy that emerges from the HQ of the MNE cannot have an impact on the innovative performance of the subsidiary itself. The previous theories have focused on a subsidiary's autonomy and its impact on the subsidiary's performance indicating a direct and positive relationship between them. This study's argument is based on the notion that autonomy is a decision made by the upper hierarchy. Hence, the most appropriate party to provide an answer to that question, from an empirical perspective, is the HQ and not the subsidiary. The findings were unsupportive of my conjecture. Indeed, autonomy is a centralized decision, but each subsidiary receives a different and 'tailor-made' degree of decentralization, possibly according to the type of R&D operations mandated by the HQ and the environment in which the subsidiary operates.

10.3. Contributions

The purpose of this research study is not only to provide academically rigorous research findings, but also to propose a certain theoretical framework and relevant

suggestions which can be effectively utilised by practitioners (i.e. managers and policy makers). Accordingly, this thesis's findings have a threefold contribution.

First, based on the review of the existing literature and the identification of existing research gaps on the particular theme of this study, this research work aims to propose a more concrete and modernised view of the subsidiary's simultaneous embeddedness in the three aforementioned knowledge networks. By augmenting the existing dichotomies suggested in the literature (e.g. Le Bas and Sierra, 2002; Patel and Vega, 1999; Phene and Almeida, 2008), this study revealed that foreign-based subsidiaries are characterised by the unique privilege to source knowledge from three distinct networks at the same time. Accordingly, the main contribution of this thesis is that it furthers both the theoretical and empirical approach of the existing literature by proposing a three-dimensional view of the subsidiary's knowledge network. Hence, apart from the already existing view of external home vs. external host, and external (host) vs. internal dichotomization, this thesis amalgamates and proposes a modernized, actual and 'tangible' view of the relationship that characterizes the subsidiary with its affiliated knowledge networks. In other words, this thesis moves from the traditional view of the dichotomization of the different forms of subsidiary embeddedness, knowledge sourcing, assimilation of knowledge, etc, and accordingly extends the idea of dichotomization to even more possible sources/networks of knowledge. Thus, by making this distinction more concrete, coherent, and empirically tested, this thesis contributes to widening our knowledge on the theme that the aforementioned three research questions elaborate on, while at the same time it opens a new (sub)field of research, where both researchers and practitioners could potentially consider the simultaneous determination and existence of more than two networks of knowledge.

As a result, this research work contributes to the ***overall understanding of academics, students, managers and policy makers*** in terms of how the subsidiary can source knowledge from its surrounding environment.

Second, this research study contributes to the ***practice of international R&D management*** and details on the following research questions: (i) Which are the unique predictors of each form of subsidiary embeddedness? (ii) Which types of embeddedness are complementary and which are substitutive? (iii) How each form of embeddedness impacts the innovative performance of the R&D subsidiary?

The findings from the above research questions help managers to improve their ***strategic decision-making***. Bearing in mind that the endeavour of a subsidiary manager is to enhance the unit's competitive advantage and performance, this study empirically shows what exactly is considered to be important for the subsidiary in order to achieve its goals. Accordingly, and based on the study's empirical findings, the manager can possibly proceed to the necessary changes in the management process in order to achieve the optimal result for the subsidiary and the MNE. Furthermore, the findings can be beneficial regarding the decision-making of policy makers as well. This applies especially to those who work closely with the institutional policies and policies related to the NSI of their country.

In the following three subsections I detail this study's contributions, focusing on three basic pillars.

(i) Theoretical and academic knowledge
(ii) Managerial and practitioners' perspective
(iii) Policy makers' point of view

10.3.1. Theoretical (academic) contributions

As was mentioned above, this study provides a more concrete and modernised view of the MNE R&D subsidiary and its relationship with all available knowledge networks. Based on the notion that foreign-based subsidiaries are surrounded by more than two knowledge networks at the same time, this study introduces a modernised framework where three knowledge networks are considered to interact at the same time. The study proposes and confirms that embeddedness is the

mechanism by which subsidiaries can access knowledge in three distinct networks; within the MNE; in the host location in which the subsidiary is based; and in the home location where the HQ (parent) is located.

This particular distinction between two and three possible knowledge networks leads to the assumption that foreign-based subsidiaries, in contrast to HQ and their home (domestic) counterparts, are in a better position in terms of sourcing more diverse forms of knowledge. This is mainly attributed to the fact that they have wider choices in terms of tapping into a greater and possibly richer variety of knowledge at the same time. Of course, this particular view (i.e. the dichotomisation of knowledge sources) is not a newly introduced idea neither is it original to the current study. On the contrary, this trend is also observed in the early 1990s and particularly in the study developed by Patel and Pavitt (1991). The authors showed that despite the increasingly globalised trend of the world's technological production, the lion's share of large firms' technological activities was still concentrated at home, rather than in the host location in which the foreign-based subsidiaries are located. This argumentation is also depicted in other studies which dichotomised the local knowledge network to home and host (Criscuolo, 2009; Le Bas and Sierra, 2002), and the MNE's knowledge to internal and external (Almeida and Phene, 2004; Ambos, 2005; Phene and Almeida, 2008).

As mentioned above, the triple embeddedness argument has been in the literature for almost two decades, or even more, and it cannot be considered to be a newly established trend. On the other hand, the fact that all the aforementioned studies did not consider the existence and importance of all the three knowledge networks at the same time provides a good reason for theorising about the triple embeddedness of foreign-based R&D subsidiaries. The modernised MNE relies a lot more on its foreign-based R&D subsidiaries compared to the recent past. The main reason for that is the creation of competitive advantage through the newly developed mechanism of reverse knowledge transfer (Ambos *et al*., 2006). The fact that the aforementioned three distinct networks are directly available only for the foreign-based subsidiary and not for the HQ or the domestically-based subsidiaries indicates

that the triple embeddedness perspective is a more concrete and holistic view of the modernised MNE. Accordingly, based on my aforementioned propositions I assume that this three-dimensional view should possibly be taken more actively into consideration by the academic community.

10.3.2. Managerial contributions

Apart from the academic implications which add to the existing theory, there are also several implications for practice. Accordingly, the findings from this research study can be effectively utilised by MNE managers and precisely by R&D managers who are in charge of the day-to-day operation of foreign-based R&D subsidiaries. This study can potentially help managers to understand and conceptualise the existing knowledge framework under which their units operate. By getting to know the exact knowledge context under which their subsidiaries are embedded they will possibly be in a better position to manage the density and form of linkages between the unit and the external/internal actors.

One of the main features of this study is to provide information regarding what sort of impact each form of embeddedness has on the subsidiary's innovative performance. The findings indicated that only internal embeddedness positively influences a subsidiary's innovative performance, while at the same time, external home and external host embeddedness are not indicated to have a particular effect on performance. Despite this aspect, it has also been found that the host location's external environment is considered to be a factor of vital importance for the enhancement of innovative performance of the subsidiary. This indicates that although the external knowledge sources are rich and impactful in nature for the subsidiary, the means by which host location resources' utilisation is achieved does not seem to produce a significantly positive outcome for the innovative activity of the subsidiary. A possible implication for managers relates to the density and form of collaboration between the subsidiary and the external environment. The fact that subsidiaries heavily rely on intra-MNE knowledge collaboration, rather than on external forms is not related to the possible poor quality of external sources of knowledge. This is also proven by the findings. A possible explanation is that other

factors, such as fear of knowledge spillovers, negatively influence the density and quality of subsidiaries' external embeddedness, which in turn results in the latter's insignificant effect on the innovative performance of the subsidiary. What can also be interpreted from this result is that the significant collaborations which have an immense impact on the competitive advantage of the MNE are developed using intra-MNE knowledge sources, while collaborations with external sources are possibly related to less important innovations, such as customer-related issues or product distribution mechanisms. Managers should focus on and observe whether the cost of developing significant innovations internally overpasses the cost of possible knowledge spillovers when collaborations with resourceful external actors occur.

While we continuously listen to discussions about location advantages and disadvantages, we are still not in position to fully understand the factors related to such a situation. These factors are mainly related to other available locations and the knowledge sources surrounding these locations. Accordingly, it is not only the host location that influences a decision to tap into a specific knowledge source, but also the home location that influences such an important decision. This is also the case for the implications derived from the examination of the second research question. What this study also examines is whether it is profitable or costly to combine a form of knowledge source with another? What makes it such a difficult decision for the R&D manager? The findings, in contradiction to what we knew from the existing literature on complementarity, indicate that the relationship between the three forms of embeddedness does not lead to an endless complementarity. Precisely, the finding of substitutability between external home and internal embeddedness reveals that there is possibly a duplicative effect taking place. Indeed, this duplicative effect is also the case when the knowledge sourced from the home location is simultaneously absorbed from the HQ and the subsidiary. Such a practice can possibly cause coordination costs between the HQ and subsidiary (Nell and Andersson, 2012). Of course, such a trade-off between those two forms of embeddedness may vary, depending on the way MNEs use ICT nowadays. Accordingly, managers can learn how each of these knowledge sources influences the performance of their unit and how they can improve the performance of the subsidiary even more by combining the appropriate knowledge sources, by knowing the exact costs and benefits arising

from such a combination, or even by improving the coordination mechanisms and ICT of their unit. Another possible implication relates to the fact that managers can also form strategic collaborations/alliances considering the output they want to achieve. The complementary/substitutive relationship is an example of how managers should strategically collaborate with available knowledge sources.

Finally, based on the assumption that each manager is aware of what form of embeddedness is beneficial in terms of performance, the findings corresponding to the first research question can be of substantial importance for the further enhancement of a subsidiary's performance. Accordingly, managers can intervene in the management of a subsidiary/HQ relationship in order to change its vital characteristics that affect the subsidiary's embeddedness towards one form of knowledge source over the other. For example, a highly centralised unit is not allowed to be highly embedded in the host location's endowment, although this location's endowment may be a rich source of knowledge for the subsidiary at the same time. Such a strategic change can be beneficial for the overall performance of the MNE. The same applies for the strategic role/mandate of the subsidiary.

10.3.3. Policy makers' contributions

Apart from the already discussed academic and managerial implications, there are several implications which apply for policy makers as well. A certain finding drawn from this study reveals that macroeconomic uncertainly forces subsidiaries to establish stronger ties with the home location's knowledge network rather than with the host location's counterpart. A possible implication for policy makers is that countries characterised by unstable macroeconomic or political environments should focus on enhancing the quality of their institutional environment in order to avoid losing possible tangible (capital, tax, profits) or intangible (innovative products, knowledge dissemination, collaboration with highly perceived MNEs) income sourcing from the subsidiaries that have chosen to locate in a particular country.

