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R&D subsidiaries? innovative performance ?revisited?: a multilevel approach.

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Abstract

This paper examines the level of innovative performance sourced from foreign research and development (R&D) subsidiaries by taking into consideration the involvement of three cross-classified factors; headquarters (HQ), host location and R&D subsidiary. Although numerous research studies have focused their interest on the above aspect, the multilevel nature of these three parameters is still greatly ignored. The empirical analysis draws on a dataset of 173 R&D subsidiaries classified by 57 parent companies (HQs) and 25 host locations (foreign countries). Accordingly, the contribution of this study is principally of a methodological nature, since a cross-classified multilevel model (MLM) is implemented using three different data sources (patent data, survey-based data and country-level data). The results suggest that the HQ?s influence is almost four times more important than host location aspects with respect to their total impact on the R&D subsidiary?s innovative performance. As concerns the multilevel regression results, it is suggested that collaboration between scientists belonging to different nationalities within the R&D subsidiary is a positive indicator of innovative performance. Furthermore, R&D subsidiaries mandated by their HQs to develop new products rather than improvements on existing inventions are found to perform better.

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ABSTRACT

This paper examines the level of innovative performance sourced from foreign research and development (R&D) subsidiaries by taking into consideration the involvement of three cross-classified factors; headquarters (HQ), host location and R&D subsidiary. Although numerous research studies have focused their interest on the above aspect, the multilevel nature of these three parameters is still greatly ignored. The empirical analysis draws on a dataset of 173 R&D subsidiaries classified by 57 parent companies (HQs) and 25 host locations (foreign countries). Accordingly, the contribution of this study is principally of a methodological nature, since a cross-classified multilevel model (MLM) is implemented using three different data sources (patent data, survey-based data and country-level data). The results suggest that the HQ's influence is almost four times more important than host location aspects with respect to their total impact on the R&D subsidiary's innovative performance. As concerns the multilevel regression results, it is suggested that collaboration between scientists belonging to different nationalities within the R&D subsidiary is a positive indicator of innovative performance. Furthermore, R&D subsidiaries mandated by their HQs to develop new products rather than improvements on existing inventions are found to perform better.

Keywords: Innovative performance; Multinational corporations; R&D subsidiaries; Patent data; Multilevel model; Variance Partitioning Coefficient

1. Introduction

Innovative performance has been increasingly considered as one of the most critical aspects of the MNC. Particularly during the last three decades, there has been a growing number of studies dedicated to the international business (IB) field showing a particular interest in exploring and explaining the factors which shape the level of innovative performance of MNCs' foreign R&D subsidiaries (Almeida and Phene, 2004; Belderbos, 2001; Ghoshal and Bartlett, 1988; Lahiri, 2010; Mudambi and Navarra, 2004; Mudambi et al., 2007; Phene and Almeida, 2008). It is known that MNCs aim to tap their R&D operations away from the HQ location in order to integrate their home-base augmenting (HBA) and/or home-base exploiting (HBE) activities (Kuemmerle, 1997). In order for an MNC to decide to enter into a foreign (host) location and consequently establish an R&D subsidiary, it is required that a precise strategic plan should be executed. This plan will define the main responsibilities of the unit, as well as the context of its organizational structure. Nowadays, it is widely known that foreign-based subsidiaries are embedded in two different, but very interesting - in terms of knowledge generation - environments at the same time; these are (a) the MNC internal environment and (b) the external environment of the host country (Almeida and Phene, 2004). In more simple words, apart from the R&D subsidiary itself, there are two other crucial elements that embrace the R&D unit and determine to a great extent the level of its innovative performance. The HQ (parent company) and the host location (environment) in which the R&D subsidiary operates.

Although the majority of the existing empirical studies on this subject (i.e. innovative performance of MNCs' foreign R&D subsidiaries) incorporate data from three different levels (location, industry and firm level data), as was also suggested by Buckley and Casson (1976), there are still a few unobserved effects that have been ignored and accordingly should be further explored with caution. First, although the great majority of related studies use subsidiary-, parent- and host location- level data, these are predominantly used in non-hierarchical models; that is, they do not consider the multilevel nature of the aforementioned data. As a result, it can reasonably be asserted that unobserved effects deriving from the implementation of non-hierarchical models on multilevel data exist and may lead to ambiguous estimates (Snijders and Bosker, 1999). Second, when multilevel data are used in a research study and accordingly an MLM is implemented, one of the advantages that is offered to the researcher is the estimation of the exact variance components which are attributed to each of the examined classifications of interest to us. Specifically, in this research study, it is possible to derive the precise level of heterogeneity of parent companies' and host countries' characteristics in regard to the degree to which these influence the level of the R&D unit's innovative performance. Consequently, it can be stated that the novelty and contribution of this study is twofold and that this principally derives from the differentiated methodological approach that is incorporated.

Bearing in mind that the innovative performance of MNCs' foreign R&D subsidiaries is considered a well-studied research topic nowadays, this study's aim is to bring to attention the estimation dynamics of an MLM when data of a multilevel nature are used. Through the inclusion of data from three different sources (patent data, survey-based data and aggregate-level data) and levels (HQ, host location and firm-level data), as well as by implementing a cross-classified MLM, this study contributes to our existing knowledge by incorporating a rather novel methodological approach. The next section analyzes the multilevel determinants affecting MNC R&D subsidiaries' innovative performance. What follows is the presentation of data used in this study, as well as the detailed analysis of each variable. Next, a comprehensive analysis of the incorporated research method (MLM) and its related aspects is presented. The following section portrays the results of the estimated models. Finally, the last part of this study includes concluding remarks, while all the recognizable caveats and future research opportunities are brought to attention.