Moreover, the finding that relates internal embeddedness to a subsidiary's innovative performance does not apply only to managers. Accordingly, policy makers should also think why a firm's performance is enhanced only when the subsidiary is embedded in internal knowledge networks, while at the same time the sources of the host location seem to be a highly regarded source of knowledge capital for the MNE. As discussed before, this finding possibly relates to the phenomenon of knowledge spillovers and weak IPR regime. Although the reinforcement of IPR is more than ever before a high priority for governments and NSIs, firms seem to be quite cautious when proceeding to important collaborations with external actors. Policy makers should further focus on that particular aspect since possible loss from establishment of ties between a foreign-based subsidiary and a host location's external actors (e.g. university, public research institute, etc.) could have a detrimental impact not only for the MNE, but mainly for the country, since the latter seeks important collaborations in order to enhance its competitive advantage on the global map, which in turn will improve its overall macroeconomic and institutional environment.

10.4. Limitations and directions for future research

The findings and their implications are, of course, limited by the nature of the data. On the one hand, the examined data are dated to the late eighties and it is possible that some of the relationships observed have been atrophied or overtaken by technology. This possible change 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. Indeed, with the increasing use of ICT HQ can nowadays manage to control and oversee more easily the day-to-day operations of the R&D subsidiary. As a result, HQ achieves a high level of centralisation, since the subsidiary is more frequently and densely connected to the HQ (mainly through formal communication and coordination mechanisms that ICT offers), while the subsidiary becomes more and more contingent upon HQ's influence and guidance. This has as a result the subsidiary to focus more on internal embeddedness, and consequently make the latter a very important mechanism and knowledge source for the whole MNE. This is a possible impact of the 21st century's

ICT adoption on subsidiary's internal embeddedness, and this is why we should be cautious with the existing dataset and the implications of the findings drawn from it.

On the other hand, despite its datedness, this survey is not very much older than the data used in several of the studies I cite in my literature review. For example the studies by Un and Cuervo-Cazurra (2008) and Nell and Andersson (2012) use subsidiary data for the period 1991-1994 and 1994 respecitvely; while Mudambi *et al*. (2007) use also subsidiary data which were collected in 1995. In order to further validate the choice of the dataset, as well as its applicability and validity until nowadays, I selected two well-cited, and recently published empirical studies which deal with similar research aspects with this thesis. My intention is to find whether similar measures of internal and external embeddedness (or knowledge sourcing) are considered to have the same magnitude with the measures of this study. First, the study by Phene and Almeida (2008) deals with a panel of US semiconductor MNE subsidiaries based in all three of the major regional bases of the industry (i.e. North America, Europe, and Asia). The descriptive statistics are in line with this study's survey and indicate that (based on patent co-authorship) the foreign-based subsidiary tends to assimilate more knowledge from home country firms and the MNE's HQ, and less knowledge from the host country environment. Another recent study by Song *et al*. (2011) investigates the relationship between knowledge sourcing pattern and the form of embeddedness with both internal and external networks of knowledge. Based on survey data of Japanese subsidiaries based in Europe and the US the descriptive statistics indicate that subsidiary embeddedness in the internal knowledge network of the subsidiary is stronger compared to the external (host) equivalent. The aforementioned descriptive results drawn from these well-regarded and recently published studies indicate that the data of this thesis are still relevant and depict the recent global trend in innovation management of MNEs and their foreign-based subsidiaries. Moreover, we should not neglect the fact that the notion of embeddedness and the constructs which are used in order to evaluate the level of it are universal across time (Nell and Andersson, 2012). Despite the extensive use and improvement of ICT nowadays, I still believe that the validity of the data used is not really atrophied by any particular datedness, simply because the social network and relational embeddedness perspective is not taken away neither is determined by

a particular date. In reality, it is the quality and strength of ties which determine the length of a particular relationship.

Another possible limitation is that the data used in this Thesis are cross sectional rather than panel and so it is not feasible to control very well for the heterogeneous abilities of parent-subsidiary pairs or for the evolution of embeddedness over time. Another drawback is that the data capture the internationalization of R&D activities of MNEs that are hosted only on fourteen countries. Since then, the 'global R&D map' has augmented to eighteen – nineteen global locations, mainly because resourceful and technologically competitive emerging markets (BRICS) have entered into the 'R&D internationalization game'.

Apart from the data issues that have mentioned above, there are several technical issues arising from this study that should be taken into consideration. Although the first research question examined important determinants of subsidiary embeddedness, including the role of mandate, centralization, and host country characteristics, it should be stressed that a possible effect of reverse causality may be present. Although all the above factors explain, or partly explain, the choice of a particular type of subsidiary embeddedness over another, there is the possibility that the dependent variables (i.e. the three types of embeddedness) have also an equally significant impact on one or more independent variables. For example, someone could reasonably argue that reverse causality may be present between internal embeddedness and the degree of centralization, or between host country richness and host embeddedness. Although the aforementioned factors are seemingly interrelated, the construction of the variables is such that makes the issue of reverse causality not a very likely phenomenon in this study. Although I acknowledge that some of the independent variables are closely connected to this study's dependent variables, I assume that the selection of questions (i.e. different questions from diverse sections of the questionnaires were selected for the construction of each variable) that were used for the development of each variable was such that makes the effect of reverse causality not a very likely event. However, the possibility of reverse causality is still a limitation and this needs to be taken into consideration.

As regards the multilevel determinants of innovative performance, and considering the complexity and multidimensionality of the incorporated model, it would not be proper to neglect the possible limitations of this part of my research work. First, due to the nature of the data, it was not feasible to incorporate some valuable and sensitive control variables that traditionally affect the level of innovation, such as the R&D subsidiary's size and age. Second, although the study has possibly brought a rather informative methodological insight to our attention, it should also be kept in mind that the data incorporated in this model are in a cross-sectional rather than panel data formation. Hence, it was not able to test whether the examined factors may or may not have a particular evolution over time. Third, another issue that should also be considered is the number of group observations (cases) incorporated at level 2. Maas and Hox (2005) indicate that a minimum of 30 observations at level 2 is usually required in order to estimate an MLM with robust results. In this study, the examined cross-classified MLM has two second (higher) level groups. While the first (HQ) includes 57 observations, the second (host country) is based on 25 observations, which is a slightly lower number than that suggested by Maas and Hox (2005). However, since the above number does not greatly differ from the 'rule of thumb' of 30 observations, it can be reasonably claimed that no serious estimation problems exist in the model. Fourth, the current form of the HQ decentralization strategy measure is probably of limited explanatory power. Although the initial conjecture is based on the notion that decentralization is a decision made by the upper hierarchy of the MNE (i.e. the HQ), and not by the subsidiary itself, the present operationalization of the variable may be a better fit if the interviewee was providing a more subsidiary-orientated answer, rather than a HQ to all subsidiaries-oriented one.

A technical issue regarding the determinants of innovative performance that I need to elaborate on is the possible presence of simultaneity. More precisely, while the level of centralization and host country characteristics are indicated as determinants of subsidiary embeddedness in research question 1, these variables are equally assumed to be determinants of innovative performance in research question 3. Although someone may well indicate that a possible issue of simultaneity is relevant in this

model, there is a reason to believe that this issue is not very likely to occur in this case. In particular, this assumption is based on the development of the variables that have been used in research questions 1 and 3. Specifically, the data on research question 1 is drawn from the subsidiary questionnaire, while the data for the estimation of research question 3 is drawn from USPTO and the HQ questionnaire. Furthermore, the measurement of each variable differs between those two models. Accordingly, although simultaneity is theoretically a well-perceived concern for those two research questions, the incorporation of variables from diverse data sources, as well as the difference in the measurement of each variable, act as buffers for this important technical issue.

Finally, a more important limitation concerns the choice of data for the measurement of innovative performance. Previous research has widely used patent data for the measurement of this particular variable. In this study I used patent counts as the relative measure of innovative performance. However, many studies have elaborated the concept of patents and excelled this measure even more by using a quite different dimension. This is the quality of innovation. The measurement of this particular proxy is based on the number of forward citations each patent receives and captures the magnitude and importance of innovation. An even more efficient measure is based on the standardization of the number of citations based on the total counts of patents a firm has generated. In that case, the researcher takes into account not only the significance of the innovation, but also the total number of innovations that the firm has produced. However, this study has chosen the most traditional measurement of innovation, which is the patent count. Of course, this does not mean that future work should necessarily use the same proxy, since the literature has provided even more concrete and well-established alternative measures.

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

First, this research work could be inspirational for researchers who are interested in taking a step forward and researching the multiple forms of embeddedness in new countries (including emerging ones). Such a study would be even more appealing considering the great achievements in telecommunications and software, as also discussed above. This would especially apply for the determinants of internal embeddedness, as well as for the relationship that is formed between the latter and the other two types of external embeddedness. Additionally, by designing a more comprehensive questionnaire the forms of embeddedness could possibly be found to be even more numerous. For example, considering the study by Meyer *et al*. (2011) on MNEs and local context it can be reasonably assumed that the number of external host locations that can be researched could be more than one. Hence the multiple host location perspective which is the outcome of the knowledge transfer practice between R&D subsidiaries located in different geographic regions could add to our knowledge regarding which determinants push subsidiaries to one form of embeddedness rather than to another.

Regarding the multilevel determinants of a subsidiary's innovative performance, future research can be focused on the same theme but following an even more complex cross-classified MLM, by incorporating data from other second level classifications, such as sister R&D subsidiaries which are located in other foreign locations, or even by introducing a level for home country characteristics. The latter may be a useful instrument, adding to our existing knowledge by measuring the level of variance attributed to home and host embeddedness of the R&D subsidiary. In general, it can be assumed that, due to the heterogeneity of parameters surrounding the MNE, an MLM is the most appropriate estimation technique for providing answers to unobserved characteristics. Furthermore, considering the positive correlation between a firm's market value and the volume of knowledge it produces (Gittelman and Kogut, 2003; Hall *et al*., 2000) future research could apply the same methodological context for assessing the market or financial performance of the subsidiary, and not exclusively its innovative performance. Finally, taking into consideration the fact that all three forms of technological embeddedness were incorporated as determinants in the last model, it could be reasonably argued that a

possible examination of complementarity/substitutability between those three forms can act as a potential future research work. Indeed, although this research question was examined and answered in this thesis (i.e. research question 2), the fact that the data for the 3rd research question is based on patent co-authorship makes the examination of this relationship even more appealing. Accordingly, I suggest that future research would benefit from the examination of such a relationship under this specific context.