2. Multilevel determinants of innovative performance

As has already been highlighted in the introduction, innovative performance of R&D subsidiaries is a feature determined by multilevel factors and not by single (horizontal) ones. The following theoretical parts are analyzed according to the level each group of determinants belongs to. Consequently, the next subsection analyzes the firm (subsidiary)-level factors affecting innovative performance, while special attention is given to cooperation among actors, both inside and outside the R&D subsidiary. The next subsection focuses on HQ characteristics and more specifically on the level of autonomy and the different roles that decentralized R&D subsidiaries are mandated to perform. The final subsection sheds light on host country determinants, derived from both the economic geography and National Innovation System (NIS) literature.

2.1. First (lower) level factors: R&D subsidiary and cooperation

As is already known from the existing literature, the level of R&D cooperation between different actors inside an organization is perceived as a factor of fundamental importance for the efficient functioning of a firm. Teamwork has multidimensional forms, and this dimensionality can be illustrated in the nature of actors cooperating in a particular R&D project. Numerous research studies have come up with findings which support the positive linkage between intra-, inter- and extra-unit collaboration and innovative performance. More specifically, MNCs' subsidiaries' teamwork, as a form of cooperation and sourcing of internal or external knowledge, has been proven to be a positive determinant of knowledge generation

(Becker and Dietz, 2004; Caloghirou et al., 2004; Lahiri, 2010; Mudambi et al., 2007; Sumelius and Sarala, 2008; Tsai, 2001; Tsai and Ghosal, 1998; Yamin and Otto, 2004). Furthermore, there is a plethora of empirical findings supporting the view that firms which expand their network and vertical cooperation (i.e. cooperation with suppliers and clients) enjoy an important enhancement in regard to their innovative performance (Belderbos et al., 2004; Bengtsson and Solvell, 2004; Chang, 2003; Miotti and Sachwald, 2003). From the above facts and figures, there is evidence that R&D cooperation with both the internal and external environment enhances the unit's overall innovative performance.

2.2. Second (higher) level factors

2.2.1. The HQ's influential role

Traditional IB theory shows that the MNC R&D subsidiary operates neither as a sole 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 Ghosal (1989) empirically confirmed the notion that subsidiaries' level of autonomy is related to enhancement of MNCs' innovative performance. In the same manner, Persaud et al. (2002), researching R&D labs belonging to MNCs 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 MNC subsidiaries based in Brazil, finds that more innovative units seem to enjoy greater autonomy than less innovative ones. Apparently, it can be derived that highly autonomous subsidiaries have the flexibility to establish ties with external actors, create synergies and interact with their peripheral environment (cluster) more regularly.

Furthermore, the mandated role of the decentralized R&D subsidiary is another factor frequently related to the innovative performance of the unit. Pearce (1999) demonstrates that MNCs are now showing a more knowledge-generating attitude, as they move in a more evolutionary direction as regards the role given to their decentralized R&D labs. As a result, the labs have now demonstrated a different approach, since they have become involved with product development rather than adaptation and improvement processes. R&D subsidiaries with a pure research-orientated profile are expected to perform better on innovation than those units mandated to complement existing knowledge or make improvements to existing products.

2.2.2. Host country characteristics

Apart from the HQ's engagement in the R&D subsidiary's activities, another factor of critical importance is the host location's particular characteristics. Traditional aspects deriving from the economic geography literature, such as the degree of geographical and cultural proximity of the subsidiary to the HQ location, as well as macroeconomic indicators shaping the level of the host economy and indicating the depth of the market (such as GDP per capita) are valued as crucial determinants of innovative performance. Besides, it is empirically known that large domestic markets are more likely to attract greater amounts of R&D investments of the HBE sort (Cantwell and Piscitello, 2002; Dachs and Pyka, 2010; Kumar, 1996; Kumar, 2001).

From the NIS perspective, even more influential for the subsidiary are the level of the intellectual property rights (IPR) protection regime and the richness of scientific endowment in the host location. Although an increased level of vertical and inter-firm cooperation may lead to the broad improvement of a firm's innovation, there is always the fear of knowledge spillovers which make firms more skeptical and reluctant to further exploit the gains of such collaboration. Cassiman and Veugelers (2002), analyzing firm level data from Belgium, find that in many cases very sensitive information is exposed to third parties, creating spillovers with immensely negative outcomes for the firm. In this situation, only firms which are capable of protecting their knowledge are in a position to establish any sort of collaboration with external actors. Despite the fact that the presence of a strong IPR protection regime is found to be a positive indicator of innovation (Krammer, 2009), the finding of Cassiman and Veugelers (2002) is also consistent with the research study of Zhao (2006), who explains that, irrespective of the level of protection in the host location of their operation, firms are in a position to communicate their knowledge more internally, since they are aware of possible leakages and knowledge spillovers to several external actors. Zhao (2006) has called his finding 'institutional arbitrage', since many MNCs are capable of internalizing their knowledge in order to avoid any possible spillover effects, regardless of the level of IPR protection in the environment of their operation. However, since firms are not always capable of protecting their internally produced knowledge autonomously, as well as considering the fact that MNCs are more than ever globalized, while they also incorporate numerous synergies and R&D collaborations in various geographical locations, it should be recognized that IPR protection is still considered one of the most influential institutional factors that MNCs take enormously into consideration when they decide to tap their R&D activities into a particular host location. This importance becomes even greater when possible knowledge spillovers and sensitive information leakages might occur in the case of R&D collaboration within or between firms.