APPENDICES

APPENDIX 1

A1.1. Sources and strategy of articles' selection

Before I proceed to the analysis of the articles, it is of vital importance to provide detailed information on how the search for articles was decided, as well as which sources were selected. First, as regards the source of this search, this is decided and accordingly developed after evaluating the existing renowned studies which have provided a specific benchmark on the quality and impact of management journals (ABS, 2010; Podsakoff *et al*., 2005; Werner 2002). After evaluating the journal lists, as well as considering the particular theme and focus of this research study, it was decided that 22 academic journals from the management and related areas (International business, innovation, organization studies) qualify for this literature review. In particular, the search included 6 IB journals (Journal of International Business Studies, International Business Review, Journal of World Business, Management International Review, Journal of International Management, and Asia Pacific Business Review), 5 Innovation journals (Journal of Product Innovation Management, Research Policy, Industrial and Corporate Change, R&D Management, and Technovation), and 11 Management and Organization studies journals (Strategic Management Journal, Organization Studies, Organization Science, Academy of Management Journal, Academy of Management Review, Administrative Sciences Quarterly, Journal of Management, Journal of Management Studies, British Journal of Management, Management Science, and Scandinavian Journal of Management). Second, after evaluating the suggestion by Michailova and Mustaffa (2012), and since the review of the literature is solely focused on academic and empirical research output, a list of business and management journals were excluded from the literature search (California Management Review, Harvard Business Review, Long Range Planning, Organizational Dynamics, and Sloan Management Review). Finally, the time-range of the search was decided to be from 1996 – early 2013, mainly due to the fact that the most dominant and pioneering work on subsidiary embeddedness started at that period of time (e.g. Andersson and Forsgren, 1996).

In order to identify and collect the relative articles, various search engines were used. First, Google Scholar search engine was utilized, since it provides a wide range of search criteria, including multiple keywords, as well as it has the unique ability to provide information on a wide range of academic journals. Second, although Google Scholar is a very efficient and reliable search engine, supplementary searches and double-checks were conducted in ABI/Inform and ScienceDirect. The identification of articles of interest was achieved with specific keywords which were incorporated in the search engine in conjunction with other specific words. In particular the word 'embeddedness' was incorporated in conjunction with the word 'multinational' and in conjunction with the word 'subsidiary'. The primary search was focused on titles and abstracts of the papers, while at a second stage (mainly due to the limited results received) the search was spread to the whole document (paper), and not solely on the abstract. For robustness check, additional search was conducted in leading and recently published works on subsidiary embeddedness in order to identify relative cited studies which were not initially identifiable through the search engine.

The first search resulted in the selection of 103 articles. As expected, some of these articles did not actually represent the field of this study (i.e. subsidiary embeddedness), and accordingly a second review round was initiated in order to double-check and exclude studies with no particular fit for this literature review. After evaluating the content, context and nature of each article, a truncation of 46 articles resulted in a final sample of 57 papers which have appeared in 16 different journals. This huge truncation of the initial sample was in a great degree dependent upon the non-IB context of some studies, as well as on the non-existent or narrow use of the key word 'embeddedness'.

The following table (Table A1) presents the exact descriptive statistics relatively to how many articles have been published in each one of the 16 academic journals. One of the most interesting findings is that the majority of the published work has been appeared in the post-2005 period (approximately the 77% of the studies). This is a strong indicator of the increasing interest of the academic world toward the concept of embeddedness and the examination of it within the subsidiary context. Another important finding is the domination of IB journals as concerns the published works on subsidiary embeddedness. In fact, all the IB journals included in this study (i.e.

IBR, JIBS, JWB, MIR, JIM, and APBR) account for the 63.15% of the total published work on subsidiary embeddedness. Of course, this outcome cannot be perceived as surprising, since the literature review focus on the notion of embeddedness under the MNE subsidiary context.

Table A1. Journals and number of articles published in the period 1996-2013

	1996-2004	**2005-2013**	**Total**
Academy of Management Review (AMR)	0	1	1
Asia Pacific Business Review (APBR)	0	1	1
Industrial & Corporate Change (ICC)	0	1	1
International Business Review (IBR)	4	10	14
Journal of International Business Studies (JIBS)	3	4	7
Journal of International Management (JIM)	0	1	1
Journal of Management (JoM)	0	1	1
Journal of Management Studies (JMS)	1	4	5
Journal of World Business (JWB)	0	7	7
Management International Review (MIR)	2	4	6
Organization Studies (OS)	1	0	1
R&D Management	0	1	1
Research Policy (RP)	0	4	4
Scandinavian Journal of Management (SJM)	1	0	1
Strategic Management Journal (SMJ)	1	4	5
Technovation	0	1	1
Total	**13**	**44**	**57**

A1.2. Geographic range, sample size and methods of analysis

A rather insightful finding which is brought to my attention through the statistical analysis of the 57 published studies on subsidiary embeddedness is that the majority of these studies have concentrated on a single country, rather than on an international set (i.e. cross-country study). Accordingly, 13 of the studies were conducted in Swedish subsidiaries (22.80%) and 19 (33.33%) in other countries (3 in Germany, 3 in the USA, 2 in Italy, 2 in China, 2 in the UK, Austria, Argentina, Finland, Taiwan, Brazil, Spain, Hungary). On the other hand, only 10 studies (17.54%) have been conducted from a cross-country perspective (either in Triads, Europe, or generally in a global range). On the other hand, the same pattern is not

repeated in terms of the MNE's Headquarters location, since the great majority of the studies has used an international perspective regarding the Headquarters country of origin diversification. Regarding the sample size of the studies, 25 out of 57 used less than 100 subsidiaries in order to assess their research questions (43.85%), while 7 studies were conceptual works (12.28%). For 1 study there is evidence only for the number of surveyed MNEs, while the rest 24 studies (42.10%) use a sample of more than 100 subsidiaries. Regarding the particular research methodologies employed in each examined study, the results of the literature review indicate that the vast majority of the empirical work uses traditional statistical techniques, such as Structural equation modeling (SEM) (e.g. Andersson, Forsgren and Holm, 2001, 2002, 2007; Hallin & Holmstrom Lind, 2012) and traditional regression techniques, such as OLS (e.g. Ambos and Schlegelmilch, 2007; Hallin *et al*., 2011; Jindra *et al*. 2009, Nell and Andersson, 2012; Nell *et al*., 2011; Yamin and Andersson, 2011; Yamin *et al*., 2011), multiple regression (e.g. Moran, 2005), and other relative regression methods (such as Partial Least Squares, Analysis of Variance, etc.). Interestingly, from the rest of the 57 studies, 7 studies were considered as conceptual works, while 10 studies were counted as case studies / qualitative studies.

A1.3. Subsidiary embeddedness used as dependent and independent variable

Another insightful and useful finding that came out of the statistical interpretation of the literature review is the limited number of studies which have used embeddedness as dependent variable. This result confirms the primary assumption that very limited evidence currently exists regarding the various determinants pushing subsidiaries towards the one form of embeddedness against the other. More specifically, only 8 out of the 57 studies have empirically examined which factors shape the inclination of subsidiaries towards a specific form of embeddedness. The form of embeddedness that has been examined as dependent variable is the external (host) or local embeddedness (Andersson, Bjorkman & Forsgren, 2005; Hakanson & Nobel, 2001; Nell & Andersson, 2012; Perri *et al*., 2012, Santangelo, 2012), while other studies have subdivided and accordingly examined the effect on relational business and technical embeddedness (Andersson, Forsgren and Holm, 2002). Finally,

Gammelgaard *et al*. (2012) examined the increases in inter- and intra-organizational network relationships, while Nell *et al*. (2011) focused on the particular effects on embeddedness overlap in the subsidiary's local network.

On the other hand, the vast majority of the reviewed studies has identified and accordingly employed the previously analysed forms of embeddedness in order to determine how these may affect the level of other organizational aspects. The latter are related to various performance indicators at the subsidiary level, such as the market performance of the subsidiary (e.g. Andersson, Forsgren and Pedersen, 2001; Andersson, Forsgren and Holm, 2001), organisational performance (e.g. Andersson, Forsgren and Pedersen, 2001), innovative performance (e.g. Figueiredo, 2011; Hakanson and Nobel, 2001; Moran, 2005). Other studies have used subsidiary embeddedness as an explanatory factor of MNE competence or capability development (e.g. Andersson, 2003; Andersson, Forsgren and Holm, 2001; 2002; 2007; Santangelo, 2012). Furthermore, since there is a strong interest on Headquarters - subsidiary relationship and given that subsidiary embeddedness plays an immensely important role on explaining various aspects of this relationship, other studies have incorporated the embeddedness measure as an explanatory variable against the role (or mandate) of subsidiary (e.g. Andersson, 2003; Bouquet and Birkinshaw, 2008; Williams and Nones, 2009), the level of subsidiary autonomy (e.g. Chiao and Ying, 2012) and perceived control (e.g. Andersson and Forsgren, 1996).