Additionally, host locations with rich scientific endowments are expected to attract knowledge-intensive industries, which in turn have a positive impact on the generation of new knowledge. The role of the domestic stock of knowledge and the existence of capable human capital in science and technology are highlighted in a great number of studies on technology-based FDI (Cantwell and Mudambi, 2000; Cantwell and Piscitello, 2002; Demirbag and Glaister, 2010; Lewin et al., 2009; Narula and Guimón, 2010; Sachwald, 2008).

3. Data

3.1. Sample

The data used in this study are gathered from multiple sources. Firstly, a unique survey-based dataset generated in 1989 is used[1]. This survey is based on a questionnaire that was sent to a sample of major enterprises which were principally selected from the Fortune 500 list of companies[2]. Specifically, the questionnaire was sent to MNC parent laboratories[3] and a total of 163 responses were received. This resulted in a response rate of almost 26.2%, which is a satisfying percentage, considering the international theme of the survey and the related difficulties in gathering responses from different countries at that period of time. The first

[1] Although this study's dataset may be perceived as dated, given that over two decades have passed since the year this survey took place, the existing literature shows that recent studies focused on innovative activities of MNCs have also incorporated relatively old data in their analyses. Some examples are the studies by Un and Cuervo-Cazurra (2008), using data from the period 1991-1994 and Mudambi et al. (2007), incorporating data corresponding to the year 1995.

[2] Apart from the Fortune 500 list, during the process of reviewing directories in order to locate the facilities for the Fortune 500 list of industrialised companies, an additional number of multinational enterprises with relevant characteristics as regards the decentralization of R&D activities was observed and accordingly selected in order to supplement the research study's target group. Accordingly, since the latter subsample was generated from a self-selecting process, and in order to control for possible selection bias, an equal number of companies with no apparent overseas R&D operations were also selected in order to match the former subsample of firms by industry and home location characteristics. In total, 622 MNCs were chosen for this survey.

[3] 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).

section of the survey asked the respondent to provide information regarding the countries where the MNC has established R&D unit(s). Accordingly, the most important information derived is the identification of host locations in which the examined MNCs operate R&D subsidiaries. Thus, one of the main purposes of the above questionnaire was to identify the exact geographical locations where the MNCs had established R&D subsidiaries[4]. Unfortunately, from the total of 163 responses only 57 could be used in the analysis, resulting in a final response rate of almost 9.2%. The reason for this significant sample truncation is that either some MNCs reported no foreign locations of operation, or the data which they entered were incomplete or inaccurate[5]. According to Armstrong and Overton (1977), and in order to test for non-response bias, I proceed to a t-test by comparing the two samples (inaccurate and incomplete responses against the accurate ones). By performing a t-test on size and age data, I find no statistically significant difference ($p < 0.05$) between the aforementioned two samples, 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[6]. Table 1 portrays the cross-tabulation between the locations of the HQs and their R&D subsidiaries from the examined sample. From the following information it can be asserted that the sample's distribution is sufficiently representative as regards the already known global research activity of MNCs. Patel and Pavitt (1991), through their renowned research study on 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 Table 1, since

[4] 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.

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

[6] The host locations are as follows: Argentina, Australia, Austria, Belgium, Brazil, Canada, Denmark, France, Germany, India, Italy, Japan, Mexico, Netherlands, Norway, Philippines, Spain, Sweden, Switzerland, Singapore, South Africa, Thailand, Taiwan, United Kingdom, USA.

American, British and Japanese MNCs are indeed well represented in this study, accounting for approximately 75% of the total responses. Apart from 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 MNCs' sales take place in their home triad region (Japan, Western Europe and North America). This percentage is well depicted in this study's sample, since almost 87% of the examined overseas R&D subsidiaries are based in the triad region.

[Table 1 goes about here]

Secondly, knowing the exact names of the MNC R&D subsidiaries and the locations in which they have been established, I can identify relevant and time-related patent data in order to construct my 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 in terms of quantity (i.e., patent generation). 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 R&D collaboration with either internal (HQ and sister subsidiaries), or external (firms and universities) actors.

Thirdly, using aggregate (country) level data, I am in a position to examine the impact of location-related factors on the innovative performance of R&D subsidiaries. These data include institutional (NIS) factors (such as the level of the Intellectual Property Rights regime), the degree of scientific endowment richness (such as the number of scientific publications), and other location-related data, which are used in order to control for unobserved effects on innovative performance (such as the subsidiary's geographical and cultural proximity to the HQ location).

3.2. Variables

3.2.1. Dependent variable

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[7]. As has been already mentioned, I make use of the USPTO database in order to collect this information, since it is already known that USPTO is the most accurate and reliable patent database, while it is widely used by leading researchers and professionals. The USPTO 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[8]. The total number of patents for this specific window is the measure for the innovative performance each R&D subsidiary has produced.

3.2.2. Independent variables

3.2.2.1. Firm level variables

[7] I use this specific 5-year period since the majority of the existing research studies allow for a 5-year window in order to observe the forthcoming patent activity of the examined subsidiaries, starting from the year that the survey took place.

[8] For observing the exact year of innovation I use the application date of the patent.

Cooperation is a term for which numerous and multidimensional definitions have been given in the past. In reality, it is very difficult for someone to give an explicit definition and characterization (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 (Glanzel and Schubert, 2004; Melin and Persson, 1996; Subramanyam, 1983). What they all suggest is that such a proxy can be used as an efficient estimator as concerns 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 co-authored patent data in order to identify the degree of cooperation between scientists. More precisely, Mudambi et al. (2007) use co-authored patent 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 becomes noticeable that patent co-authorship has been integrated as a rather efficient and realistic measure of intra-, inter- and extra-organizational research collaboration. Accordingly, the following variables are created using co-authorship data.

International cooperation: This variable is measured as the number of patents in which the inventors are reported to be from two or more international locations. The USPTO search engine provides patent information in regard to the inventor’s exact location when the patent application was submitted to the USPTO. By examining such information, the author is able to identify whether the patent is a product of international cooperation between inventors in multiple geographic locations. The proxy for this measure is developed by dividing the total number of patents in which two or more inventors are based in different international locations by the total number of patents applied for to the USPTO for the 5-year period examined. A similar technique has been implemented by Nerkar and Paruchuri (2005) and Lahiri (2010), but in order to measure intra-organizational linkages between subsidiaries.

Parent cooperation: Apart from international linkages there is also a particular interest in identifying whether innovation in R&D subsidiaries occurs in association with their HQs' 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) as co-inventor, including the location where the HQ is based. This measure is created by dividing the sum of the patents in which such a relationship (HQ as co-assignee) is reported by the total number of patents assigned to the R&D subsidiary for the 5-year period examined.

Subsidiary cooperation: Similarly to the previous variable, I calculate this measure by examining whether the patent's co-inventor is a sister R&D subsidiary[9]. Again, I divide the sum of the patents in which such a relationship occurs (the co-inventor appears to be a sister R&D subsidiary) by the total number of patents registered by the examined R&D subsidiary for the 5-year period of interest.

External firm cooperation: 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. This specific variable measures the degree of external firms' involvement in the R&D subsidiary's innovation process. In particular, I estimate this measure by identifying

[9] In order to identify if a sister R&D subsidiary is the co-inventor of the patent, I observe the co-assignee name, which should be the name of the firm located in any country except the HQ location.

whether the patent's co-assignee name is an external firm located in either the host or another location. As for the synthesis of the two previous variables, I divide the sum of the patents in which a subsidiary – external firm 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.

University cooperation: Universities are considered as one of the most powerful sources of knowledge on which MNCs' research centers rely. Following the same methodology as for the previous variable, I estimate the degree of subsidiary – university cooperation by dividing the number of inventions produced via such cooperation by the total number of patents developed in the examined R&D subsidiary for the aforementioned 5-year period.

3.2.2.2. HQ (parent) level variables

R&D Mandate: The survey questionnaire asked the HQs (parent firms) to identify the role of their decentralized R&D units' activities based on the following typology. i) Does the unit produce basic/original research? ii) Does the unit develop new products in the present industry? iii) Does the unit develop new production technology in the present industry? iii) Does the unit improve existing products and/or techniques? The answers to the above questions have a categorical-Likert formation, ranging from 1 (relatively less important in overseas R&D units than in parent) to 3 (relatively more important in overseas R&D units than in parent) based on the importance of the decentralized R&D compared to the parent. Accordingly, the variables created from the above questions are *Basic research*, *New products*, *New technology* and *Improvement*.

Autonomy: This is a survey-based question which asks the respondent parent company whether its foreign R&D subsidiaries are closely or autonomously associated with the HQ. 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 in percentage scale, ranging from 0-100%. For data homogeneity purposes, the answers are transformed to a 0-10 scale.

3.2.2.3. Country level variables

Intellectual Property Rights (IPR) regime: Numerous studies have examined the impact of IPR protection that exists in a specific location in order to capture its impact on the level of innovative activity, knowledge creation and knowledge assimilation. In order to assess the level of the IPR protection regime corresponding to each of the examined host countries, I incorporate a measure called IPR regime. This variable is constructed by considering the Intellectual Property Rights Protection Index (Park, 2008) for the period 1960-1990. The original scores of the IPR Protection Index range from 1 (weakest) to 5 (strongest).

Scientific Publications: This variable is in a scale formation and is constructed by estimating the natural logarithm of publications in scientific and technical journals (per million people) in the host location. The values for this variable correspond to the year of the survey.

3.2.2.4. Control variables

Geographical Distance: The existing literature provides evidence that the less the geographical distance between the parent and the host country, the greater the volume of innovation produced in the R&D subsidiary. Indeed, we already know that MNCs prefer to locate their R&D activities in close proximity to their corporate HQs. This strategy is principally in order to better control the affiliate's activities. 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.