Table A2. Literature review on studies researching on various forms of subsidiary embeddedness (presented in alphabetical order)

A/A	Study	Sample	Host country	Home country	Form of embeddedness	Dep.	Ind.	Researching effect on / from			
1	Ambos (2005)	134 R&D subsidiaries	Germany	Triads	Internal and External (host)						
2	Ambos & Reitsperger (2004)	134 R&D subsidiaries	Germany	Triads	External (host)						
3	Ambos & Schlegelmilch (2007)	134 R&D subsidiaries	Germany	Triads	External (host)		x	Management control			
4	Andersson (2003)	97 subsidiaries	Sweden	Mainly Europe	External technical (host)		x	MNE capability development		Role of subsidiary	
5	Andersson & Forsgren (2000)	98 subsidiaries	Sweden	Mainly Europe	External technical (host)		x	Subsidiary importance		Subsidiary influence	
6	Andersson & Forsgren (1996)	78 subsidiaries	Sweden	Mainly Europe	Total, corporate and external (host)		x	Perceived control			
7	Andersson, Forsgren & Pedersen (2001)	98 subsidiaries	Sweden	Mainly Europe	Technology embeddedness		x	Market performance		Organisational performance	
8	Andersson, Forsgren & Holm (2001)	97 subsidiaries	Sweden	Mainly Europe	External technical embeddedness		x	Market performance		MNE competence development	
9	Andersson, Forsgren & Holm (2002)	97 subsidiaries	Sweden	Mainly Europe	Relational business embeddedness & Relational technical embeddedness	x	x	Relational technical embeddedness	Market performance	MNE Competence development	
10	Andersson, Bjorkman & Forsgren (2005)	158 subsidiaries	Finland & China	Western-owned	Local embeddedness	x	x	Use of expatriates	Emphasis on knowledge development	Yearly profit	Knowledge creation

11	Andersson, Forsgren & Holm (2007)	97 subsidiaries	Sweden	Mainly Europe	External network embeddedness	x	MNE strategic decisions	MNE competence development	HQ knowledge
12	Barner-Rasmussen (2003)	89 subsidiaries	Finland	Europe & USA	External embeddedness		Top manager's feedback-seeking through monitoring		Top manager's feedback-seeking through inquiry
13	Bouquet & Birkinshaw (2008)	Conceptual paper			External embeddedness & corporate embeddedness	x	Subsidiary typologies (mandates)		
14	Chiao & Ying (2012)	1473 subsidiaries		Taiwan	Internal and external network range & strength	x	Subsidiary autonomy		
15	Ciabuschi *et al*. (2011)	63 subsidiaries	Triads	Triads	Internal embeddedness	x	Involvement of HQ in the development of the innovation	Impact of the innovation at subsidiary	The importance of the developed innovation to the MNE
16	Collinson and Wang (2012)	5 subsidiaries	Taiwan		External (host) and internal (corporate) embeddedness	x	Patterns of capability-accumulation at the subsidiary level		
17	Criscuolo (2009)	4751 citations	USA	Europe	External (home) country embeddedness	x	Reverse technology transfer		
18	Dellestrand (2011)	63 subsidiaries	Triads	Triads	internal relational embeddedness & external relational embeddedness	x	Involvement of divisional HQ during the transfer of the innovation		
19	Dhanaraj *et al*. (2004)	140 joint ventures	Hungary		Relational embeddedness	x	Transfer of tacit knowledge	Young vs mature IJVs	

20	Drogendijk & Andersson (2013)	Conceptual paper			Relationship strength between subsidiary and HQ, affiliate units, local market actors, governmental & non-governmental actors		x				
21	Echols & Tsai (2005)	80 venture capital firms	USA		Network embeddedness		x	Firm performance			
22	Egelhoff (2010)	Conceptual paper			Embeddedness of subsidiaries within local environments		x	Level of new innovations generated at the subsidiary level			
23	Figueiredo (2011)	7 subsidiaries	Brazil		Dual embeddedness (i.e. intra-corporate and local embeddedness)		x	Innovative performance			
24	Jack *et al*. (2008)	18 subsidiaries	UK	Australia	Service embeddedness		x	Foreign market entry mode choice			
25	Gammelgaard et al. (2012)	350 subsidiaries	UK, Germany & Denmark	UK	Increases in inter- and intra-organizational network relationships		x	Subsidiary performance			
26	Garcia-Pont et al. (2009)	1 ten-year case study	Spain	UK	Strategic, capability and operational embeddedness		x	Subsidiary distinctiveness within the MNE	Intra- & inter-organizational network relationships		
27	Hakanson & Nobel (2001)	110 R&D subsidiaries	International	Sweden	External (host) embeddedness	x	x	Cultural distance	Subsidiary technological capacity	Age - time	Innovativeness

28	Hallin & Holmstrom Lind (2012)	210 R&D subsidiaries	Sweden	International	External (host) embeddedness	x	Intentional knowledge diffusion
29	Hallin *et al*. (2011)	376 subsidiaries	Sweden	International	External (host) embeddedness and internal (corporate) embeddedness	x	Received innovation's contribution to subsidiary business performance
30	Hong & Nguyen (2009)	4 subsidiaries	China	Japan	Technical, systemic and strategic knowledge embeddedness	x	Knowledge transfer mechanisms
31	Jindra *et al*. (2009)	458 subsidiaries	5 Eastern European countries		Internal & external technological embeddedness	x	Extent and intensity of vertical linkages with domestic firms.
32	Kramer *et al*. (2011)	2 subsidiaries	Germany and UK	Germany and UK	Regional MNEs' embeddedness	x	Regional organisation of innovation
33	Lam (2003)	4 subsidiaries	UK	USA & Japan	External (host) embeddedness	x	Organizational learning and innovation within MNEs
34	Li *et al*. (2007)	164 subsidiaries	Finland & China	Western-owned	External (host) embeddedness	x	Outward transfer of subsidiary knowledge
35	London & Hart (2004)	4 MNEs	Active in EMs		Social embeddedness (integration with the local environment)	x	Success
36	Marin & Bell (2010)	333 subsidiaries	Argentina		Corporate integration (internal embeddedness) and local integration (external embeddedness)	x	High levels of local innovative activity

37	Meyer *et al.* (2011)	Conceptual paper			Dual embeddedness (i.e. internal and external embeddedness)						
38	Moran (2005)	120 subsidiaries	International		Structural and relational embeddedness (direct ties, indirect ties, closeness & relational trust)		x	Managerial sales	Innovative performance		
39	Mu *et al.* (2007)	234 subsidiaries	USA	International	External (host) embeddedness		x	Localised innovation by the subsidiary		Knowledge outflow from the subsidiary	
40	Nell & Andersson (2012)	97 foreign-based subsidiaries	Sweden	Mainly Europe	Relational (external host) embeddedness	x		Complexity of the business network context			
41	Nell *et al.* (2011)	168 subsidiaries	International	Europe	Embeddedness overlap in the subsidiary's local network	x		Environmental uncertainty	Subsidiary partner multinationality	Subsidiary resource importance	Subsidiary past performance
42	Nell & Ambos (2013)	124 subsidiaries	International	Mainly Europe	HQ embeddedness in the subsidiary's context		x	Value added by the HQ		Strongly embedded subsidiary	
43	Newburry (2001)	477 subsidiaries	Triads		Local embeddedness		x	Increased global integration effect on office careers			
44	Newburry & Yakova(2006)	398 subsidiaries	Triads		Employee's local embeddedness		x	Employee's relationship with activity standardization	Employee's cultural background	Cultural impacts on standardization preferences	
45	Perri *et al.* (2012)	97 foreign-based subsidiaries	Sweden	Mainly Europe	Quality of vertical local linkages	x		Local competitive pressure		Subsidiary capabilities	

46	Pinkse & Kolk (2012)	Conceptual paper			Institutional embeddedness in home, hostand supranational contexts		x	Green market development			
47	Rizopoulos & Sergakis (2010)	Conceptual paper			Institutional embeddedness in home and host context		x				
48	Santangelo (2009)	20 subsidiaries	Italy	Triads	Local linkages creation	x		Local market strategy		Organizational structure	
49	Santangelo (2012)	20 subsidiaries	Italy	Triads	External embeddedness (relational ties with domestic actors)		x	Rival vs. non-rival subsidiaries	Knowledge production	Competence-creating vs. non-competence-creating motivation	
50	Schmid & Schurig (2003)	2110 subsidiaries	Europe	Triads	Internal network partners and external network partners		x	Development of critical capabilities	The parent company, market customers, external market customers, external suppliers, external R&D and internal R&D units		Younger vs older subsidiaries
51	Song *et al*. (2011)	26 R&D subsidiaries	Europe & USA	Japan	External (host) and internal embeddedness		x	Level of knowledge sourcing from host countries by overseas R&D labs			
52	Spencer (2008)	Conceptual paper			Local embeddedness (as a form of vertical & horizontal linkages)		x	Crowd local firms out of the MNE's industry in the short run	horizontal spillovers	Horizontal spillovers for firms in the MNE's industry in the long run.	
53	Sun *et al*. (2010)	3 cases studies accompanied by 142 interviews	China	International	Political embeddedness		x	Long-run competitive positions			

54	Williams & Lee (2011)	Conceptual paper			External (host) embeddedness and empowerment between headquarters managers and subsidiary managers (internal embeddedness)		x	Effective coordination of entrepreneurial knowledge		
55	Williams & Nones (2009)	138 R&D subsidiaries	Austria	Europe & USA	R&D Subsidiary Isolationfrom internal and externalnetworks	x		Proximity between R&D subsidiary and parent HQ	Experience of parent in broad product markets, and of subsidiary in R&D patenting and transfer	Subsidiary role & subsidiary personnel development
56	Yamin & Andersson (2011)	97 foreign-based subsidiaries	Sweden	Mainly Europe	Internal embeddedness		x	Its importance for product development in the MNE	External embeddedness effect on subsidiary's importance for production and product development	
57	Yamin *et al*. (2011)	129 studied transfer projects	Sweden	Europe & USA	Dyadic relationship (Partner similarity, cooperation experience)		x	Transfer performance	HQ involvement	

APPENDIX 2

A2. 1. STATA Do. File

REGRESSIONS FOR RQ1

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summ EHome EHost Internal SLs LILs IILs Centralization Endowment
Macro_uncertainty Greenfield ln_Size ln_Years ln_Geo_Dist Cult_Dist
US UK CP EC PH

pwcorr EHome EHost Internal SLs LILs IILs Centralization Endowment
Macro_uncertainty Greenfield ln_Size ln_Years ln_Geo_Dist Cult_Dist
US UK CP EC PH, star(10)

corr EHome SLs LILs IILs Centralization Endowment Macro_uncertainty
Greenfield ln_Size ln_Years ln_Geo_Dist Cult_Dist US UK CP EC PH,
means

reg EHome SLs LILs IILs Centralization Endowment Macro_uncertainty
Greenfield ln_Size ln_Years ln_Geo_Dist Cult_Dist US UK CP EC PH,
beta

vif

corr EHost SLs LILs IILs Centralization Endowment Macro_uncertainty
Greenfield ln_Size ln_Years ln_Geo_Dist Cult_Dist US UK CP EC PH,
means

reg EHost SLs LILs IILs Centralization Endowment Macro_uncertainty
Greenfield ln_Size ln_Years ln_Geo_Dist Cult_Dist US UK CP EC PH,
beta

vif

corr Internal SLs LILs IILs Centralization Endowment
Macro_uncertainty Greenfield ln_Size ln_Years ln_Geo_Dist Cult_Dist
US UK CP EC PH, means

reg Internal SLs LILs IILs Centralization Endowment
Macro_uncertainty Greenfield ln_Size ln_Years ln_Geo_Dist Cult_Dist
US UK CP EC PH, beta

vif


sureg (EHome SLs LILs IILs Centralization Endowment
Macro_uncertainty Greenfield ln_Size ln_Years ln_Geo_Dist Cult_Dist
US UK CP EC PH) (EHost SLs LILs IILs Centralization Endowment
Macro_uncertainty Greenfield ln_Size ln_Years ln_Geo_Dist Cult_Dist
US UK CP EC PH) (Internal SLs LILs IILs Centralization Endowment
Macro_uncertainty Greenfield ln_Size ln_Years ln_Geo_Dist Cult_Dist
US UK  CP EC PH)
```

REGRESSIONS FOR RQ2

```
summ EHome EHost Internal Production_sub Centralization Endowment
Greenfield ln_Size ln_Years ln_Geo_Dist Cult_Dist US UK  CP EC PH

pwcorr EHome EHost Internal Production_sub Centralization Endowment
Greenfield ln_Size ln_Years ln_Geo_Dist Cult_Dist US UK  CP EC PH,
star(10)
corr EHome Production_sub Centralization Endowment Greenfield
ln_Size ln_Years ln_Geo_Dist Cult_Dist US UK  CP EC PH, means

reg EHome Production_sub Centralization Endowment Greenfield ln_Size
ln_Years ln_Geo_Dist Cult_Dist US UK  CP EC PH, beta

vif

corr EHost Production_sub Centralization Endowment Greenfield
ln_Size ln_Years ln_Geo_Dist Cult_Dist US UK  CP EC PH, means

reg EHost Production_sub Centralization Endowment Greenfield ln_Size
ln_Years ln_Geo_Dist Cult_Dist US UK  CP EC PH, beta

vif

corr Internal Production_sub Centralization Endowment Greenfield
ln_Size ln_Years ln_Geo_Dist Cult_Dist US UK  CP EC PH, means

reg Internal Production_sub Centralization Endowment Greenfield
ln_Size ln_Years ln_Geo_Dist Cult_Dist US UK  CP EC PH, beta

vif

reg EHome Production_sub Centralization Endowment Greenfield ln_Size
ln_Years ln_Geo_Dist Cult_Dist US UK  CP EC PH, cluster (HCOUNTRY)

predict resid1, residual

reg EHost Production_sub Centralization Endowment Greenfield ln_Size
ln_Years ln_Geo_Dist Cult_Dist US UK  CP EC PH, cluster (HCOUNTRY)


predict resid2, residual

reg Internal Production_sub Centralization Endowment Greenfield
ln_Size ln_Years ln_Geo_Dist Cult_Dist US UK  CP EC PH, cluster
(HCOUNTRY)

predict resid3, residual

pwcorr resid1 resid2 resid3, star(10)

summ LnPatents Production_sub Centralization Endowment Greenfield
ln_Size ln_Years ln_Geo_Dist Cult_Dist US UK  CP EC PH New_Home
New_Host New_Internal HMxHS HMxI HSxI HMxHSxI

pwcorr LnPatents Production_sub Centralization Endowment Greenfield
ln_Size ln_Years ln_Geo_Dist Cult_Dist US UK  CP EC PH New_Home
New_Host New_Internal HMxHS HMxI HSxI HMxHSxI, star(10)
```

```
corr LnPatents Production_sub Centralization Endowment Greenfield
ln_Size ln_Years ln_Geo_Dist Cult_Dist US UK  CP EC PH New_Home
New_Host New_Internal HMxHS HMxI HSxI HMxHSxI, means

reg LnPatents Production_sub Centralization Endowment Greenfield
ln_Size ln_Years ln_Geo_Dist Cult_Dist US UK  CP EC PH New_Home
New_Host New_Internal HMxHS HMxI HSxI HMxHSxI, beta

vif

logit LnPatentsp11 SLs LILs IILs Centralization  Endowment
Greenfield ln_Size ln_Years ln_Geo_Dist Hofstede US UK  CP EC PH
b100 b010 b001 b110 b011 b101 b111

scalar m1 = e(ll)

logit LnPatentsp11 SLs LILs IILs Centralization  Endowment
Greenfield ln_Size ln_Years ln_Geo_Dist Hofstede US UK  CP EC PH
b100 b010 b001 b110 b011 b101 b111 if b111 + b001 - b011 - b101 > =
0

scalar m2 = e(ll)

di "chi2(2) = " 2*(m2-m1)

di "Prob > chi2 = "chi2tail(2, 2*(m2-m1))

logit LnPatentsp11 SLs LILs IILs Centralization  Endowment
Greenfield ln_Size ln_Years ln_Geo_Dist Hofstede US UK  CP EC PH
b100 b010 b001 b110 b011 b101 b111 if b110 - b100 - b010 > = 0

scalar m3 = e(ll)

di "chi2(2) = " 2*(m3-m1)

di "Prob > chi2 = "chi2tail(2, 2*(m3-m1))

logit LnPatentsp11 SLs LILs IILs Centralization  Endowment
Greenfield ln_Size ln_Years ln_Geo_Dist Hofstede US UK  CP EC PH
b100 b010 b001 b110 b011 b101 b111 if b111 + b001 - b011 - b101 < =
0

scalar m4 = e(ll)

di "chi2(2) = " 2*(m4-m1)

di "Prob > chi2 = "chi2tail(2, 2*(m4-m1))

logit LnPatentsp11 SLs LILs IILs Centralization  Endowment
Greenfield ln_Size ln_Years ln_Geo_Dist Hofstede US UK  CP EC PH
b100 b010 b001 b110 b011 b101 b111 if b110 - b100 - b010 < = 0

scalar m5 = e(ll)

di "chi2(2) = " 2*(m5-m1)

di "Prob > chi2 = "chi2tail(2, 2*(m5-m1))

logit LnPatentsp11 SLs LILs IILs Centralization  Endowment
Greenfield ln_Size ln_Years ln_Geo_Dist Hofstede US UK  CP EC PH
b100 b010 b001 b110 b011 b101 b111 if b111 + b010 - b011 - b110 > =
0
```

```
scalar m6 = e(ll)

di "chi2(2) = " 2*(m6-m1)

di "Prob > chi2 = "chi2tail(2, 2*(m6-m1))

logit LnPatentsp11 SLs LILs IILs Centralization  Endowment
Greenfield ln_Size ln_Years ln_Geo_Dist Hofstede US UK  CP EC PH
b100 b010 b001 b110 b011 b101 b111 if b101 - b100 - b001 > = 0

scalar m7 = e(ll)

di "chi2(2) = " 2*(m7-m1)

di "Prob > chi2 = "chi2tail(2, 2*(m7-m1))

logit LnPatentsp11 SLs LILs IILs Centralization  Endowment
Greenfield ln_Size ln_Years ln_Geo_Dist Hofstede US UK  CP EC PH
b100 b010 b001 b110 b011 b101 b111 if b111 + b010 - b011 - b110 < =
0

scalar m8 = e(ll)

di "chi2(2) = " 2*(m8-m1)

di "Prob > chi2 = "chi2tail(2, 2*(m8-m1))

logit LnPatentsp11 SLs LILs IILs Centralization  Endowment
Greenfield ln_Size ln_Years ln_Geo_Dist Hofstede US UK  CP EC PH
b100 b010 b001 b110 b011 b101 b111 if b101 - b100 - b001 < = 0

scalar m9 = e(ll)

di "chi2(2) = " 2*(m9-m1)

di "Prob > chi2 = "chi2tail(2, 2*(m9-m1))

logit LnPatentsp11 SLs LILs IILs Centralization  Endowment
Greenfield ln_Size ln_Years ln_Geo_Dist Hofstede US UK  CP EC PH
b100 b010 b001 b110 b011 b101 b111 if b111 + b100 - b101 - b110 > =
0

scalar m10 = e(ll)

di "chi2(2) = " 2*(m10-m1)

di "Prob > chi2 = "chi2tail(2, 2*(m10-m1))

logit LnPatentsp11 SLs LILs IILs Centralization  Endowment
Greenfield ln_Size ln_Years ln_Geo_Dist Hofstede US UK  CP EC PH
b100 b010 b001 b110 b011 b101 b111 if b011 - b010 - b001 > = 0

scalar m11 = e(ll)

di "chi2(2) = " 2*(m11-m1)

di "Prob > chi2 = "chi2tail(2, 2*(m11-m1))

logit LnPatentsp11 SLs LILs IILs Centralization  Endowment
Greenfield ln_Size ln_Years ln_Geo_Dist Hofstede US UK  CP EC PH
b100 b010 b001 b110 b011 b101 b111 if b111 + b100 - b101 - b110 < =
0

scalar m12 = e(ll)
```

```
di "chi2(2) = " 2*(m12-m1)

di "Prob > chi2 = "chi2tail(2, 2*(m12-m1))

logit LnPatentsp11 SLs LILs IILs Centralization  Endowment
Greenfield ln_Size ln_Years ln_Geo_Dist Hofstede US UK  CP EC PH
b100 b010 b001 b110 b011 b101 b111 if b011 - b010 - b001 < = 0

scalar m13 = e(ll)

di "chi2(2) = " 2*(m13-m1)

di "Prob > chi2 = "chi2tail(2, 2*(m13-m1))
```

REGRESSIONS FOR RQ3

```
summ lnPatents Internal External_Host External_Home Autonomous
factor1 factor2 lnGeoProx Hofstede CHEMICALSPETROLEUM ELECTRONICS
MOTORSANDMECHANICHALPRODUCTS PHARMACEUTICALS

pwcorr lnPatents Internal External_Host External_Home Autonomous
factor1 factor2 lnGeoProx Hofstede CHEMICALSPETROLEUM ELECTRONICS
MOTORSANDMECHANICHALPRODUCTS PHARMACEUTICALS, star(10)

corr lnPatents Internal External_Host External_Home Autonomous
factor1 factor2 lnGeoProx Hofstede CHEMICALSPETROLEUM ELECTRONICS
MOTORSANDMECHANICHALPRODUCTS PHARMACEUTICALS, means

reg lnPatents Internal External_Host External_Home Autonomous
factor1 factor2 lnGeoProx Hofstede CHEMICALSPETROLEUM ELECTRONICS
MOTORSANDMECHANICHALPRODUCTS PHARMACEUTICALS, beta

vif

xtmixed lnPatents ||  Parentcompany: || Hostcountry: , var ml

estat ic

xtmixed lnPatents Internal External_Host External_Home  ||
Parentcompany: || Hostcountry: , var ml