Cultural Proximity: Colonization is a notion of great importance in international business studies. MNCs consider colonies or locations with common language and cultural characteristics as ideal for establishing their R&D subsidiaries. Institutional characteristics, cultural values and ethics are strongly related to common language sharing. Apart from strong location indicators for the MNC, these characteristics can also be proved to be prominent indicators of innovative performance. Cultural proximity is operationalized as a dummy variable, taking the value 1 if the R&D subsidiary is based in a host location where the official language is the same as that of the parent country, and value 0 otherwise[10].

GDP per capita: By incorporating GDP per capita in the model, I aim to measure the impact of market size on the level of innovative performance. Especially in cross-sectional data, where a large number of countries are researched, such a measure is a reliable control of heterogeneity issues. A logarithmic transformation has been applied to the variable.

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).

Accordingly, Table 2 presents the descriptive statistics of the data.

[Table 2 goes about here]

4. Research method

4.1. Multilevel model (MLM)

[10] Both geographical and cultural distance data were gathered from Institute for Research on the International Economy (CEPII).

Hierarchical and multilevel models are predominantly used in 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 as the most effective research method for analyzing multiple phenomena and behaviors across different levels. This particular assumption is also depicted in the recent special issues of The Academy of Management Journal (edited by Hitt et al.), and the Journal of International Business Studies (edited by Arregle et al.) in 2007 and 2012 respectively.

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 MLMs has been implemented until the recent past. Analytically, the author acknowledges the following recent works as influential for the extension of the above theme. Specifically, Lederman (2010) analyzes the multilevel determinants of product innovations by incumbent firms nested under three different levels (countries, firms, sectors). Also, Srholec (2010 & 2011), from an economic geography point of view, introduces a multilevel approach to the geography of innovation and uses a two level model (firms and regions and firms and countries respectively) in order to demonstrate how research on geography of innovation can benefit from MLMs. The above research work portrays the increasing interest of the academic community in MLMs, while there is also evidence that academic scholars have spotted a value-added element in this particular research method, especially when their endeavors are focused on explaining multilevel determinants of innovation.

4.2. 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, we are 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 deal with three different levels (subsidiary, HQ and host country), in reality, my 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 1 portrays the cross-classified nature of the examined relationship more clearly.

[Figure 1 goes about here]

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

$Y_{i(jk)} = \beta_{0(jk)} + e_{i(jk)}$ (1), 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:

$$\beta_{0(jk)} = \gamma_{00} + u_{0j} + v_{0k} \quad (2),$$

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 (2) for equation (1), the intercept-only (empty) model is structured as follows:

$$Y_{i(jk)} = \gamma_{00} + u_{0j} + v_{0k} + e_{i(jk)} \quad (3),$$

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.

4.3. Variance Partitioning Coefficient

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, in 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%.

In this study I am interested in explaining the degree to which the heterogeneity of HQs' (parent companies) and host countries' characteristics influences the level of innovative performance. By measuring the variance-partitioning coefficient (VPC)[11], I am in position to estimate the level at which parent companies' and host countries' characteristics are less or more important for explaining the R&D subsidiary's level of innovative performance. VPC is estimated as follows:

$$VPC = \frac{\sigma^2_{uoj} + \sigma^2_{vok}}{\sigma^2_{uoj} + \sigma^2_{vok} + \sigma^2_{\varepsilon_i(jk)}} \qquad (4),$$

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}).

4.4. 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.

[11] VPC is also known as intra-class correlation (ICC).

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, I 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 author decided to proceed with a logarithmic transformation of the dependent variable in order to handle the count nature of the dependent variable[12].

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

$$\mathrm{Ln}(1+Y_{i(jk)}) = \gamma_{00} + \gamma_{01}F_{i(jk)} + \gamma_{02}P_j + \gamma_{03}H_k + \gamma_{04}C^F_{i(jk)} + \gamma_{05}C^H_k + u_{0j} + v_{0k} + e_{i(jk)} \qquad (5),$$

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, 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

[12] 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, 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. Apparently, negative binomial multilevel regression is not feasible, since STATA does not support such an estimation command for MLM. Hence the logarithmic transformation is valuable since it has enabled the incorporation of a cross-classified MLM in the aforementioned software.

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. Results

5.1. Multicollinearity issues

A quite frequent problem faced in regression analyses, particularly when a large number of dummy variables are used, is the presence of multicollinearity (Hair et al., 1998). The possible presence of multicollinearity can be identified through the correlation matrix, where variables can be highly, but imperfectly, correlated (Greene, 2003). In such a case, and although the regression model is processed, it is almost certain that severe statistical problems will arise and the model will turn out to be of insufficient quality. The correlation matrix (Table 3) indicates that the possible presence of multicollinearity may hold for three variables (*IPR_regime*, *ln_Publications* and *ln_GDPPC*). In order to further assess whether multicollinearity is an issue, I proceed to estimate the variance inflation factors (VIFs) for each coefficient. The results reported in the following Table reveal that the VIFs scores range from 1.09 to 6.17. The general assumption is that no significant multicollinearity exists if the VIFs scores are less than 10, and hence it can be assumed that multicollinearity is not an issue in our case.

[Table 3 goes about here]

5.2. VPC estimates

As also highlighted in the methodology section, one of the most important aspects of the MLM is the measurement of the variance components which are attributed to each of the examined classifications (HQ, host country and R&D subsidiary). The empty model in Table 4 (Model A) reports the variance components corresponding to all the aforementioned levels. From the estimates it is suggested that approximately 16.27% of the total variance is attributable to the HQ level, while 4.83% of the variance is attributable to the host location level. In total, it can be seen that 21.10% of the total variance is credited to HQ and host location (level 2) characteristics, while the remaining 78.90% is ascribed to other factors. The findings reveal that HQ attributes are almost four times more influential than host location aspects, in respect to their total impact on the R&D subsidiary's innovative performance.

[Table 4 goes about here]

Since HQ and host location variation coefficients are larger than their standard errors, it is suggested that a still significant variation accounts for both levels. Hence, the incorporation of level 2 variables in the model is considered crucial in order to explain some of the unobserved variance. Accordingly, in model C, when parent company (HQ) predictors are incorporated the total VPC accounts for 14.24% of the total variance, while in model D, when host country characteristics are included the total VPC is truncated to 5.86%. Finally, in model E a set of control variables corresponding to both subsidiary and host location levels are added. In the final model (model E) the results indicate that a very small amount of variation is still considered as unexplained (1.33%), while the standard errors are no longer larger than the variation coefficients. The results indicate that the inclusion of the higher level variables has accounted for a great portion of the variance in the examined dependent variable.

5.3. Estimates of MLM explanatory variables

As can be observed from Table 4, the cross-classified MLM was implemented following a stepwise regression. Apart from the VPC estimates which show that model E 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 (model E) is greatly preferable to all the previous models. In particular, a quite significant difference ($\Delta Deviance_{A-E} = 39.598$) among the deviances of models A and E is observed.

Concerning the regression estimates, it is suggested that cooperation between scientists belonging to different nationalities has a significant and positive impact on the subsidiary's innovative performance. This result is accompanied by a highly significant coefficient reported in all stages of the model. Regarding the remaining four level-1 explanatory variables, the results indicate no significant impact on the examined dependent variable. There is only a slightly significant and positive impact of parent (HQ) cooperation on innovative performance as concerns the estimation of model B and model C, although when host location characteristics and controls are incorporated in the final model, no such impact is observed. As regards the parent company (HQ) attributes, these are found to have a rather influential impact on the subsidiary's innovative performance. Specifically, it is observed that parent companies which mandate their R&D subsidiaries to develop new products in the present industry are found to have a positive and significant effect on the subsidiary's innovative performance. On the other hand, parent companies mandating their subsidiaries to develop improvement techniques on existing products are found to negatively influence the level of innovation. As far as country level variables are concerned, the estimates suggest no significant impact of this explanatory group on the examined dependent variable. Finally, when controls are introduced in the final model (model E) it is found that the electronics industry exhibits a significant indication of a positive impact on the innovative performance of the R&D subsidiary.

6. Conclusion

6.1. Contribution of the study

Following a traditional and well-studied IB theme, 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. 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. First, although the aforementioned relationship is associated with three interrelated parameters, each one corresponding to a different level (classification), the majority of the existing studies have neither considered nor identified the multilevel nature of this relationship. Second, this paper adopts a methodological approach providing, apart from the cross-classified multilevel regression results, also the VPC measure, under which the level of variance for each examined classification is accordingly reported. Hence, apart from the factors shaping the level of the subsidiary's innovative performance, the study contributes by providing information on the extent to which HQ and host country characteristics are less or more important in explaining the R&D subsidiary's level of innovative performance.

The VPC estimates provided evidence that the variance attributable to the HQ (parent company) level is roughly four times greater than the variance accountable to the host location level, while in total, the second (higher) level factors account for approximately 21% of the total variance. It becomes obvious that innovative performance is a factor enormously determined by the HQ's decisions, rather than the subsidiary's host location characteristics. Although the existing IB theory and related empirical studies have treated these two classes (HQ and host location) almost equally, the findings suggest that the HQ plays a vastly superior role as concerns the impact on the innovative performance of foreign-located R&D subsidiaries.

As regards the cross-classified multilevel regression estimates, the findings have shown that cooperation between multinational scientists is found to have a strong and positively significant effect on the level of innovative performance produced in the examined subsidiaries. It seems that diversification in terms of nationalities is identified as a factor of critical importance for R&D subsidiaries' innovative performance. The empirical results also suggest that R&D units mandated to produce new products in the present industry are positively associated with innovative performance, while those mandated to complement the existing technological activities by developing improvement techniques for the MNC's existing products show a rather negative effect on the R&D unit's innovation. It is already known that globalization of innovation may occur in several ways (Archibugi and Iammarino, 1999; Kuemmerle, 1997). However, the present findings reveal that MNCs which move toward the wave of global generation of innovations and global technological collaborations are more likely to perform better in terms of innovation generation.

6.2. Limitations and suggestions for future research

Considering the theme of this study, as well as the complexity and multidimensionality of the incorporated model, the author cannot ignore the possible limitations of this research. First, due to the nature of our 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 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, the author 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 amount 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.