estat ic

xtmixed lnPatents Internal External_Host External_Home Autonomous
||  Parentcompany: || Hostcountry: , var ml

estat ic

xtmixed lnPatents Internal External_Host External_Home Autonomous
factor1 factor2   ||  Parentcompany: || Hostcountry: , var ml

estat ic

xtmixed lnPatents Internal External_Host External_Home Autonomous
factor1 factor2 lnGeoProx Hofstede CHEMICALSPETROLEUM ELECTRONICS
MOTORSANDMECHANICHALPRODUCTS PHARMACEUTICALS  ||  Parentcompany: ||
Hostcountry: , var ml

estat ic
```

APPENDIX 3

A3.1. Subsidiary questionnaire

X @2INIT SAS ⇒ To set the screen
SAS @2 ⇒ To input data
PERMANENT DATA FILE = @2.SASDATA

UNIVERSITY OF READING

Department of Economics
Faculty of Letters and Social Sciences
PO Box 218, Whiteknights
Reading RG6 2AA
England

Telephone: (0734) 875123 Ext. 4045

REFERENCE for CODES
Questionnaire Used To set-up
the Screen for Data In

Questionnaire for
Subsidiary R & D Centres on

Global Research Strategy and International Competitiveness

SAS @2NEW ⇒ To get into the data file

SECTION I : SOME BASIC DATA

1 Name of the Company

S101 $16 I.1 Company Name

2 Name and Nationality of the Parent Company

Name S102a $16 I.2 Parent Co Name

Nationality S102b $16 I.2 Parent Co Nation

3 Year of incorporation of R and D facility

S103 2 I.3 Year of R D Incorpn

4 Is this R and D facility associated with a production subsidiary ? ***Please tick***

S104 2 I.4 Assn with Prod Sub

(i) Yes 1

(ii) No 0

5. If answer to question No. 4 is yes, in which year was the production subsidiary formed?

S105 2 I.5 Yr Prodn Sub Fmd

6. Please fill in the following data for one recent year

Year S106a 2 I.6 Year

R and D Expenditure S106b 2 I.6 R&D Exp

R and D Employment S106c 2 I.6 R&D Emp

SECTION II: ORIGIN AND BACKGROUND OF THE R AND D UNIT

1. How did this R and D unit originate? ***Please tick*** II.1

(i) fresh installation for specific purpose(s) S2Q1A 1

(ii) acquisition of an independant existing R and D facility S2Q1B 1

(iii) acquisition as part of company involved in merger/takeover S2Q1C 1

(iv) collaboration joint R and D venture with another company S2Q1D 1

(v) others, please specify ____ S2Q1E ____ ____ ____ ____ 1

2. Which conditions or circumstances do you consider have most influenced recent decisions with regard to the development of this unit. **Please grade** the relevance of each of the following possible influences as

1: Irrelevant to decisions
2: Of some influence on decisions
3: A major factor contributing to the decisions

(i) a distinctive local scientific, educational or technological tradition conducive to certain types of research project ..... S2Q2a 2 II.2 i

(ii) presence of a helpful local scientific environment and adequate technical infrastructure ..... S2Q2b 2 II.2 ii

(iii) availability of research professionals ..... S2Q2c 2 II.2 iii

(iv) favourable wage rates for the research professionals ..... S2Q2d 2 II.2 iv

(v) need to provide technical services to the local production unit ..... S2Q2e 2 II.2 v

(vi) to help modify/standardise products

(a) for the local market ..... S2Q2fa 2 II.2 via

(b) for overseas markets ..... S2Q2fb 2 II.2 vib

(vii) to help develop new products

(a) for the local market ..... S2Q2ga 2 II.2 viia

(b) for overseas markets ..... S2Q2gb 2 II.2 viib

Contd

(viii) to provide technical support to other parts of the multinational group. S202H 2 II.2.viii ☐

(ix) large and growing local market where R and D is seen to play a critical role..... S202I 2 II.2.ix ☐

(x) absence of local R and D competitors which may allow the firm to derive distinctive new product lines S202J 2 II.2.x ☐

(xi) to forestall entry of another firm..... S202K 2 II.2.xi ☐

(xii) to match local R and D of competitor firms..... S202L 2 II.2.xii ☐

3. How important was the influence of the following factors on the growth of this R and D unit? ***Please grade*** each factor according to following scale

1: of no importance
2: of some importance
3: of major importance

(i) growth of host country market..... S203a 2 II.3.i ☐

(ii) growth of overseas affiliate (and Parent's) market..... S203b 2 II.3.ii ☐

(iii) rate of change of technology in the industry..... S203c 2 II.3.iii ☐

SECTION III : RESEARCH METHODS

1. What are the most likely sources of project ideas initiated in this unit? ***Please grade*** each alternative source by the scale

N.A = 0

1. never a source of ideas.
2. occasionally a source of ideas
3. a regular source of ideas

(i) suggested by Parent ..... S301a 2 III.1.i ☐

(ii) suggested by sister affiliates..... S301b 2 III.1.ii ☐

(iii) own proposals approved by Parent..... S301c 2 III.1.iii ☐

(iv) feedback from local

(a) production units..... S301da 2 III.1.iva ☐

(b) marketing units ..... S301db 2 III.1.ivb ☐

(c) sales channels ..... S301dc 2 III.1.ivc ☐

Contd

(d) customers' desires S301dd 2 III.1iv ☐

(v) feedback from foreign

(a) production units S301ea 2 III.1va ☐

b) marketing units S301eb 2 III.1vb ☐

(c) sales channels S301ec 2 III.1vc ☐

(d) customers' desires S301ed 2 III.1vd ☐

(vi) part of collaborative research with another enterprise S301f 2 III.1vi ☐

(vii) independent local researchers S3019 2 III.1vii ☐

2. What is the normal length of a research project ?

S302a 2 III.2 ☐

3. Are the parent or other sister R and D units involved in your projects in any of the following ways ? ***Please grade*** each form of intervention by scale

1: never
2: occasionally
3: regularly

(i) systematic co-ordination of your projects into wider programmes .. S303a 2 III.3i ☐

(ii) to bring about a major change in the direction of the project..... S303b 2 III.3ii ☐

(iii) to advise on the development of a project..... S303c 2 III.3iii ☐

(iv) technical assistance at the request of the R and D unit ..... S303d 2 III.3iv ☐

4. Are promising projects shifted to parent or other strategic labs of the group around the world? ***Please tick***

(i) never S304 2 III.4 1

(ii) occasionally 2

(iii) regularly 3

(iv) automatically 4

5. Does this unit undertake the following types of work? ***Please grade*** each type by scale

1: never 2: occasionally 3: regularly

(i) basic/original research..... S3.05a 2 III.5i ☐

(ii) applied research:

(a) to derive new products in present industry..... S3.05ba 2 III.5iia ☐

(b) to derive new production technology in present industry... S3.05bb 2 III.5iib ☐

(iii) applied research:

(a) to adapt existing products to the local market..... S3.05ca 2 III.5iiia ☐

(b) to adapt existing production technology to the local environment..... S3.05cb 2 III.5iiib ☐

(iv) to derive additional products in new areas of specialisation .. S3.05d 2 III.5iv ☐

6. How is expenditure on R and D allocated? ***Please tick*** S3.06 2 III.6

(i) as fixed percentage of sales revenue ..... S3.06A ☐ 1

(ii) as a lump sum ..... S3.06B ☐ 1

(iii) complex planning cycle to determine the budget..... S3.06C ☐ 1

(iv) more funds allocated in times of need ..... S3.06D ☐ 1

(v) no rigid procedure ..... S3.06E ☐ 1

7. How important are the following as a source of finance for research projects? ***Please grade*** each source according to the codes:

1: of no importance
2: of some importance
3: of major importance
4: the only source of financing

(i) parent..... S3.07a 2 III.7i ☐

(ii) sister affiliates overseas..... S3.07b 2 III.7ii ☐

(iii) associated local manufacturing unit..... S3.07c 2 III.7iii ☐

(iv) host country government..... S3.07d 2 III.7iv ☐

(v) others, please specify ____ S3.07e 2 III.7v ☐

8. If the host government offers any support for your R and D operations, what form does it take?

S308
BLANK = 0
NA = 1
NO SUPPORT = 2
FISCAL SUPPORT = 3 ⇒ Tax, Exp Subsidy
MONETARY SUPPORT = 4 ⇒ Many
OTHERS = 5
If 3+4 = 6

9. What form of support for your R and D work would you most welcome from host government?

S309
BLANK = 0
NA = 1
NO SUPPORT = 2
FISCAL SUPPORT = 3
MONETARY SUPPORT = 4
OTHERS = 5
If 3+4 = 6
write up and/ No Support

10. Have any host country R and D policies hampered your research work? If so please specify.

S3@10a
BLANK = 0
NA = 1
YES = 2
NO = 3
write up = 4

SECTION IV : AFFILIATE - PARENT R AND D UNIT RELATIONSHIP

1. How would you classify this R and D unit in terms of the types listed below?
Please grade each type according to the scale:
1: predominantly this type of laboratory
2: partially this type of laboratory
3: not this type of laboratory

(i) Support Laboratories (SL); to assist production and marketing facilities in the host country to make effective use of parent's existing technology S401a 2 IV.1i ☐

(ii) Locally Integrated Laboratory (LIL) which though predominantly oriented to the local market and/or production conditions, involves more fundamental development activity than the SL S401b 2 IV.2ii ☐

Contd

(iii) International Interdependent Laboratory (IIL); playing a role in an integrated R and D programme co-ordinated by the parent (or other major) laboratory S401C 2 IV.1iii [ ]

2. If the unit has grown in size over time has this been: ***Please tick***

(i) mostly at the encouragement of the parent? S402a 2 IV.2i [1]

(ii) mostly as a result of its own success? S402b 2 IV.2ii [2]

(iii) because of both (i) and (ii) above S402C 2 IV.2iii [3]

3. If the answer to previous question is (ii) how do you perceive the parent's attitude to this growth? ***Please tick*** S403 2 IV.3

(i) support for continued autonomous growth S403A [1]

(ii) increased desire to integrate the facility into a wider programme S403B [1]

(iii) treating the unit with suspicion as a potential threat S403C [1]

(iv) others; please specify S403D [1]

4. How do you perceive the strategy of the parent towards its various R and D units? ***Please tick*** S404 2 IV.4

(i) allowing substantial autonomy S404A [1]

(ii) allowing them to develop independent initiatives, but under close central scrutiny S404B [1]

(iii) incorporating their work into a carefully co-ordinated programme S404C [1]

(iv) others; please specify S404D [1]

S405

5. To whom does the head of the centre report about the progress and results of the project?

(i) Central R and D abroad S505a 2 IV.5i [1]

(ii) local Management S505b 2 IV.5ii [2]

(iii) others S505c 2 IV.5iii [3]

(iv) (i) and (ii) [4]

6. Do this and other R and D units of the parent company interact? ***Please tick*** S406 2 IV.6

(i) very often [1]

(ii) seldom [2]

(iii) never [3]

SECTION V : DIFFUSION OF R AND D

1. How would you rate the size of this R and D unit? ***Please tick***

S5Q1 2 V.1