Nevertheless, and to the best of the author’s knowledge, a considerable research gap in the field of MLM and its application in IB studies and particularly in R&D subsidiaries’ innovative performance is observed. The above facts give a value-added element to the present study, while the implementation of an MLM may serve as an inspiration for other researchers who are interested in hierarchical and multilevel studies. While the proportions of these levels may have been modified in recent years and the examined factors may now be less or more significant due to a variety of economic, political and environmental changes in the global scene, the author believes that the present study has managed to motivate and show the way toward multilevel research on the examined and related fields when more up to date data become available.

Consequently, 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 MNC, an MLM is the most appropriate estimation technique for providing answers to unobserved characteristics.

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APPENDIX

Figure 1. Conceptual diagram for cross-classified structure

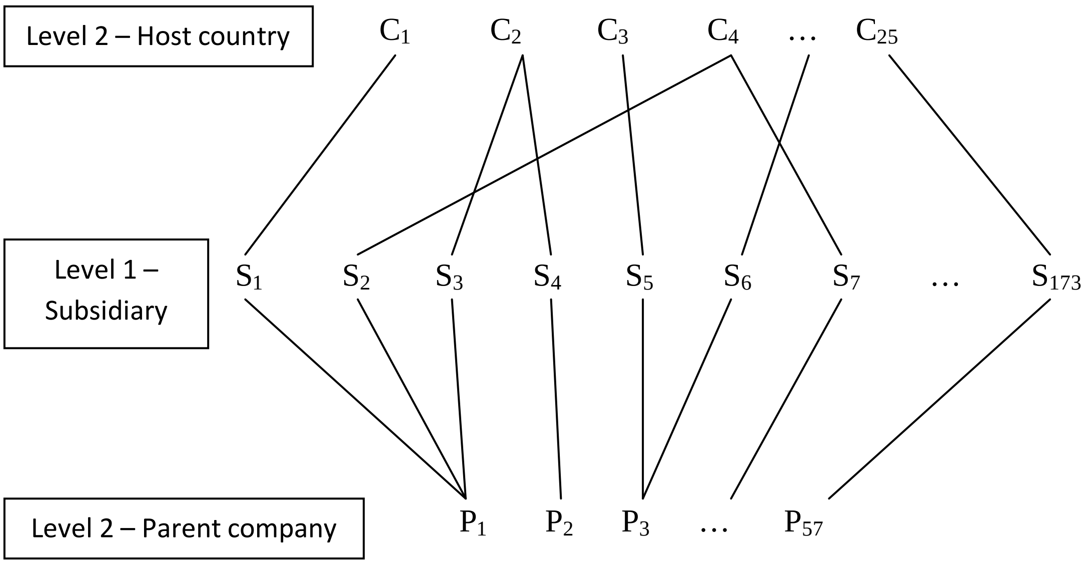

Table 1. Cross-tabulation table between parent and host locations.

		HQs (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**

Total (H) corresponds to N=173 R&D subsidiaries based in 25 host countries.
Total (P) corresponds to N=57 parent companies based in 11 home countries.

Table 2. Descriptive statistics

Variables	N	Mean	Std. Dev.	Min	Max
ln_Patents	173	0.921	1.309	0	4.430
Intern_Coop	173	0.051	0.163	0	1
Parent_Coop	173	0.014	0.107	0	1
Sister_Coop	173	0.006	0.047	0	0.5
External_Coop	173	0.057	0.216	0	1
University_Coop	173	0.011	0.107	0	1
Autonomy	57	1.430	2.736	0	10
Basic_research	57	1.271	0.471	1	3
New_products	57	1.884	0.617	1	3
New_technology	57	1.884	0.672	1	3
Improvement	57	2.069	0.576	1	3
IPR_regime	25	3.131	0.651	0.950	4.140
ln_Publications	25	5.896	1.049	0.907	6.863
ln_GDPPC	25	9.646	0.615	5.863	10.242
ln_Geo_Prox	25	8.056	1.203	5.153	9.828
Cultural_Prox	25	0.289	0.454	0	1
CP	173	0.225	0.419	0	1
EC	173	0.242	0.430	0	1
MM	173	0.184	0.389	0	1
PH	173	0.196	0.398	0	1
MISC	173	0.144	0.352	0	1

Table 3. Correlation matrix

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	ln_Patents	1																			
2	Intern_Coop	0.24	1																		
3	Parent_Coop	0.15	0.19	1																	
4	Sister_Coop	0.05	0.10	0.02	1																
5	External_Coop	0.05	0.19	0.21	0.10	1															
6	University_Coop	-0.01	0.29	-0.01	-0.01	0.22	1														
7	Autonomy	-0.08	-0.11	-0.06	-0.06	0.05	-0.05	1													
8	Basic_research	-0.01	-0.03	-0.05	0.05	0.12	0.16	0.03	1												
9	New_products	0.20	0.05	-0.06	-0.01	-0.21	-0.15	-0.09	-0.09	1											
10	New_technology	0.04	-0.16	-0.07	0.11	0.06	-0.14	0.23	0.28	0.23	1										
11	Improvement	-0.12	0.06	0.01	0.02	-0.08	-0.01	-0.25	-0.28	0.08	-0.17	1									
12	IPR_regime	0.23	0.02	0.09	-0.01	0.00	0.00	0.02	-0.09	0.17	0.03	0.04	1								
13	ln_Publications	0.21	0.06	0.05	0.07	0.04	0.04	0.03	-0.02	0.10	0.04	0.01	0.76	1							
14	ln_GDPPC	0.20	0.05	0.04	0.04	0.10	0.03	0.03	-0.06	0.06	0.03	0.01	0.69	0.86	1						
15	ln_Geo_Prox	-0.06	-0.09	-0.05	-0.01	0.21	-0.05	-0.01	0.00	-0.28	-0.18	-0.06	-0.09	-0.15	-0.15	1					
16	Cultural_Prox	0.01	0.03	-0.03	0.10	-0.05	0.05	-0.05	0.06	0.01	-0.04	-0.03	0.16	0.23	0.03	-0.01	1				
17	CP	-0.03	-0.05	0.06	0.07	0.11	-0.05	-0.24	0.07	0.05	0.09	0.07	-0.01	0.03	-0.00	-0.08	0.05	1			
18	EC	0.11	0.01	-0.07	-0.07	-0.08	-0.06	0.08	-0.09	-0.02	-0.04	0.26	-0.10	0.02	0.02	-0.07	-0.09	-0.30	1		
19	MM	0.03	-0.12	-0.06	-0.06	-0.11	-0.05	-0.03	-0.18	0.08	0.03	-0.13	0.10	0.03	0.01	0.03	-0.07	-0.25	-0.26	1	
20	PH	-0.04	0.08	0.06	0.04	0.03	0.22	-0.12	0.17	-0.09	-0.15	-0.16	-0.06	-0.17	-0.09	0.06	-0.09	-0.26	-0.28	-0.23	1
21	MISC	-0.10	0.10	0.00	0.01	0.04	-0.04	0.37	0.04	-0.02	0.07	-0.07	0.08	0.07	0.06	0.08	0.20	-0.22	-0.23	-0.19	-0.20
	VIFs	-	1.32	1.16	1.09	1.38	1.33	1.50	1.37	1.33	1.47	1.36	2.78	6.17	4.76	1.30	1.35	2.60	2.44	2.32	2.47

All the correlated coefficients with values greater than 0.15 and lower than -0.12 are significant at 10% level of significance.

Table 4. Cross-classified multilevel regression model on R&D subsidiaries innovative performance in parent companies and host countries

Dependent variable: ln_Patents	**Model A** (Empty model)	**Model B** (Empty model + Level 1)	**Model C** (Empty model + Levels 1 & 2a)	**Model D** (Empty model + Levels 1, 2a & 2b)	**Model E** (Full model + controls)
Intercept (γ_{00})	0.840*** (0.140)	0.737*** (0.140)	0.938 (0.673)	-0.241 (0.796)	-2.441 (2.548)
Fixed effects					
Intern_Coop		1.825*** (0.602)	1.775*** (0.607)	1.794*** (0.605)	1.938*** (0.608)
Parent_Coop		1.503* (0.885)	1.439* (0.875)	1.207 (0.874)	1.349 (0.861)
Sister_Coop		-0.208 (1.943)	0.062 (1.932)	0.304 (1.918)	1.081 (1.891)
External_Coop		-0.109 (0.454)	0.019 (0.457)	0.063 (0.454)	0.062 (0.469)
University_Coop		-0.618 (0.951)	-0.457 (0.951)	-0.658 (0.936)	-0.494 (0.931)
Autonomy			-0.040 (0.041)	-0.045 (0.038)	-0.046 (0.038)
Basic_research			-0.086 (0.241)	-0.048 (0.226)	0.032 (0.214)
New_products			0.378** (0.180)	0.335* (0.172)	0.384** (0.161)
New_technology			0.055 (0.176)	0.037 (0.165)	0.047 (0.155)
Improvement			-0.405** (0.192)	-0.424** (0.179)	-0.550*** (0.174)
IPR_regime				0.269 (0.226)	0.379 (0.233)
ln_Publications				0.085 (0.138)	-0.062 (0.212)
ln_GDPPC					0.202 (0.315)
ln_Geo_Prox					0.053 (0.083)
Cultural_Prox					0.036 (0.225)
CP					0.259 (0.333)
EC					0.895*** (0.314)
MM					0.371 (0.339)
PH					0.122 (2.548)
Random effects					
Parent company Variation (u_{0j})	0.276 (0.144)	0.268 (0.138)	0.143 (0.116)	0.070 (0.110)	5.35E-09 (0.001)
Host country Variation (v_{0k})	0.082 (0.073)	0.079 (0.068)	0.064 (0.063)	0.011 (0.047)	0.017 (0.050)
R&D Subsidiary Variation ($e_{i(jk)}$)	1.338 (0.175)	1.220 (0.162)	1.246 (0.167)	1.299 (0.179)	1.275 (0.143)
Total VPC	21.10%	22.14%	14.24%	5.86%	1.33%
Model fit statistics					

Wald Chi-square	-	15.13***	25.45***	35.76***	53.89***
Deviance (-2LL)	574.766	560.274	551.812	546.258	535.168
ΔDeviance	-	14.492	8.462	5.554	11.090
AIC	582.766	578.274	579.813	578.258	581.168
BIC	595.379	606.653	623.959	628.711	653.694

***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).