(i) average for the group..... 1

(ii) above average for the group..... 2

(iii) below average for the group..... 3

2. What percentage of your total employment is made up of local personnel?

S5Q2 2 V.2

.....

0-20 =
20-40 = 2
40-60 = 3
60-80 = 4
80-100 = 5

3. Are training programmes held for local staff? ***Please tick***

(i) on recruitment. S5Q3a 2 V.3i 1

(ii) during employment. S5Q3b 2 V.3ii 1

4. Are local R and D staff shifted to the parent or other sister R and D units? ***Please tick***

S5Q4 2 V.4

(i) never..... 1

(ii) rarely / sometimes..... 2

(iii) frequently for short durations..... 3

(iv) frequently for long durations..... 4

(v) (iii) & (iv) — — — — — — — 5

5. Do any personnnel transferred to the parent R and D unit ? ***Please tick as appropriate***

S5Q5 2 V.5

(i) continue to mainly carry out R and D work..... 1

(ii) become involved in R and D decision making and co-ordination activity. 2

(iii) do both (i) and (ii)..... 3

6. What is the turnover rate of local R and D personnel? ***Please tick***

S506 2 V.6

(i) less than 5% p.a..... 1

(ii) 5-10% p.a..... 2

(ii) 10–20% p.a..... 3

(iii) over 20% p.a..... 4

7. Does there exist any liaison between this R and D unit and home country:

(i) research institutions S507a 2 V.7i .....

(ii) universities S507b 2 V.7ii .....

(iii) R and D labs of local and/or foreign companies S507c 2 V.7iii .....

Please grade each of these institutions according to the following scale
1: regular contacts 2: occasional contacts 3: no contacts

8. Are seminars relating to ongoing research in this unit held either on its own or in collaboration with other research units/institutions? ***Please tick***

S508 2 V.8

(i) never..... 1

(ii) as and when required..... 2

(iii) systematic program of seminars..... 3

9. What is the extent of this unit's reliance on local libraries, libraries of local research institutions/laboratories, personal collection of scientists, for its research needs? ***Please tick***

S509 2 V.9

(i) high..... 1

(ii) moderate..... 2

(iii) low..... 3

10. Are research findings of this unit published in journals? ***Please tick***

S510 2 V.10

(i) never..... 1

(ii) sometimes..... 2

(iii) frequently..... 3

11. Does this unit provide any technical support/assistance to its local suppliers? ***Please tick*** S5 11 2 V. 11

(i) never..... 1

(ii) sometimes..... 2

(iii) frequently..... 3

12. Have any product(s)/process(es) developed by this R and D unit been successfully copied for production by local firms? ***Please tick***

(i) never... S5 12 2 V. 12 1

(ii) sometimes..... 2

(iii) frequently..... 3

13. Does this R and D unit undertake consultancy work/contract jobs for public research institutions, universities, or other firms? ***Please tick*** S5 @ 13 2 V. 13

(i) never..... 1

(ii) sometimes..... 2

(iii) frequently..... 3

14. Does this R and D unit give contract jobs to the following institutions in this country

(i) independent S5 14a 2 V. 14i research laboratories ..... [ ]

(ii) universities... S5 14b 2 V. 14ii ..... [ ]

(iii) R and D Labs S5 14c 2 V. 14 iii of other firms..... [ ]

(iv) others; please specify S5 14d 2 V. 14 iv ____ 4

Please grade each of the above institutions according to the scale
1: never 2: sometimes 3: frequently

15. Does there exist any exchange programme of scientists between this unit and other local research institutions/labs? ***Please tick*** S5 15 2 V. 15

(i) never..... 1

(ii) sometimes..... 2

(iii) regularly..... 3

SECTION VI : DYNAMICS OF R AND D

1. What changes has this unit undergone in the nature of its work since inception ?

S601 2. VI.1

Blank = 0

N. A = 1

None = 2

Minor = 3

Myriad = 4

write up = 5

2. What further changes does this unit envisage in the nature of work in the future?

S602 2. VI.2

Blank = 0

N. A = 1

None = 2

Minor = 3

Several = 4

write up = 5

3. Have you seen any change in the attitude of the host government over time towards this R and D unit?

S603 2. VI.3

Blank = 0 Negative = 5

N. A = 1 write up = 6

No = 2

Yes = 3

Positive = 4

4. Do you foresee or suggest any changes in the work and role of this R and D unit in the near future?

S6044 2 VI.4

Blank = 0

N.A = 1

No = 2

Minor changes = 3

Major changes = 4

Write-up = 5

For Office Use Only

1. Questionnaire Serial No A91 53 $7 UNITTO ATTEMPTS
2. Country Code $3 COUNTRY
3. Industry Code $3 INDUSTRY
4. Parent Country Code $3 PCOUNTRY
5. Parent Industry Code $3 PINDUSTRY
6. Date Sent 28.2.89 dd/mm/yy DATE SENT 4
7. Date Received dd/mm/yy DATE RECV 4

A3.2. HQ (Parent) questionnaire

* USE FOR CODES *

UNIVERSITY OF READING

Department of Economics
Faculty of Letters and Social Sciences
PO Box 218, Whiteknights
Reading RG6 2AA
England

Telephone: (0734) 875123 Ext. 4045

SAS 01 = Jo input Data ⇒ old
01INIT SAS = Jo Set-up the Screen
Permanent Data Set = 01.SASDATA

Questionnaire for
Parent R & D Centres on

Global Research Strategy and International Competitiveness

NEW
01NEW.SASDATA

01SASDATA | Still on
01ORIGIN | Disk

IS 01 NEW = Jo Get into Data file ⇒ New

SECTION I: SOME BASIC DATA

1 Name of Company

Q101 Name

Date of incorporation of Company

Q101 Year

2. Total number of foreign manufacturing and/or marketing affiliates [branches, subsidiaries, associates, etc] Q902 Numexma = Blank

3. Please fill in the following:

Country where the Group has R & D unit (s)	Number of R & D units	Dates established	R & D Expenditure for a recent year.Pl.specify year. US or any currency
[1]	[2]	[3]	[4]

4. (a) Percentage of total group R & D expenditure carried out by foreign affiliates

.....%

(b) Percentage of total group R & D employment in foreign affiliates

.....%

SECTION II: ORIGIN AND BACKGROUND OF THE R & D UNIT

1. In which year did this R & D unit originate? (at current or previous location)

.....

2. How did this R & D unit originate? ***Please tick***

(i) fresh installation for specific purpose(s)..... 1

(ii) acquisition of an independent existing R & D facility..... 2

(iii) acquisition as part of company involved in merger/takeover..... 3

(iv) collaboration in joint R & D venture with another company..... 4

(v) to centralise existing R & D activities..... 5

(vi) others, please specify ——————————— 6

3. Which conditions or circumstances do you consider have most influenced recent decisions with regard to the development of this unit. ***Please grade*** the relevance of each of the following possible influences as:

1 : irrelevant to decisions.
2 : of some influence on decisions.
3 : a major factor contributing to the decisions.

(i) a *distinctive* local scientific, educational or technological tradition conducive to certain types of research project..... ☐

(ii) presence of generally helpful local scientific environment and adequate technical infrastructure..... ☐

(iii) availability of research professionals..... ☐

(iv) favourable wage rates for the research professionals..... ☐

(v) out of concern to avoid being left behind in the long run technological competitiveness of the firm's major industries..... ☐

(vi) large and growing market where R & D is seen to play a crucial role..... ☐

contd

(vii) absence of local R & D competitors which may lead firms to derive distinctive new product lines..... ☐

(viii) reaction to R and D activities by other firms..... ☐

4. How important was the influence of the following factors on the growth of this R & D unit? ***Please grade*** according to following scale:

1 : of no importance.
2 : of some importance.
3 : of major importance.

(i) growth of home country market..... ☐

(ii) growth of foreign affiliate markets..... ☐

(iii) rate of change of technology in the industry..... ☐

5. If you have a number of affiliate R & D units, how do you rate the size and importance of this unit? ***Please write appropriate numbers.***

1. The smallest / least important 2. Below average 3. Average 4. Above average 5.The largest/most important.

Size..... ☐

Importance..... ☐

6. How do you rate the importance of this unit in terms of direction and lead taken in group research. ***Please tick.***

1. Sole decision maker on direction taken by group R & D..... ☐ 1

2. Leading coordinating role in direction taken by group's R & D..... ☐ 2

3. Only influences the direction of its own R & D..... ☐ 3

CONTINUED

SECTION III: RESEARCH METHODS

1. What are the most likely sources of project ideas initiated in this unit. ***Please grade*** each alternative source by the scale:

   1 : never a source of ideas.
   2 : occasionally a source of ideas.
   3 : a regular source of ideas.

(i) proposals put up by the personnel of this R & D unit..... ☐

(ii) suggestions from affiliate R & D units..... ☐

(iii) feedback from:

(a) local production unit..... ☐

(b) foreign production unit..... ☐

(c) local marketing units..... ☐

(d) foreign marketing units..... ☐

(e) local sales channels..... ☐

(f) foreign sales channels..... ☐

(g) local customer's desires..... ☐

(h) foreign customer's desires..... ☐

(iv) part of collaborative research with another enterprise..... ☐

(v) Others, please specify _____ 1

2. What is the normal length of a research project?

Months : [transfer from yrs] ⟶ to ⟶ (Range)

3. Does this unit undertake the following types of work? ***Please grade*** each type according to the codes:

   1 : Never 2 : Occasionally 3 : Regularly

(i) Basic/original research..... ☐

contd

(ii) Applied research

(a) to derive new products in present industry..... ☐

(b) to derive new production technology in present industry.... ☐

(iii) improvement of existing products and/or techniques..... ☐

(iv) to derive additional products in new areas of specialisation.. ☐

4. How is expenditure on R & D allocated? *Please tick*

(i) as a fixed percentage of sales revenue..... 1

(ii) as a lump sum..... 2

(iii) more funds allocated in times of need..... 3

(iv) no rigid procedure..... 4

5. What percentage of your current projects are receiving government funding support?

N.A. Input / Actual figures

6. Approximately what percentage of your R & D budget is accounted for by government funding?

Input Actual figures

PLEASE OMIT SECTION IV IF YOU DO NOT HAVE ANY FOREIGN R AND D UNITS

SECTION IV: GLOBAL STRATEGY AND PARENT - AFFILIATE R AND D UNIT RELATIONSHIP

1. Does the group have a clear strategy on international decentralisation or centralisation of R & D and innovative activity? If so could you describe briefly?Please use extra sheet, if necessary.

Blank = 0

N.A = 1

No = 2

YES = 3

write-up = 4

.....

.....

.....

2. What proportion of foreign R & D units do you consider to be:

(i) closely coordinated with the parent R & D unit..... %

(ii) loosely coordinated with the parent R & D unit..... %

(iii) autonomous from parent R & D unit..... %

3. Given the following categories of R & D:

(i) Basic/original research..... ☐

(ii) Applied research:

(a) to derive new products in present industry..... ☐

(b) to derive new production technology in present industry ... ☐

(iii) improvement of existing products and/or techniques..... ☐

(iv) to derive additional products in new areas of specialisation..... ☐

Which categories of above type of work you consider to be:

(1) relatively more important in overseas R & D units than in parent?
(2) equally important in overseas and parent R & D units
(3) relatively less important in overseas R & D units than in parent's.
(4) not applicable since this type of work is not carried out in either foreign or parent R & D units.

Please mark the numbers 1, 2, 3 or 4 in appropriate boxes above

4. Which of the following factors influence the type of work done in overseas R & D units? ***Please grade*** each according to the following codes.

1 .Never relevant. 2 .Sometimes relevant. 3. Nearly always relevant.

(i) a *distinctive* local scientific, educational or technological tradition conducive to certain types of research project..... ☐

(ii) cost factors..... ☐

(iii) only room for a small number of basic R & D laboratories..... ☐

(iv) need to adapt product to local market..... ☐

(v) need to adapt production techniques to local conditions..... ☐

contd

(vi) need to develop distinctive new products for the local market..... ☐

(vii) other factors, please specify ⟹ All Blanco

5. What is the overall level of interaction between parent and foreign affiliate R & D units? ***Please tick.***

(i) Systematic coordination..... 1

(ii) Ad hoc consultations..... 1

(iii) Infrequent interaction..... 1

6. Are promising projects shifted from an affiliate R & D laboratory to the parent R & D unit at crucial stages of its development? ***Please tick***

(i) Automatically..... 1

(ii) Frequently..... 2

Sometimes ---------- 3

(iii) Rarely..... 4

(iv) Never..... 5

7. When promising projects are shifted from an affiliate R & D unit to the parent, is this done: ***Please tick***

(i) to better complete the research work..... 1

(ii) because the parent country is the most likely market for innovation of a new product..... 1

(iii) Other reasons; please specify ---------- 1

8. Are promising projects shifted from parent R & D units to a foreign R & D unit? ***Please tick***

(i) Automatically..... 1

(ii) Frequently..... 2

(iii) Sometimes ---------- 3

(iii) Rarely..... 4

(iv) Never..... 5

9. When promising projects are shifted from parent R & D units is this done: ***Please tick***

(i) to better complete the research work..... 1

(ii) to ensure that the outcome is best directed to a particular market..... 1

(iii) Other reasons; please specify. Please use extra sheet, if necessary. 1

SECTION V: DIFFUSION OF R & D

1. What is the total employment in this R &D unit?
.....

2. How would you rate the size of this R & D unit? *Please tick.*

(i) average for the industry..... 1

(ii) above average for the industry..... 2

(iii) below average for the industry..... 3

3. (a) What percentage of total employment is made up of foreign personnel?
.....

(b) Of these foreign personnel what percentage are: ~~Please tick~~

(i) recruited on the open market.....

(ii) seconded from within foreign laboratories of the group.....

4. Are training programmes held for the staff? *Please tick*

(i) on recruitment..... 1

(ii) during employment..... 1

5. Are parent R & D staff seconded to foreign affiliate R & D units? *Please tick*
(Please omit this question if you do not have any foreign R & D units)

(i) Never..... 1

(ii) Rarely / Sometimes..... 2

(iii) Frequently for short durations..... 3

(iv) Frequently for long durations..... 4

(v) (iii) (iv) ----------5

6. Are staff from foreign R & D units appointed to positions in parent R & D unit? *Please tick*
(Please omit this question if you do not have any foreign R & D units)

(i) Never..... 1

(ii) Rarely..... 2

(iii) Frequently. [for short or long duration] 3

7. If the answer to previous question is positive, then do such foreign personnel: ***Please tick***
(**Please omit this question if you do not have any foreign R & D units**)

(i) mainly carry out R & D at the parent facility..... 1

(ii) mainly take part in global R & D decision making..... 1

(iii) do both (i) and (ii)..... ✓

8. What is the turnover rate of R & D personnel? ***Please tick***

(i) Less than 5% p.a..... 1

(i) 5-10% p.a..... 2

(ii) 10-20% p.a..... 3

(iii) Over 20% p.a..... 4

9. Does there exist any liaison between this R & D unit and home country:

(i) Research institutions..... ☐

(ii) Universities..... ☐

(iii) R & D laboratories of other local and/or foreign companies. ☐

Please grade each of these institutions according to the following scale:
1 :Regular contacts 2 :Occasional contacts. 3:No contacts.

10. Are seminars relating to ongoing research in the unit held on its own or in collaboration with other research units/institutions? ***Please tick***

(i) never..... 1

(ii) as and when required..... 2

(iii) systematic programme of seminars..... 3

11. What is the extent of this unit's reliance on local general libraries, libraries of local research institutions/universities, personal collections of scientists, for its research needs? ***Please tick***

(i) High..... 1

(ii) Moderate..... 2

(iii) Low..... 3

12. Are research findings of this unit published in journals? *Please tick*

(i) Never..... 1

(ii) Sometimes..... 2

(iii) Frequently..... 3

13. Does this unit provide any technical support/assistance to local suppliers? *Please tick*

(i) Never..... 1

(ii) Sometimes..... 2

(iii) Frequently..... 3

14. Have product(s) / process(es) developed by this R & D unit been successfully copied for production by other firms? *Please tick*

(i) Never..... 1

(ii) Sometimes..... 2

(iii) Frequently..... 3

15. Does this R & D unit give contract jobs to the following institutions in this country ?

(a) Public research laboratories..... ☐

(b) Universities..... ☐

(c) R & D Laboratories of other firms..... ☐

(d) Others, please specify..... ☐

Please grade ***each*** of the above institutions according to the scale:
1 :Never. 2 :Sometimes. 3 :Frequently.

16. Does this R & D unit undertake consultancy work / contract jobs for public research institutions, universities, or other firms? *Please tick*

(i) Never..... 1

(ii) Sometimes..... 2

(iii) Frequently..... 3

17. Do there exist any exchange programme of scientists between this unit and other local research institutions/laboratories? ***Please tick***

(i) Never..... 1

(ii) Sometimes..... 2

(iii) Regularly..... 3

SECTION VI: DYNAMICS OF R AND D

1. What changes has this unit undergone in the nature of its work since inception?. Please describe briefly. Please use extra sheet, if necessary.

Blank = ~~0~~ (Blank)

N.A = 1

None = 2

Minor = 3

Myriad = 4

Write-up = 5

2. Do you foresee or suggest any changes in the work and role of this R & D unit in the near future? Please use extra sheet, if necessary.

Blank = ~~0~~ (Blank)

N.A = 1

None = 2

Minor = 3

Major = 4

Write-up = 5

3. Do you foresee any changes in the international location of R & D within your company. ***Please tick as appropriate.***

(i) more use of the centralised facility..... 1

(ii) more emphasis on autonomous overseas laboratories 1

(iii) increased emphasis on a globally integrated R & D network..... 1

(iv) No Change → 1

4. What influence is the R & D work of rival firms likely to have on the functioning of this unit? *Please tick as appropriate*

(i) None..... 1

(ii) It is likely to hasten / intensify our own R & D plans..... 1

(iii) It is likely to stimulate increased use of our overseas R & D units... 1

PLEASE OMIT SECTION VII IF YOU HAVE FOREIGN R AND D

SECTION VII: COMPANIES WITH NO FOREIGN R AND D

1. Have you recently considered initiating, or permitting the establishment of, a foreign R & D facility ? *Please tick*

(i) Yes..... 1

(ii) No..... 0

2. If foreign R & D facilities have been considered did the main stimulus favouring such units stem from: *Please tick*

(i) the desire to incorporate foreign located sources of expertise in centrally coordinated international research programmes..... 1

(ii) the desire of foreign producing facilities to upgrade their technological capability..... 1

(iii) host country government pressures..... 1

(iv) increased internationalisation of R & D by our rivals..... 1

(v) others, please specify _____ 1

3. If overseas R & D facilities were considered and rejected please grade the influence of each of the following factors on this decision, according to the scale:
(1) irrelevent to decision
(2) of some influence on rejection
(3) a major cause of rejection

(i) research economies of scale (i.e. critical mass) requires centralised facilities..... ☐

contd

(ii) communications problems with dispersed units would harm the type of R & D we do..... ☐

(iii) no overseas R & D locations have the expertise to rival the home country units..... ☐

(iv) none of our overseas markets are large enough to require separate R & D support..... ☐

(v) none of our overseas markets are sufficiently distinctive to require separate R & D support..... ☐

(vi) the sensitivity of our research requires close home country control... ☐

(vii) others, please specify

4. If your company has not actively considered foreign R & D **please grade** each of the following possible reasons, according to the scale:
(1) of no influence on consideration of foreign R & D
(2) of some influence on excluding possible foreign R & D
(3) a major factor ruling out consideration of foreign R & D

(i) No, or very limited, foreign markets..... ☐

(ii) sensitivity of our research..... ☐

(iii) scale factors must limit our research to one site..... ☐

(iv) the home country research environment, including skills of scientists,is fully adequate for our needs ..... ☐

(v) others, please specify _____ 5

FOR OFFICE USE ONLY

1. Questionnaire Serial Number_____ ATTEMPTS _____

2. Country Code_____

3. Industry Code_____

4. Date Sent_____

5. Date Received_____

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